# BACTERIA AND CELLS OF HUMAN ORIGIN ON VAN LEEUWENHOEK'S SECTIONS OF 1674

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# Bacteria and Cells of Human Origin on van Leeuwenhoek's Sections of 1674[1,2]

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*Abstract.* Antony van Leeuwenhoek laid the foundations of modern microscopy, and some of the original specimens which he sent to London in the seventeenth century have survived to the present day. Their discovery provides an opportunity to examine first-hand material from the earliest days of microscopy. Van Leeuwenhoek's expedient of wrapping the specimens in paper proved to be an excellent means of preserving them in near-perfect condition. Modern-day images of some of the sections cut by van Leeuwenhoek through one of his original instruments were recorded using a specially constructed photographic arrangement. Scanning electron microscopy revealed the presence of human blood cells and coccus bacteria, probably representing the personal legacy of van Leeuwenhoek, on one of the elder pith sections. Their presence offers tantalizing possibilities for future analyses which might yield more detailed information on this great pioneer of modern microscopical science.

The "father of microscopy," Antony van Leeuwenhoek of Delft, laid the foundations of modern microscopy with his systematic and painstaking work. He is best known as a microbiologist, and the extent of his work in this field has been documented in detail (Dobell, 1932). Perhaps his greatest conceptual step, however, was the essential revelation that there were structures which a microscope could reveal, and which would remain unknown without it. This view can be contrasted with the work of Hooke (1665) which concentrated on magnifying structures that already were familiar (Ford, 1973a).

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During his life-time, van Leeuwenhoek made upwards of 400 microscopes, most of which have since been lost (Ford, 1973b). It is recorded that only nine of the original instruments remain extant (van Zuylen, 1981), and there are doubts about one or two of those. However, it has now become apparent that some of the original specimens which van Leeuwenhoek sent to London in the seventeenth century have survived intact to the present day (Ford, 1981a). Their discovery offers an opportunity to examine first-hand material from the earliest days of microscopy, and in this paper I present some of the detailed findings that have been made through a systematic study of the fine sections he sent to London in June 1674.

## Discovery of the Specimens

The circumstances by which the original material came to light have been detailed in a paper for the Royal Society of London (Ford, 1981b). Briefly, I undertook a systematic examination of the papers filed in the archives of the Royal Society at Carlton House Terrace, London. The bulk of the seminal observations made by van Leeuwenhoek were in the form of lengthy letters sent to the Royal Society, following his introduction to that body by the great Dutch anatomist de Graaf in the year 1673 (Dobell, 1932; Ford, 1981b). Between the pages, I discovered a total of nine small paper packets. Each was annotated with a brief description of the specimen that had been secreted inside. In one case, the handwriting was clearly not that of van Leeuwenhoek; he had been sent a specimen of dried algal mat from Courland (now in Latvia), and the description is likely in the handwriting of the correspondent who sent it. In one other case (annotated by van Leeuwenhoek), the specimen was found to be missing. In this instance, the material was described as "white from a quill," and would have been of limited microscopical significance.

The remaining specimens (documented more fully in Ford, 1981d) are as follows:

#1. Fine sections of cork (May 1674);
#2. Fine sections of elder pith (May 1674);
#3. White from a quill (missing by 1981);
#4. Bovine optic nerve in transverse section (January 1675);
#5. Cotton seed cut into 24 slices (March 1686);
#6. Cotton seeds dissected to show embryonic structures (March 1686);
#7. Black film of dried algae (1687);
#8. Pale brown algal mat (1687); and
#9. Black papery algal mat (14 or 15 March 1686).

All of the specimens were prepared by van Leeuwenhoek, with the exception of #9 which was sent to him from Courland some considerable time after it had been collected (Ford, 1981b).

