The first descriptions of cilia and ciliary movement by van Leeuwenhoek and de Heide

E. H. Huizing, Leiden, The Netherlands

AT the end of the seventeenth century two Dutch scientists independently discovered cilia and ciliary movement. One of them, Antoni van Leeuwenhoek of Delft, is known to virtually every scientist and to many laymen as well. He probably made more discoveries than any single investigator in human history, and one of his many findings was the existence of cilia and ciliary movements in Protozoa and Mollusca.

The other discoverer was Anton de Heide, a general practioner in Middelburg, whose name is familiar only to specialists in the field of ciliar anatomy and physiology. In the literature de Heide is generally credited with the important discovery of cilia and ciliary movement (Tremble, 1962), whereas the name of van Leeuwenhoek is rarely mentioned in this connection.

ANTONI VAN LEEUWENHOEK AND HIS DESCRIPTIONS OF CILIA IN 1674, 1677, 1680, and 1713

Figure 1.
One of van Leeuwenhoek's seals.

Antoni van Leeuwenhoek (1632-1723) is a unique phenomenon in the world of scientific investigators. Having received no more than a limited education, he was appointed Chamberlain to the Sheriffs of Delft at the age of 27 and some years later also became the city's winegauger.

In 1671, van Leeuwenhoek began to grind lenses and make microscopes. Contrary to what is often stated, he was not the first to construct a microscope. In this, his compatriots Janssen and Drebbel and the Italians Fontana and Gallileo preceeded him, but the quality of van Leeuwenhoek's instruments was such that he outstripped all other microscopists for at least a century (Dobell, 1932). At his death he left no less than 247 microscopes, only a few of which have survived. The resolution capacity of his best instruments appears to have been about 1 μ.

Over a period of fifty years van Leeuwenhoek studied an overwhelming amount of living and dead material with his microscopes. His discoveries were described

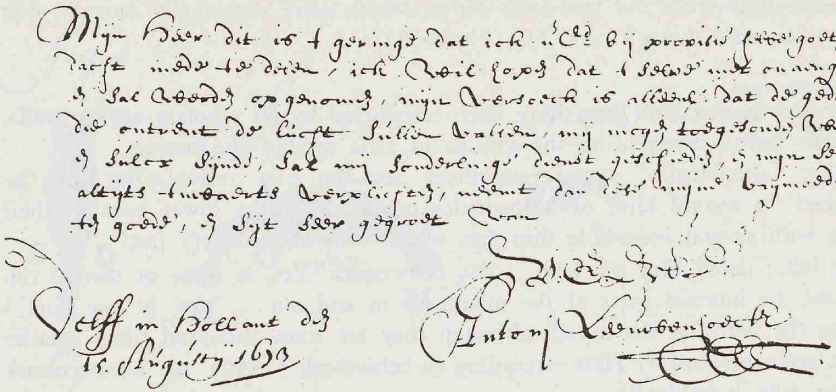

Figure 2. Last lines of van Leeuwenhoek's second letter to the Royal Society in London, written in his own handwriting.

in letters (mostly in Dutch) addressed to the Royal Society of London. Between 1673 and his death in August 1723, he wrote about 280 of those letters. His most revolutionary contributions were the visualization and description of Protozoa, Bacteria, and Spermatozoa. In the field of medicine he discovered the cross-striation of muscle fibres, confirmed the existence of blood corpuscles and capillary circulation, and demonstrated that nerves were not hollow tubes. Apart from these important contributions he made interesting studies of the brain, the eye lens, and the intestines.

Cilia are mentioned several times in van Leeuwenhoek's letters, mainly as part of a description of a particular animal. His first reference to these structures seems to be the one in his letter dated September the 6th, 1674, which contains the first report of his detection of Protozoa and Bacteria. The text reads: "Among these there were, besides, very many little animalcules, whereof some were roundish, while others, a bit bigger, consisted of an oval. On these last I saw two little legs near the head, and two little fins at the hindmost end of the body. Others were somewhat longer than an oval, and these were very slow a-moving, and few in number". [1]) According to Dobell and others, there can be no doubt that this description concerns Protozoa (in all probability Rotifers and Ciliates, respectively), the "two little legs" representing their cilia.

In the much more famous van Leeuwenhoek letter of October the 9th, 1676, where he describes the living animalcules in rain-water, we read the following. "Of the first sort that I discovered in the said water, I saw, after divers observations, that the bodies consisted of 5, 6, 7 or 8 very clear globules, but without being able to discern any membrane or skin that held these globules together, or in which they were enclosed. When these animalcules bestirred themselves,

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1) Translation by Dobell, 1932.

they sometimes stuck out two little horns, which were continually moved, after the fashion of a horse's ears".[1]) (Figure 3).

