



CRITICAL FOCUS

Brian J. Ford

Focusing on Microscopy – Books that Open Our Eyes

Publishing books about microscopes is a specialist niche. The classical titles speak volumes about how the field has progressed and provide a unique insight into the story of science.

When first I wrote books on the microscope, I had only one or two historic titles on my own bookshelves. Now I have hundreds. Curiously, it was writing my own books that led me to acquire the others, and they inspire me every day. Their authors have bequeathed to us a wealth of insight, and we can watch our science unfolding as we move from one book to the next.

Producing a book is costly; a publishing company would easily lay out \$100,000 to originate a single volume.

So a book has referees who appraise its merit, editors who peruse the text and ensure that it's marketable, text specialists who scrutinize the manuscript for grammatical infelicities and double-check to eliminate factual errors, and designers who ensure that the layout pleases the reader's eye. Since so much money is invested in the product, it has to be right.



The dangers to public health lurking in London water had been suspected for decades, and the artist William Heath had published this popular cartoon as long ago as 1828. Subsequent epidemics of water-borne diseases including cholera and typhoid had raised the profile of those hidden microorganisms, so the public were eager to learn more.

So the best microscopists in Britain scrutinized my book *The Revealing Lens*, *Man-kind and the Microscope*, prior to publication, to ensure it would stand up to scholarly appraisal by its readers. *The Optical Microscope Manual, Past and Present Uses and Techniques*, a book in which I surveyed the history of microtechnique, was published around the same time. That also had to be reviewed by the leading authorities. Did you buy one when they came out? If so, you're showing your age – they are both 50

years old.

REVELATION AND THE PUBLIC

The Revealing Lens was intended to fill a gap in our scientific understanding. I had been fascinated by the development of the microscope ever since first

Ford, Brian J.

**Single Lens : The Story of the Simple Microscope
[Brian Bracegirdle's copy]**

London: Heinemann 1985. First Edition. x, 182 pages.
Microscopical historian Brian Bracegirdle's copy with his
bookplate on the front pastedown. A well read copy with
bumped corners, and overall wear. A nice association. Very
Good / Very Good. Boards. [29153]

*Brian Ford is an entertaining writer and also lecturer - if
you have a chance see one of his InterMicro 'Evenings with
Brian Ford' in Chicago sometime (see the McCrone Institute
for more information - great microscopical resource).*

Price: \$25.00

Leading microscopists were keen to purchase these books, because they broke new ground. My copy of *The Revealing Lens* is from Brian Bracegirdle's collection, bearing his library label, and was sent to me by a thoughtful book dealer. Bracegirdle also purchased *Optical Microscope Manual*, only to follow it with publications of his own on the evolution of microtechnique.

encountering Leeuwenhoek at school (see: "Leeuwenhoek Microscopes, Mystery and Mischief," *The Microscope*, Vol. 63:3, pp. 131-142, 2015) and I had created comparative images of specimens from the seventeenth century when viewed through present-day microscopes. The London publisher, George Harrap, were interested in my writing a book and my editor there, Hugh Bingham, proved to be meticulous and erudite.

In those days, long before the office computer, the manuscript was composed on a typewriter, with corrections and amendments marked in pen along the margins. Bingham mailed back the top copy, with amendments, and I returned it to him by special delivery.

Next week, he admitted he'd lost the entire book; left it in a taxi, or on the train. I always kept a copy of all the amendments; indeed I have always kept a backup of everything (there are three copies of this article, as I write). Just as well – Bingham lost that copy, too. All that remained was the last carbon copy, each letter blurred and indistinct. I had to use a photocopier to smarten it up (and delivered it by hand). Shortly afterwards, I purchased a photocopier for my own use – and said goodbye forever to carbon paper.

The book was enthusiastically reviewed, mostly in Britain but also in the Netherlands and the US, where Walter McCrone reviewed it for this journal (see: Wal-

ter C. McCrone, *The Microscope*, Vol. 22:4, p. 278, 1974). The common theme throughout was the opening of a new window of insight into a topic that affected everybody but about which few people felt properly informed. Yet that wasn't the only theme, for there was much original laboratory research published in that book. I paid due regard to the remarkable pioneering investigations of Robert Hooke, after being allowed access to his remarkable, folio-sized book *Micrographia* published in 1665.

At the Natural History Museum in London, my great friend Clive Jermy had retrieved a copy from their antique book collections and allowed me to turn its pages. I included Hooke's intricately engraved study of cork tissue in *Revealing Lens*, accompanied by something that had never been accomplished before – I took a photomicrograph through an antique microscope of a similar specimen and published the correlated images alongside each other (it's on p. 37 of the book). The comparison between Hooke's portrayal of the specimen, and its actual appearance in a modern micrograph, was highly illuminating. Microscopists found it fascinating; for the first time we could compare the ancient rendition with its modern counterpart, and we could appreciate how accurate was Robert Hooke's fine engraving in comparison with a photographic image.

And there was more. The head louse *Pediculus* was a spectacular sight in the fold-out engraving Hooke published in *Micrographia*. But how had it appeared to a pioneering microscopist in the 1600s? I prepared a bead-lens from melted soda-lime glass and imaged the head of a louse through this simple magnifier. Then I took a fresh specimen of *Pediculus*, cleared and mounted it in Canada balsam, with a human hair placed diagonally across the field of view corresponding to Hooke's original drawing. Once again, we had correlated micrographs and could see exactly how the present-day specimens compared with the engraving by Hooke (*Revealing Lens*, pp. 44-45).

Feathers had been studied by Robert Hooke, and their delicate structure fascinated the early philosophers, so I had prepared correlated micrographs of these too (*The Revealing Lens*, pp. 174-175). The finer structure was shown through a simple bead lens, an early compound microscope, a research microscope of the 1970s, and lastly a JEOL scanning electron microscope. Once more, the eye could run from one to the next, recreating the pioneer's view of what we see today.

This broke new ground. For centuries scholars

had mused over how specimens really appeared, compared with the way the pioneering observers had represented them; and now we could see the comparison. This is a field of experimentation to which I have more recently returned, but it was in this now 50-year-old book that the evidence was first published.

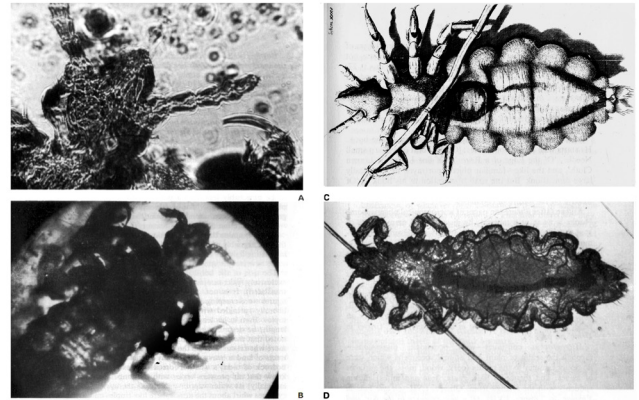
TECHNIQUES OF MICROSCOPY

My other new book, *The Optical Microscope Manual*, was also attracting attention. The British company of David & Charles first published it, and then it came out from Crane, Russak in New York, and Reed International in Australia. My editor there was David St. John Thomas, co-founder of the company, and an enthusiast for historical engineering. He loved the idea of a book on the techniques of microscopy, and it included some innovations – not pictures this time, but revelations set in juxtaposition. I revealed that the specimens Leeuwenhoek had described bore an unmistakable resemblance to Hooke's own experiments described in his book.

