



Cheese mites and other delicacies: the introduction of test objects into microscopy

Jutta Schickore

Department of History and Philosophy of Science, University of Cambridge, Free School Lane, Cambridge CB2 3RH, UK

In the 1820s, certain minute objects began to be used regularly as tests for microscopes. Scales of insects, animal hairs and tiny leaves served as convenient means to assess their optical performance. It was a peculiar conjunction of optics, astronomy and natural history that formed the intellectual background for the emergence of the tests; and their establishment was greatly facilitated by the culture of conversation and competition in which microscopical practice was embedded. The introduction of the tests soon gave rise to a peculiar and highly productive interaction: the application of test objects incited instrument makers to aspire after technical improvements. These pursuits led, in turn, to a differentiation and refinement of the tests themselves, which then again suggested specific kinds of improvements. Historians have paid only scant attention to these issues. But the early history of test objects deserves thorough investigation. In fact, it provides a key to the understanding of the intellectual and social contexts and the dynamics of microscopy in early 19th-century Britain.

In the 1820s and 1830s, the Edinburgh-trained microscope enthusiast Charles R. Goring kept the instrument makers busy. Eager to improve the microscope's optical performance, he collaborated with the Edinburgh maker Alexander Adie, as well as with Cornelius Varley, John Cuthbert, William Tulley and Andrew Pritchard in London on various enterprises. One of Goring's pet projects was the advancement of the compound microscope. Although at first convinced of the optical superiority of the simple microscope, he had a 'lurking fondness' for the compound because of its great practical advantage: it was much less demanding on the eyesight and offered a considerably larger field of view. If only the optical performance of this device could be improved, it would be far superior to the single lens. Whilst examining and comparing the properties of the two types of instrument, Goring encountered certain specific objects that appeared to be extremely useful tools to test the optical performance of microscopes [1].

Optics, astronomy and natural history

No much is known about Goring's life, but the wide range of his published writings indicates that he was an

extremely versatile gentleman of science. Trained as a physician, he occupied himself also with natural history and had a keen interest in astronomy and optics. All these interests and occupations merged in his studies of the microscope. Comparing the compound and the single lens microscope, Goring found that common compounds could not discriminate the fine lines on the feathers and scales of certain insects that he was perfectly able to see with a single lens, even though the compound possessed a greater magnifying power. Goring thus claimed that a good microscope required another property besides magnification.

To grasp this particular power of the optical device, Goring appropriated the terminology that had been introduced to characterize the optical performance of telescopes. In 1800, the astronomer William Herschel had published a paper in which he showed that a telescope's power of exhibiting faint and distant clusters of stars critically depended on the size of the instrument's aperture [2]. Herschel suggested the term 'penetrating power' for a telescope's power of extending into space and showing distant nebulae and double stars (and indeed, the Oxford English Dictionary mentions Herschel as the originator of this term). Inspired by Herschel's insight Goring referred the impossibility of viewing fine lines through a compound microscope to its small aperture [3].

In an ingenious move, Goring suggested using the very objects that had shown him the comparative ineffectiveness of his compound in exhibiting fine lines as reference points to assess and compare the powers of different instruments. Just like distant clusters of stars and nebulae served as reference objects to ascertain the penetrating power of telescopes, the fine lines and patterns on the scales and furrows of insects could serve 'as a standard of comparison, whereby to scrutinize the pretensions, the defects and excellencies of different microscopes, and prove beyond dispute whether they are effective or not.' [4] Goring's article of 1827 described and depicted a number of organic objects suitable for this purpose, for example the finely-striped wings of the insect *Papilio brassicae* (Fig. 1) and the exquisitely delicate foot of a blue-bottle fly (Fig. 2), but also 'artificial stars' made of minute mercury particles and an artificial plate with white letters enamelled on black. Goring's collaborator, the instrument maker Tulley, used this object to ascertain chromatic and spherical aberration (Fig. 3).

Corresponding author: Jutta Schickore (js427@cam.ac.uk).

