Deep Blue https://deepblue.lib.umich.edu/documents

2015

Through the magnifying glass: a short history of the microscope

Alvarez, Pablo; Sobocinski, Gregg

https://hdl.handle.net/2027.42/120285

https://creativecommons.org/licenses/by/4.0/

Downloaded from Deep Blue, University of Michigan's institutional repository

Through the Magnifying Glass:
A Short History of the Microscope

9 April – 20 August 2015

Special Collections Exhibit Space
7th Floor • Hatcher Graduate Library
University of Michigan Library
Ann Arbor, Michigan

© 2015 University of Michigan Library (Special Collections Library)
All rights reserved

This exhibit was curated by Pablo Alvarez, Outreach Librarian & Curator, Special Collections Library. The guest curator, Gregg Sobocinski, Microscope Imaging Specialist in the University's Molecular, Cellular, and Developmental Biology Department, is responsible for the "modern" section of the exhibit. Thanks go to Cathleen A. Baker, Tom Hogarth, and Lauren O'Meara of the Preservation & Conservation Department for their help in designing, preparing, and installing this display.

Through the Magnifying Glass:
A Short History of the Microscope

This exhibit showcases a selection of books from the seventeenth and eighteenth centuries that contain extraordinary illustrations of animals and plants as they were originally seen through the lenses of early microscopes. During the course of the Scientific Revolution, leading microscopists such as Marcello Malpighi, Robert Hooke, Nehemiah Grew, Jan Swammerdam, and Antonie van Leeuwenhoek adhered to the Baconian method of relying on observation as opposed to trusting the sole authority of books. Most of them gravitated around the innovative scientific milieu of the Royal Society in London. In their desire to understand natural mechanisms, these revolutionary scientists examined the functioning of the smallest parts of the fabric of nature in order to comprehend better how humans, animals, and plants were born and work. In brief, they concluded that the interaction of small, previously unobservable "corpuscles" of matter helped them understand the properties of individual organs.

Our display also includes three eighteenth-century microscopes, one of which, the Culpeper-style English model, came to us with nine antique specimen slides. Guest curator Gregg Sobocinski has brought these historical slides to new life by capturing images using a modern microscope. These are displayed in the wall cases located to your right. Additionally visitors of this exhibit have the opportunity to view actual organic specimens by using the microscope located in the exhibit room. Both the books and the historical microscopes are part of the Special Collections Library.

Image on the exhibition poster:

Schem. XXXIV Cooperplate engraving of a flea
Robert Hooke (1635–1703)
Micrographia: Or some physiological descriptions of minute bodies made by magnifying glasses with observations and inquiries thereupon
London: Printed by John Martin and James Allestry...and are to be sold at their shop..., 1665

Tall Case 1

Francesco Stelluti (1577–1653)

Persio tradotto in verso sciolto e dichiarato da Francesco Stelluti
Roma: Giacomo Mascardi, 1630

The first reproduced images of small creatures as seen through the lenses of a microscope were engravings of a bee included in a bilingual edition (Latin and Italian) and commentary of the poetry of the 1st-century Roman satirist Aulus Persius.

The editor and translator of this book, Francesco Stelluti, was one of the founders of the Academy of the Lynx (Accademia dei Lincei, 1603–1630), an early Italian society devoted to promote scientific research. Galileo Galilei, a close friend of Stelluti, joined the Lynx in 1611, and it is very likely that he provided Stelluti with a microscope so that this edition of Persius could include detailed illustrations of a bee and its parts. Why include a bee? In 1623, Cardinal Maffeo Barberini became Pope Urban VIII. The coat of arms of the Barberini family was a shield with three bees. Someone then had the brilliant idea to seek the patronage of the Pope by prominently displaying not only the engraving one sees here but also Barberini's coat of arms on the title page.

