ISTITUTO E MUSEO
DI STORIA DELLA SCIENZA

A CENTURY OF DISCOVERIES

1610: PRECIOUS TESTIMONY
The first descriptions of compound microscopes date from the early 17th century. John Wedderburn (1583-1651), a disciple and admirer of Galileo Galilei (1564-1642), testifies that, by this year, the Pisan scientist had already built a microscope and conducted observations. It is probable that the first Galilean microscopes featured the combination of a convex and a concave lens.

1614: GALILEO SPEAKS OF THE MICROSCOPE
In mid-November Galileo is visited in Florence by Giovanni Tarde (1561/62-1636), to whom he speaks of his microscope and shows the ephemerides of the Medicean Planets.

1619: DREBBEL'S MICROSCOPES
In England, between 1619 and 1623, the Dutch physicist and mechanist Cornelius Drebbel (1572-1633) constructs several microscopes, none of which have survived. They seem to have been Keplerian microscopes, that is, with convex lenses showing a reversed image. One of these microscopes was brought to Rome in December 1623, and was examined by Galileo in 1624.

1623: A TELESCOPE TO SEE OBJECTS CLOSE UP
In *Il Saggiatore* [The Assayer], written between 1619 and 1622 and published in 1623, Galileo mentions "a telescope adjusted to see objects very close up". This first type of Galilean microscope probably consisted of the elongated cylinder of a telescope with two lenses.

1624: A "THING OF GREAT CONSEQUENCE FOR MEDICINE"
In a letter dated October 4, Bartolomeo Imperiali (?-1655) informs Galileo that a physician in Genoa "says that with this *occhialino* we will know for sure the site of a certain tiny particle of the heart, which it has never been possible to see with simple vision, and which will show itself to be a thing of great consequence for medicine ...".

1624: GALILEO'S GIFT TO CESI
Galileo perfects the construction of the compound microscope. On May 10, on the occasion of a meeting held in Rome, the Pisan scientist donates to Cardinal Federico Eutel of Zollern a microscope with which he shows those present the magnified image of a fly. On September 23 he sends Federico Cesi (1585-1630) an "*occhialino* to see minute things close up". Galileo observes, "I have contemplated a great many animals with infinite admiration; among them, the flea is most horrible, the mosquito and the moth are beautiful; and with great satisfaction I have seen how flies

and other tiny creatures can walk attached to mirrors, and even upside down. But Your Excellency will have occasion to observe thousands and thousands of details, of which I request you to notify me of the most curious things."

1625: THE NAME OF THE INSTRUMENT
In a letter dated April 13 to Federico Cesi (1585-1630), Johann Faber (1574-1629), a member of the Accademia dei Lincei, called "microscope" the "new eyepiece to see minute things ". Writes Faber: "…and I call it microscope, if it may please Your Excellency, and may I add that the Lyncei, since they named the former instrument, the telescope, have wished to give a suitable name to this one too, and deservedly, because they were the first here in Rome to have it...".

1625: THE COPY OF THE APIARIUM
On September 26, 1625 Prince Federico Cesi (1585-1630) sends Galileo in preview a copy of the *Apiarium*, a text on bees, which constitutes a significant chapter in the naturalist, historical-erudite and literary program of the Accademia dei Lincei.

1625: THE MELISSOGRAFIA
The first iconographic document realized with the aid of the microscope is printed in Rome. It was a gift from the Accademia dei Lincei to Pope Urban VIII. This document, known as the *Melissographia,* presents the observations conducted by Francesco Stelluti (1577-1651), a member of the Accademia dei Lincei, whose subject is a bee observed supine, in profile and on its back, surrounded by an abundant corona of its dissected parts. The great plate was engraved by Matthaus Greuter (1566-1638).

1625: THE APIARIUM
The *Apiarium* is published in Rome. This work, covering a single folio of extraordinary size (63X101 cm), contains much information of historical, scientific and poetic nature on these hymenoptera. Prince Federico Cesi (1585-1630) thus pays homage to Pope Urban VIII (1568-1644), whose coat of arms was emblazoned with bees.

1628: GALILEO SENDS A MICROSCOPE TO PHILIP OF HESSE
From Florence, Galileo sends one of his microscopes to the Landgrave Philip of Hesse (1581-1643).

1630: GALILEO SENDS A MICROSCOPE TO THE KING OF SPAIN
Galileo sends a microscope to the King of Spain.

