Robert Hooke and Antoni van Leeuwenhoek are credited with discovering the microbial world during the 17th century. However, some of the details about their contributions are garbled, leading to an unintended mythology. According to microbiologist Milton Wainwright of Sheffield University in Sheffield, England: “Unfortunately, much of what is taught about the history of microbiology has been oversimplified to the point where plain untruths are being told; at best a fascinating and convoluted story has been reduced to the minimum for easy, uncritical consumption.”

Thus, a critical study of 17th-century documents reveals that the primary role of Robert Hooke was diminished, starting in the 1920s. Greatly oversimplified accounts, such as the popular book published in 1926 by Paul de Kruif, dramatized the unusual life story of Antoni van Leeuwenhoek, identifying him as the “First of the Microbe Hunters.” More than 1 million copies of de Kruif’s book were sold, and his romanticized essays described the lives of a dozen famous scientists. However, some of those tales strayed from the truth. One of the essays led Nobel Laureate Sir Ronald Ross to castigate de Kruif for statements that Ross considered libelous. Meanwhile, the early discoveries of Hooke were either ignored or given short shrift.

Early in His Career, Hooke Showed Broad Curiosity and Talent

In 1653, Hooke enrolled as a “poor scholar” at Christ Church, University of Oxford. Although there is no record of his receiving a bachelor’s degree, he was awarded an M.A. in 1663. Awarding him that M.A. “may have been brought about by the influence of people in high places who wanted to ensure that the Royal Society’s newly appointed Curator of Experiments was a fully incorporated member of the learned establishment,” according to historian Allan Chapman of Oxford University in Oxford, United Kingdom. The degree was likely awarded in absentia and was not recorded in the University Register.

Hooke’s outstanding abilities in “mechanics” were recognized at a very young
age and led to his appointment as Curator in 1662 and subsequent election as a Fellow in 1663. As curator, his duties were to conduct “considerable” experiments at the Society’s weekly meetings, and to do research officially recommended to him. Hooke became a commanding intellectual presence in the Society, and as curator provided the main substance of many meetings. His interests ranged over physics, mechanics, astronomy, chemistry, geology, and biology. Moreover, he was a prolific inventor, especially in connection with microscopes and telescopes.

**Hooke’s Micrographia Is the First Systematic Account of the Microscopic World**

After *Micrographia* appeared in bookshops in January 1665, it quickly became a best seller. Its profound impact is aptly described by Chapman in his critical biography of Hooke:

[*Micrographia*] possessed a dazzling, immediate quality, being written in an easy style... It was, moreover, the first proper picture book of science to come off the press, for its 60 Observations were accompanied by 38 beautiful engravings of the objects seen with the new instruments... Modern science is replete with visual images, and in our own time the visual image is the most powerful medium through which its ideas are now communicated to the lay public. So we must not forget that this tradition of visual communication in science largely begins with Hooke’s *Micrographia*.

In his studies, Hooke used a microscope that was about six inches long and had two convex lenses. He examined mainly biological specimens, including sponges, wood, seaweed, leaf surfaces, hair, peacock feathers, wings of flies, eggs of silkworms, mites, a flea, and a louse, even though his primary interests were in mechanics and the physical sciences. The printed illustrations of microscopic views in *Micrographia* were prepared from engravings based on Hooke’s excellent drawings, which attest to his acute powers of observation and skill as a draftsman.

The 1663 Journal Book of the Society has an entry for April 22 which says: “Mr. Hooke brought in two microscopical observations—one was of Leeches in Vinegar; the other a blueish mould upon a mouldy piece of leather.”

Hooke’s studies on the “mould” resulted in Observation XX of *Micrographia*. This chapter is devoted to the microfungus *Mucor*, which includes a detailed drawing of its reproductive structures (sporangia). Thus, *Mucor* was the first microbe described and depicted in the scientific literature (Fig. 1).

Hooke described white spots of “hairy mould” on the red sheepskin covers of a small book:

These spots appear’d, through a good microscope, to be a very pretty shap’d vegetative body, which, from almost the same part of the Leather, shot out multitudes of small long cylindrical and transparent stalks, not exactly straight, but a little bended with the weight of a round and white knob that grew on the top of each of them; many of these knobs I observ’d to be very round and of a smooth surface, such as A A, etc. others smooth likewise, but a little oblong, as B.; several of them a little broken, or cloven with chops at the top, as C; others flitter’d as ‘twere, or flown all to pieces, as DD. The whole substance of these pretty bodies was of a very tender constitution, much like the substance of the softer kind of common white Mushrooms, for by touching them with a Pin, I found them to be brused and torn; they seem’d each of them to have a distinct root of their own; for they grew neer together in a cluster, yet I could perceive each stem to rise out of a
distinct part or pore of the Leather; some of these were small and short, as seeming to have been but newly sprung up, of these the balls were for the most part round, others were bigger and taller, as being perhaps of a longer growth, and of these, for the most part, the heads were broken, and some much wasted, as E.