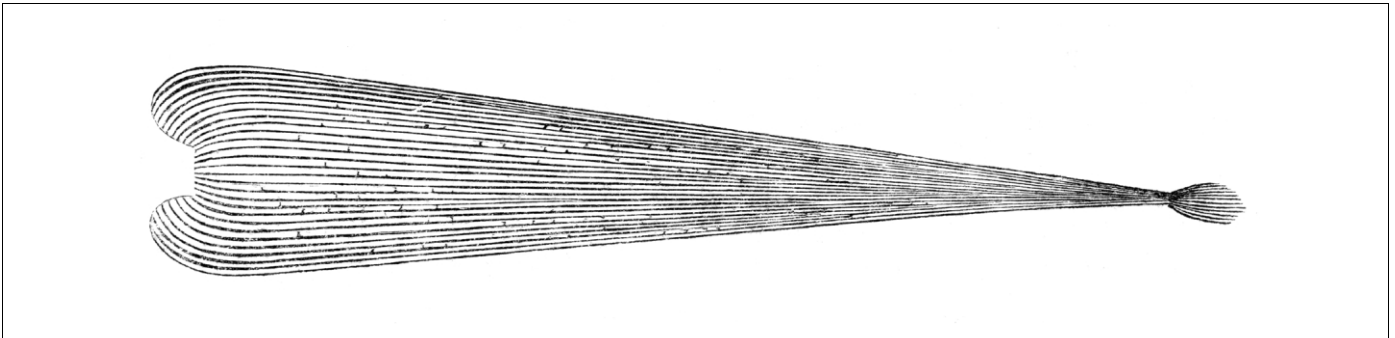


Fig. 1. The upper surface of the under wing of the male *Papilio brassicae*. Goring noted that this object required an 'enormous' angle of aperture to be exhibited satisfactorily. Reproduced by permission of the Syndics of Cambridge University Library [4].

The productivity of test objects

Historians have attached great significance to the year 1830, the alleged 'turning point' in the history of microscopy [5]. In this year, Joseph Lister published a paper in which he described a specific arrangement of lens systems so as to minimize aberrations [6]. But the insights described in this paper were in fact a direct outcome of the collaborations and practices related to the early test objects. The wine merchant and gentleman of science Lister, who devoted his spare time to the microscope, was in personal contact with Goring and Tulley, following closely their experiments – or rather, Tulley's experiments, as Goring had left the practical realization of his insight concerning the size of apertures to Tulley, requesting him to make 'an achromatic object-glass for diverging rays of as short a focus as possible' [7]. Tulley bowed to the task and set to work. Around 1825, he succeeded in making triple lenses of outstanding performance. It was these objectives that Lister inspected and tried with natural tests and 'artificial stars', minute globules of mercury [8]. Based on these trials, Lister commissioned Tulley to make thinner lenses and compared these to sets of lenses constructed by the French maker Chevalier. Lister's explorations of various lens systems not only led to the formulation of the concept of the two aplanatic focal points, but they had also a more tangible outcome. The combination of a Tulley triplet and a

Chevalier doublet proved extremely successful, so powerful in fact that it allowed the close examination of blood globules. The results of these investigations, which Lister undertook together with a young physician from Guy's Hospital, Thomas Hodgkin, formed the basis for a paper on the structure of animal tissue, which was in later years hailed as the proper beginning of histology [9]. Yet the paper itself opens up a different perspective. Presenting the blood globules as particles that 'must unquestionably be classed amongst the objects most difficult to examine with the microscope' [10], it places this work firmly into the context of testing microscopes. This notable contribution to histology owes its existence in many ways to the new practice of trying microscopes with 'difficult objects'.

Conversation and competition

The collaborations and exchanges between the gentleman physician, the wine merchant and the instrument maker nicely exemplify the social context of microscopy in early 19th-century London. Microscopy was very much a collective enterprise and social event. Scientific gentlemen gathered at private homes to pass pleasant evenings with the microscope. They looked at peculiar insects, plants and whatever else arose their curiosity, and frequently embarked on eager competitions for the best instruments in their possession. These microscope enthusiasts quickly seized on the practice of using 'difficult objects' as reference points to assess and compare the different types of microscopes.

