Reflecting Realities – Leeuwenhoek's Limner and the Engraving of Life

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Historical accounts of Antony van Leeuwenhoek, the microscope pioneer, repeatedly refer to his drawings of microbes and of microscopic structure. In fact, not one of the drawings was made by his hand. Born 24 October 1632 in Delft, the Netherlands, he lived in that town all his life and died on 26 August 1723. From the age of forty he laid the groundwork for present-day microscopists with detailed and precise descriptions of the microscopic realm. This programme of research means that, for the first time, we can now reconcile the original drawings with present-day reality.

In a letter that Leeuwenhoek sent to Henry Oldenburg dated 15 August 1673, in which he had reported his observations on bees, the transport of sap in wood, the composition of air, and food for body lice, Leeuwenhoek added: 'As I am not a draughtsman myself, I have had them drawn for me … ' He said again to Oldenburg in his letter of 22 January 1676: 'Sir, be assured that my microscope showed the same as clearly and distinctly as one can imagine to see figures with the naked eye but the fault is mine, since I cannot draw.' The figures accompanying Leeuwenhoek's letters were not his. But were they representative of reality?

I am now revealing how true to life they were. His letter of 25 December 1702 is accompanied by a vivid drawing of aquatic microbes, drawn by an unknown hand. Leeuwenhoek's limners are mostly anonymous though Willem van der Wilt is known to have drawn microscopical images for Leeuwenhoek during the eighteenth century, though Wilt would have been only 11 at the time of this letter.

Scholars have tended to doubt the worth of the earliest investigators, including J. Sachs[1] who dismissed Leeuwenhoek as 'inconsequential' and L. M. Becking[2] who denigrates him as an 'immortal dilettante'. J.D. Bernal[3] was equally dismissive in his monumental work *Science in History*, a view born with Voltaire in 1733 who, in *Philosophical Letters,* dismissed the early microscopists as preoccupied with 'counting microbes in a drop of water' rather than being serious investigators. E.G. Ruestow[4] remarked on Leeuwenhoek's lack of formal academic training as an obstacle to acceptance.

The accuracy of Leeuwenhoek's observations has remained a matter of conjecture, and Nick Lane[5] has emphasised that the response of some members of the Royal Society to Leeuwenhoek's depictions was of consternation. Still nobody knew exactly what he saw, and questions about the nature of Leeuwenhoek's microbes remain unresolved. Lane states, 'Even with the powerful tools of modern biology, the answers are far from resolved—these questions still challenge our understanding.' Nick Lane was kind enough to add: 'Only the galvanizing work of Brian J. Ford … resurrected the glory of the single-lens microscope'.

Can a pioneer's drawings refect reality?

How can we reconcile those earliest microscopical investigations with our present-day understanding of microbiology? There are opportunities for invention and exaggeration at every stage of discovery: firstly, when Leeuwenhoek wrote up his original observations in his voluminous letters, again when his limner set out to record what had been observed as sketches on paper. There is the further possibility for error when the drawings are transcribed for publication, and the process of engraving images of a vital, limpid living organism introduces an essential artifice; the impression of the original specimen is conveyed with crisp, sharply delineated lines which cannot accord with what we observe in life. Each stage represents a compromise.

A century of curiosity

The first person to attempt to reconcile Leeuwenhoek's drawings and the modern microscopical image was Jan Cornelis Mol, a popular documentary film producer in the Netherlands 100 years ago.

Modern accounts by non-scientist scholars refer incorrectly to the filming of microscopic organisms as 'microcinematography'[6]. This term definitively connotes the making of a film of minute size, analogous to microphotography (the science of creating minuscule photographs). The discipline of taking photographs through a microscope is *photomicrography*, and making movies of microorganisms is *cinephotomicrography,* a term apparently unknown to literary historians.