1630: THE GRAIN WEEVIL
Francesco Stelluti (1577-1651), a member of the Accademia dei Lincei, with an illustration of the "aphis" or grain weevil, portrayed both in natural size and magnified by the microscope, inaugurates an iconographic practice that will be followed by many microscopists for at least two centuries.

1631: THE DRAWING OF THE COMPOUND MICROSCOPE
One of the earliest drawings of the tripod-type compound microscope dates from 1631 and is found in the diary of the Dutch scientist Isaac Beeckman (1588-1637). Copernican in his cosmology, Beeckman shared the ideas of William Harvey (1578-1657) on the circulation of the blood, and developed a tendentially atomist perspective in physics.

1633: MICROSCOPIC IMAGE OF A PLANT

The work *De florum cultura* by Giovan Battista Ferrari (1584-1655) is published in Rome. It contains the first image of vegetal matter, a hibiscus seed, drawn on the basis of microscopic observation.

1642: DEATH OF GALILEO
On January 8th, Galileo dies at the Villa il Gioiello at Arcetri near Florence. Galileo's experimental method was to be continued, to various degrees and in different directions, by his many pupils and admirers.

1643: THE LYMPHATIC VESSELS
The Danish anatomist Thomas Bartholin (1616-1680) publishes in Copenhagen *Vasa lymphatica*, in which he describes his discovery of the lymphatic vessels.

1644: THE MICROSCOPE 'A PERLINA'
It is very probably in this year that Evangelista Torricelli (1608-1647), mathematician to the Grand Duke, designs the microscope 'a perlina', a simple microscope formed of a small spherical lens placed at the end of an optical tube.

1644: THE FLY'S EYE
The close bond between the telescope and the microscope is shown by the fact that, in the first half of the 17th century, numerous astronomers occasionally conducted microscopic observations. In 1644, for example, the Sicilian astronomer Giovanni Battista Hodierna (1597-1660) publishes in Palermo *L'occhio della mosca*, [The fly's eye], a work in which the new technique of microscopic investigation of nature was shown to be an important aid to anatomy.

1645: ATOMISM AND MICROSCOPY
The *Zootomia democritaea, id est anatome generale totius animantium opifici* by Marco Aurelio Severino (1580-1656) is published in Nuremberg. In this work, on the basis of microscopic investigation, a Democritean atomistic concept of the anatomical structures of animals is proposed again.

1646: THE ARS MAGNA LUCIS ET UMBRAE BY KIRCHER
The *Ars magna lucis et umbrae* by the erudite Jesuit priest Athanasius Kircher (1602-1680) is published in Rome. The work includes, among other things, a precious record of the microscope 'a perlina' designed by Evangelista Torricelli (1608-1647). The microscopic findings reported by Kircher are extraordinary; tiny living organisms are observed in cheese, milk and vinegar.

1646: FONTANA CLAIMS CREDIT FOR DISCOVERING THE MICROSCOPE
Francesco Fontana (c.1585-1656) publishes his *Novae caelestium terrestriumque rerum observationes*, a text in which he claims to have invented the telescope composed of two convex lenses in 1608 and a compound microscope in 1618, consisting of two converging lenses, one functioning as objective, the other as eyepiece.

1654: THE TESTIMONY OF VIVIANI
Vincenzo Viviani (1622-1703) writes an excellent *Racconto istorico della vita del Sig. Galileo Galilei* [Historical account of the life of Galieo Galilei] in the form of a letter to Prince Leopoldo de' Medici (1617-1675), which remained unpublished until 1717. Viviani credits Galileo with the invention of both the simple and the compound microscope.

1655: DUTCH ORIGIN OF THE INSTRUMENT?

According to documents published by Pierre Borel (c.1620-1671) in his text *De vero telescopii inventore*, both the microscope and the telescope are alleged to have been invented around 1590 by two Dutch opticians, Hans and Zacharias Janssen (who may have been either father and son or brothers). This thesis appears plausible due to the fact that, toward the end of the 16th century, the Dutch spectacle makers were remarkably creative. Janssen's primitive instruments, fabricated by uniting several lenses inside a fixed cylinder, resting on a tripod, were capable of magnifying an object as much as thirty times. They were not employed for scientific purposes, however, but designed to be sold as curiosities to princes and notables.

1656: THE GLANDULAR SYSTEM
Thomas Wharton, in his *Adenographia, or a Description of the Glands of the Whole of the Body*, describes the glandular system.

1657: FOUNDATION OF THE ACCADEMIA DEL CIMENTO
The Accademia del Cimento is founded at the Medicean Court, with the objective of relaunching Galileo's scientific heritage. Although microscopy is not one of the particular activities carried out by the Accademia del Cimento, it is cultivated by two of its members: Giovanni Alfonso Borelli (1608-1679) and Francesco Redi (1626-1697).

