Ronchi, Vasco

New History of Optical Microscopy

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Tekst jest udostępniony do wykorzystania w ramach dozwolonego użytku.
A great number of eminent specialists in the history of science have surveyed the history of the microscope and chronological researches have been carried out with such wealth of data and with such accuracy that it would seem that the argument had been thoroughly and definitely settled. However, as in the last twenty years my researches on the evolution of optics in antiquity and in the Middle Ages as well as in the later centuries have put into evidence some historical and philosophical phenomena over which a thick veil of oblivion had been drawn, noticeable effects of my researches have been felt also in some marginal branches of optics, and particularly in the history of microscopy. Since these effects are of interest, especially from a philosophical point of view, but also in general, I think it will be interesting to summarize briefly the *New History of Optical Microscopy* in order to point out how it fills some considerable gaps in its history as it has been known so far.

This history, as I have said, has been outlined with care and great competence by noteworthy historians, but leaves a side open to criticism.

(1) It concentrates its attention on the “compound microscope” and considers the simple microscope as a device too simple to have a right to be placed in the history of science and technology.

(2) While historians of the microscope have often paid great attention and devoted research work to the biological and naturalistic applications of the microscope, they have not bothered to frame the employment of the instrument within the fundamental optical notions of the epochs in which it was used.

(3) Several well-known and very strange circumstances have been overlooked not only without explaining them but even without bringing them into evidence, whereas they can be exhaustively explained
when the history of the microscope is thoroughly examined in the general frame of antique and medieval optics.

The soundness of this criticism will become evident following my narration. This will be divided into two parts: first, the history of the "compound microscope" will be summarized in its general lines, as it can be found already in numerous other publications. The purpose of this summary is just to emphasize the lack of some consideration and the setting of some questions, to which an answer can be given with the information and the details pointed out in the second part of this memoir. Therefore, the first part shall serve prevalingly as a background for the second that will have a historic-philosophical character.

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The question which has received an answer several times is: who constructed the first compound microscope? In this regard some claims to priority for the Dutchman Drebbel have been brought forth against Galileo, and occasionally the argument is taken up, although Galileo's priority is now unquestionable.

A brief indication regarding this will perhaps eliminate all doubts. That in 1609 Galileo constructed many telescopes for telescopic observations that he also applied an optical system consisting of an objective lens and an eyepiece for the observation of very near objects, is testified in a passage from the Scotchman John Wodderborn's (a disciple of Galileo) answer in June, 1610, to the libel written by Martin Horky slandering the telescope. Shortly after, a brief writing was published entitled "Quatour problematum quae Martinus Horky contra Nuntium Sidereum de quartour planetis novis disputanda proposuit. Confutatio per Johannem Vodderbornium." The preface signed by the English Ambassador in Venice is dated 16th October, 1610. The interesting passage runs as follows: 1

"...Ego nunc admirabilis huius perspicilli perfectiones explanare non conabor: sensus ipse iudex est integerrimus circa objectum proprium. Quid, quod eminus mille passus et ultra, cum neque vivere judicas objectum, adhibito perspicillo, statim certo cognoscas esse hunc Socratem Sophronisci filium venientem; sed tempus nos docebit et quotidianae novarum rerum detectiones, quam egregie perspicillum suo fungatur munere, nam in hoc tota omnia instrumenti sita est pulchritudo. Audirem paucis ante diebus auctorem ipsum [that is to say, Galileo] Excellentissimo D. Cremonino purpurato philosopho varia narratem, scitu dignissima et inter cetera, quomodo ille minimorum animantium organa, motus et sensus ex perspicillo ad unguem distinguat; in parti-

culari autem de quodam insecto, quod utrumque habet oculum membrana crassiuscula vestitum, quae tamen, septem foraminibus ad instar larvae ferreae militis cataphracti terebrata, viam praebet speciebus visibilium...”

Thus, there is no doubt that Galileo carried out microscopic observations with an optical system analogous to the one of the telescope, that is to say, he had assembled a fine compound microscope since 1610.

