Pioneer Microscopists of the Seventeenth Century

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Introduction

As compared with the preceding and succeeding centuries, the seventeenth century was one of outstanding achievement in the field of microscopy. The microscopes which were made and used during this century had been perfected to as great a degree as was possible until the use of achromatic lenses was achieved. This latter accomplishment did not take place until the nineteenth century. As the result, the advancement made in the seventeenth century was not continued during the eighteenth, and progress in microscopy lay dormant for over a hundred years. The lives of Hooke, Leeuwenhoek, Malpighi, Grew, and Swammerdam therefore mark a period of brilliant success in the early history of this subject. In this paper it is desired to discuss at some length the lives and work of the first three of these men.

Robert Hooke (1635-1703)

Robert Hooke was a versatile experimenter in many different fields. He was born at Freshwater, Isle of Wight, where his father was minister of the parish. After some early tutoring followed by a period of schooling at Westminster, Hooke entered Christ Church College, Oxford, at the age of 18. He made good use of his opportunities there, and two years later was employed by Robert Boyle in scientific work including the construction of a famous air pump. Through the influence of Boyle, Hooke was appointed curator of the Royal Society at the age of 27, and elected to fellowship in the Society the following year. A year later he received an appointment of a "mechanical lectureship" carrying £50 per year. This lectureship was instituted by Sir John Cutler for the especial benefit of Hooke. The year following he was nominated Professor of Geometry in Gresham College. Hooke took up permanent residence there for the rest of his life.

After the "Great Fire" of 1666, Hooke constructed and submitted a model for rebuilding the city of London. This model was highly approved although the one submitted by Sir Christopher Wren was given preference. Hooke, however, acted as surveyor and accumulated several thousand pounds as the result of this lucrative appointment. After his death, this money was discovered in an old iron chest which had evidently remained unopened for over 30 years.

For a period of five years (1677-1682), Hooke served as secretary of the Royal Society. During this time he published the papers read before the society under the title of "Philosophical Collections." This appeared in the years 1681-82.

In 1691 Hooke was granted an M. D. at Doctors Commons when 56 years of age. Five years later he received a monetary grant from the Royal Society for the purpose of enabling him to finish his philosophical inventions. Death at the age of 68, however, prevented the completion of this task.

As to his appearance, may I quote briefly from an English author.[1] "In personal appearance, Hooke made but a sorry show. His figure was crooked, his limbs shrunken, his hair hung in disheveled locks over his haggard countenance."

Many circumstances served to embitter Hooke and render him unpopular in the latter years of his life. These circumstances included a protracted controversy concerning the advantages of telescopic over plain sights, the death of a well loved niece, a law suit over his salary, and repeated anticipation of his discoveries which inspired him with a morbid jealousy.

In spite of Hooke's fine mental endowment and good scientific training, he cannot be considered a scientist of the "first water" because his interests were too diversified. According to one author, Hooke "originated much, but perfected little." At the same time, the list of his achievements is impressive. Here are some of his contributions.

Hooke:

(1) adopted a form of undulatory theory of light,

(2) anticipated the doctrine of interference,

(3) independently observed diffraction,

(4) was the first to state clearly that the motion of the heavenly bodies is a mechanical problem,

(5) approached the discovery of gravitation,

(6) invented the wheel barometer,

(7) discussed the application of the barometer to weather forecasting,

(8) suggested a system of optical telegraphy,

(9) investigated the nature of sound,

(10) investigated the function of air in respiration and combustion,

(11) originated the use of the pendulum for measuring gravity,

(12) invented anchor escapement for clocks and spiral springs for watches, and

(13) constructed and made extensive use of a compound microscope.

It is the latter achievement which I wish to consider briefly at this point. Hooke's microscope was a compound microscope consisting of two lenses—an objective lens and an eye piece lens. Horizontal and vertical adjustments were effected by sliding mechanisms with thumb screws for locking in position. The microscope was focused by means of spiral screw threads on the lower end of the barrel. Objects under examination were impaled upon a sharp pointed spindle which in turn was mounted on the microscope base. Light for illuminating the experimental objects was focused by means of a planoconvex lens.

Hooke carried out a great number of observations upon a very diverse list of subjects. These he published in his "Micrographia" in 1664. This book was the first of its kind. In it, Hooke, with the aid of over eighty

[1] Richard Waller, then Secretary of the Royal Society of London.

plates of figures, described his microscope and numerous observations on the minute structure of various objects including charcoal, sponges, book worms, and cork. This work of Hooke's gave great impetus to microscopical study, especially in England. In this book he pictured and described, probably for the first time, the cellular structure of plant tissues. A selection from the chapter entitled "Of the Texture of Cork" is therefore of considerable interest to botanists. "I took a good clear piece of cork . . . (and) cut off . . . an exceeding thin piece of it . . . and casting the light on it with a deep plano-convex glass, I could exceeding plainly perceive it to be all perforated and porous, much like a Honey-comb in these particulars. First . . . it had very little solid substance in comparison of the empty cavity that was contained between . . . Next . . . these pores, or cells, were not very deep, but consisted of a great many little Boxes, separated out of one continued long pore, by certain Diaphragms."