Hooke significantly advanced the techniques of microscopy, several of which are discussed in *Micrographia* and an important compilation that was published 13 years later in 1678, *Lectures and Collections*. This collection is in two parts. The first, “Comet A,” consists of an extended discourse on the Comet of 1677. The second part, *Microscopium*, includes a detailed description of microscopic techniques as well as a discussion of “Mr. Leeuwenhoek’s two Letters concerning some Late Microscopical Discoveries” and “The Author’s Discourse and Description of Microscopes, improved for discerning the nature and texture of Bodies.”

**Contrasting Hooke and Leeuwenhoek**

The 28-page preface to *Micrographia* is a remarkable document. For instance, it includes Hooke’s precise description of how to make a single-lens, hand-held miniature microscope of the kind Leeuwenhoek later improved and used extensively.

Many microbiologists mistakenly believe that Leeuwenhoek invented this kind of hand-held microscope. However, in contrast to Hooke’s lengthy published descriptions of such devices, Leeuwenhoek was notoriously secretive about his own methods and microscopes. He never disclosed the techniques that he used for grinding lenses or his conditions for illuminating samples.

As late as 1685, Leeuwenhoek’s approach to microscopy remained obscure. In 1685, the Royal Society sent Thomas Molyneux to visit Leeuwenhoek in the hope of obtaining more information about van Leeuwenhoek’s experimental techniques. Molyneux reported to the society that Leeuwenhoek refused even to let him see the “best” microscopes. Expressing skepticism about Leeuwenhoek’s grasp of what others were thinking and observing, Molyneux wrote:

As for the microscopes I looked through, they do not magnify much, if any thing, more than several glasses I have seen, both in England and Ireland: but in one particular, I must needs say, they far surpass them all, that is in their extreme clearness, and their representing all objects so extraordinarily distinctly. For I remember we were in a dark room with only one window, and the sun too was then off of that, yet the objects appeared more fair and clear, than any I have seen through microscopes, though the sun shone full upon them, or though they received more than ordinary light by help of reflective specula or otherwise: So that I imagine ’tis chiefly, if not alone in this particular, that his glasses exceeds all others, which generally the more they magnify, the more obscure they represent the object; and his only secret, I believe is making clearer glasses, and giving them a better polish than others can do. I found him to be a very civil complaisant man, and doubtless of great natural abilities; but contrary to my expectations, quite a stranger to letters, master of neither Latin, French or English, or any other of the modern tongues besides his own, which is a great hindrance to him in his reasonings upon his observations; for being ignorant of all other mens thoughts, he is wholly trusting to his own, which, I observe, now and then lead him to extravagancies, and

Much effort has been spent in trying to find an authentic portrait of Hooke, with no success. The drawing above appears in historian Allan Chapman’s 2005 book *England’s Leonardo: Robert Hooke and the Seventeenth-Century Scientific Revolution*, Institute of Physics Publishing, Bristol and Philadelphia, 2005 and is by Rachel Chapman. Chapman’s book has an appendix which discusses the mystery of why an original portrait has never been found.

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suggest very odd accounts of things, nay, sometimes such, as are wholly irreconcilable with all truth.

Leeuwenhoek, a Cloth Merchant and Lens Maker, Was Curious about Biology

In 1654, at the age of 22, Leeuwenhoek set up shop as a draper in Delft, Holland. He remained in that city during his long life, at times serving as a functionary in municipal offices. Some historians suggest that Leeuwenhoek’s use of a magnifying glass to inspect cloth helped to trigger his scientific career. He eventually developed the skills to make very small lenses of excellent quality for use in miniature microscopes that Hooke designed.

Despite limitations such as those that Molyneux described, Leeuwenhoek was a keen observer and had extraordinary curiosity about the living world. With simple single-lens microscopes, he made many important discoveries. These were described in numerous, frequently lengthy, letters sent to the Royal Society. This remarkable shopkeeper, who had little formal education, was the first to describe protozoa and yeast cells, as well as the sperm cells of animals and red blood cells.

In regard to Leeuwenhoek’s relationship with Hooke, there is clear-cut evidence of translators providing Leeuwenhoek with information from *Micrographia* before he began communicating his own findings to the Royal Society. For example, Leeuwenhoek’s first letter to the Royal Society, dated 28 April 1673, was submitted by a Dutch corresponding member of the Society.

The profound differences between Hooke and Leeuwenhoek in their practices in regard to making new technical knowledge available to other scientists needs no further comment.

Hooke’s Old Records, Now Called the Hooke Folio, Were Discovered in 2006

In 1677, Hooke became Secretary of the Royal Society. Thus, in addition to conducting experimental demonstrations, he was obliged to record all activities of the Society for subsequent publications in its journals, including the *Journal Book of Ye Royal Society*. The records during Hooke’s tenure are incomplete, and many temporary binders were left empty.

Unexpectedly in 2006, more than 650 pages of Hooke’s missing notes were discovered in a cupboard in a private country house in England. Hours before those notes were to be auctioned, the Royal Society secured funds from more than 150 donors to purchase what is now called the “Hooke Folio.”