But it is also certain that he soon lost interest in this kind of observation.

Now, two questions immediately come forth: why did all historians take such great interest in the invention of the compound microscope, and no one, at least as far as I know, cared to find out who had invented the simple microscope? The question is entirely justified, because the step from the simple to the compound microscope is, so to say, a technical and secondary feature, whereas the great novelty consisted in applying the observation carried out by means of lenses to the study of the animal, vegetal and mineral kingdoms. Therefore, the real history of microscopy should first establish who had accomplished this great step and, in the second place, set the problem of finding out who had eventually brought microscopy an advantage by substituting a simple microscope with a compound one, admitting that this advantage had occurred. It will be presently seen, that beneath this there is a very great question.

The other problem that also offers a certain interest is the following: why did Galileo lose his interest in observations carried out by means of the compound microscope that, as Wodderborn informs us, he had already begun to use?

In order to answer these questions let us go on with the history of the instrument.

Some compound microscope had been constructed and even employed, but without much success and also without any revolutionary results. The most interesting document from this point of view is Robert Hooke’s *Micrographia* published in 1665. In the Museums of the History of Science very interesting collections of microscopes are to be seen, which had been constructed during the seventeenth, but above all during the eighteenth, centuries. A remarkable improvement from a technical viewpoint, but principally from an aesthetical point of view, can be noticed. But we notice that the mounting, which initially consisted of wood and cardboard, is gradually substituted by metal; the base gaining in stability, the illumination device in power; but, all in all, the instrument maintains its characteristics of an object of luxury rather than of a working-tool.

To an optical technician it is evident that an instrument that has both an objective consisting of a single lens and an eyepiece consist-
ing of one or two simple lenses could not render very remarkable services. Enormous aberrations, especially chromatic, hindered the employment of elevated magnifications, if not at the risk of a complete confusion of images; a very scarce luminosity and difficulty in the handling made observations actually painful, apart from their uselessness.

All these difficulties began to be diminished and even to disappear when objectives started being achromatized. However, this situation continued until the end of the eighteenth, and the beginning of the nineteenth, centuries. The most prominent, especially English, opticians were paying much attention to the improvement of the microscope objective and, at the same time, also the eyepiece and the base were improved.

Thus we come to the times of G. B. Amici (born at Modena in 1786, died at Florence in 1863). As it is known he at first attempted to construct achromatic microscopes by employing a concave mirror objective, thus applying the criterion that Isaac Newton had devised in the field of astronomical instruments for the construction of achromatic telescopes. But later Amici resumed the construction of dioptric objectives, with numerous lenses of various optical glasses, such as crown and flint which then were already produced in various qualities, and he obtained considerable improvements, until at last he was able to construct objectives having a hemispherical frontal lens and also immersion objectives.

By now no documentation was known of this great innovation, the importance of which will be pointed out in some detail here. No one has asserted the priority of it, and it was everywhere claimed to be the work of G. B. Amici, but without any proofs.

Since in 1963 the centenary of Amici's death was celebrated some researches were carried out in Amici's voluminous and copious correspondence, now belonging to the Estense Library of Modena, together with numerous other manuscripts of his. Among these many letters there is a copy of one to F. O. Mossotti, dated 25th October, 1855. Amici was then Director of the Museum of Natural History in Florence and Mossotti, Professor of Rational Mechanics at Pisa University, was famous for his ability in the calculation of optical systems, as can be seen in the classical book he has left us.

The following passage quoted from the letter is particularly important: "... You are right to believe that with two glasses of different dispersion power or, even better, with three glasses, colours can be destroyed in a tolerable degree and good compound objective lenses can be constructed. The objective lenses of my microscopes consisting of six lenses, three of crown and three of flint, prove to be achromatic. But I have found that the series consisting of three pairs of lenses, as I have said,
were not the best fitted to obtain the greater magnifications particularly on account of the lower doublet towards the object being too thick, which makes impossible a making of the focal distance of the system very small and its aperture very great. I then thought of replacing the lower doublets with a simple lens, i.e. half of a sphere of any transparent substance whatsoever, either crown, or flint, balas ruby, diamonds, fused rock crystal, etc., and eliminate their aberrations by the two upper doublets conveniently designed. For this purpose I needed a flint of very great dispersion power that I was able to obtain from Faraday through Airy's mediation. The English opticians laughed at my request, but when in 1844 I demonstrated in London the superiority of the new construction, they at once set to imitate it, and so did the Americans. The French, paying no attention to it and underestimating the improvement, were left behind the others..."