Pierre Borel (ca. 1620–1671)

De vero telescopii inventore, cum brevi omnium conspiciliorum historia. Ubi de eorum confectione, ac vau, seu de effectibus agitur, novaque quaedam circa ea proponuntur. Accessit etiam centvria observationvm microcospicarum
The Hague: A. Vlacq, 1655

While the first part of Borel's book discusses the subject of the true inventor of the telescope, the second section includes 100 microscopical observations, which are often accompanied by small woodcuts like this one: Observation 45 describes a rather mysterious unidentified insect: *De insecto quodam anonimo*. Among his many other observations, Borel saw the compound eyes of insects, the circulation of blood in a louse, and the beating of a spider's heart. He also inspected the fabric of the human heart, kidney, liver, and testicles.

Thomas Bartholin (1616–1680)

De pulmonum substantia & motu diatribe: Accedunt Cl. V. Marcelli Malphighij de pulmonibus observationes anatomicae
Copenhagen: Henricus Gödianus & P. Hauboldus, 1663

The second half of the 17th century was a thriving time for the study of human anatomy. Microscopical research helped anatomists identify the smallest components of the human body, including the capillary blood vessels, the corpuscles of the blood, and the spermatozoa.

Danish physician Thomas Bartholin is perhaps best-known for discovering the lymphatic system in humans. Like other scientists of his time, he made ample use of microscopical observations. On display is our copy of the 1st edition of Bartholin's treatise on the substance and movement of the lungs. The opening shows a woodcut with three images: a small section of the outermost layer of the lung showing a net-like structure (I); the inner vesicles and a dissection of the intermediate part (II); and a schematic representation of the various adaptations of the lobes over the trachea (III).

The Microscopes

Before 1700 we have only few extant statements about the exact magnification provided by a microscope. In 1654, Christiaan Huygens estimated the magnification of a compound microscope (two or more lenses) in his possession to be 56 times. Eustachio Divini stated in 1667 that a microscope he had fabricated could magnify 41, 90, 111, or 143 times. Johann Frantz Griendel von Ach said in 1687 that his microscope was able to magnify a 100 times. Obviously, a proof of the quality of magnification is provided by the illustrations of the books themselves in the form of woodcuts and copperplate engravings, as shown in this exhibit.

In 2013, an important book collection on the history of medicine was transferred from the Taubman Library to the Special Collections Library at the University of Michigan. As part of this collection, there were three historical microscopes. After being repaired in the conservation lab, they are here exhibited for the first time. The first microscope on the left is styled after the so-called French box microscope, whose models can be dated around

1700. The one in the middle is a typical English tripod microscope closely based on the model designed and sold by John Yarwell in the 1680s. Made of wood, these two microscopes have their tubes covered with decorated paper and dyed ray skin. They were beautiful objects, perhaps designed not only for the industrious scientist but also for the curious gentleman.

Culpeper-Style English Microscope, ca. 1760

The third microscope is named after his maker, Edmund Culpeper (c. 1670-1737). This type had a brass tripod supported by a wooden base. To focus the image, one slides the inner tube inside a support tube, up and down. In our microscope, the support tube is made of rolled paper covered with dyed ray skin, and the inner tube is also made of rolled paper, this time covered with green-dyed vellum. The eyepiece holds a bi-convex lens; the objective lens (the one closest to the sample) was mounted into an interchangeable brass cell that was screwed into the bottom of the support tube. On the base of the microscope, there is a concave mirror to concentrate and reflect the light from a candle or the sun onto the specimen. The microscope came to us with nine specimen slides. Part of our exhibit in the Wall Cases consists of a selection of images captured from these slides.

Francesco Redi (1626–1698)

Left:
Esperienze intorno alla generazione degl' insetti fatte da Francesco Redi... e da lui scritte in una lettera all'illustrissimo signor Carlo Dati
Firenze: All'insegna della Stella, 1668

Right:
Osservazioni di Francesco Redi...intorno agli animali viventi che si trovano negli animali viventi
Firenze: P. Matini, 1684

In the first part of Book V of the *History of animals*, Aristotle (384–322 BCE) presented his theory of spontaneous generation. In brief, Aristotle argued that some animals grow from putrefying earth or vegetable matter, like some insects, while others are spontaneously generated in the inside of animals out of the secretions of their organs. In the 17th century, Francesco Redi was one of the earliest scientists to challenge this explanation. With the aid of the microscope, Redi proved that maggots are not spontaneously generated from decaying animal matter. The results of his microscopical observations can be appreciated in these two treatises, the *Esperienze* and *Osservazioni,* which include magnificent engravings such as the unfolded plate on the right: an earthworm found in the kidney of a dog: *lombrico trovato nel rene di un cane.*