The Protozoa described here have been recognized by all scholars as Vorticella, the little horns representing the groups of cilia around the mouth.
In other "animalcules" van Leeuwenhoek saw the cilia individually when he described "a second kind of animalcules provided on the lower part of their bodies with several incredible thin legs which were moved very fast".
In his letter dated May the 13th, 1680, he writes: "Yes, in some of them I can even see the internal parts of the mouth go in and out ... Yes, in one kind I can see the hairs on the mouth although they are some thousand times smaller than a grain of sand.[2]) Here, according to Schierbeek (1950) van Leeuwenhoek saw the cilia individually.
Some years later (March 3rd, 1682), van Leeuwenhoek gave a description of cilia movement in the gills of the oyster: "I took advantage of the time when the oysters were brought to us from England in a short period of time and I then saw with surprise the very large movements made by the gills of the oysters, and although I took very small pieces of the gill of the oysters, so small that several hundreds of such pieces could not make a grain of rough sand, the movement in such a small sample of the gill was so large that it was uncomprehensible .... and besides this, the small fibres which seemed to be present on such a small piece made the same movement as the parts of the whole gill".[2]) Many years later, on June 28th, 1713 van Leeuwenhoek recorded some further observations on Rotifers. He then wrote: "Furthermore, I paid great attention to their revolving, toothed wheelwork; and I saw that an incredibly great motion was brought about by the said instrument, in the water round about it, whereby many little particles, that could be made out with the magnifying-glass, were wafted towards the animalcule, while others were carried away from it: whereof some, being borne into the middle of the revolving instrument, were used by the animalcule".[1])

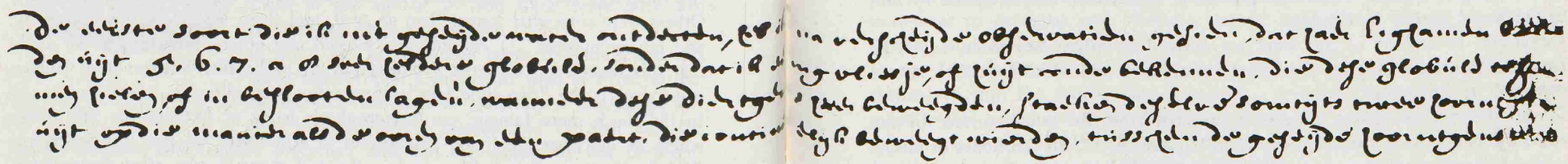

Figure 3. Part of the original of the famous letter of October 9th, 1676 where he describes ciliary movement in Vorticella (the handwriting is not van Leeuwenhoek's). For translation see text.

[1]) Translation by Dobell, 1932.
[2]) Own translation.

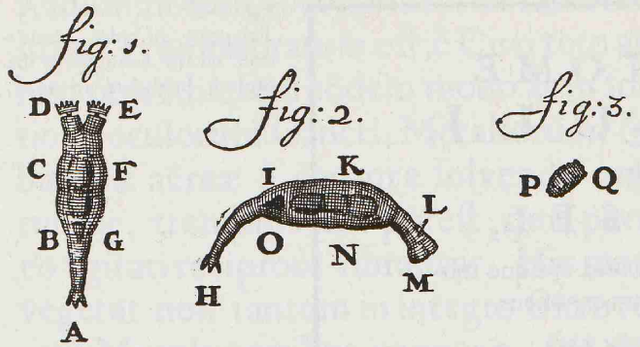

Figure 4. Illustrations of one of van Leeuwenhoek's letters on Rotifers.

As we see from these four quotations, van Leeuwenhoek observed and described cilia and ciliary movement on at least four different occasions. Nevertheless, his contributions in this field did not become generally known, probably being overshadowed by his many other discoveries which had much more influence on future developments.

ANTON DE HEIDE AND HIS DESCRIPTION OF CILIA IN 1684

In the literature Antonius de Heide (1646-169?) is usually credited with the discovery of cilia and the detection of ciliary movement. De Heide was a general practitioner in Middelburg, the capital of the province of Zeeland, having been born in 1646 in Phillipine, a small fishing village on the Schelde River in the Flamish part of the province. In 1667 he registered as a medical student at the University of Leiden, where he later defended a thesis entitled "De Cancro" (On cancer), which was printed at De Weduwe en Erven Johannis Elsevier, a name which is still renowned in publishing.
De Heide wrote several books, among them one on therapy which was reprinted several times, even after his death. In 1684 he published a treatise entitled *Anatome*