The letter goes on and enters technical and constructive particulars that are very interesting to the specialists in the calculation of microscope objective lenses, but do not pertain to the discussion I am about to reach.

I have rapidly come to Amici's work, without mentioning other famous predecessors, especially of the second half of the eighteenth centuries, because it would be too long a list and would not be of great importance; but at this point we must recall Chevalier who, during the first half of the nineteenth century in Paris, made considerable improvements to his microscopes, although he never reached Amici's level.

After Amici there came Ernst Abbe's very interesting and important studies at Jena; he was able to give an interferential theory of the formation of images in the microscope, a theory that was considered definitive until a few decades ago. Also Siedentopf's ultramicroscope had a certain renown, but principally the definitions of the so-called "resolving power of the microscope" were important in the history of the optical microscope apart from the definition based precisely on Abbe's undulatory theory: of the limit that constitutes a sort of barrier against the penetration into the infinitely small by means of radiations capable of stimulating the human retina.

Substantially, their limit has been reached by Amici's apparatuses; later improvements, such as observation in a dark field, the phase contrast and the interferential microscopy, represent very interesting techniques and very useful to facilitate microscopical observation in special cases, but substantially they have not notably shifted the limit of the possibilities of the optical microscope of penetration into the infinitely small.

A recent novelty is the "energetic theory" of the resolving power that represents a clear advancement in respect to Abbe's theory. According to
the new theory, the “resolving power of the microscope” considered as a feature of the instrument (or rather of its objective lens) independently from any other circumstance not belonging to the instrument itself is to be considered non-existent; if we accurately criticize the reasoning resulting in its definition, we shall find that it is merely “conventional”, whereas the resolving power that is experimentally achieved with a given microscope depends on numerous factors, among which the structure of the objective lens in only one and not even the most important. But first of all the useful energy of the source of illumination intervenes and afterwards the functioning of the optical condenser; then the observer’s eye with its sensitiveness and acuity intervenes as well as other factors such as the duration of the observation, the knowledge concerning the preparation, the fatigue of the observer. The optical resolution came out as an exquisitely energetic phenomenon, and this represents a novelty that can bring also interesting developments.

But now I must leave aside this part of the technical and theoretical history of the microscope, and turn back to examine its nature and value.

As I have said, after having carried out some observations with what was called the occhialino (small eyeglass; occhiale—eyeglass)—at first indicated exactly what later was called a “telescope”, regarded as a “special eyeglass which enables to see far away, enlarged and distinctly”) Galileo was not interested any more in the microscope or in microscopical observations. With his acute spirit of observation and with the “good sense” that distinguished him, he at once knew how to estimate the slight efficiency of the instrument that he had already used for some observations, and he devoted himself instead to the great astronomical and philosophical questions hinged upon the observation of stars. Perhaps the fact that Galileo had no intention of devoting himself to naturalist investigations also contributed to this decision. But it is certain that about half a century was still to pass before microscopy exhibited a real development. This was the work of a very interesting personage: Antony van Leeuwenhoek.

We may recall that he was born at Delft (Holland) in 1632 and therefore was scarcely ten years old when Galileo died. At the age of sixteen he was working in a textile establishment where, it seems, he had learnt to use lenses to count the threads of the materials. The most remarkable fact is that later he became an usher in a Government office and spent his time in waiting-rooms constructing microscopes and carrying out observations. Clifford Dobell has translated and studied all Leeuwenhoek’s correspondence. What has emerged from it is that he

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was absolutely a self-taught man without any scientific culture and that he only knew the Dutch language. He did everything by himself with no help. Often he could not even find suitable words to describe properly the discoveries he was making with his microscopes. He carried out the most astonishing experiments, such as observing the conflagration of gunpowder through a microscope, and nearly lost his sight.