Mol's method was simple. He attached a 16mm camera to a standard Carl Zeiss bench microscope, and throughout 1923-4 he acquired a film archive of microscopical images at low and medium

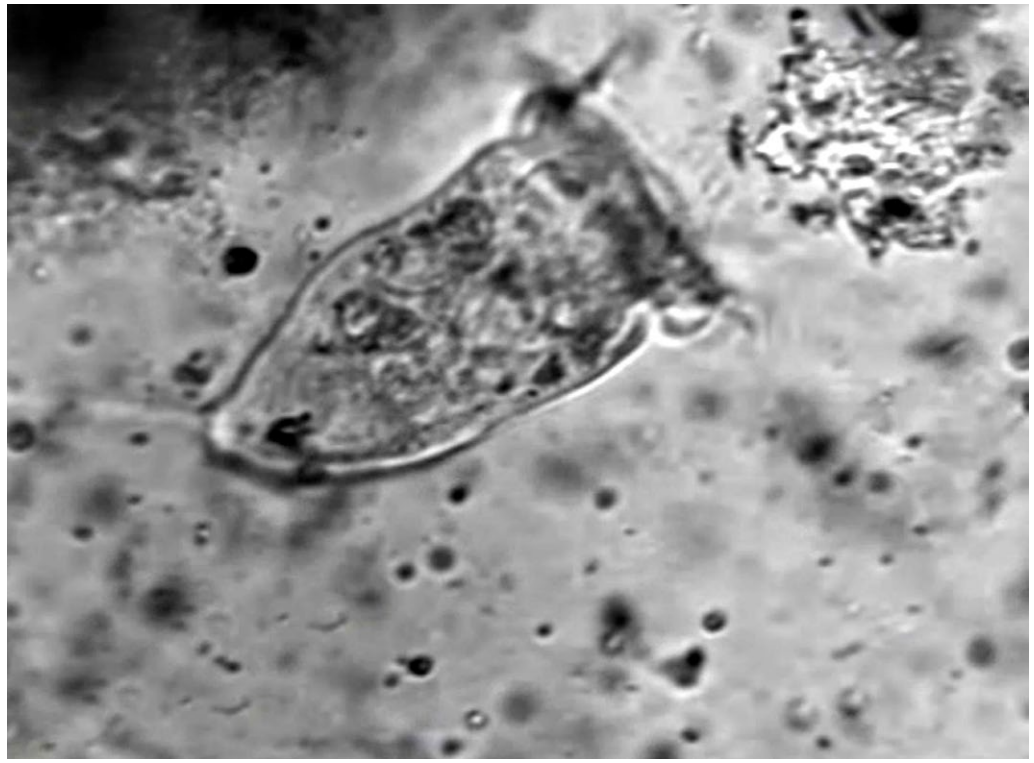

Figure 1a. A single cell of Vorticella captured by Hendrik van Seters in 1924 for Jan Cornelis Mol's silent film Antony van Leeuwenhoek. The micrograph was taken through a Zeiss microscope and was the first attempt to provide a contemporaneous comparison to Leeuwenhoek's seventeenth-century observations. 120x.