Marcello Malpighi (1628–1694)

Marcello Malpighi graduated from the University of Bologna in 1653, where he studied philosophy and medicine. Then he became a lecturer in logic at Bologna in 1655 but left in 1656 to become professor of theoretical medicine at Pisa, where he worked closely with Giovanni Borelli, a mathematician who had turned his attention to the analysis of the movement in animals. In his *Opera posthuma,* Malpighi recalls that Borelli convinced him about the value of the experimental method as well as the mechanical conception of nature: by examining the physiology of individual organs, we could understand how nature works! By 1667, Malpighi's work had aroused the interest of the recently formed Royal Society in London, and one of its secretaries suggested that he communicate his results to the society. Malpighi agreed, and most of his later books were published in London. He was elected a foreign member of the Royal Society in 1668.

Opera omnia, seu, thesaurus locupletissimus botanico-medico-anatomicus: viginti quatuor tractatus complectens et in duos tomos distributus
Leiden: Pieter van der Aa, 1687

As the Latin title indicates, this book consists of 24 treatises on botany, medicine, and anatomy. Here we are showing one of the engravings that illustrate his treatise on the silkworm moth (*De bombyce*), originally published in 1669. It depicts the bead-like oviducts of the female reproductive system. Prior to his study, it was commonly believed that small invertebrates lacked internal organs. However, Malpighi discovered that the moth was just as complex as larger animals. He was able to discern the trachea and spiracles, the system of tubes and holes through which insects breathe. Moreover, he was the first to describe the nerve cord and ganglia, the silk glands, the multi-chambered heart, and the urinary tubules.

Wall Case 1

Jan Swammerdam (1637–1680)

Table 20
Structure of the compound eye of the bee
Bibel der natur, worinnen die insekten in gewisse classen vertheilt, sorgfältig beschrieben, zergliedert, in saubern kupferstichen vorgestellt, mit vielen anmerkungen über die seltenheiten der natur erleutert, und zum beweis der allmacht und weisheit des schöpfers angewendet werden. Nebst Hermann Boerhave vorrede von dem leben des verfassers. Aus dem Holländischen übersetzt Leipzig: J.F. Gleditschens buchhandlung, 1752

Robert Hooke (1635–1703)

Plate 24
Eyes and head of the grey drone fly
Micrographia; or, some physiological descriptions of minute bodies made by magnifying glasses. With observations and inquiries thereupon
London: Printed by J. Martyn and J. Allestry, 1665

Govard Bidloo (1649–1713)

Table 13
Describes the tongue, including a set microscopical observations
Anatomia hvmani corporis, centum & quinque tabvlis, per artificiossis. G. de Lairesse ad vivum delineatis, demonstrata, veterum recentiorumque inventis explicata plurimisque, hactenus non detectis, illvstrata
Amsterdam: Widow of J. à Someren 1685

Tall Case 2

Jan Swammerdam (1637–1680)

Tractatus physico-anatomico-medicus de respiratione usuque pulmonum. In quo, praeter primam respirationis in foetu inchoationem, aëris per circulum propulsio statuminatur, attractio exploditur; experimentaque ad explicandum sanguinis in corde tam auctum quam diminutum motum in medium producuntur
Leiden: D., A., & A. à Gaasbeeck, 1667

Jan Swammerdam became a doctor of medicine in 1667 after defending his doctoral dissertation on the respiratory system of the lungs (*de respiratione pulmorum*). In this treatise, he presents a series of experiments and vivisections to prove that the air is not attracted to the lungs as a result of a vacuum, but it is pushed into the lungs because the chest is expanded. However, after defending his thesis, Swammerdam never practiced the profession of medicine, devoting the rest of his life to research.