![Diagram of resolving power against magnification](image)

Fig. 1. Plot of the resolving power against the magnification of the microscopes in charge of the Museum of the History of Science at Utrecht according to the measurements carried out by Dr and Mrs van Cittert

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<th>Curve</th>
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<td>1</td>
<td>Hartnack ± 1870</td>
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<td>2b</td>
<td>Amici 1836</td>
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<td>3</td>
<td>Oberhauser ± 1845</td>
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<tr>
<td>4</td>
<td>simple 1700-1830</td>
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<td>5</td>
<td>Chevalier 1837</td>
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<td>6</td>
<td>chromatic compound ± 1700-1820</td>
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Over 300 microscopes which have been constructed by him still exist. They consist of a tiny lens; the object was fixed to the point of a needle and a rudimental system of screws gave the possibility of bringing the object into focus of the lens. The measurements carried out on van Leeuwenhoek's lenses by H. Bakes in 1740 have given focal distances ranging between 5 mm and 1.2 mm, i.e. capable of rendering as many as 200 conventional magnifications. Using such inconvenient and difficult instruments, van Leeuwenhoek was able to obtain really admirable results in fineness, reliability and importance. His fame called the attention even of ruling monarchs; he received the visits of Charles II, George I and Queen Anne; in 1698 he showed Czar Peter I the circulation of blood in the tail of an eel.

But the most important thing to be remarked now is that a person
like van Leeuwenhoek who had constructed and used hundreds of simple microscopes with so much success, working on them throughout his long life (he died in 1723 at the age of 91), never used a compound microscope, although it had been invented over a century before.

The explanation of this becomes quite evident if we technically study the performance of the compound microscope constructed in various epochs and still existing in numerous specimens in several museums of the history of science. In the *Descriptive Catalogue of the Collection of Microscopes in Charge of the Utrecht University Museum* P. H. van Cittert published an “Introductory Historical Survey of the Resolving Power of the Microscope”, in which, on the basis of many observations carried out by means of the rich collection of microscopes at his disposal, he demonstrated that the resolving power of the simple microscope was superior to that of the compound microscope in the whole period between the seventeenth and the first half of the nineteenth centuries. Only after the application by G. B. Amici of the hemispherical frontal lens to the objective for microscopes, the compound microscope came into prominence; Chevalier’s microscopes (1837) were still inferior to the single one. Oberhäuser's (1847) definitely marked the beginning of the useful employment of the compound microscope. The diagram here unmistakably demonstrates the change that took place in the field of microscopy towards the middle of the nineteenth century.

Thus the history of microscopy may be synthetized as follows: microscopy, starting shortly after the middle of the seventeenth century, by the work of van Leeuwenhoek rapidly established itself and developed using exclusively the simple microscope; in the meantime many attempts were made to improve the compound microscope, but without success; an advancement in this sense was made in the second half of the eighteenth century when achromatic objectives began to be constructed; but only towards the middle of the nineteenth century the compound microscope decidedly prevailed over the simple one after G. B. Amici had introduced the hemispherical frontal lens in the objective one. This last great innovation was followed by further improvements that brought the compound microscope to the theoretical limit of penetration in the microcosmos by means of optical radiations. The simple microscope was progressively reserved for less engaging operations, until it nearly disappeared out of circulation.