The text followed the emergence of the achromatic microscope and, in later chapters, I reviewed the extremes that designers had reached. We had the pocket microscope designed by Dr. John N. McArthur, which was invaluable for use in the field. John and his wife would come for the day when we had moved to Cambridgeshire and regaled us with stories of his remarkable life.

At the other extreme, we had the huge reflecting microscope designed by Cecil Burch, who used polished aspheric mirrors to allow us to illuminate a specimen at ultraviolet wavelengths. Burch and I used to lunch together at his university in Bristol, England, and the attic of his department had the cast iron bodies of these gigantic microscopes waiting to have their mirrors installed. Each weighed over 200 pounds and stood 5 feet tall. I have one here still.

Optical Microscope Manual was well received internationally; it was reviewed in this journal (Walter C. McCrone, *The Microscope*, Vol. 23:4, pp. 286-288, 1975). This time, although the editors didn't manage to lose the manuscript, the final proofs (complete with corrections) were lost in the mail. Nobody thought to follow it up, so the book had several uncorrected errors, and the publishers had to insert a page of corrections in the front of each copy. We had 'insufion' instead of infusion, and 'Kepeer' in place of Kepler. To this day, the book still refers to its counterpart as *The Lens Reveals* in the bibliography.



Optical microscopes and the louse.
A: Reconstructed lens made by the author gives a pioneer's-eye view of the louse *Pediculus humanus*. The lens, produced by melting a fine drawn-out rod of glass but without any subsequent polishing, gives a remarkably clear view in spite of its crude nature.
B: An original specimen photographed by the author using

a Wilson screw-barrel microscope from the collection of Carl Routledge.
C: Hooke's fine engraving of the louse appeared in *Micrographia* (page 36).
D: For comparison, this mature louse has been specially mounted in Canada balsam and photographed using a modern research microscope.

Reconciling the record with reality. For centuries, scholars had been perplexed by the relationship between the drawings produced by the pioneers and the appearance of a microscopical specimen. My book, *The Revealing Lens*, introduced views of a preparation through microscopes old and new. These were pioneering demonstrations that date back 50 years.

BIRTH OF A LIBRARY

Even then, I did have a few antique books; my student friend, Ray Batten, gave me a 1944 copy of *Gray's Anatomy*, still illustrated with many of the original engravings. The highlight of my limited book collection at the time was a second-hand 1937 edition of *The Microbe Hunters*, by Paul de Kruif, first published in New York in 1926, which I had bought in my teens. I had been browsing in a bookstore to while away time, because I'd arrived early for band practice (I used to play piano in a blues band, and the church hall where we rehearsed was across the street from the store).

A few years later I found the Dover reprint of *Micrographia*, published in New York in 1961. Then we went to Hay-on-Wye, a tiny town in Wales famous for its numerous bookstores and host to an annual literary festival. In one of the shops was a section on the history of science, and there, in a dark corner and gleaming white in the gloom, stood Clifford Dobell's masterful biography *Antony van Leeuwenhoek and his "Little Animals"* published in 1932. It cost £40 (over \$800 today).

Soon after, a copy of Henry Baker's *The Microscope Made Easy* fell into my hands. It had been published in 1743, and I had consulted the book in London with Clive Jermy, so owning my own was very exciting. We had all been to Canterbury to see the graduation of my son Anthony (yes, his name had been inspired by Leeuwenhoek). The ceremony took place in the mag-

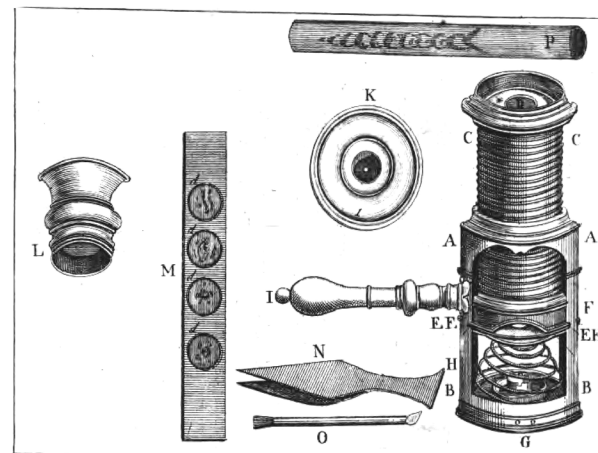
nificent cathedral, founded in 597 and rebuilt in 1174. By chance, I was seated next to the picture editor of *Vogue* magazine, and we spoke afterwards at the reception. About a month later, my wife Jan and I were in central London, and had been discussing antique books on the train to town – including the Henry Baker volume. Strolling through Cecil Court (claimed by some to be the inspiration for Diagon Alley in the Harry Potter books and movies) we were hailed by the same couple. We chatted happily, and then we all wandered into Watkins Books, a famous shop founded in 1893 and renowned for beautiful bindings of esoteric titles and spiritual books. I said to the owner that no, I didn't think they'd have a title of interest to me. "I work with microscopes," I said. "That's not one of your core specialties, is it?" He chuckled. "No, it isn't," he said, "But I did have a book come in with a job lot – that's an old book about microscopes. Let me fetch it."

He reached into a box and pulled out a book in an antique binding. To my astonishment, it was Henry Baker's *The Microscope Made Easy* – the very book we'd been talking about that morning. Needless to say, I bought it on the spot. It's a wonderful volume and was written by someone who had intimate knowledge of Leeuwenhoek: Baker studied the microscopes bequeathed to the Royal Society (which they later lost) and he used them too. This book is an evocative link with the dawn of microscopy.

Some months later, my family were off to spend the day in Greenwich, London, when my son Stuart came across a copy of Maria Roseboom's book *Microscopium*, published by the science museum of Leiden in 1956. It seemed to him the kind of book I'd like, and he was right. It's a large format volume of only 50 pages and records the structural development of the microscope over the centuries. In format and scope, it's unique – indeed, it is too tall for most bookshelves, measuring over a foot tall.

THE SILENT CENTURY

Some of these titles I mentioned in my previous column, and readers were keen to know what else lurks in my library. It is within the pages of books on microscopy that we can see the way attitudes changed, and cultural priorities rose and fell over the centuries. I've never been a book collector – the volumes on my bookshelves got there because somebody mentioned one, or because I saw a title in a shop while browsing to kill time, sometimes because of an email or a casual phone-call, but not because I was out hunting for



Henry Baker published *The Microscope Made Easy* in 1743, and a copy in its original binding was brought to my attention through a casual visit to a store in London. One of Baker's illustrations featured this Wilson screw-barrel microscope; a single-lensed instrument where focusing took place by rotating a brass barrel engraved with a thread.

them. My haphazard collection of microscopy books was soon demanding a case of their own. I rarely had to go elsewhere to check facts and figures; I now had an accidental library to consult.