Jan Swammerdam (1637–1680)

Ephemeri vita: or, the natural history and anatomy of the Ephemeron, a fly that lives but five hours. Written originally in Low-Dutch by Jo. Swammerdam
London: Printed for H. Faithorne, and J. Kersey, 1681

As opposed to other illustrious microscopists like Marcello Malpighi and Robert Hooke, Swammerdam never attempted to resolve the big question about how living beings were born and functioned. In other words, he was not interested in developing a theory to explain the mechanism of nature. Indeed, he believed in producing results based on observations, but he was also a profoundly religious man. *The ephemeral life* reflects this conflict between science and religion. While it is an extraordinary study of the mayfly, the treatise at times communicates an agonizing feeling on the futility of life.

Antonie van Leeuwenhoek (1632–1723)

Vervolg der brieven, Geschreven aan de Wytvermaarde Koninglijke Societeit in Londen door Antoni van Leeuwenhoek
Leiden: C. Boutesteyn, 1687

Antonie van Leeuwenhoek was not the typical scientist of his age. He did not know Latin, the *lingua franca* of science, and began his research career at the age of 40. However, he was the microscopist who attracted the most attention during a long career that covered nearly three decades. Leeuwenhoek was enthusiastically received in the circle of the Royal Society in London, whose members encouraged him to communicate his findings via its *Philosophical Transactions*. On display is a selection of microscopical observations originally written in the form of letters addressed to the Royal Society. The plate shows a study of buckwheat.

Antonie van Leeuwenhoek (1632–1723)

Opera omnia, seu Arcana naturæ, ope exactissimorum microscopiorum detecta, experimentis variis comprobata, epistolis, ad varios illuſtres viros, ut et ad integram, quæ Londini floret, ſapientem Societatem, cujus membrum eſt, datis, comprehenſa, & quatuor tomis diſtincta. Editio noviſſima, prioribus emendatior, cum indicibus cuique tomo accommodatis
Leiden: J.A. Langerak, 1719–1722

The Special Collections Library holds the first Latin edition of Leeuwenhoek's complete works in four volumes. The publication was completed just a year before the author's death, being an appropriate testimony of his scientific reputation all over Europe.

Leeuwenhoek employed his own handcrafted single-lens microscopes, constantly adding improvements throughout his long research career. Along with Marcello Malpighi, he believed in the uniformity of nature. In other words, by using the analogical method, researchers could argue that structures observed in plants could be replicated in human beings! For instance, he thought that the plant embryo was analogous to the spermatozoon: if he could easily see the particulars of a miniature plant in a seed, he was sure that a similarly structured being was inside the spermatozoon.

This engraving displays Leeuwenhoek's microscopical observation of a bird feather, showing the clear methodology he used to record his observations. Starting with a full-size version of the bird feather seen in *figura 1,* the reader is shown increasingly magnified versions of each of the parts of the feather, including amazing details of its texture and vessels.

Using samples from salmon and other kinds of fish, Leeuwenhoek examined the composition of their blood, extrapolating the results to the composition of human blood. For instance, he concluded that the blood corpuscles were composed of six globules and that each globule consisted of six smaller globules. This is aptly illustrated by the wax models represented in *figurae 5 and 6*; the representation of the capillaries is shown in *figura 7.*

Here Leeuwenhoek examines a small sample of the scales (*fibrillae pisculentae*) taken from a hake (*asellus*; a fish). In brief, his obsession for determining the exact structure of animals and plants made him repeat the same observation many times through the years. He employed the so-called "concentric method": he would come closer to the truth the more often he examined the same specimen at different moments.