The discovery is a matter of intense excitement, for it has long been claimed that there are no seventeenth-century specimens still in existence, and that

they would have been of poor quality even if any had survived (Bracegirdle, 1978). For purposes of future progress in analytical microscopy, two-thirds of the material in each little packet was left undisturbed, so that a future generation with more sophisticated apparatus may be able to examine them in greater detail and extract further evidence about the circumstances in which the specimens were first prepared. The packets have since been removed from the letters to which they were attached by van Leeuwenhoek, and it has been recommended to the Royal Society that they be stored in an atmosphere of nitrogen. However, it is important to note that the expedient chosen by van Leeuwenhoek (namely, to wrap the specimens in paper) proved to be an excellent means of preserving them in near-perfect condition for the benefit of posterity.

## Van Leeuwenhoek's View of the Sections

It is tempting to imagine that the image quality of a single-lensed (i.e., simple) microscope is inevitably poor. This is an erroneous view. A single magnifying element is able to produce satisfying images (van Cittert, 1954) and even a melted bead of soda-glass will provide reasonable results using a collimated light-source (Ford, 1971a). The view of nature obtained by the pioneers using single-lensed microscopes was surprisingly clear (Ford, 1971b), and under the best circumstances, a lens no larger than the head of a pin can enable the microscopist to resolve living bacteria without difficulty (see fig. 3, Ford, 1981b). The most powerful of the microscopes remaining (van Zuylen, 1981) provides a magnification of ×266 and is preserved at the University of Utrecht, Netherlands. Through the courtesy of the Museum Director at the University, Dr. Peter Kylstra, I was able to reconstruct for the first time a modern-day image of the sections cut by van Leeuwenhoek through this original instrument.

The Utrecht microscope is typical of those fashioned out of home-refined metals by van Leeuwenhoek. This example is of brass and takes the form of two rectangular plates 46 mm × 24 mm perforated by an aperture approximately 0.7 mm in diameter. The lens, held sandwich-fashion in this aperture, is 1.22 mm in thickness and its magnification of ×266 provides a resolution