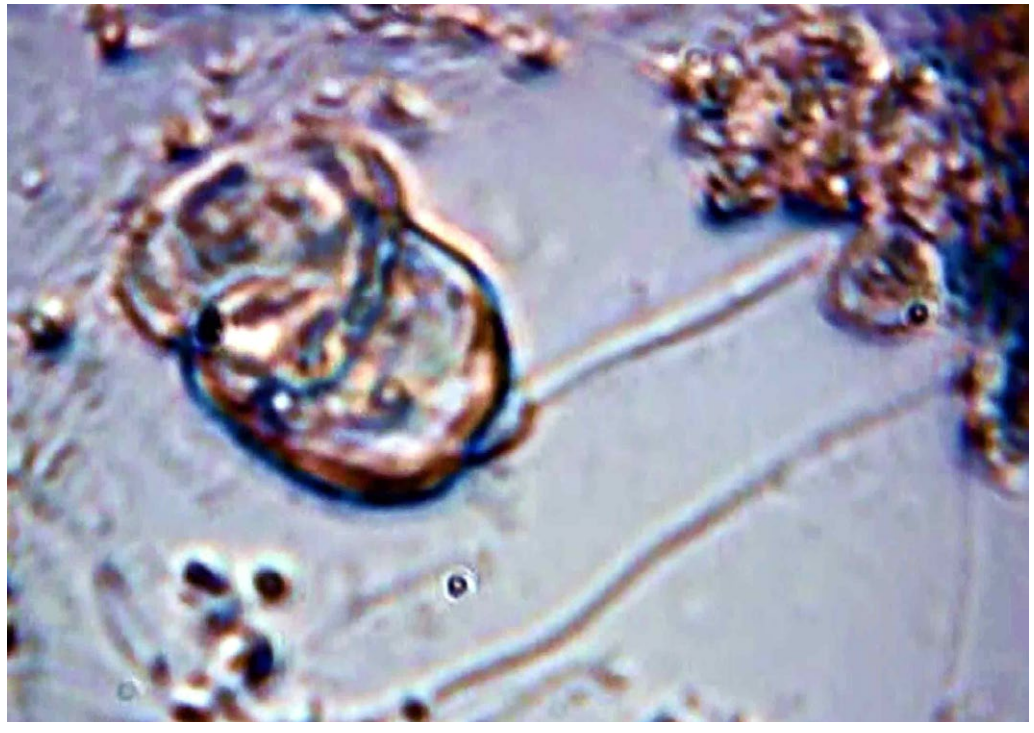

Figure 1b. Single lens microscopy, utilising a simple microscope with a soda-lime lens ground for me by Es Reid, provides this image of a living Vorticella cell. The lens magnifies 160x and it offers a view comparable to what could have been attained by the pioneering microscopists using lenses they ground by hand. 150x.

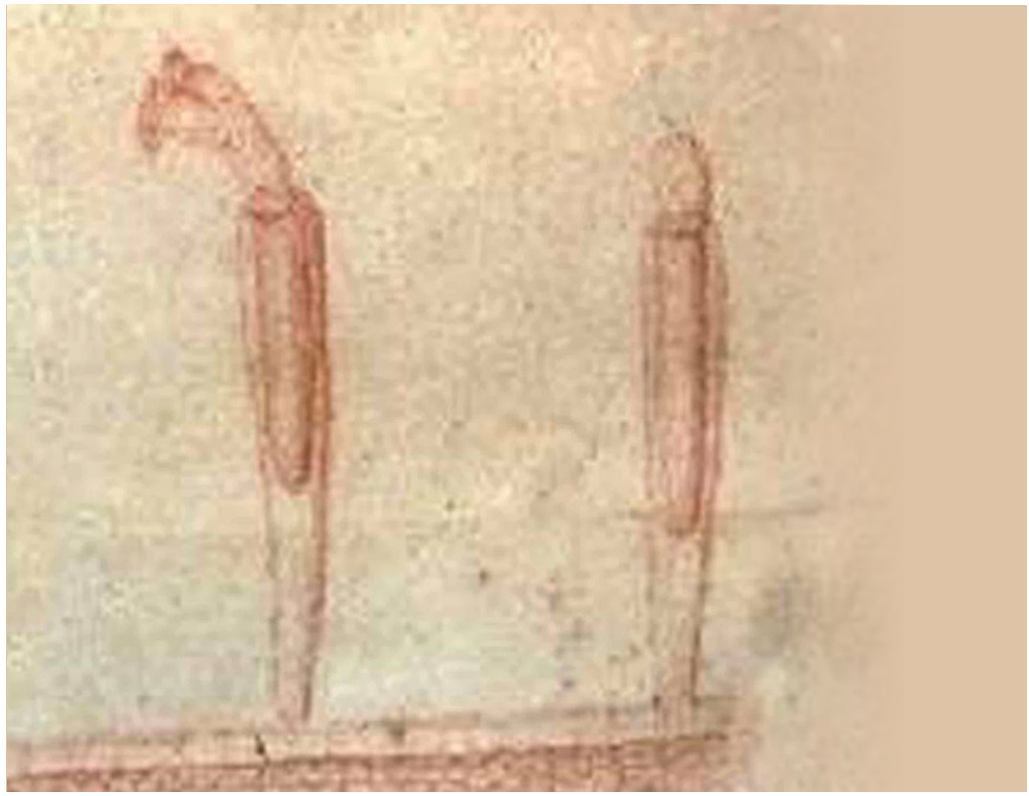

Figure 2a. Antony van Leeuwenhoek sent this drawing of sessile rotifers to London on 25 December 1702, now at Shelfmark: L-408 of the Royal Society of London and originally shown to me by Sir Andrew Huxley in 1981. Leeuwenhoek's limner captured two organisms, one fully extended.