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Thus having reconstructed the history of the microscope, I will go on to the second part of this paper, and will begin by putting the following question: since microscopy originated with the simple microscope which consists of a single and simple converging lens, why did microscopy start only after the middle of the seventeenth century?
Lenses had been known for a long time. Leaving aside some very questionable forerunners (it seems that they were already known by the Ayuredi, 2000 B.C. that a rock-crystal lens has been found in the ruins of Nineveh, that Seneca used transparent spherical vases full of water to make observations, and Plutarch, Plinius, Svetonius, Galen, Jambliccus and others quote examples of lenses) it is a fact that Ibn-al-Haitan, better known by the vulgarized name of Alhazen towards 1050 used glass hemispheres as magnifying lenses, and Roger Bacon (1214—94) speaks of them in his *Opus Majus* that was presented to Clement IV in 1267. In any case, starting from 1285 “glass lenses”, *i.e.* converging lenses, were applied as eyeglasses for the correction of presbyopia. Magnifying lenses were used by Leonardo da Vinci (*Codice F.*, folio 33, verso). There was then an optical instrument that could make microscopy possible. Why was it not put into practice?

But there is even more. Also a concave mirror is a microscope. Now it is well known that concave mirrors had already been studied in Euclid’s *Catoptrica*, that is to say, twenty centuries before the seventeenth century. As these had actually been constructed and used, at least as burning mirrors, whoever had handled them and polished them must have noticed that they magnified images. In the second century A.D. Ptolemy made a systematic study of the images that are given through concave mirrors; why then had they not been employed to practise microscopy?

The question is still more interesting, if we recall that the Florentine Giovanni Rucellai published in 1523 a short poem entitled *Bees*, in which lines 963—995 run as follows:

Io già mi posì a far di questi insetti incision, per molti membri loro, che chiama Anatomia la lingua greca: tanta cura ebbi dello piccole api. E parrebbe incredibil, s’io narrassi alcuni lor membretti come stanno che son quasi invisibili ai nostri occhi; ma s’io tì dico l’instrumento e'l modo ch’io tenni, non parra impossibil cosa. Dunque se vuoi saper questo tal modo, prendi un bel specchio lucido e scavato, in cui la picciol forma d’un fanciullo ch’uscito sia pur or dal matern’alvo, ti sembri nella vista un gran colosso; Così vedrai moltiplicar la imago dal concavo riflesso del metallo, in guisa tal che l’ape sembra un drago od altra bestia che la Libia mena. Indi potrai veder, come vid’io, l’organo dentro articulato e fuori, la sua forma, le braccia, i pie’ le mani,
Thus even if we leave aside all that regards the centuries prior to
the thirteenth century A. D., it is a fact that since then both the catoptric
and dioptric microscopes were available to scientists, but no one used
them. When in 1523 Rucellai published his short poem describing what
he had observed using a concave mirror for microscopical observations,
no one considered it a miracle that finally the great idea of employing
this technique to study Nature had been realized and no one follo­
wed him.

The reason that Rucellai’s innovation met with no success cannot be
attributed to the modesty of the means of observation or to its scarce
practicability. This justification could be put forth if the optical device
met with criticism or were carried out and exploited to the utmost and
gave insignificant results unworthy of notice; but instead the possibili­
ties, although very modest, were not even taken into consideration and
Rucellai’s work was simply forgotten.

If however, microscopy did not start before the second half of the
seventeenth century, it was not because the microscope was lacking, as
it already existed and could have been immediately and easily put to use.

It is a historical phenomenon of considerable importance and it is
really strange that it has escaped the notice of all the historians of scien­
ce who up to now had studied this argument. Its explanation is evident
within the framework of ancient and medieval optics, as I have recon­
structed it with respect to the invention of eyeglasses and of the te­
lescope. 5

Prior to Galileo’s achievements, philosophers and cultured people we­
re decidedly hostile towards observations carried out by means of optical
devices of any kind. Therefore, the deepest scepticism was rooted in the
minds of everyone and was explicitly practised and widespread by the
luminaries of all schools of science of philosophy. The terrible words
that summarized this scepticism were attributed to Euclid: “Non potest
fieri scientia per visum solum” (It is not possible to work out science by
means of sight alone). In conclusion one was always to be distrustful of
what was seen, if it was not conditioned by the other senses, possibly by
touch. The only useful sense that deserves complete faith (although at

5 V. Ronchi, Histoire de la lumière, Paris 1955; V. Ronchi, Il cannocchiale di
Galileo e la scienza del 600, Torino 1958.
times also this sense had been found at fault) was touch. Sight had been put under the guardianship of touch.