Henry Baker's book had been crucial, since after 1750 there was a silent century in microscopy. A few people published experiments involving their own microscopes – in 1744 Abraham Trembley published his book *Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes* (Memoirs for the History of a Genus of Freshwater Polyps with Horn-Shaped Arms) which contains many microscopical illustrations. I do not have the original in my collections, though I do possess the annotated reprint presented by my good friends Sylvia and Howard M. Lenhoff that was published in California in 1986.

Similarly, William Withering published *A Botanical Arrangement of All the Vegetables Naturally Growing in Great Britain*, a detailed account of British plants – and not only the flowering species. As I turn the pages of my own copy, I mostly value the occasional microscopical images. There is a plate showing his own simple microscope, a crude design in a simple wooden box; but the botanical illustrations are fine, and the descriptions detailed and scholarly.

George Adams, a prominent eighteenth-century instrument maker, published his book *Essays on the Microscope* in 1787. It was the only book in the period to discuss microscopy as a science, though his illustrations owed much to previous publications. His pictures of *Hydra* were borrowed from Trembley, pond

organisms (like *Vorticella*) copied from Leeuwenhoek, houseflies directly from Hooke. Plagiarism marked out the early history of microscopy and, as regular readers will know, it still does. *Essays on the Microscope* looked back at the era of revelation, and served to promote the sale of the microscopes Adams made; it was not a step into an unknown future. When Leeuwenhoek passed away in 1723, microscopy died with him.

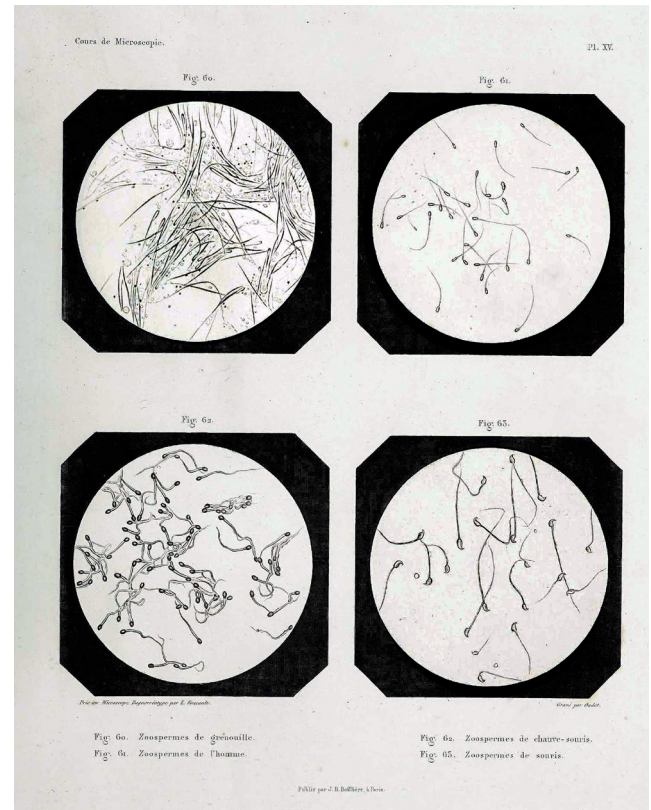
The first microscope book of the nineteenth century is often said to be *Microscopic Illustrations* by C.R. Goring and Andrew Pritchard, published in 1827. Don't believe it: there are very few spectacular lithographic plates, but most of the specimens are magnified only a few times, and there are very few details you could not make out with the naked eye. Their descriptions of microtechnique – methods of illumination, etc. – are much the same as those published a century earlier. In fact, the first book on the subject in that new century was *The Select Works of Antony van Leeuwenhoek, Containing His Microscopical Discoveries in Many of the Works of Nature* translated by Samuel Hoole and published in 1807. Leeuwenhoek's revelations were attracting a new generation of readers – though anything to do with spermatozoa, or the acts of reproduction, were omitted; the religious British establishment wanted none of that.

MICROSCOPY CLIMBS THE CHARTS

Subjects in science rise and fall like popular music in the charts. In my reprinted satire on "nonscience," I called it fashionism (see: Brian J. Ford, *Nonscience Returns*, Curtis Press, 2020). Once it was rising sea levels, then it was global warming, followed by climate change, or perhaps not. It used to be vitamin C, then it was Q10 and glucosamine, currently it's turmeric. Once vaccination was our savior, now it's to be shunned at all costs. There was a time when microscopy held everybody spellbound; now it's deep space. For some 100 years after 1750, few people were interested in microscopes, and microscopy languished as a specialist hobby of interest to a very few ingenious investigators.

People were using microscopes but, as scientific instruments, they weren't considered of interest. John Ellis developed a design of simple microscope around 1740, which was advanced and perfected by the London instrument-maker John Cuff and became known as the Ellis aquatic microscope. Ellis published research on the corals, with studies using these instruments.

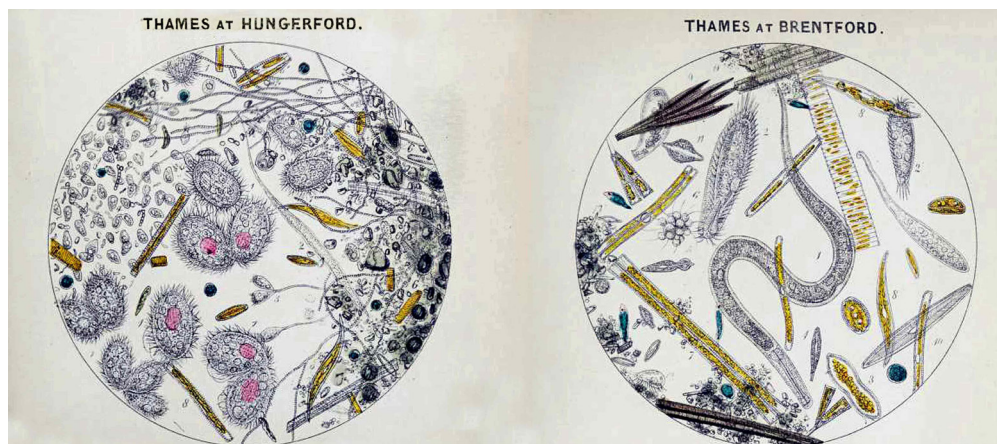
Robert Bancks took up the design and produced



The first microscopical images taken with a camera were published by a French microscopist, Alfred Donné, in 1845. His plates featured steel engravings taken from daguerreotype photographs of a range of bodily fluids. Plate 15 showed spermatozoa from frog, bat, human, and mouse. This was the first textbook to feature plates derived directly from photomicrographs.

a version known as a botanical microscope (it was the same, but used for plants rather than marine specimens). Charles Darwin used one for decades, and Robert Brown studied both Brownian motion and the cell nucleus using one of these little instruments. Brown followed the process of fertilization in the gymnosperms, an extraordinarily detailed and demanding piece of research, using a Bancks microscope, but little was said about them. I brought a group of these microscopes together, and had to discover afresh how they were used, for there were no accounts giving the details (see: Brian J. Ford, "Charles Darwin and Robert Brown – Their Microscopes and the Microscopic Image," *InFocus, Proceedings of the Royal Microscopical Society*, No. 15, pp. 18-28, 2009).