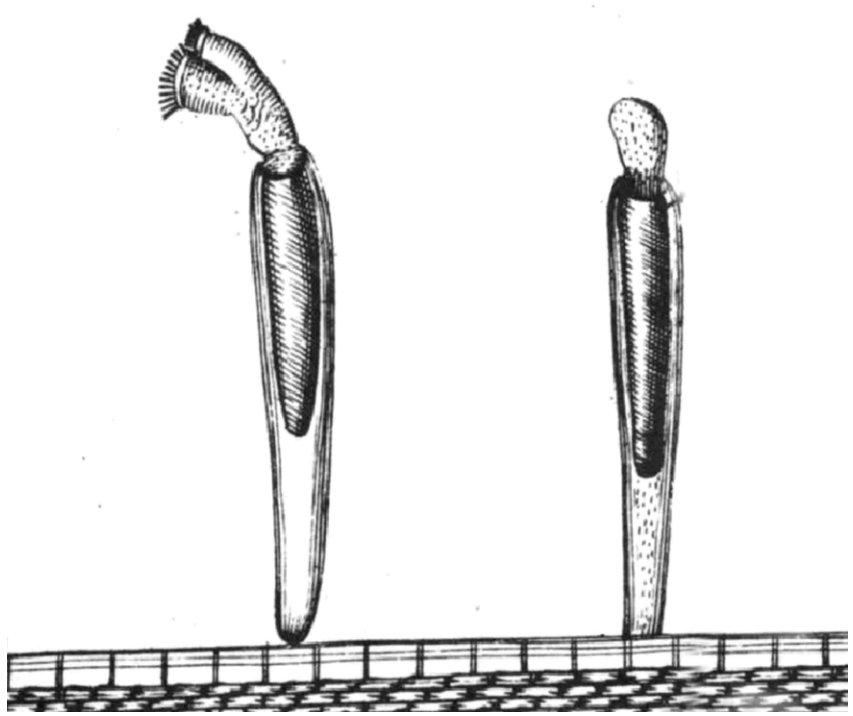

Figure 2b. Engraving for publication was typically carried out using a steel needle on a polished copper plate, and the accuracy of the rendition is remarkable. The studies by Leeuwenhoek's limner were faithfully conveyed on the printed page, though scholars have debated how realistic was the final portrayal.