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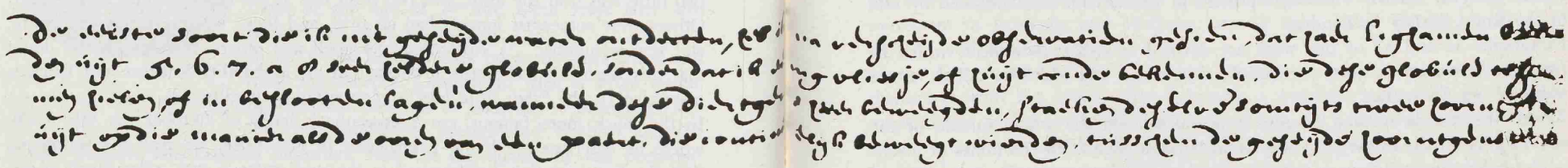

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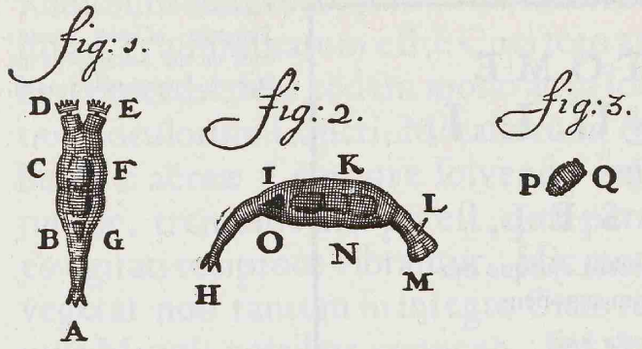

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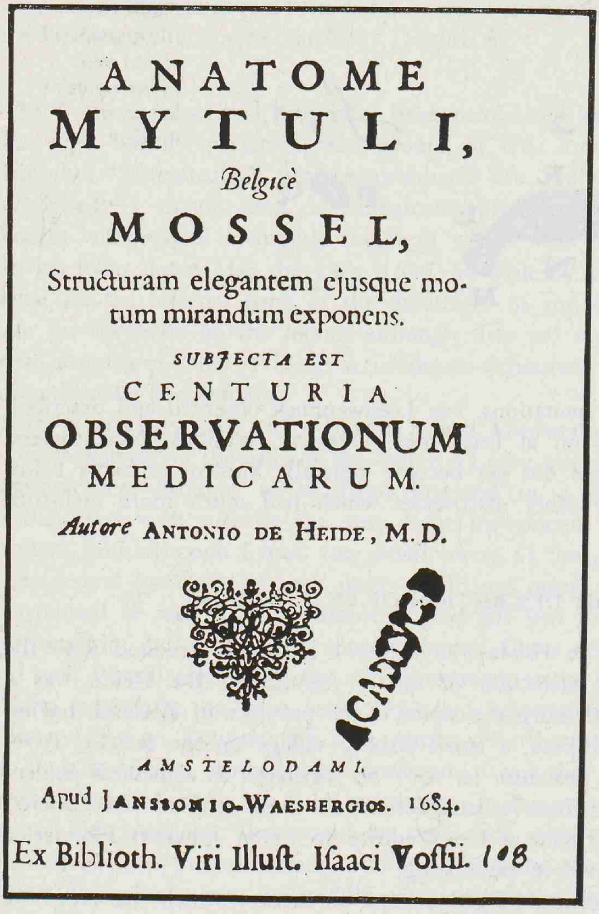
ANATOME
MYTULI,
Belgicè
MOSSEL,
Structuram elegantem ejusque motum mirandum exponens.
SUBJECTA EST
CENTURIA
OBSERVATIONUM
MEDICARUM.
Autore ANTONIO DE HEIDE, M. D.
AMSTELODAMI,
Apud JANSSONIO-WAESBERGIOS. 1684.
Ex Biblioth. Viri Illuſt. Iſaaci Voſſii.

Figure 5.
Titlepage of de Heide's book on the Anatomy of the Mussel, published in 1684.

Mytuli, Belgice Mossel, which was printed in Amsterdam and dedicated by him to the Royal Society in London.

Paragraphs 36 and 37 of this work are devoted to ciliary movement, which he found to be present in many parts of the sea mussel, and which he called "motus radiosus" or "tremulus".

"I call the motion radiant, because it proceeds from the whole surface of the cirrus (gill) almost in the same way as air-bubbles issue from crabstones or metals while undergoing solution; it may be called tremulous, because the parts affected by a vibrate. This motion goes on not only in the entire gill connected with the rest of the mussel, but even in the smallest pieces cut off from it, which by their radiant motion swim briskly through the seawater". [1]) (Figure 6).

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[1]) Translation by Sharpey, 1835.