In nineteenth century Paris, Charles Chevalier was making microscopes for hobbyists. He was an optician, like his father and grandfather, and found a way to make an achromatic microscope that might appeal to the serious user. The best way to promote it? Why,



A British physician, Arthur Hill, produced a survey of the organisms in London water that was published in 1850. Swarms of scavenging *Coleps* seem to predominate in samples from Hungerford, along with diatoms like *Gyrosigma* and *Surirella*. From Brentford, he extracted nematodes, protozoa (including *Stylonychia* and *Lacrymaria*), and several diatoms.

a book, of course; and so he self-published a 290-page volume entitled *Description des Microscopes Achromatiques Simplifiés et Exécution d'un Nouveau Système* (Description of Simplified Achromatic Microscopes and Carrying Out a New System) to promote his products. Chevalier makes his purpose plain – he relates the fact that microscope books of the past rarely spoke of how the instrument was set up and used; his book, he states, is to be a practical manual. So there's plenty on the instruments, but little on the specimens. Several plates are devoted to optics, and to his microscopes; but there is just one showing microscopic objects, and the drawings are amateurish. Chevalier was a superb optical specialist with a keen eye for history, and for practical detail. His book is a wonderful read, but if you seek pictures of living cells you will face disappointment.

And you'd not be the only one. A Parisian physician named Alfred Donné was equally perplexed at the absence of microscopic images from the published record. Donné was preoccupied with bodily fluids (from semen to synovial fluid, and from breast-milk to blood) and had captured images of them in an historic series of experiments – they were photomicrographs taken as daguerreotypes. These were faithfully copied as engravings on steel plates, and so he published an unprecedented book entitled *Cours de Microscopie Complémentaire des Études Médicales, Anatomie des Corps Organisés et Physiologie des Fluides de l'Économie, Accompanyé d'un Atlas de 80 Planches Gravées sur Acier d'après les Photographies Daguerriennes* (Course in Microscopy Complementary to Medical Studies, Anatomy of Organized Bodies and Physiology of Fluids of the Economy, Accompanied by an Atlas of 80 Plates Engraved on Steel from Daguerreian Photographs).

This historic book was published in Paris in 1845

by Jean-Baptiste Baillière and appeared in two volumes. It was the second volume that contained the unprecedented micrographs, each looking almost like a photograph, yet engraved, by hand, on the metal printing plates. Each picture was about 10 cm. (4 in.) square, and he fitted four onto each 44 × 30 cm. (17 × 12 in.) plate.

Donné had a co-author to supervise those magnificent illustrations, a physicist and illustrator named Léon Foucault. The name should be familiar – it is the pendulum that Foucault pioneered which hangs from the ceiling of so many museums around the world, slowly scribing the rotation of the earth. When you think of the Foucault pendulum, spare a thought for his pioneering initiative in the publication of the first book ever produced that featured photo-realistic illustrations of the microscopic world. The specialist theme of the book, and the narrow scope of the subject matter, limited its appeal, but it was a harbinger of what was to come.

Across the channel in England, a similar book was taking shape. Arthur Hill Hassall, a physician and enthusiastic amateur microscopist, compiled *A Microscopical Examination of the Water Supplied to the Inhabitants of London and the Suburban Districts*, and featured five spectacular hand-colored plates of the organisms he could find. Each plate bore two eye-catching circular engravings, each 10 cm. (4 in.) in diameter. The microscopic images show organisms tightly packed, creating the impression of a fetid and putrid water supply – indeed, that's not so far from the truth. Londoners had known their water was contaminated for decades, and in 1828 the cartoonist Edward Heath had published a cartoon showing monstrous microbes that Hassall's book seemed to confirm. This was a book that captured attention, though (like Alfred Donné)

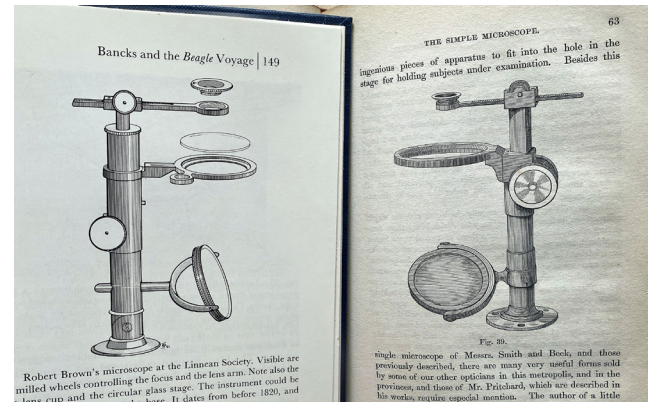
Arthur Hassall did not write much about microscope; just what you could see through them.

MICROSCOPES FOR THE MASSES

Meanwhile, a young enthusiast from southwest England named John Quekett had become obsessed with the panoply of what microscopes could reveal. He gave his first illustrated lecture on the topic when aged just 16. I was about the same age when I gave my first lecture on microbes – but mine was nothing on his. In my presentation, I demonstrated how bacteria were cultured in the laboratory (in my case, in the back bedroom) and what they looked like under a microscope, all well-known stuff that I was explaining to a young audience. Nothing Quekett said was well known to anybody; his first microscope was one he made himself, and he was breaking new ground. His audience wasn't confined to school children – adults wanted to hear what he had to say. Quekett must have been a remarkable young man.

He began to develop novel techniques to make permanent preparations, sometimes by injecting specimens, occasionally staining them, and often mounting them whole. So impressive was Quekett's collection, that the Royal College of Surgeons purchased them all in 1846, a total of some 2,500 slides. They are the greatest collection of microscope slides that survive from the period, and they created a wave of interest. Quekett himself was so stimulated by the growing emphasis on his work that he wrote the first important book on the microscope as a scientific instrument: *A Practical Treatise on the Use of the Microscope*, published in 1848. He starts with a survey of the history of the instrument, paying generous tribute to Hooke and Leeuwenhoek, with illustrations of their microscopes, and describing in some detail what was known of their work.

Quekett's book marked a turning point for science. No longer was a microscope a curious little device used by occasional specialists – the achromatic microscope was now in production, and Quekett's book is respectfully dedicated to Joseph Jackson Lister, for "perfecting the achromatic compound microscope." This suddenly fashionable device could reveal the secrets of the world around us. The book features engravings of contemporaneous microscopes, drawings that Quekett says were executed by Tuffen West, an emerging enthusiast for microscopical illustration and a superb artist. You will search in vain for cascades of beautiful images revealing the microscopical world, for there are only 5 pages of pictures. They show hairs,