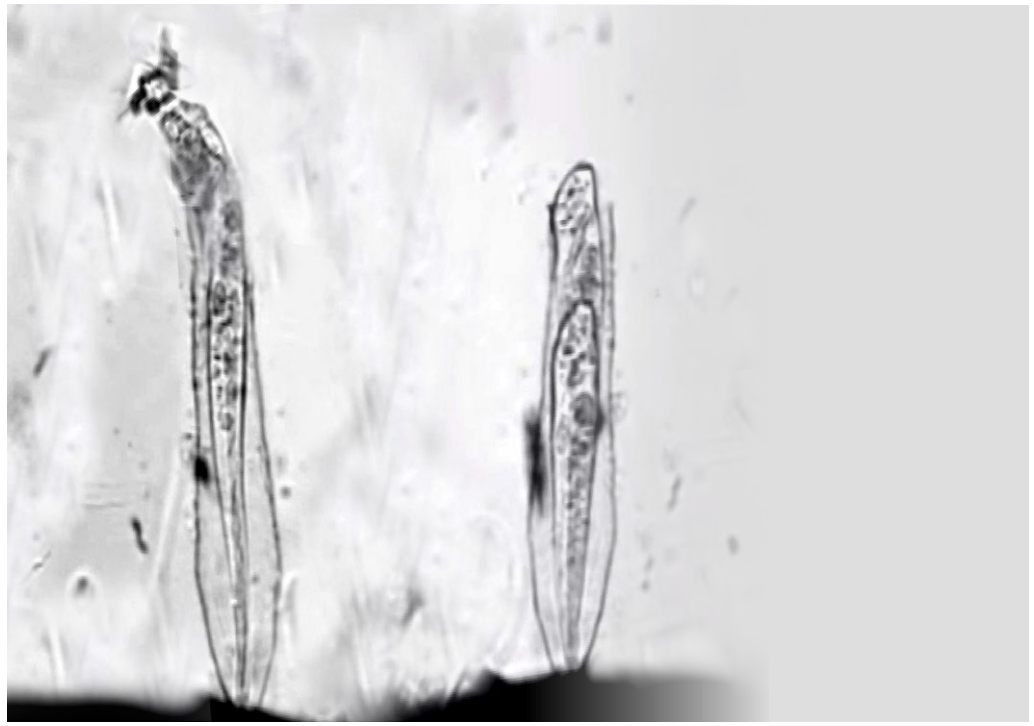

Figure 2c. Here I have extracted images of two sessile rotifers from still frames of the Mol movie. The sequence was filmed to exemplify the microscopical appearance of the organisms in the Leeuwenhoek correspondence and published in Philosophical Transactions. The organisms were identified by van Seters as Cothurnia.

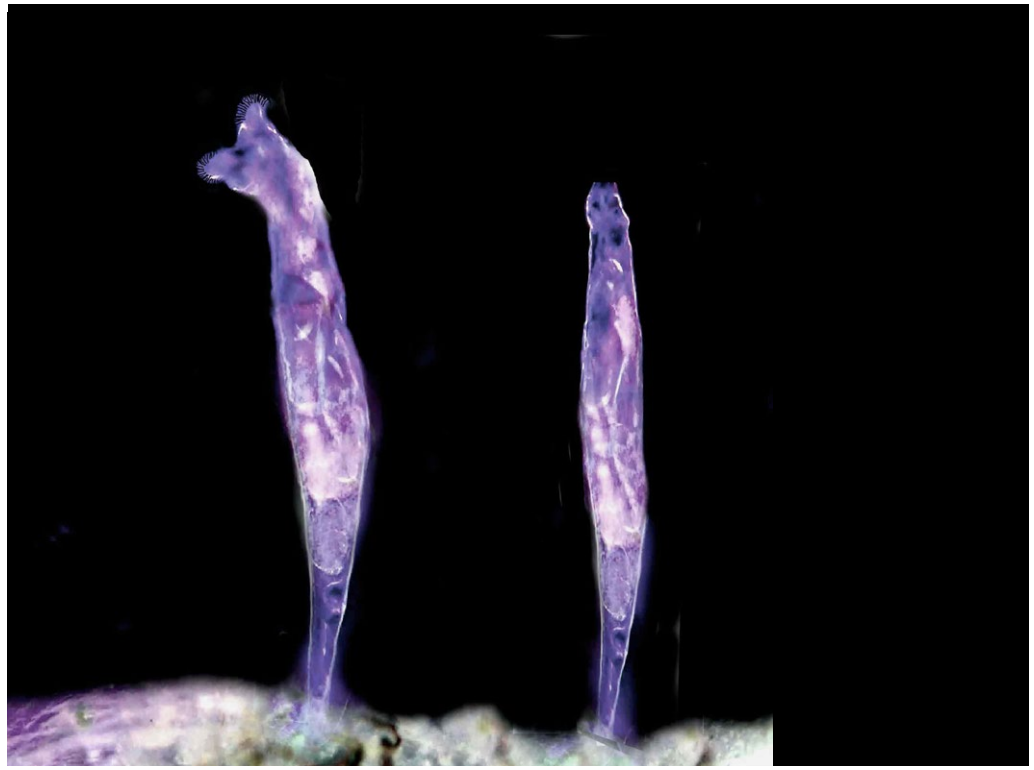

Figure 2d. The sense of vitality and proportion in the Leeuwenhoek drawings can be compared with this dark-ground study of rotifers by Dr Robert Berdan. They have been extracted and retouched to give a useful comparison with the previous images, and to substantiate how accurate was the original portrayal. 175x.

Figure 3a. Antony van Leeuwenhoek discovered vorticellid protozoa and had them drawn by his limner for his letter to London at the close of 1702. The independent origination of each stalk from the substrate suggests this is fully extended Vorticella. It was identified by van Seters as Carchesium, though that genus features divided suspensory stalks which are not evident in this sketch.