I recently visited the Royal Society in London to pore over that Folio, especially with the aim of examining entries for 1677–1678 that might address Hooke’s confirmation of Leeuwenhoek’s discovery of bacteria (“little an-

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**FIGURE 1**

Microscopic view of a “hairy mould” colony described by Robert Hooke in 1665 (in *Micrographia*). This image was the first published depiction of a microorganism. The reproductive structures (sporangia) are characteristic of the microfungus *Mucor*. Sporangia in different stages are identified by the letters A, B, C, and D. Hooke included a scale reference; the length of the bar under the diagram represents 1/32 inch.

(Reproduced courtesy of The Lilly Library, Indiana University, Bloomington, Indiana.)
imalcules”). In addition, the visit gave me the opportunity to reexamine Hooke’s other major publications, including journals of the Royal Society and relevant letters.

The records of 1677 and 1678 are particularly important in regard to the first observations of bacteria. Folio entries help to pinpoint the timeline of Hooke’s experiments aimed at checking Leeuwenhoek’s claims of seeing very large numbers of tiny “animalcules” in a single drop of pepper-water infusion. It is easy to understand why in the 1670s Leeuwenhoek’s claims of seeing more than 1 million per drop were considered dubious.

Nevertheless, Hooke was determined to see for himself. Here are several excerpts from his Folio (edited slightly, mainly to use modern English spellings):

“The Society met at 4 and ye President being Absent Mr Henshaw ye Vice president took the chair. The first thing exhibited was the Expt. charged on Mr. Hooke the Last Day of Examining pepper water with better microscopes and thinner & smaller pipes” [i.e., glass capillary tubes]. . . . “But not withstanding the pepper mixture was very strong being made of Rainwater & whole black pepper Steepd for 3 days and not withstanding the microscope was much better than was shewed ye Last Day/yet we could see nothing of Mr Lewenhooks animalcules. Mr Henshaw conjectured with a great Deal of Reason that twas very likely that it might now be a proper season for their generation. . . . It was further added that a person who had seen those creatures in holland this Last summer with a microscope of his own could not within this fortnight find any such in pepper water made here. Dr Whistler conjectured that these small imagined creatures might indeed be nothing else but the small particles of the pepper Swimming in ye water. But Dr Mapletost answered that Mr Lewenhooke affirmed to shew them both alive & dead. Dead when he put vinegar to the said tincture. [from Folio page 189 on 8 November 1677]

That section is followed by a description of a method that Hooke then was developing to measure the size of objects using a capillary tube “not bigger than a pigs bristle” that would appear as a cylinder of about 3 inches diameter once magnified.

The Society met at the usual place and the President being Absent mr Henshaw the vice president took the chair. The first Experiment exhibited was the pepper water which had been made with Rain water & a small quantity of common black pepper put whole into it about 9 or 10 days before. In this RH had all this week Discovered great numbers of exceeding small animals swimming to & fro in the water and by all that saw them they were verily believed to be animals and that there could be no fallacy in the appearance. They were seen by mr Henshaw, Sir Chris. Wren, Sir John Hoskins and diverse others so that there was no longer any doubt of mr. Leeuwenhoek’s Discovery. Notice was ordered to be taken of this Discovery and further trial was Desired to be made upon Raine water alone & upon Rainewater in which had been steeped wheat barley and other seeds & graines. The shape of the microscope and the manner of Examining the liquor was as follows. [Folio pages 111–114; 15 November 1677]

Many details are given including how the samples were illuminated. Subsequent discussion, in which Sir Christopher Wren was prominent, concerned the desirability for further control experiments.

During November 1677, Hooke was also very busy (as usual) with many other matters, including experiments on respiration and blood circulation in higher animals. The Catalogue of Manuscript Letters of the Royal Society lists a letter written by Hooke to Leeuwenhoek, identified as H.3.54 from December 1677. It is signed: Your very great admirer and honorer, RH. Microscopium (1678, pages 81–104) contains
the text of two of Leeuwenhoek’s important letters and an extensive discourse on microscopy, describing further improvements in detail. For example, Hooke notes: “By this means I examined the water in which I had steeped the pepper I formerly mentioned; and as if I had been looking upon a Sea, I saw infinite of small living Creatures swimming up and down in it, a thing indeed very wonderful to behold.”

In a letter dated 8 February 1680, Hooke informed Leeuwenhoek of his being elected as a fellow of the Royal Society by a unanimous vote. Leeuwenhoek became a celebrity and was visited in Delft by many notables, including Tsar Peter the Great of Russia.

Coda
There is little doubt that, when the Hooke Folio is fully transcribed, other aspects of Hooke’s genius will emerge. What we know about him gives us reason to anticipate fresh surprises about this distinguished, early experimental scientist. Historian Chapman points out:

...Robert Hooke was one of the greatest experimental scientists of all time. While modern historical scholarship can now place that genius within a wider intellectual and social context, and enable us to develop a balanced understanding as a man, what cannot be denied is that he, more than anyone else, showed that the experimental method actually worked, and could transform mankind’s understanding of nature. And this he achieved through the communication of his findings by writing, by demonstration, and by the spoken word—to the wider world, wherein they could inspire scientists, inventors and poets.”

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SUGGESTED READING
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