"Nor is this kind of Texture peculiar to cork only, for upon examination with my Microscope, I have found that the pith of an Elder, or almost any other Tree, the inner pulp or pith of the cany hollow stalks of several other vegetables . . . have much such a kind of Schematisme, as I have lately shown that of Cork."

Anthony van Leeuwenhoek (1632-1723)

Leeuwenhoek, famous Dutch microscopist, was born in Delft, Holland, in 1632. When still but a boy, he was sent to Amsterdam where he worked at the cloth trade for a time. After several years, he returned to Delft where he married at the age of 22. Six years later he accepted a minor political office, "Chamberlain of the Sheriff," which he held for 39 years, and then retired on full pay. The duties, as well as the salary were, however, light. The salary amounted to £26 per year, but since certain members of the family had acquired wealth in the brewing industry, Leeuwenhoek evidently possessed sufficient funds to keep soul and body together for better than 90 years.

Leeuwenhoek early became interested in magnifying lenses, probably while working in the draper's shop in Amsterdam. Certainly, while there he learned to use the magnifying glass which drapers then used to count the threads in their goods. This interest led him to master the art of grinding fine lenses, and to the manufacture of microscopes of his own design. He found single lenses of very short focus to be preferable to the then existing compound microscopes. Leeuwenhoek's lenses were small and of great curvature. They gave a small field, but clearer definition than such compound microscopes as that of Hooke. Most of Leeuwenhoek's lenses were made of glass, but a few were made of rock crystal, and according to one author Leeuwenhoek even tried diamond as a lens material. Each lens was mounted between two metal plates. The object was held on a pin, unless of liquid nature, in which case it was placed on a thin glass or mica plate. Adjusting screws were used to bring the object into the desired position before the lens. The largest of these screws served as a handle for the instrument.

It is interesting to note that some of Leeuwenhoek's microscopes were constructed for examining and comparing two or even three objects. He made different microscopes to suit different purposes, so that he is said to have owned some 247 microscopes, besides 172 lenses set between metal plates. This brings the total to 419 lenses which he made. The magnifying powers of these lenses varied from 40 to 270 diameters. The metal plates, which formed an important part of the microscopes, were of copper in some instruments, silver-bronze in others, and even of silver or gold in still others.

In 1673, Leeuwenhoek, at the age of 41, was introduced to the English Royal Society by his fellow countryman, De Graaf. Thus began a stream of scientific communications from Leeuwenhoek to London which resulted in the publication of 112 distinct papers in the "Philosophical Transactions." Seven years after his introduction, Leeuwenhoek was elected a fellow of the Royal Society and presented with a medal in token of esteem. In gratitude to this body, Leeuwenhoek willed the Royal Society 26 of his microscopes. He notified them of this fact 22 years before his death in a letter, a portion which reads as follows: "I have a small black cabinet, lackered and gilded, which has 5 little drawers in it, wherein are contained 13 long and square tin boxes covered with black leather. In each of these boxes are 2 ground microscopes, in all 6 and 20: which I did grind myself and set in silver; and most of the silver was what I extracted from minerals; . . . and an account of each glass goes along with them."

"This cabinet . . . I have directed my only daughter to send to your Honors, as soon as I am dead, as a mark of my gratitude, and acknowledgement of the great honor which I received from the Royal Society."

In 1697 Leeuwenhoek was elected a corresponding member of the Paris Academy, and as a result, published 26 papers in the "Memoirs" of this society.

Leeuwenhoek remained active in his work up to within 36 hours of his death. He died in his native city, Delft, and was buried in "The Old Church" of that city. A translation of a portion of his epitaph runs thus:

"Here lies Antony van Leeuwenhoek, oldest member of the Royal Society of England, born at the city of Delft the 24th of October, 1632, and died the 26th of August, 1723, having reached the age of 90 years, 10 months and 2 days."

"You, O wanderer, having respect for old age and wonderful talent, stand in veneration. Here gray science lies buried with van Leeuwenhoek."