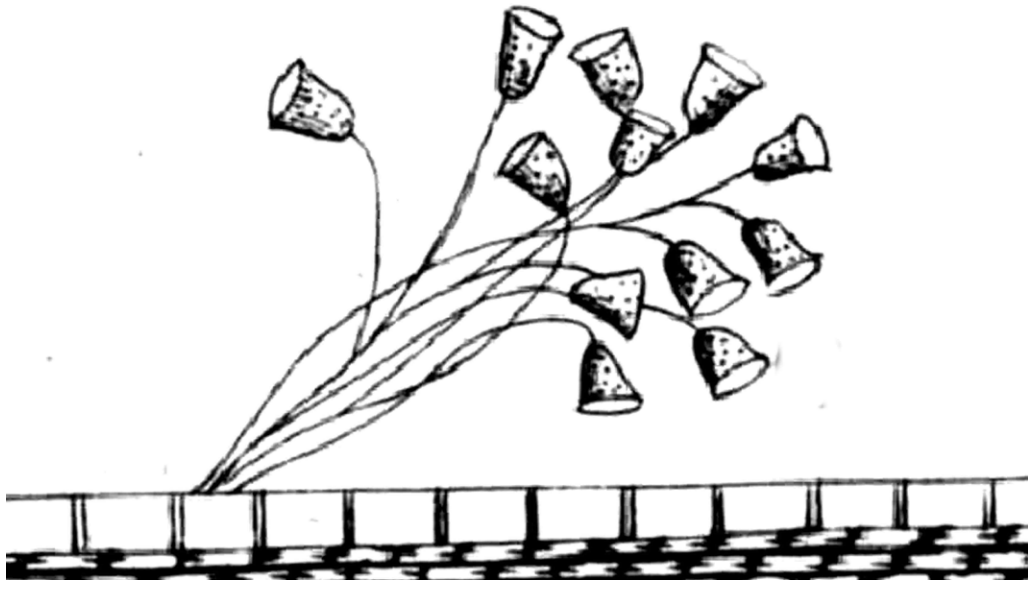

Figure 3b. When published in London the drawing was copied for engraving with a steel scribe on a polished copper plate. It was published in Philosophical Transactions of the Royal Society volume 23 pp 1304-1311 (1703) and, in spite of the uncompromising nature of the printed line, the flowing structure and vital essence of the living organisms was conveyed with a degree of insight.

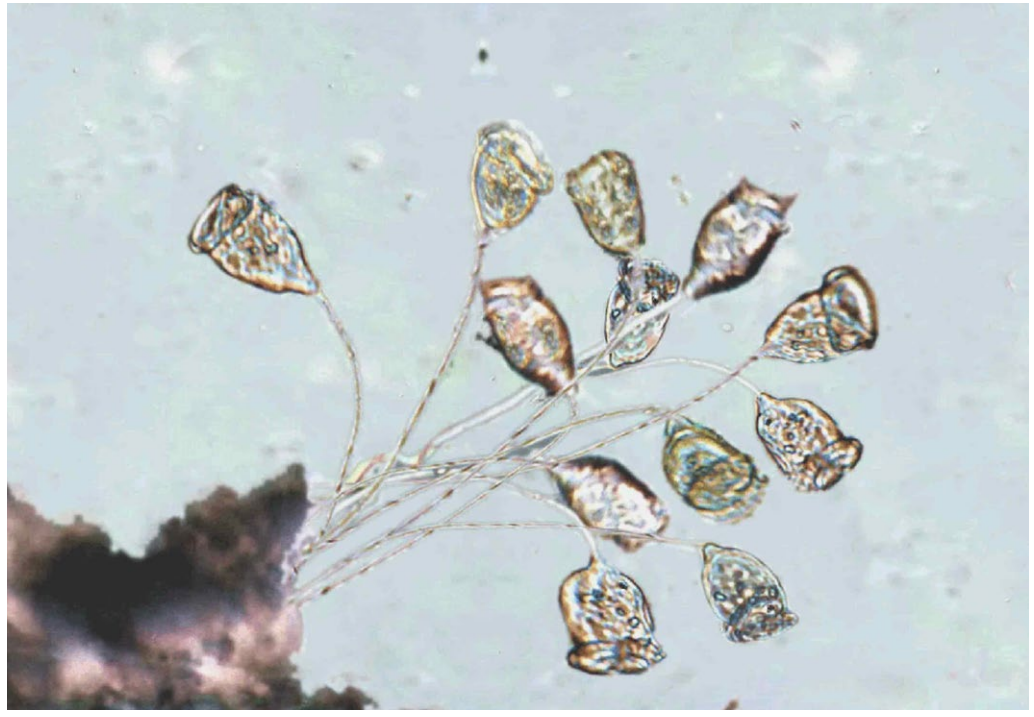

Figure 3c. Twelve photomicrographs of living Vorticella, each separately imaged with a replica single lens microscope, are here selected to provide the discrete cells in this montage to match the sketch in the Leeuwenhoek letter. The 60x lens was ground for this research by my Cambridge colleague Es Reid.