Louis Joblot (1645–1723)

Descriptions et usages de plusieurs nouveaux microscopes, tant simples que composez; avec de nouvelles observations faites sur une multitude innombrable d'insectes, & d'autres animaux de diverses especes, qui naissent dans des liqueurs préparées, & dans celles qui ne le sont point
Paris: J. Collombat, 1718

A professor of mathematics at the École Nationale des Beaux-Arts, Joblot lectured on a wide range of disciplines including perspective, optics, and geometry. During the period between 1680 and 1716, he concentrated on the use of the microscope for his research. Here is a copy of the 1st edition of his masterpiece, *Descriptions and usages of many new microscopes,* where he explained his own improvements and modifications of the microscope, observations of protozoa, and his opposition to the theory of spontaneous generation. Joblot's new microscopes allowed precise focusing by eliminating stray light and enabling the mounting of a diverse array of specimens. In this engraving is an example of a single-lens microscope which, according to Joblot, could be useful to anatomists, designers, engravers, and painters working with miniatures: "tres-utile aux Anatomistes, aux Desinateurs, aux Graveurs, aux Peintres qui travaillent en Mignature."

Wall Case 2

Robert Hooke (1635–1703)

Schem. 1
Describes the microscope used by Hooke
Micrographia; or, some physiological descriptions of minute bodies made by magnifying glasses. With observations and inquiries thereupon
London: Printed by J. Martyn and J. Allestry, 1665

Wilhelm Friedrich von Gleichen-Russwurm (1717–1783)

Table 4
Describes what is perhaps a gentleman's microscope
Découvertes les plus nouvelles dans le règne végétal; ou, observations microscopiques sur les parties de la génération des plantes renfermées dans leurs fleurs, & sur les insects
Nuremberg: Chrétien de Launoy, 1770

Floor Case 1

Robert Hooke (1635–1703)

Micrographia; or, some physiological descriptions of minute bodies made by magnifying glasses. With observations and inquiries thereupon
London: Printed by J. Martyn and J. Allestry, 1665

Robert Hooke made extraordinary contributions to the fields of astronomy, optics, physics, mechanics, and architecture. In 1662, he was made curator of experiments of the Royal Society. Undoubtedly his masterpiece was the *Micrographia*, an outstanding treatise containing 57 microscopical and three telescopical observations. He begins by examining samples of inorganic matter, such as the tip of a needle, continuing with studies of vegetable and animal specimens. Readers were astonished. He examined for the first time numerous animal structures like that of the polyzoo, fish scales, a bee's sting, the compound eye of the fly, the louse, and the flea. Samuel Pepys recorded the following in his diary after reading Hooke's book on 21 January 1665:

> Before I went to bed I sat up till two o'clock in my chamber reading of Mr. Hooke's Microscopicall Observations, the most ingenious book that ever I read in my life.

Nehemiah Grew (1641–1712)

The Anatomy of Plants. With an Idea of a Philosophical History of Plants, and Several other Lectures, read before the Royal Society
London: Printed by W. Rawlins, for the author, 1682

Nehemiah Grew worked closely with Hooke, who proposed him to be elected a member of the Royal Society. Later they would share the appointment of secretary of the Society, collaborating in numerous microscopical investigations. Grew is best remembered for discovering that a plant's stamen, with its pollen, functions as the male sex organ, while its pistil is like the female sex organ. In general, the engravings of *The Anatomy of Plants* show the magnified structure of plant tissues, confirming the existence of cells as first argued by Hooke. On display is an engraving representing the construction of vegetable matter. Essentially Grew thought that plant structure was built from finely intertwining fibers.

Johann Frantz Griendel von Ach (1631–1687)

Micrographia nova: sive nova & curiosa variorum minutorum corporum singularis cujusdam & noviter ab autore inventi microscopii ope adauctorum & miranda magnitudine repraesentatorum descriptio
Nuremberg: J. Ziegerus, 1687

The *New Micrographia* includes an account, with numerous engravings, of a microscope designed by Griendel that considerably improved on Hooke's and Leeuwenhoek's microscopes by augmenting the observer's area of vision and lengthening the distance between the objective and the specimen. In this engraving we can see the seeds of various plants such as the poppy ("semen papaveris"), flax plant ("semen lini"), and cumin ("semen cumini").

Floor Case 2

Martin Frobenius Ledermüller (1719–1769)

Amusement microscopique, tant pour l'esprit, que pour les yeux; contenant cinquante estampes dessinées d'après nature et enluminées, avec leurs explications
Nuremberg: A.W. Winterschmidt, 1764–1768

Ledermüller designed the engravings that were executed by the Nuremberg artist and publisher, A.W. Winterschmidt. The beauty of this book, and the elegant sophistication of the design of the microscopes, probably suggests that the intended audience was not limited to the scientific community but addressed the educated reader in general.