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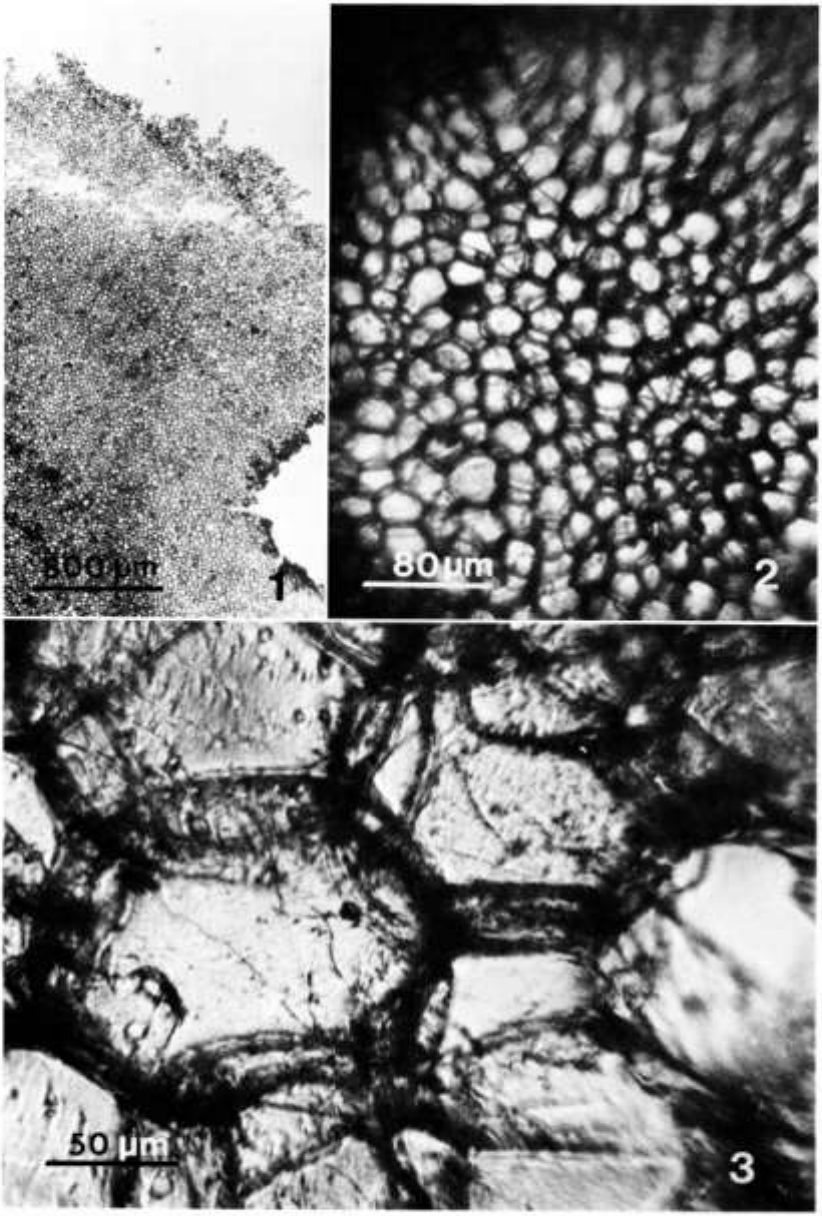
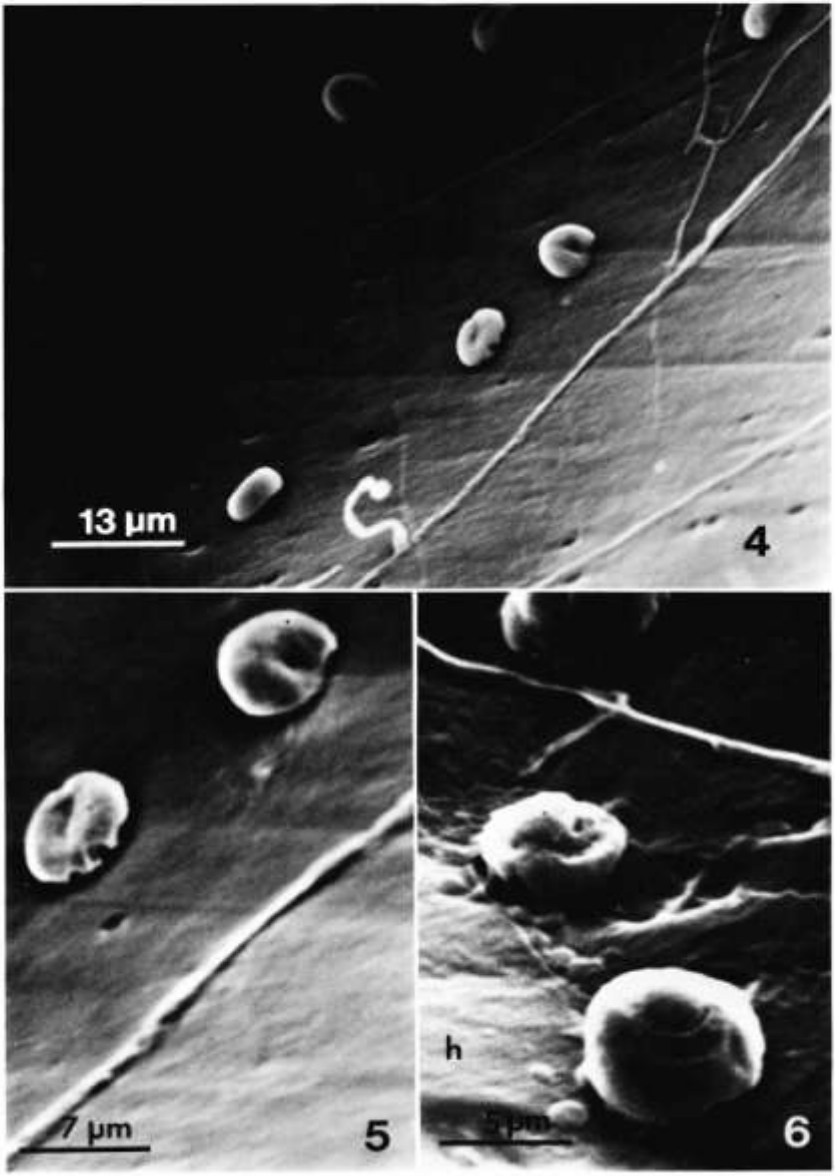
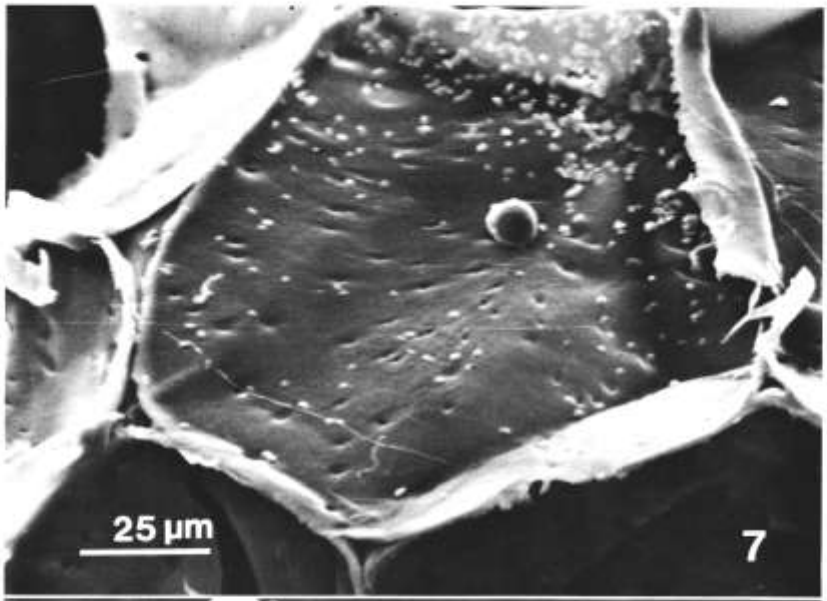
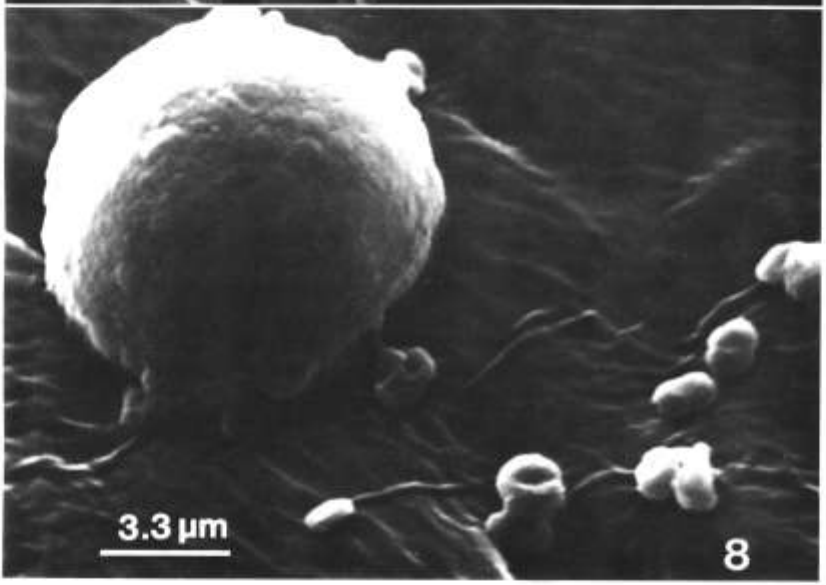
FIG. 1. Cork section cut by Antony van Leeuwenhoek in May 1674, imaged through a Prior 45-mm, ×2.7 objective on a modern Leitz Dialux photomicroscope assembly. FIG. 2. Central portion of specimen in Fig. 1 viewed through the original van Leeuwenhoek microscope in the collection of the University of Utrecht, using focusing stand designed by the author. FIG. 3. A specimen of elder pith, sectioned by van Leeuwenhoek, imaged through the Utrecht microscope. Note surface features on cell membranes.