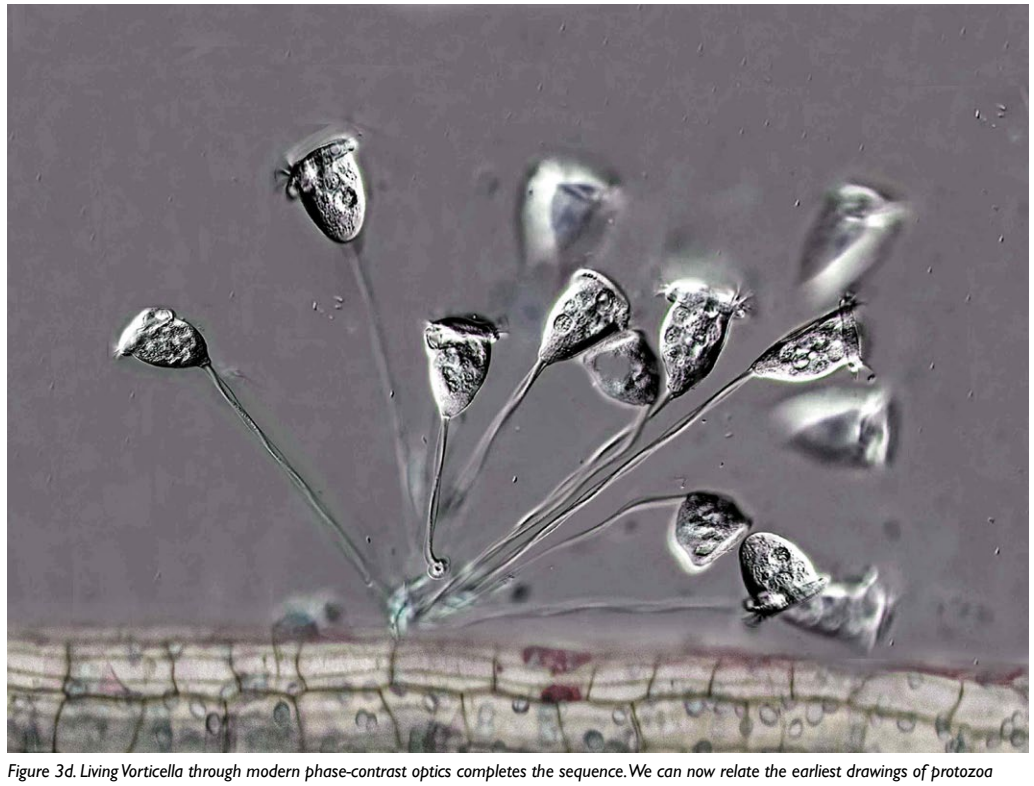

Figure 3d. Living Vorticella through modern phase-contrast optics completes the sequence. We can now relate the earliest drawings of protozoa ever made to the appearance that would be familiar to a present-day microscopist. This study resolves details of the food vacuoles, peristome and buccal cavity which were unresolved but indicated by stippling in the original drawing from 1702. 80x.

magnification, including aquatic protozoa ranging from *Stylonychia* to *Vorticella*, and of multicellular genera including *Cyclops* and *Hydra*. Mol was advised and assisted throughout by Hendrik van Seters, an authority on biological microscopy. The results, now a century old, were the first to show contemporaneous micrographic images in comparison with the published Leeuwenhoek studies. Comparing 17th-century published images with micrographs from 20th-century microscopes was enlightening, but what we needed to see was the same specimen imaged through microscopes ancient and modern.