It has not been difficult to reconstruct the reasons that caused such a deep and general distrust in the sense of sight. For centuries and centuries attempts to find the clue of the mechanism of vision had stumbled over insurpassable difficulties, the theories devised being so unconvincing and queer that they were open to a number of even elementary objections.

As can be seen in the literature mentioned, the principal theories were two: the theory of visual rays, coming out of the eyes to explore the outer world, and the theory of species, or skins, or simulacres that were to be emitted by luminous or illuminated bodies, in all directions, and penetrated into the eyes through the pupil.

I can also add, briefly, that the theory of visual rays upheld by mathematicians, who were interested in perspective, had dominated the world of science for over fifteen centuries until the eleventh century A.D.; during that period, in fact, optics and perspective were often interchanged with one another. But when Alhazen (eleventh century A.D.) called attention to the known phenomenon of the persistence of the retinal images (today called the vision, prolonged in time, of the figure of a very intense source, such as the sun, even when one closes one's eyes after having stared at it for some time), the theory of visual rays was potentially demolished and the theory of the species prevailed; by then it had been followed by very few physicists.

I have said that the theory of visual rays had been potentially demolished, because in fact it continued to be used especially by mathematicians so that during the centuries between the eleventh and the sixteenth the greatest theoretical confusion reigned in optics.

It could not but negatively influence the faith in the functioning of vision in direct observation and still more in observation through optical devices, which showed images certainly not corresponding to real objects as they were indicated by touch. All the more so that many of the observations, carried out from a critical point of view by those who were attempting to settle this unfortunate theory, appeared always the more to be optical illusions.

It was only too natural that an organ, the functioning of which was unknown and had been found at fault more than once, should cause the loss of faith in it for ever. It was inevitable that teachers in the schools should hand down to their pupils the fruits of their experience, namely, that one was not to believe in the illusion of vision.

If this was the attitude of learned people towards direct vision, that is to say, carried out without any special optical means placed between the eye and the object, the distrust towards all optical devices must have been still greater, no matter whether they were catoptric, dioptric,
plane or curved. At any rate it was too easy to bring accusations of deceit and fallacy against them. If was too evident that they showed figures in places where the corresponding objects did not exist (a first demonstration was given by the plane mirror, yet so simple and elementary); furthermore they showed enlarged what was small, small what was big, and at times would show upside down what was straight, coloured what was colourless. It was inevitable that this should be considered an alteration of reality, or rather, deceit, falsehood, fallacy. Whoever examined the question from the viewpoint of the current theories, found that they agreed in considering optical systems unfavourable for vision. The theory of visual rays required, for the right functioning of the ocular system, that the visual rays emitted by the eyes should be absolutely rectilinear and not bent on their way by reflexions or refractions; the species theory required that these species, in order to carry correctly to the eye the shape and colours of the body from which they had departed, should not be distorted in the least along their path. In conclusion, one was not to look in mirrors or through lenses: to look through them meant to ask to be deceived.

It was for this reason that mankind, although it had had at its disposal the simple microscope, had not utilized it for twenty centuries. It had in its hands a miraculous means for investigation and thought it deceitful!

It is very little known but has been unquestionably demonstrated in the literature mentioned that, after lenses had been applied for the correction of presbyopia towards the end of the thirteenth century, science unanimously would not take them into consideration and they remained for three whole centuries merely an artisan production. The first one to take the initiative to speak of lenses in a printed book was the Neapolitan Giambattista della Porta, and he treated of them only because he wrote his well-known *Magia Naturalis*. That is to say, lenses entered into literature as “magic”. This happened for the first time in 1589. The events that occurred the following year have been reconstructed in many of their details in the literature quoted. There was a rapid change of direction in optical questions; but the great merit of having shattered the bimillenary scepticism of philosophers and scientists with respect to direct vision and observation through optical instruments was Galileo’s. He was the first man of science who claimed that the “telescope” was “an instrument of inestimable usefulness”, as he wrote in his letter of 24th August, 1609, to the Venetian Senate; this he proclaimed when the whole scientific world was still convinced, profoundly convinced, that it was “a fallacy”.