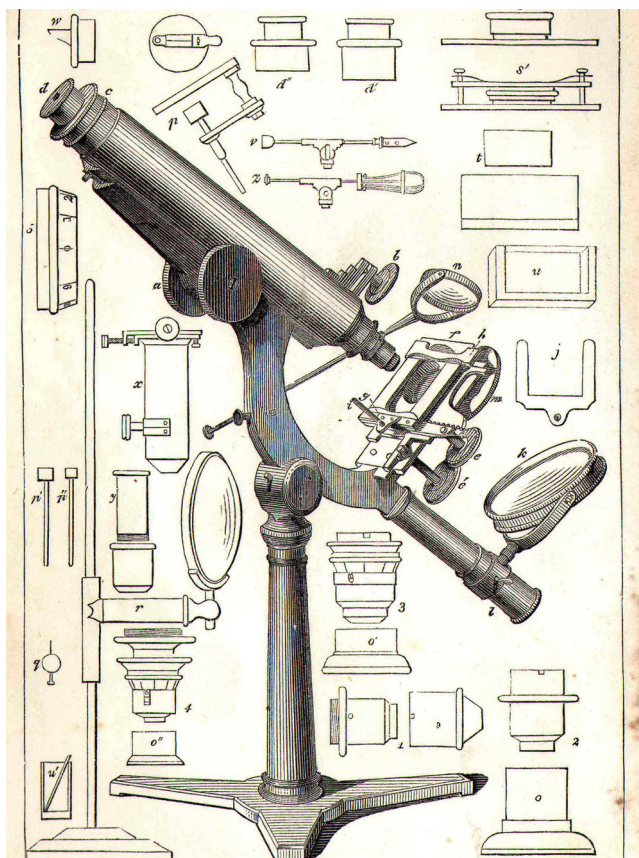
Single-lensed microscopes were made by Robert Bancks and Son and they supplied versions to notables from King George IV, an ardent follower of science, to Charles Darwin. I prepared this illustration of a microscope made by Bancks (left) for my book *Single Lens, the Story of the Simple Microscope* (1985). Decades later, I was given John Quekett's masterful *Treatise* (1848) and was astonished to see this woodcut of a Smith & Beck microscope (right). Not only are the two images remarkably similar, but also they are reproduced exactly the same size on the printed pages.

butterfly scales, and diatoms – though the fourth plate reveals Quekett's remarkable skills as a microtommist: it shows striated muscle in astonishing detail. Most mysterious of all is a signature, tucked into the corner of most of the plates, reading JDC Sowerby.

James De Carle Sowerby was a prominent naturalist and illustrator, and would have been the ideal person to provide illustrations for Quekett's pioneering new book, but Quekett nowhere acknowledges him in the text. The careful dissection of striated muscle fibers is meticulously explained, but there is no reference to the extraordinary plates that feature the result. Sowerby marks the birth of high-resolution microscopy with his vivid illustrations. The details of diatoms like *Navicula* are exquisitely rendered, as are the hairs of bats; but it is the teased muscle fibers that hold the key – these photo-realistic images could fit well into a scientific paper published today, yet they are over 175 years old. The dawn of achromatic microscopy was the key, and now the floodgates would open.

PHILADELPHIA POINTS THE WAY

When did the popular craze for microscopes take off? Here is a book that is often overlooked: *The Microscopist*. Written by Joseph H. Wythes, physician and microscopist, it was published by Lindsay and Blakiston of Philadelphia in 1851, the same year in which Foucault announced his pendulum. In his book, Wythes sketched the history of the microscope, misspelt



John Wythes published *The Microscopist* in Philadelphia in 1851, just as interest in microscopes was gathering pace. Subtitled "a complete manual," it features this engraving of a Smith & Beck No. 1 microscope as its frontispiece. Note the stage forceps (near top) used for holding insects and minerals. They are no longer manufactured, but were popular until a century ago.

Leeuwenhoek as Lewenhoeek (and having his dates wrong) while omitting Hooke altogether. But he puts his finger on the pulse, by beginning with these prescient words: "The employment of achromatic instruments [means] microscopic research has ceased to be merely an amusement but has been elevated to the dignity of a science." Wythes was correct. His book follows the emergence of achromatic optics, from the Wollaston lens through Holland's triplet, and with detailed explanations of the fight against chromatism. Indeed, he has a detailed engraving of an elegant Smith & Beck microscope as the frontispiece to his book.

The new achromatic lenses gave microscopists the chance to view their specimens at high resolution, and in comfort. The earlier simple microscopes made by Adams, Ellis, and Bancks could give surprising results, but now the images were crisp and beautifully sharp when properly focused – and, more to the point,

these new microscopes were bulky, impressive, and costly. They were objects of desire, conferring status on the owner. And the dimensions of the body occupied the exact distance between the level of the users' desk, and the position of their eyes. No more bending over to use a botanical microscope or squinting into a distant window with an instrument like Leeuwenhoek's. Now you sat at ease, a gleaming new device on your desk, and watched life unfold at your leisure.

This was a new window on the world – it was the birth of a new science. The world of scientific publishing was about to expand like never before. Microscopes would be everywhere, and everyone would be keen to learn about them. The answer lay in books – and publishers keen to cash in on the craze produced them in large numbers.

BURGEONING BIBLIOGRAPHY

I don't think of my books the way you are supposed to – alphabetized by author, perhaps by title, possibly with the Dewey Decimal System in mind. Mine are remembered by what they look like. Tall thin book, pale blue binding (that's the Roseboom). Crown octavo, with worn leather and replacement title band (Henry Baker).

Here's another: squat stout book, maroon with gold: must be William B. Carpenter's *The Microscope and its Revelations* (3rd edition, 1858). This book is testimony to the rapid growth in popularity of the microscope to Victorian enthusiasts – neither Hooke nor Leeuwenhoek are mentioned, even in passing; there is no dwelling on the past, for this is all about the application of the microscope, what it can do, and how you use it to reveal the secret world that lies beneath its lens. Excellent woodcuts of microbes, pollen grains, algae, and pond life abound – and plenty of contemporaneous microscopes.

Nuzzling nearby is a tall, fat book with green cloth and faded gold lettering. It's Lionel S. Beale's *How to Work with the Microscope* (5th edition, 1880), the most lavishly illustrated book of its type. The book runs to 524 pages, with another 400 pages of plates; there are up to 20 pictures on each plate, thousands of them. Some of the full-page woodcut images are printed in color. It is a magnificent compendium of techniques, instruments, accessories, and specimens. This time, it is living tissues that predominate; nerve cells, muscle fibers, capillary networks, and teased tissues.

Octavo red cloth-bound volume, small gold lettering; it's John H. Martin's *Microscopic Objects, Featured and Described* of 1870 (and recently reprinted by For-

gotten Books). Apart from the appendix, each page of this 114-page book alternates with a lithograph bearing two illustrations of microscopical specimens, from zoological and botanical sections to microbes and minerals. It sounds like a gem; but it isn't. There is nothing particularly wrong with the pictures, but there isn't much that's right, either. They lack the vitality, flair, and realism of the beautiful images in other books. Those were often drawn by artists like Tuffen West, that great illustrator of books on microscopy. In Martin's book, the drawings are all his.

Martin's studies represent their subjects reasonably well, but are chunky, plodding, and unrefined. Some of his drawings of insects are life-size, and crude. Martin's flea (and the louse) are not remotely as detailed, or as accurate, as those of Robert Hooke some two centuries earlier. Other images – like some of the botanical cross sections and studies of foraminifera – are nicely captured with a sense of realism. Few are of permanent preparations; the majority are of freshly prepared specimen material, some illuminated from above, others with darkfield. He is also wasteful, of space. Each substantive page, 9 inches tall, bears just two illustrations a mere 6 cm. (2.5 in.) in diameter. Tuffen West would squeeze 30 meticulous, vibrant drawings into a page no bigger than a postcard.