Enter the simple microscope

We can travel back over a half-century when I published my first cautious experiments in this unexplored area. Charles Lavell was prominent in the English literary scene and one day, at my London club, he set down a screw-barrel microscope on the table in front of me. His questions were elementary: What was it? And what could it do? This little device was a Wilson screw-barrel microscope. It concealed a single lens mounted into a brass cylinder, focusing on a slider that would contain the specimen. The design was actually originated by the Dutch physicist, Nicholas Hartsoeker in 1694, and it offered a more robust version of the simple microscope utilised by Leeuwenhoek. James Wilson, an English instrument maker, took up the idea, manufactured hundreds for the burgeoning community of amateur microscopists, and has had his name attached to it ever since.

Next day I examined the little instrument. This was my first view through an original single lens microscope, and the detail that was visible was astonishing. I arranged it to capture images with a 35 mm SLR camera and took micrographs of hairs, then of fern sporangia. The most complex experiment followed; I set up a squamous-cell preparation lightly stained with methylene blue and captured a micrograph of a cell surrounded by commensal bacteria with the screw-barrel microscope mounted on an optical bench. Then I set about identifying precisely the same area through my Leitz microscope. The field of view measured about 100µm in diameter and, by tracking methodically across the microscope slide in successive parallel passes, I was eventually able to locate the same field. I now had correlated images of the same cell through instrumentation spanning some 250 years[7].

Are the Leeuwenhoek images true to life?

In the decades following the 1970s I pursued this line of research and captured many images of microscopical preparations through a range of early microscopes. Novel methods were developed for capturing an image from an instrument designed without that in mind, and the results of this research attracted international attention.[8]

There remained the question of how these results had originally been communicated. Flagrant plagiarism has long been rife in microscopical research (and is becoming increasingly widespread). Many of the published engravings from the seventeenth and eighteenth century were crudely distorted images copied from the true pioneers. Robert Hooke, who frequently complained about other philosophers plagiarising his research, was himself a plagiarist in his 1665 book *Micrographia*.[9]

How can we reconcile the original sketches with the published versions known to historians of science? To clarify this matter I took examples of the drawings from the original Leeuwenhoek letters now in the archives of the Royal Society of London. Using Photoshop where necessary, I repositioned micrographs of similar specimens to match, so we can now peruse those alongside the original drawings and relate those to the published engravings.

Conclusions

These unprecedented results are revealing. We can at last view the sight that Leeuwenhoek approved for transmission to London at the time of his discoveries, in conjunction with the organisms themselves viewed through single-lens microscopes and instruments from the 20th and 21st centuries. The microscopical detail that this pioneer could reveal can be seen to relate accurately to the published versions from *Philosophical Transactions*, and the clarity of the single-lens image compares favourably with that obtained from modern microscopy.

Acknowledgements

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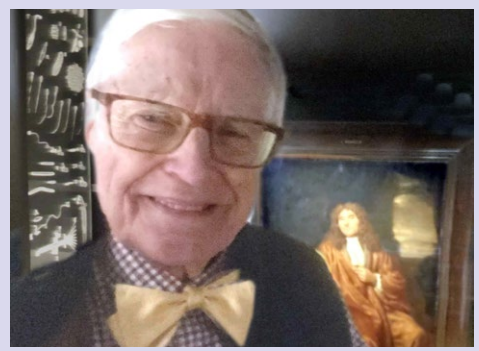
About the author

Brian J Ford was elected a Fellow of the RMS in 1962, and an Honorary Fellow in 2017. During the past 60 years he has authored some 270 research publications on Leeuwenhoek and is the leading Leeuwenhoek scholar of our age. His research appears in Nature, New Scientist, the British Medical Journal, Cell, and Scientific American, and many other journals. Recreating the pioneering microscopical observations, and relating them to the modern age, has him described in Nature as the 'world's leading expert on the topic'. Professor Ford's research on Leeuwenhoek has featured at both the Conversazione and the Soirée of the Royal Society, where he has also lectured on his revelations. He is the author of over thirty books published in some 140 editions around the world, many devoted to microscopy. His best-selling books The Revealing Lens, Mankind and the Microscope, and The Optical Microscope Manual were published fifty years ago. Professor Ford is associated with the universities of Cambridge, the Open university (where he is a former Fellow), Cardiff University (where he is a Fellow) and others. He lectures around the world and has been awarded medals by the State Microscopical Society of Illinois and New York Microscopical Society.



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