FIG. 4. Portion of elder section (Fig. 3) gold-sputtered and imaged through Cambridge Stereoscan 600 at University College, Cardiff. Note erythrocytes. FIG. 5. Two erythrocytes from Fig. 4 at higher magnification, showing slight cell membrane damage but with characteristic biconcave shape. FIG. 6. Examples of erythrocytes from elsewhere in the elder pith section. These examples show evidence of deterioration after three centuries of storage.


800 µm
1
80 µm
2
50 µm
3


13 µm
4
7 µm
5
h
6


25 µm
7


3.3 µm
8

of ≤1.3 μm (van Zuylen, 1981), although objects finer than this can be visualized (for one aspect of the distinction between resolution and visualization, see Ford, 1968). The specimen is held by means of wax or glue to the tip of a stage pointer, which can be focused by turning a series of screws.

For purposes of the reconstruction, these screws were detached and laid to one side. The microscope body was mounted in a purpose-built slider mounted to an Olympus OM2N 35-mm camera body with a microscope-to-negative distance of 60 mm, which was empirically found to provide an image diameter of approximately 35 mm. Therefore, most of the entire field of view could be captured on the photographic negative. The studies that accompany this paper show the appearance of the sections which van Leeuwenhoek could have experienced in May 1674 (Figs. 1–3).

## Scanning Electron Microscopy (SEM)

The image quality of the van Leeuwenhoek lens is sufficient to reveal fine structures on the sections. Tenuous thread-like hyphae are visible, as are spores and pollen grains. However, an SEM examination of the elder pith sections has revealed traces of material which, without reasonable doubt, represents the personal legacy of van Leeuwenhoek (Figs. 4, 5). Several examples of rounded or ovoid bodies were seen. Measurement with the integral scale marker of the Cambridge Stereoscan 600 demonstrated a diameter of the order of 7 μm. Further examples were observed with the characteristic biconcavity of the erythrocyte (Fig. 5).

It is known that van Leeuwenhoek used a shaving razor to cut his sections. Since full precautions were taken throughout these maneuvers to avoid any extraneous contamination, van Leeuwenhoek's razor provides one likely route through which these cells were deposited on the sections. It is possible that they were transferred during dry shaving, since the use of a wet razor would result in lysis of the cells (Ford, 1981c). No ghost erythrocytes (i.e., cell membranes following cell lysis) have thus far been observed.

An alternative possibility is that of direct deposition on the section during coughing. In either event, these are intact cells in a form that would be amenable to detailed analysis in the future. The possibility that a summary of the genetic status of van Leeuwenhoek might at some time be obtained is greatly intriguing.

On one of the sections upon which optical microscopy was carried out, a more refractile, rounded cell-like body was located (Figs. 7, 8). High-power SEM showed that the body was associated with a number of smaller entities.

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FIG. 7. Single cell of elder section (compare with image through van Leeuwenhoek lens, Fig. 3) imaged in Cambridge Stereoscan 600 at higher magnification, showing presumptive neutrophil granulocyte and associated cocci. FIG. 8. The cell surface shows clearly in this SEM study of the features in Fig. 7. Note stages of cell division in adjacent bacterial cells.

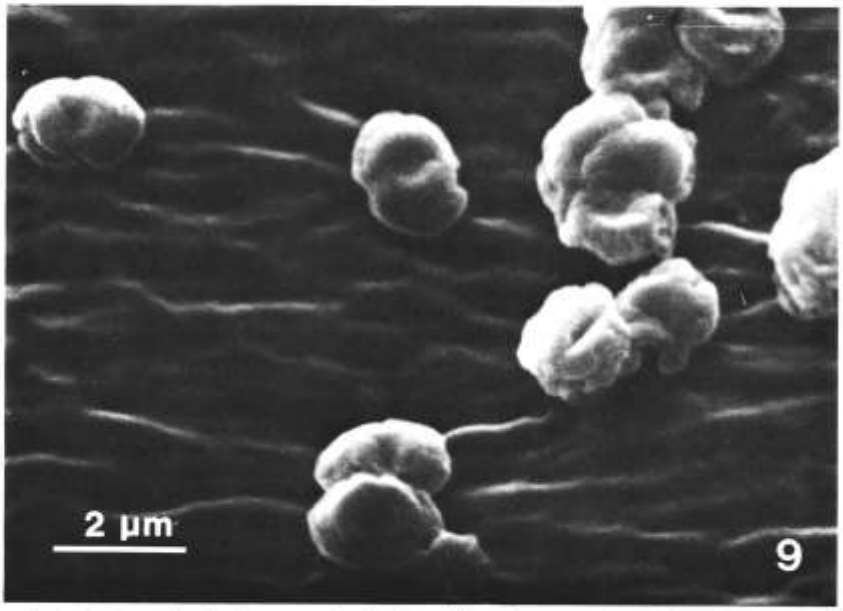


FIG. 9. Bacterial cells showing early (left), middle (above center), and late (below center) stages of cell division. Erosion and signs of deterioration are seen in individual organisms at right.