And when Galileo, by means of the telescope, and only by means of the telescope, discovered the satellites of Jupiter and communicated it to the world in his marvellous book, *Sidereus Nuncius*, the whole
world remained incredulous and accused Galileo of error, of insidiousness, if not actually of fraud. He affirmed his complete faith in the existence of the satellites of Jupiter, giving them the name of “Medicean Planets”, the name of his patrons, the Grand Dukes of Florence. This act is not to be thought of as an adulation but as a pledge, for Galileo was setting his whole future on the true existence of the Jupiter satellites, because if they proved to be an illusion or a deception, as all scholars of the time insisted, to have given the name of the Medici to an illusion would have meant Galileo’s civil death.

The furious controversy, of colossal proportions that followed, had all the characteristics of a great, decisive battle, in which all weapons were used to demonstrate the truth of classical theories and the fallacy of the telescope. The publication of Francesco Sizi’s Dianoja represented the synthesis, the range of conservative forces. This marvellous book has recently been restored to light and translated from Latin into Italian. All the reasons, for which the sixteenth century science concluded that one was not to look through the telescope are marked by extreme precision and faultless logic.

But events precipitated: on the 10th September, 1610, Kepler, then the most competent person in optics of the whole scientific milieu, after a keen experimental critique such as would be made by one who wanted to reach the conclusion that the telescope was a fallacious instrument, had to admit that the telescope was not a fallacy and wrote Galileo the famous phrase of the dying Julian the Apostate: “Vicisti, Galilaee!”

Galileo and the telescope had won their great battle.

Although since then the scientific mentality regarding both direct observation and observation through optical instruments was to undergo a deep change, this could not, however, take place within a few years. As it always happens when there occur profound revolutions, the older people continue to believe what they have learnt in youth, and it is the young people who follow the road outlined by new ideas; that is to say: the assertion of these new ideas requires a few generations.

Therefore, microscopy started in the second half of the seventeenth century and not before; and in full harmony with this historical reconstruction is the fact that the father of microscopy was a young technician with an industrial rather than scientific background, and who had indeed a very modest education and held a very modest position, such as that of an “usher”, and was illiterate.

It was necessary that it should be a “new man” lacking the culture and the prejudices in order to devote himself to microscopy with entire faith and with so much enthusiasm: such was van Leeuwenhoek.

The work of these pioneers has changed the scientific mentality to such a point and, above all, their discoveries, besides their influence, have so modified the judgment about the value of observations carried out
with optical instruments that today not only we blindly believe (it seems a pun) in what can be seen through these instruments, but we cannot believe that there could have been times in which people could have thought differently to the point of not seriously believing in what they saw. In fact no one has ever reconstructed antique and medieval history on these bases, as has been done in the quoted literature: however the documentation quoted in this literature is unquestionable.

To complete the historical picture summarized here, we must add, that at the same time that Galileo was affirming his faith in observation through optical instruments and was able to infuse it into the whole sixteenth-century scientific milieu, Johann Kepler was bringing to a conclusion the great bimillenary effort to find the key of the mechanism of sight and gave the rules that still today are at the basis of the optical theory. This great discovery, published in 1604 in the book, *Ad Vitellionem Paralipomena*, allowed to confine “optical illusions” to a modest role of negligible size and importance in the optical theory, instead of forming an outstanding part of it as it had been during the antique and medieval period. This has contributed in a decisive manner to strengthen the “faith” that now allows to look through telescopes and microscopes with hope of success.

By the work of two great men, Kepler and Galileo, scientific progress and faith, have brought about the establishment of microscopy, though not they but an usher endowed with very modest culture has been the direct introducer of the new optical technique.