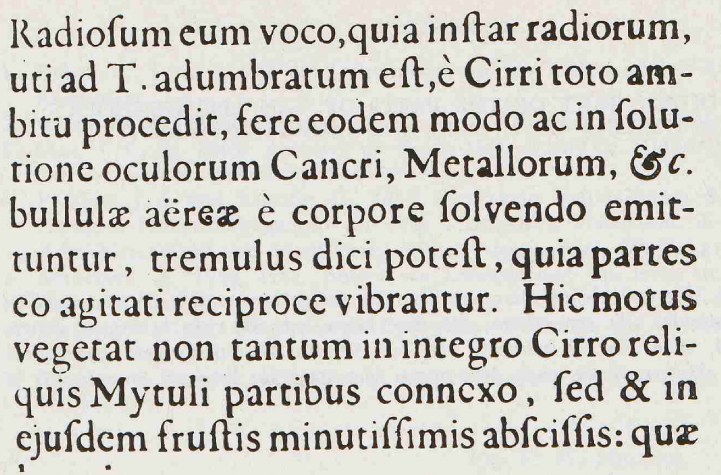
Radioſum eum voco, quia inſtar radiorum, uti ad T. adumbratum eſt, è Cirri toto ambitu procedit, fere eodem modo ac in ſolutione oculorum Cancri, Metallorum, &c. bullulæ aëreæ è corpore ſolvendo emittuntur, tremulus dici poteſt, quia partes eo agitati reciproce vibrantur. Hic motus vegetat non tantum in integro Cirro reliquis Mytuli partibus connexo, ſed & in ejuſdem fruſtis minutiſſimis abſciſſis: quæ

Figure 6. De Heide's description of cilia and ciliary movement. For translation see text.

The findings of de Heide and his description are in many respects similar to the observations van Leeuwenhoek recorded in his letter of March the 3rd, 1682. As far as we know, however, de Heide and van Leeuwenhoek never met and remained unaware of each other's studies on the oyster and mussel, although they lived not only in the same country, but also not more than sixty kilometres from each other.

In contrast to what is generally thought, the findings of van Leeuwenhoek and de Heide were not forgotten in the period that followed. In the middle and at the end of the eighteenth century other investigators continued to study ciliary movement in Infusoria and Mollusca, among them Baker (1744), Spallanzani (1787), and Müller (1786).

In the first decades of the nineteenth century so many investigators occupied themselves with the subject that it became a scientific topic. For the progress made in that period and in the preceding century, the interested reader is referred to the review prepared by Sharpey, a famous investigator in the field, for the Cyclopedia of Anatomy and Physiology in 1835.

The discovery of ciliary movement in mammals dates from 1834 and was made by Purkinje and Valentin. While examining the Fallopian tube of a rabbit, they accidently observed movements of the mucous membranes, which they recognized as ciliary motion. On further study they found the same phenomenon to be present in the nose, sinuses, Eustachian tube, larynx, trachea, and bronchi.

ORIGINAL DUTCH TEXT OF THE PARTS OF VAN LEEUWENHOEK'S LETTERS DEALING WITH CILIA AND CILIARY MOVEMENTS

From the letter of September 6th, 1674:

"en daer beneffens, seer veel kleijne diertgens, daer van eenige rontachtigh, die een weijnich grooter waren, bestonden uijt een eijront; aen dese laeste heb ick twee beentgens gesien, omtrent het hoofd, ende aen het achterste van het lichaem, twee vinnetgens b), andere waren wat langer als een eijront, ende dese waren seer traag int bewegen en weijnich in getal".

From the letter of October 9th, 1676:

"De eerste soort die ik in 't geseijde waten ontdecten, heb ik na verscheijde observatien gesien, dat haer lighamen bestonden uijt 5. 6. 7 a 8 seer heldere globule, sonder dat ik eenig vliesje of huijt conde bekennen, die dese globule te samen hielden, of in beslooten lagen; wanneer dese diertgens haer beweegden, staeken deselve somtijts twee hoorntgens uijt, op die manier als de ooren van een paert, die continuelijk beweegt wierden".

"een tweede soort diertgens aan het onderlijf versien van verscheijde ongelooflijk dunne pootgens of beentgens, die seer vaerdig bewogen wierde".

From the letter of May 13th, 1680:

"ja ik kan selfs in eenige de inwendige deelen van haar mont sien uyt en insteken en als daarmede spelen, ja aan een soort de haartjes aan haar mont sien, schoon deselve eenige duysenden kleynder sijn dan een sant".

From the letter of March 3d, 1682:

"Ik heb de tijd waargenomen, dat de Oesters uit Engeland tot ons in korten tijd overquamen, en heb daar alsdoen met verwondering gesien, wat een overgroote beweginge de baarden van de Oesters maakten, en schoon ik seer kleine stukjens van de baart van de Oester nam, ja die soo klein waren, dat eenige honderd soodanige deeltjens geen grof santgroote soude konnen uitmaken, egter zulken groote beweginge in soo een klein afgebrooke deeltje van de baart hadde, dat het onbegrijpelijk was .... en daar beneffens hadden de veseltjens die aan soodanig klein deeltje pooten geleken, deselve beweging die de deelen van de gantsche baart hadden".

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Dr. E. H. Huizing,
Department of Otorhinolaryngology,
University of Leiden,
The Netherlands.