As the micrograph clearly reveals, these appear to be cocci. These small bacteria are 1.5–2 $\mu$m in diameter, and successive stages of cell division are clearly visible (Fig. 9). In the nutrient-lacking microenvironment of the elder pith surface, the phenomenon of division would not be anticipated for such bacteria. It is safer to conclude that they were deposited, while undergoing reproduction, from a more favorable circumstance. The likely explanation appears to be coughing impact.

In light of this interpretation, the central body may be a leucocyte. Its spheroidal configuration shows clearly in the plate, and with a diameter near 10 $\mu$m, it could be a polymorphonuclear granulocyte. A basophil cell would be smaller in diameter, in this mode of presentation nearer 8 $\mu$m, and there is not the granularity one might associate with a cell of this type or of the somewhat larger eosinophil.

These cell structures reveal their age by the apparent surface irregularities (Figs. 5, 8, 9). Three centuries of storage have helped to erode the bacterial cell walls and blood cell membranes in some instances, but this does not detract from their general appearance, and becomes visible only at higher magnifications. It thus appears that we are able to obtain a more detailed

insight into van Leeuwenhoek himself. The use of his original microscope(s) provides us with a valuable insight into how he viewed his specimens in the seventeenth century. Analyses of fine details with SEM provide some evidence on the circumstances in which the material was prepared. In addition, some tantalizing insight into van Leeuwenhoek himself emerges—as well as his state of health in May 1674. Future analytical methods may provide yet more detailed information on this great pioneer of modern microscopical science.

## Literature Cited


Bracegirdle, B. 1978. *A History of Microtechnique*. Cornell Univ. Press, Ithaca, New York. 359 pp.

Citters, P. H. van. 1954. On the use of glass globules as microscope-lenses. *Prod. Ned. K. Acad. Wet.*, 57(B): 103–111.

Dobell, C., 1932. *Antony van Leeuwenhoek and his "Little Animals."* John Bale, Sons & Danielsson, London. 435 pp.

Ford, B. J. 1968. The concept of "antipoint" applied to submicroscopic fibrillar structures. *Proc. Roy. Microsc. Soc.*, 3: 14–16.

1971a. Recreating the pioneer microscopist's view. *New Sci.*, 51: 324–325.

1971b. The microscopic view of nature two-and-one-half centuries ago. *Brit. J. Photog.*, 118: 682–685.

1973a. *The Optical Microscope Manual: Past and Present Uses and Techniques*. Crane, Russak, New York. 205 pp.

1973b. *The Revealing Lens—Mankind and the Microscope*. Harrap, London. 208 pp.

1981a. Leeuwenhoek's specimens discovered after 307 years. *Nature*, 292: 407.

1981b. The van Leeuwenhoek specimens. *Notes Rec. R. Soc. Lond.*, 36: 37–60.

1981c. Ce qu'observaient les premiers microscopistes. *La Recherche, Paris*, 126: 1147–1149.

1981d. The annotation of Leeuwenhoek's packets of specimens: a preliminary account. *Proc. R. Microsc. Soc. Oxf.*, 16: 393–395.

Hooke, R. 1665. *Micrographia, or some Physiological Descriptions of Minute Bodies made by Magnifying Glasses with Observations and Enquiries Thereupon*. Martyn & Allestry, Roy. Soc. London, 1665 (reprinted by Dover Publications, New York, 1961).

Zuylen, J. van. 1981. The microscopes of Antoni van Leeuwenhoek. *J. Microsc. Oxf.*, 121: 309–328.