Borelli, during his stay in Tuscany (1656-1666), stimulates numerous scholars to conduct investigation with microscopes; among them are Marcello Malpighi (1628-1694), Claude Aubery (1607-1658/9), Carlo Fracassati (1630-1672) and Lorenzo Bellini (1643-1704).

The Arezzo scientist Francesco Redi (1626-1697) shows himself capable of combining experimentation with utilization of the microscope. In his naturalist studies, he calls upon artists to faithfully illustrate what is observed by means of optical magnification, thus underlining the close relationship existing at the time between science and art, a bond so close that the term "art of microscopic observation" is used.

1658: THE RED BLOOD CELLS
The Flemish scientist Jan Swammerdam (1637-1680), one of the greatest masters in the art of microscopic observation in the second half of the 17th century, observes and describes the red blood cells. He is also one of the first to formulate the theory of preformation according to which an organism is entirely constituted from the beginning, and development consists only of a process of enlargement.

1658: A DISCOVERY MADE WITH THIN ANATOMY
The physician and anatomist of Lorraine origin Claude Aubery (1607-1658/9) publishes in Florence the pamphlet *Textis examinatus*, reporting observations on the canaliculated structure of the testicle. These observations are conducted through the art of “thin” anatomy and not with the microscope.

1660: THE ROYAL SOCIETY
The Royal Society for the Improvement of Natural Knowledge is founded, and is officially recognized by Charles II (1630-1685) about three years later. The prestigious London society is also attentive to research conducted using the microscopic.

1661: MALPIGHI'S STUDIES OF THE LUNGS
Marcello Malpighi (1628-1694), one of the outstanding observers in the second half of the 17th century and the founder of microscopic anatomy, publishes the *De pulmonibus observationes anatomicae. Epistulae ad Jo. Alphonsum Borellium*, a work in which he analyzes the mechanism through which venous blood is oxygenized by the lungs and transferred into arterial circulation.

Through observation of the capillaries, he confirms the discovery of the principle of circulation of the blood postulated by William Harvey (1578-1657), described in the *Exercitatio anatomica de motu cordis et sanguinis in animalibus* (1628). The microscope allows Malpighi to describe for the first time the alveolar structure of the lungs. To microscopic investigation he combines the art of preparing tissues to be examined, thanks to which he puts in evidence a great number of structures otherwise invisible to the naked eye. But he does not always accompany his texts with illustrations, thus rendering them less effective.

1662: BELLINI'S STUDIES OF THE KIDNEYS
Lorenzo Bellini (1643-1704), at the age of only nineteen, publishes in Florence the *Exercitatio anatomica de structura et usu renum*. Superseding the theory of Galen (129-199), according to which the kidneys were composed of a "parenchymatic" substance and produced the urine thanks to a particular faculty, Bellini gives an explanation of purely mechanical type.

1665: HOOKE'S MICROGRAPHIA
Robert Hooke (1635-1703), one of the most brilliant and versatile English scientists of the 17th century, publishes the *Micrographia* in London. This work contains the detailed figure of a compound pillar-type microscope. The beauty of the illustrations, plates depicting insects, leaves and small objects, and the precision of the observations exert a forceful impact on the scientific community, showing a new side of nature distinguished by microscopic realities. Hooke is the first to observe the cells of plants, although this discovery was to have no practical consequences.

1665: DIVINI'S MICROSCOPES
Around 1665, Eustachio Divini (1610-1685) builds a microscope consisting of a set of cardboard telescopic tubes that slide into one another for focusing. The instrument is mounted on a small tripod. Divini is also attributed with introducing the reflecting mirror to light the objects under observation.

1665: STUDIES ON THE TONGUE
The Bolognese physician and anatomist, Carlo Fracassati (1630-1672), publishes in Bologna the *Exercitatio epistolica de lingua ad J. Alf. Borellum*, a work in which he describes the anatomical structure and the functions of the tongue. In the same year the Florentine Lorenzo Bellini (1643-1704) publishes, also in Bologna, the *Gustus organum novissime deprehensum*, a work that proposes to explain the origin of the flavors, maintaining that they depend on the papillae of the tongue.

1665-1666: THE SENSORIAL RECEPTERS
In 1665 and 1666 Marcello Malpighi (1628-1694) publishes four pamphlets on neuroanatomy: *de cerebro*; *de lingua*; *de externo tactus organo*; *de cerebro cortice*. In the second and third pamphlet Malpighi describes the great discovery of the sensorial receptors: the papillae of taste and touch.
di Marcello Malpighi, «Physis», Year VIII (1966), pp. 253-266.