Something should now be said concerning Leeuwenhoek's personal attributes and scientific contributions. As may be gathered from the foregoing discussion, he did not have the advantage of a thorough schooling, but was largely self-trained. His schooling ended at the age of 16. He was ignorant of all languages save his own. This handicapped him greatly in the exchange of ideas with individuals of other countries who were interested in scientific pursuits. Thus thrown on his own resources, he spent his time and energies in the careful and painstaking collection of more or less unrelated facts. But his facts were accurately observed and carefully recorded. One contemporary author states that Leeuwenhoek had not only constructed the finest microscopes, but that he also had the keenest eye in Europe.

Leeuwenhoek's studies with the microscope resulted in a long and impressive list of discoveries. Important among them are these:

(1) confirmation and extension of Malpighi's demonstration of blood capillaries,

(2) first accurate description of red blood corpuscles (circular in man, oval in frogs and fishes),

(3) discovery of spermatozoa in dogs and in other animals including man,

(4) investigation of the structures of the teeth, lens of the eye, and muscle fiber,

(5) observation that yeast consists of minute globular particles,

(6) observation of the characteristically different structures of monocotyledenous and dicotyledenous stems,

(7) accumulation of evidence opposing the idea of spontaneous generation—weevils from eggs, not from wheat; fleas from eggs and larvae, not from sand, dust, pigeon dung, or urine; mussels from spawn, not generated from mud or sand; eels from previous forms, and not from dew as held by many "respectable and learned men,"

(8) discovery of protozoa, and

(9) the discovery of bacteria.

Marcello Malpighi (1628-1694)

Another versatile investigator of this period was Marcello Malpighi, an Italian physician. Malpighi was born near Bologna of peasant parentage in 1628. His parents, however, were financially able to give him the advantages of a good education. This they did, and at an early age he entered the University of Bologna where he devoted himself to the study of Aristotelean philosophy. After a break of two years in his studies owing to the death of his parents, he returned to the University and took up the study of medicine. This he completed in 1653 at the age of 25.

Several years after, Malpighi was appointed professor of medicine in the University of Bologna, but kept up his practice of medicine as well as devoting himself to his teaching and investigation at the University. His success at teaching is indicated by the fact that he was soon called to the University of Piza. Here he became associated with Borelli who was his senior by 20 years. Borelli assisted in many ways in aiding Malpighi to begin a successful scientific career. After three years, he left Piza because of unsuitable climatic conditions and returned to teach again at Bologna. Here he devoted himself to the study of minute anatomy, but shortly afterwards was called to a professorship at Messina at a good salary. Four years later he again returned to Bologna where he was active in teaching and investigation for 25 years. In 1691, when in his 64th year, he went to Rome as private physician to the Pope, but being in failing health died of apoplexy three years later.

In spite of a good deal of friction and jealousy aroused by certain enemies, Malpighi received recognition and numerous honors both at home and abroad. These honors included his election as Fellow of the

Royal Society of London, an honor which he repaid with his portrait, numerous communications, and his original drawings illustrating the anatomy of the silkworm and the development of the chick.

With respect to his scientific discoveries Malpighi made important contributions to several distinct fields of biology. His work in physiological anatomy involved a microscopic study of tissues for the purpose of explaining their anatomy. In 1660 he demonstrated the structure of the lungs, basing his work particularly upon the lung of the frog. In this connection he actually saw the movement of blood through the capillaries of the transparent wall of the lung.

Malpighi also discovered the intermediate, mucous layer of skin which bears his name. He made extensive observations upon the structure of glands. He worked out and published a "Monograph on the Structure and Metamorphosis of the Silkworm" which is a landmark in work of its kind.

In the period 1675-79, he brought out his "Anatomy of Plants," one of his best and most extensive works. A quartor edition of this work contained 162 pages and was illustrated by 93 plates of figures. In this work the author describes in considerable detail the microscopic structure of the bark, stem, roots, and seeds. He also includes a discussion of germination and a treatise on galls. By this contribution, Malpighi has earned a share in the title of "fathers of plant anatomy," a distinction which he divides with the English physician Nehemiah Grew.

In conclusion, permit me to contrast the points of view represented by the three men discussed. Hooke and Leeuwenhoek were inventors who developed their microscopes to a certain degree of perfection and then proceeded to use them upon whatever came to hand. These they observed, drew, and described as accurately as they were able. For them the emphasis was upon as wide a search as possible for materials which could be exploited by their microscopes.

Malpighi, and also Grew and Swammerdam not discussed in this paper, were biologists whose chief interests were living organisms. The microscope to them, therefore, was but a tool with which to elucidate the structures of animals and plants so that a clearer understanding could be gained of these organisms. It is perhaps needless to add that both types of individuals have made valuable contributions to microscopy, since the improvement of equipment and the execution of preliminary exploratory studies are necessary for the advancement of more purposeful research.

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