Govard Bidloo (1649–1713)

Anatomia hvmani corporis, centum & quinque tabvlis, per artificiossis. G. de Lairesse ad vivum delineatis, demonstrata, veterum recentiorumque inventis explicata plurimisque, hactenus non detectis, illvstrata
Amsterdam: Widow of J. à Someren 1685

In this large anatomical atlas, Bidloo attempted to include the entire existing knowledge on the human body. Moreover, he included illustrations of the microscopical structures of various human parts like the skin, tongue, liver, kidney, brain, and lung. Designed by the artist Gerard de Lairesse, the 105 engravings in this book were promptly admired for their artistic intensity. However, some scholars have recently challenged the scientific accuracy of some of these images, arguing that they often replicate, or even misrepresent, Marcello Malpighi's observations rather than being based on original dissections performed by Bidloo. For instance, for the illustration of the brain cortex on display here, Bidloo tried to follow Malpigui's description: there were spheres (glands) covered with capillaries that were in turn arranged in clusters. Malpighi, however, never described the glands as being of the size proposed by Bidloo.

Wilhelm Friedrich von Gleichen-Russwurm (1717–1783)

Découvertes les plus nouvelles dans le règne végétal; ou, Observations microscopiques sur les parties de la génération des plantes renfermées dans leurs fleurs, & sur les insectes
Nuremberg: Chrétien de Launoy, 1770

Gleichen spent his early life as a soldier in the forces of the Margrave of Bayreuth. In 1760 he met microscopist Martin Ledermüller, under whose influence he became interested in physiology and the design of microscopes in general. Though he lacked a formal scientific education, the illustrations of this book reflect carefully conducted observations, proving how an enlightened gentleman could participate in the scientific discourse of the age.

• A modern microscope is set up so that visitors can view the same types of specimens seen on display •

Wall Cases 4 through 6

Modern Microscope Images of Historic Samples

The antique specimens included with the Culpeper-style antique microscope that is on display in this exhibit are very different from samples prepared for modern use. Because glass made in the 18th century was so fragile, expensive, and lacked optical clarity, each of these samples was mounted between two thin pieces of mica (a naturally occurring laminate mineral) and placed into holes drilled into thin strips of bone and secured with brass rings. We captured images of these unidentified samples using modern microscope-imaging technology and have included many of them in the wall cases to your right. All the images are in color, but because they were backlit through the mica, they have a sepia-tone appearance, and some of the natural colors have faded over time.

The images are grouped in two categories: Recognizable Structures and Patterns in Nature. We hope you appreciate the expert manner in which 17th- and 18th-century scientists captured details from such samples, which are shown in the books displayed in this exhibition.

Photo credits: Images for the facsimiles were captured by Gregg Sobocinski (Microscope Imaging Specialist of the U-M Molecular, Cellular, and Developmental Biology Department) on a Nikon E600 Eclipse microscope using a 10x objective and a Spot RT Slider camera, and on a Leica MZFLIII stereo dissecting microscope using a 0.8x objective and a Leica DC480 camera.

The plant- and animal-specimen facsimiles on display include:

Introduction

louse; hummingbird semi-plume feather

Recognizable Structures

two very small spiders; spider leg showing hair, joints, and claws;
insect body and wing; hummingbird flight-feather structures;
unknown, could be insect or plant scales and hair/spines;
unknown, possibly aquatic moss or algae

Patterns in Nature

unknown, resembles animal quill cross-section;
unknown, could be fern spores, small poppy seeds, or insect eggs; unknown;
iconic plant epidermis cells; stellate parenchyma (pith) from inner part of
Juncus effusus (grass); dissected insect eye, likely *Drosophila* (fruit fly)

Thank you for coming to see this exhibition.
Check the Library's website for more information about
our collections, exhibits (physical and online), and upcoming events:

www.lib.umich.edu/special-collections-library

www.lib.umich.edu/events