1667: END OF THE ACTIVITY OF THE ACCADEMIA DEL CIMENTO
With the publication of the *Saggi di naturali esperienze*, edited by the Secretary Lorenzo Magalotti (1637-1712), there concludes, after ten years, the experimental activity of the Accademia del Cimento, promoted as a development of Galileo's experimental method.

1667: OBSERVATIONS ON THE MUSCLES
The Danish Niels Steensen (Niccolò Stenone, 1638-1686), during his first stay in Tuscany (1666-1667), conducted important anatomical dissections and published in 1667 his fundamental work on the structure of the muscles (*Elementorum myologiae specimen, seu Musculi descriptio geometrica*)

in the appendix to which he includes a famous memorandum on the dissection of a shark's head. In addition to describing the structure of the muscles, Stenone also studied the glandular and lymphatic systems and the anatomy of the brain. He discovered the excretory duct of the parotoid gland**,** which he described in his *Observationes anatomicae* (Leyden, 1662).

1668: REDI AND THE CONFUTATION OF SPONTANEOUS GENERATION

The *Esperienze intorno alla generazione degl'insetti* [Experiments on the generation of insects] is published in Florence. This text, Redi's true masterpiece (1626-1697), is to be a milestone in the history of modern science. He confutes the age-old theory of the spontaneous generation of insects through a successful experiment, which introduces into the scientific method the serial procedure and the comparison between research experiments and control experiments. The work is illustrated by numerous engravings of insects observed by the scientist under the microscope.

1669: MALPIGHI'S STUDIES ON THE SILK WORM

The *Dissertatio epistolica de Bombyce* by Marcello Malpighi (1628-1694), with a description of the anatomy and metamorphosis of the silk worm, is the first book dedicated to the anatomy of an invertebrate.

1669: SWAMMERDAM'S STUDIES ON INSECTS

The illustrious Flemish microscopist Jan Swammerdam (1637-1680), a master of microdissection, publishes a general study on insects.

1671: LA DIOPTRIQUE OCULAIRE

The Capuchin monk and valid physicist Chérubin d'Orléans (1613-1697) publishes *La dioptrique oculaire*, one of the first texts in an important body of works dedicated to techniques of constructing microscopes. In this work he also analyzes instruments for binocular vision.

1672: MALPIGHI'S STUDIES ON PLANTS

With the *Anatome plantarum* and its subsequent addendum in 1675 (*Anatome plantarum pars altera*), Marcello Malpighi (1628-1694) offers an example of the potentialities of the microscope used for scientific research.

1673: MALPIGHI'S STUDIES ON THE FORMATION OF BABY CHICKS

The prestigious Royal Society of London publishes the work of Marcello Malpighi (1628-1694) *De formatione pulli in ovo*. Through systematic, uninterrupted observations on the development of baby chicks inside the egg, Malpighi recognizes the formation of a primitive fetal structure, already visible only a few days after fecundation. This discovery was to lend credibility to his generation's belief in preformation, according to which ontogenetic development proceeds from an embryonic organism already endowed with its major parts (heart, brain, preliminary thoracic structure).

1674: LEEUWENHOEK DISCOVERS THE PROTOZOANS

Antoni van Leeuwenhoek (1632-1723) discovers the protozoans. A Dutchman who was a modest public employee and an incomparable lens-maker, he was not merely an amateur curious to discover the mysteries of the infinitely small, but also a great experimenter and scientist possessing a vast knowledge of anatomy and embryology. He fabricated many microscopes consisting of a single, tiny biconvex lens, extraordinarily efficient.

His fellow-countryman Johann van Musschenbroek (1660-1707), in addition to constructing microscopes for Leeuwenhoek, designed a model of a compass microscope. He was also the designer of special ball-and-socket joints, known as "Musschenbroek nuts". With this device, adjustable arms of different length could be built, used to support lenses or stages.

1677: LEEUWENHOEK'S MICROSCOPIC OBSERVATIONS
The Dutchman Antoni van Leeuwenhoek (1632-1723) sends the prestigious Royal Society of London some of his microscopic observations conducted on hairs, grains of sand, sperm, blood, insects, the flora and fauna of a pond, accompanied by numerous explanatory drawings. During these years he observes spermatozoids, at the time called "spermatic animalcules", red blood cell, rotifers, and bacteria.