And then there's a gem: octavo, bottle-green cloth boards, embossed spine. It's a hugely important volume in the development of achromatic microscopy, *The Microscope, its History, Construction and Applications*, written by surgeon and microscopist Jabez Hogg, published in 1854. The first edition, spanning 440 pages, includes a frontispiece, 15 lithographic plates, and over 500 woodcut engravings within the text, featuring detailed illustrations of microscopes, their components, and microscopic specimens. Hogg includes a detailed history, too; Leeuwenhoek and Hooke are both mentioned at some length. There are mistakes over some of the dates, but Hogg notes Robert Hooke's description of making a single-lensed microscope. The text is readable even today. The title page bore a subtitle: *Being a Familiar Introduction to the Use of the Instrument and the Study of Microscopical Science* that prepares the reader for a journey of discovery. This is a majestic, authoritative work. It was hugely influential; indeed I also have the 15th edition, published in New York and London in 1898. Replica publishers reissued it in the last century.

There is a similar book alongside, bound in dark-green cloth and with an uncompromising title: *How to Work with the Microscope*. It was published in Philadelphia by Lindsay and Blakiston at the same time as the



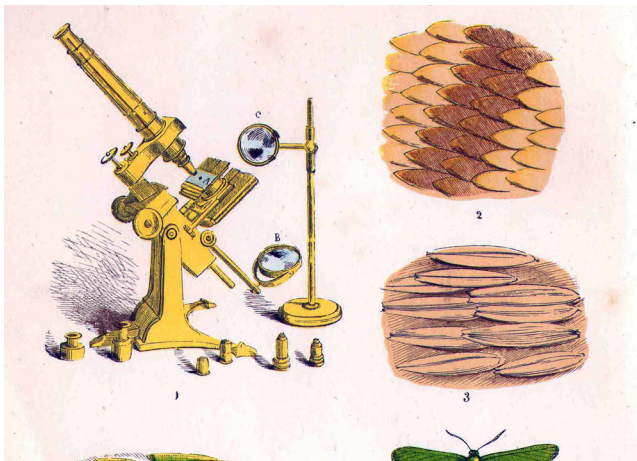
Color illustrations mark out later editions of Lionel S. Beale's book *How to Work with the Microscope*. This detailed study of the hyoid muscle of the green tree frog, *Hyla arborea*, was made with a Powell & Lealand achromatic microscope magnifying 1,700×. The plate is printed with two colored woodcuts; a process the Victorians called chromoxylography.

British edition, and was compiled by Lionel S. Beale, a professor at King's College, London. The book soon became a classic; my copy is the 5th edition, dated 1880, which is considered the most authoritative. It extends to 743 pages, large octavo 23 cm. tall (9 in.), and contains 112 illustrations, both woodcuts and plates, several in color. This was an intensely practical book and became a cornerstone of the microscopical laboratory.

POCKET BOOKS FOR THE ENTHUSIAST

Here's one for the amateur. You need to extract this book from the shelf to appreciate its beauty. It is bound in olive-gray cloth, the pages brightly gilt-edged, with a floral design printed on the front cover and *Ilex aquifolium*, the holly, embossed on the back. It is entitled *The Microscope* and was written by a prolific author, the Hon. Mrs Mary Ward (see "Forgotten Women Who Lit the Way," *The Microscope*, Vol. 68:3/4, pp. 139–150, 2020).

Ward wrote many books on microscopy. *Sketches with the Microscope* came first, in 1857, a collection of illustrated letters to her friend Emily Filgate, describing microscopical observations of insect wings and plant tissues, illustrated with a few colored lithographs. Then came *A Windfall for the Microscope* on fungi and spores, which she self-published in 1856. That little book was later picked up by the London publishers Groombridge and Sons, for whom Ward wrote *A World of Wonders Revealed by the Microscope* (1858) a book so popular that it was reprinted many times until 1880. Then came *Microscope Teachings* (1864) and *The Microscope; or, Descriptions of Various Objects of Es-*



On the frontispiece to Mary Ward's *The Microscope* is an instrument by Andrew Ross, a No. 1 bar-limb microscope, made about 1845. It cost £48 12s 8d, currently about \$9,000, and is on display at Castle Ward in Northern Ireland, her husband's family home. The green forester moth, *Adscita statice*, features too, with microscopic views of its scales.

pecial Interest and Beauty Adapted for Microscopic Observation in 1869.

My edition bears no publication date, though it was aimed at the informed amateur enthusiast, with no history and starting with how you unpack your new microscope and set it up at home. Ward pays generous tribute to other writers throughout her text, and recommends readers to consult Carpenter's book *The Microscope and its Revelations*. Ward addresses the novice from the start in a style that is approachable and easy on the eye. There are several full-color lithographic plates, showing specimens from butterfly scales and mammalian hairs to pollen grains and fern sporangia, while tardigrades and rotifers are featured in the text pages as woodcuts. And it is filled with practical hints and tips, even alluding to "polarizing light" as a useful adjunct in studying anisotropic minerals.

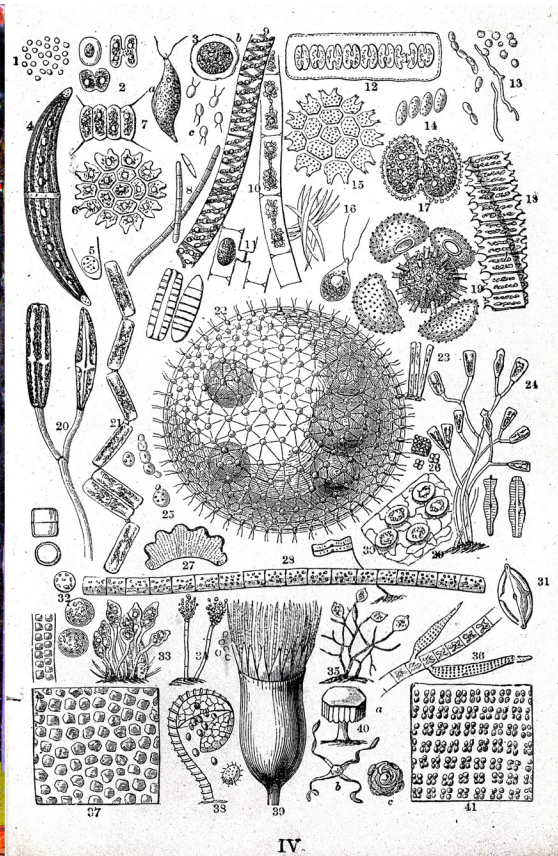
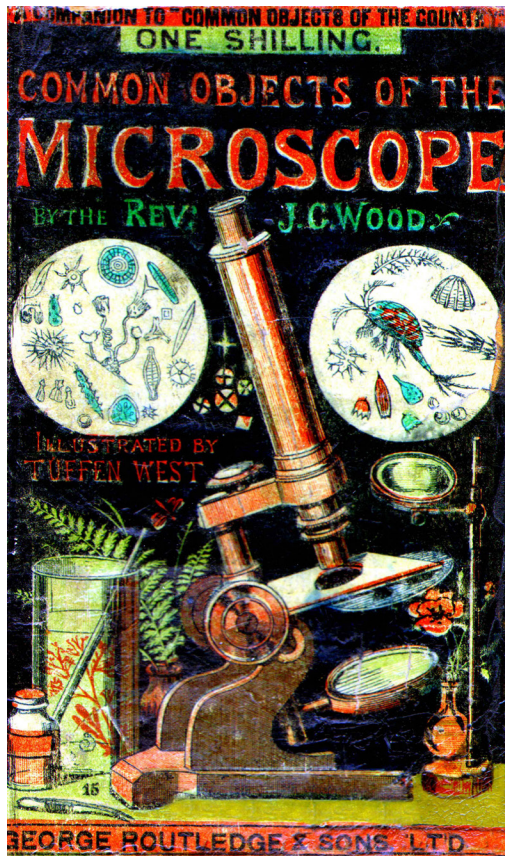
The front cover floral design of my edition isn't listed online – though it is printed from the same blocks as a book she wrote entitled *The Telescope: a familiar sketch combining a special notice of objects coming within the range of a small telescope*. This was published posthumously. Perhaps mine was too. Mrs. Ward had died in 1869, when at the height of her career. She had excitedly boarded an experimental steam-propelled vehicle devised by her cousin Richard Parsons, Earl of Rossea, but she was thrown out on a bend and crushed to death at the age of 42. Thus, the first eminent woman microscopist became the first person to die under a car. Her books lived on, however; *A World*