1680: MICROSCOPY AND MECHANISM
The *De motu animalium* by Giovanni Alfonso Borelli (1608-1679) is published in Rome (1680-1691). It is a treatise of mechanistic physiology based entirely on the corpuscular nature of matter. It represents the attempt to extend to the biological sphere the rigorous style of geometric analysis employed by Galileo in the mechanist field.

1683: THE CATALOGUES
The sales catalogue of John Yarwell (1648-1712) is published in London. He is, with John Marshall (1663-1712), one of the most important English microscope builders of the late 17th – early 18th century. The catalogues of the time advertise not only microscopes and telescopes, but also instruments such as burning glasses, magic lanterns, spectacles, prisms, concave and convex lenses.
In the 18th century the compound microscope was to assume, as the evolution of seventeenth-century mechanics, three main forms: the tripod type, developed around 1725 by Edmund Culpeper (1660-1738); the cylinder or drum type, designed in 1738 by Benjamin Martin (1705-1782); the lateral pillar type, perfected in its design by Henry Baker (1698-1774) and fabricated by John Cuff (1708-1772). The latter model was to mark a crucial stage in the history of the microscope.

1683: LEEUWENHOEK DISCOVERS BACTERIA
The Dutchman Antoni van Leeuwenhoek (1632-1723) discovers bacteria with the microscope but, as in the case of spermatozoids, the great importance of his discovery is not fully recognized.

1683: THE LAWS OF MECHANICS IN PHYSIOLOGY
The Florentine Lorenzo Bellini (1643-1704) publishes in Bologna the *De urinis et pulsibus* in which, drawing inspiration from the works of Giovanni Alfonso Borelli (1608-1679) and Thomas Willis (1621-1675), he continues the attempt to apply the laws of mechanics to the study of physiology.

1684: REDI AND PARASITOLOGY
Redi publishes in Florence the *Osservazioni intorno agli animali viventi che si trovano negli animali viventi*, a treatise on parasitology and comparative anatomy that he planned to complete with a second section, which was however never written.

1685: THE BIBLIA NATURAE
The *Biblia Naturae* by the illustrious Flemish microscopist Jan Swammerdam (1637-1680) is published posthumously. It contains many zoological and entomological observations, as well as interesting illustrations of microdissection procedures. In 1737 the work was also published in German under the title *Bibel der Natur*, in commemoration of the centennial of the author's birth.

1686: CAMPANI'S MICROSCOPES
In the *Acta Eruditorum* the drawing of a microscope by Giuseppe Campani (1635-1715) is published. In over fifty years of activity he produced many optical instruments, among which the compound microscopes and the telescopes, with lenses of excellent workmanship, are outstanding for their high quality. Campani produces tripod-type microscopes, but also microscopes with a stage

equipped with spring hooks and threaded tubes to allow more precise focusing than the sliding and friction system utilized up to then. More than for the design of his microscopes, Campani's superiority to Eustachio Divini (1610-1685) and the other instrument makers is recognized for the performance of his lenses.

1687: THE PARASITOLOGICAL NATURE OF SCABIES

The *Osservazioni intorno a' pellicelli del corpo umano* by Giovanni Cosimo Bonomo (1666-1696) is published, in the form of a letter/treatise addressed to Francesco Redi (1626-1697). Through microscopic observations on scabies conducted in collaboration with the Livornese physician Giacinto Cestoni (1637-1718), Bonomo recognizes the parasitological nature of scabies, until then deemed the consequence of alterations in the metabolism and the humours, and also describes the manner in which the scab mite penetrates into the skin through contagion, thus refuting the theses and therapies of Galenic medicine.

1691: THE HORIZONTAL MICROSCOPE

The Jesuit priest Filippo Bonanni (1638-1725) publishes the *Micrographia curiosa* in conjunction with the *Observationes circa viventia quae in rebus non viventibus reperiuntur*. Among the illustrative plates, he includes the drawing of a refined horizontal microscope with which he conducts important observations. The instrument is composed of an eyepiece, a field lens and an objective lens; furnished with a device for focusing on the object examined, it extends horizontally. The light of an oil lamp is concentrated on the stage by two convex lenses, mounted at the ends of a small tube (mobile condenser). With this microscope he performs numerous observations. In the *Observationes circa viventia quae in rebus non viventibus reperiuntur* the Roman Jesuit returns to defending the thesis of the spontaneous birth of some animal species, in contradiction to the convictions of Marcello Malpighi (1628-1694), Francesco Redi (1626-1697) and the other critics of spontaneous generation.