of Wonders Revealed by the Microscope was still being published in 1880.

Groombridge soon announced a similar book. It is hard to conclude that it was not influenced by (or even derived from) Mary Ward's successful books. It has the same size binding, though it is a thicker book (232 pages compared to Ward's 154 pages) and the style is very similar. This is *Objects for the Microscope: Being a Popular Description of the Most Instructive and Beautiful Subjects for Exhibition* by Louisa Lane Clarke, who, like Ward, was an Irish enthusiast. Many of her plates are identical to Ward's – for instance, Ward's Plate 4 (facing page 48) on weevils and eel-skin is re-used as the frontispiece of Clarke's volume. Similarly, we find Ward's Plate 3 on lepidopteran wings, facing page 49, reborn in Clarke's book as Plate 6, opposite page 40. Ward's Plate 7 becomes Clarke's Plate 2. Richard Groombridge, who had founded the publishing company in 1828, clearly knew he had a profitable line and managed to perpetuate the product long after Mary Ward's spectacular demise.

Here is an unusual one: small octavo, thin book, with a pictorial cover showing a microscope. It's *Common Objects of the Microscope* by the Rev. J.G. Wood, first published in London and New York in 1861. If ever you wanted evidence of popular interest in Victorian microscopy, this is the one. It might have been the most successful book on the microscope ever produced. We do not know how many were sold, but its companion volume (*Common Objects of the Country*, about wildlife, plants and animals) is said to have sold 100,000 copies. Mine is the 21st edition of *Common Objects of the Microscope*, published in 1896 – imagine that: 21 editions in 35 years. *Common Objects of the Microscope* was still being published in the 1920s. Wood had given up being a cleric in 1854 at the age of 27 to become a full-time writer on natural history. And he was famous. One of his books was quoted by Mark Twain in *Roughing It*; another was mentioned in the Sherlock Holmes story *Adventure of the Lion's Mane* by Sir Arthur Conan Doyle. By the 1860s, the microscope was a core component of common culture, and this book proves the point.

The cover is decorated by a pictorial design, with a Society of Arts microscope made by Charles Baker in the center. Either side are two views down a microscope (one showing microorganisms, the other copepods) with some starch grains viewed with crossed polars nuzzling by the body tube and some pinnules of the fern *Athyrium* adorning the base. It's a beautiful little book with Tuffen West providing pictures packed with specimens.



This popular pocket-sized book by J.G. Wood is said to have sold 100,000 copies in some 30 editions. There are over 400 specimens illustrated by Tuffen West packed into 12 plates at the end of the book. The fourth plate shows *Spirogyra*, *Desmidium*, and *Closterium*, with uredospores, and a fern sporangium dwarfed by *Volvox* in the center.

An early pocket-book on microscopy was Edwin Lankester's *Half Hours with the Microscope*, first published in London in 1859; it was followed by an edition published in New York for the American enthusiast. Like so many of the writers, Lankester was a physician and amateur microscopist. There are numerous woodcuts of microscopes and accessories scattered through the text, with another 250 of Tuffen West's exquisite pictures of cells, minerals, and microbes crammed into 8 plates.

Here's a stout little book: 18 cm. (7 in.) tall and 4.5 cm (1.75 in.) in thickness – *Evenings at the Microscope* by Philip Henry Gosse, first published in 1859. My copy is a revised edition dated 1877, and republished copies are still in print. Gosse illustrated the book himself, and there are scattered illustrations of microscopic organisms including rotifers and *Vorticella*. Gosse was a zoologist and was preoccupied by rearing small animals in captivity for further study. Indeed, he is the person who coined the term "aquarium." His 1854 book *The Aquarium: An Unveiling of the Wonders of the Deep Sea* marks the introduction of this new term into popular use.

By the end of the nineteenth century, half-tone

photographs began to appear in books, and the eagerness for microscopy was on the wane. The last book of Victorian format appeared as late as 1921 – it was *The Microscope* by Conrad Beck, published by his company, the microscope manufacturers R & J Beck. No photographs, no art paper, no color; it is printed on cheap machine-made wood pulp paper with illustrations derived from antique woodcuts. The slender book has just 144 pages bearing 131 black and white blocks, bound in olive-green cloth. Turning the pages is reminiscent of a book from the previous century. The style is readable and authoritative, though the illustrations of microbes are sketchy and amateurish. The best illustrations are the full-page promotional pictures of the range of microscopes produced by the company. Just like George Adams, who had used a book to sell his microscopes in 1787, Conrad Beck used his book to promote his company's products – and his slender book marked the end of an era.

THE LEGACY OF LEEUWENHOEK

Here is a more modern work. It's a large format book, measuring 20 × 24 cm. (8 × 9.5 in.) but slender,

with 185 pages. On the cover is a drawing of a Leeuwenhoek microscope, and there are plenty of photographs within. It's my own book, *The Leeuwenhoek Legacy* of 1991. It nestles modestly against the copy of Dobell's *Antony van Leeuwenhoek and his "Little Animals"* that I had found in Hay-on-Wye. You should regard my *Leeuwenhoek Legacy* as a modest supplement to Dobell's definitive account. His book weighs over 1.8 kg (4 lbs.) so tops the size scale above all its Victorian predecessors. But wait – what's this next volume? It is another copy of the same book. Open it gingerly, and you will see it is signed by the author – it is Dobell's personal copy which his widow Monica gave to me some 40 years ago. We used to have tea together at the family home in Hampstead, and on my final visit she pressed into my hands Dobell's own copies of his textbooks on intestinal protozoa. On the inside front cover she wrote: "To Brian J Ford, with best wishes from Monica Dobell." The detailed images of curious cell structures portrayed in these books had been dismissed as artefacts by Dobell's fellow-microbiologists, though my late friend Lynn Margulis told me that identical phenomena had since been confirmed using the electron microscope. She had met Carl Sagan, later her husband, when both were students at the University of Chicago, and, as he espoused astronomy, she continued to advance our understanding of the microbe world.

Here are two similar books bound in navy cloth and both well handled by the previous owner – one is *The Microbe Hunters*, the same book which had been the first in my accidental collection, and the other is titled *The Hunger Fighters*, both published in New York. The author, Paul de Kruif, has signed them both to Dobell at the time of publication. In *Microbe Hunters* he wrote: "To Clifford – With Pantagruelian affection – from Paul, Jan 27, '26." Pantagruelian is a curious adjective I have never seen before. It derives from the 16th-century character Pantagruel, described by Rabelais, and means huge, extravagant, or jovial. On the title page of *Hunger Fighters* de Kruif has written: "To Clifford with the eternal love of his brother Paul – Sep 18, '28."

It all exudes warmth and friendship, but it was not to last. By 1930 they had become estranged, even bitter enemies. Dobell came to dislike de Kruif's accessible style, brash, exuberant, even novelistic, compared to his own crisp, rigorous, academic approach. De Kruif writes of Leeuwenhoek's microbes with flair: "He saw them dancing, wriggling, swarming" then he calls microbes "tiny transparent coffins" and said Leeuwenhoek was a "janitor turned genius." Dobell's approach

was scholarly and detached, and he came to feel it was an unbridgeable gap. De Kruif had just turned writer after a short career in microbiology, whereas Dobell had devoted 25 years of his life to studying Leeuwenhoek.

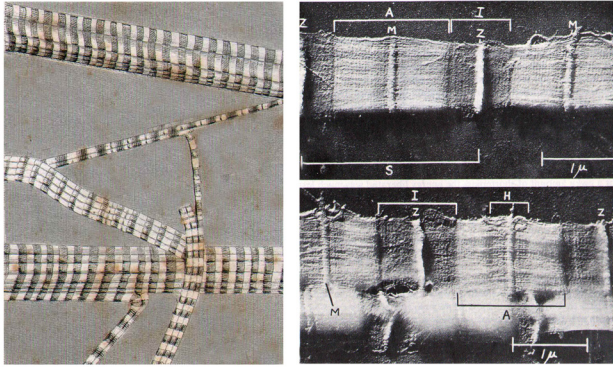
Clifford Dobell's rejoinder to being a "brother" appears in his book. There is a Latin dedication plate at the front of the volume, which few would trouble to read or understand: "Hoc opus mortui Batavi editor Anglus (sicut animalculum animalculo) dat, dicat, dedicat fratri suo dilectissimo, spurio, Paulo de Kruif Americano" – This work of the dead Dutchman, this publisher the Englishman (like one animalcule to another animalcule) gives, devotes, and dedicates to his beloved, spurious brother, Paul de Kruif, an American.

There are further resonances among Dobell's acknowledgements on page 423, where he writes: "My debt to my two "Brothers" I have attempted to repay by dedicating this volume to them. Without their fraternal encouragement it would never have been written, and I therefore owe them both more than I can express—big brother D'Arcy for his unattainable example and incomparable scholarship in wider fields, little brother Paul for his equal enthusiasm on common ground." One is D'Arcy Wentworth Thompson, mathematician and biologist; the other, "Paul" – why, that's a covert reference to Paul de Kruif. In the index, "de Kruif" is referenced on page 423, but the surname does not appear. Dobell would have his way.

Here is a slender book, just 112 pages of closely written, perfect prose. This is a groundbreaking monograph on striated muscle, and it was written by Sir Andrew Huxley. He delves into the mechanics of muscle contraction, reflecting on his pioneering research that led to the development of the sliding filament theory. This concept elucidates how muscle fibers contract by the sliding movement of actin and myosin filaments past each other, the fundamental concept in explaining how muscles work. I much admired Huxley, and he was a great source of encouragement to my research into Leeuwenhoek. He signed his copy of the book to me when it was new, with best wishes. It's a treasured reminder of a great research project; without Huxley's encouragement, my research in the first microscopes might never have progressed so far.

MICROGRAPHIA BEARS THE CROWN

So we arrive at the end of that shelf. Dark corner; tall folio books; three of them. You won't believe what they are: Robert Hooke's *Micrographia*, that's correct,



Among the plates of Quekett's *Treatise* of 1848, is this steel engraving of striated muscle (left) created by using a pointed burin to create a photo-realistic image. Sir Andrew Huxley's scanning electron micrograph of striated muscle (right) was published in 1980, and reveals the nature of the striations for the first time.* The two make an interesting comparison that exemplifies the history of microscopy.

three copies. There used to be four, but one is on permanent display in a glass-fronted case in the Sala Património, a room dedicated to the microscope, in the Museo Nacional de Ciencia y Tecnología (MUNCYT, the National Museum of Science and Technology) in La Coruña, Spain.

They arrived in my life through pure chance. I was discussing the importance of the restoration of old books with a bookbinder one day, and he showed me a pile of broken, discolored pages. "When we have to rebuild the spine of a vintage book," he said, "I always make sure we glue it back to shape with antique pages from a similar vintage." He waved casually to his heap of ancient paper. Then he smiled. "Actually," he said, "I have something here that might interest you," and he lifted up a thick pile of printed pages. They were unmistakably from *Micrographia*. "Old microscope book – seventeenth century," he said. "You can have 'em, if you want to buy 'em."

I did. When I was back at home, I sorted them out. They were four copies of Hooke's book, just the pages. Two were the first edition from 1665, two others the second printing of 1667. They cannot be confused. The first edition had a title page printed in red and black, the second was just black; and Plate V (showing a human hair, and globules from iron sparks) is printed as a mirror image in the 1667 printing with the hair image on the left, whereas it was originally on the

*The A band is birefringent and contains overlapping actin and myosin filaments, while the I band is comprised of actin filaments, bisected by the Z-line. The M-Line in the A band is where myosin filaments are cross-linked, providing structural stability, and the Z-line marks the boundary between sarcomeres. It anchors the actin filaments.



Robert Hooke's engraving of the louse, *Pediculus humanus*, captivated the attention of Dr. Gary Laughlin when he visited me in my home in Cambridgeshire. This first edition was bound with cloth boards and, as the other copies were painstakingly restored, they too were bound in covers that resonate with the originals. One is now on permanent display in La Coruña, Spain.

right. There is no way of knowing why the plate was re-engraved; but the Great Fire of London occurred in 1666, and many printing houses seized their essential equipment and fled. A plate might have been damaged in the panic – or it may have been compromised some other way.

Whatever the reason, that single figure was printed as a mirror image. Engravers used to prick holes through the lines of a drawing, and then they'd dust it with charcoal powder, so the outline of the image was transferred to the copper plate beneath, a process known as pouncing. A fine engraving tool, the burin, was then used to scratch ink-retaining lines onto the polished copper surface.

So there we have it; the story of microscopy told in a modest private library. They are just a small selection from the couple of thousand in my library, but they are precious, for they reveal the story of the instrument we hold so dear – and they hold up a mirror to the way society came to understand a greater reality. ■