Goring and Tulley played an important part in establishing these objects. They literally carried their new

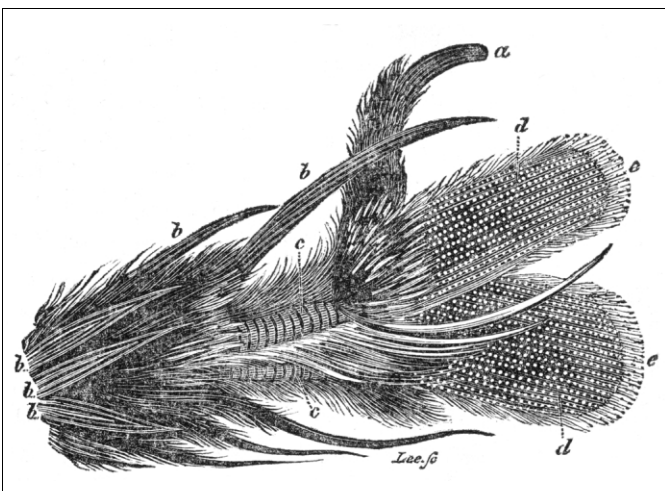


Fig. 2. Another of Goring's early test objects, the foot of a blue-bottle fly. Reproduced by permission of the Syndics of Cambridge University Library [4].



Fig. 3. Tulley's artificial test plate, which he used for assessing spherical and chromatic aberration. The degree of nebulosity indicates the degree of spherical aberration, and chromatic aberration shows in a fringe of colour mixed with the diffused borders. Reproduced by permission of the Syndics of Cambridge University Library [4].

microscope around for public inspection, and with it the objects that testified to its goodness. J.S. Bowerbank, the president of the Royal Microscopical Society from 1846 to 1847, remembered in 1870 that he was first introduced to Mr. Tulley in 1828 at the house of a friend, while Tulley was showing some of his favourite test objects. Bowerbank, impressed by the quality and performance of Tulley's instrument, commissioned a similar one from him. But Tulley was too busy to comply with the request, and placed his own instrument in Bowerbank's hands, whereupon Bowerbank was 'favoured by the visits of numerous eminent men of science of the period, and among them Dr. Marshall Hall, Mr. George Newport, Mr. Kiernan, Mr. Gulliver, Dr. Mantel, Professor Owen, and others, who brought their specimens with them, and verified their more laborious investigations by the Tullian facile combinations.' [11]. To stem the flood of visitors to his house, Bowerbank eventually appointed one evening of the week for these meetings, and it was this regular Monday gathering that was the nucleus of the Microscopical Society of London, founded in 1839 (which later became the Royal Microscopical Society).

The home of Mr Thomas Carpenter was another buzzing center for these contests. Thomas Gill, the editor of the *Technological Repository; or, Discoveries and Improvements in the Useful Arts* reported in this journal that he was frequently invited 'to bring his Varley's single microscope..., in order to prove its powers by the inspection of a few test objects.' [12] Gill then related in detail what tests his microscope had to undergo, some of them familiar from Goring's publications, others slightly more extraordinary. At first he had to try 'the feathers of the Menelaus, the cabbage-butterfly, and others,' after which Carpenter presented Gill with a somewhat more curious object, a cheese mite, 'placed upon a slip of glass, and covered with a slice of talc; telling him, that he had endeavoured to discover the anatomy of the mite, but not mentioning in what respect. However, upon submitting the object to the microscope, the Editor quickly found, that two sets of teeth and the jaws were most beautifully displayed on each side of the object. On mentioning this, Mr. Carpenter said they were what he wished to try the power of the microscope with, but would not have previously mentioned them, but let the Editor find it out himself. The teeth are, as may be supposed, exceedingly delicate, but are most distinctly displayed, and form exquisite microscopic objects.' [13] Gill's microscope stood the test admirably. The description of the double jaws of the cheese mite caused quite a stir, and the next issue of the journal reported that 'great curiosity' had been excited by it – so much so that he felt urged to supply his readers with an engraving of Carpenter's findings (Fig. 4). By the late 1820s, the cheese-mite's jaws, bat's hairs, the scales of cabbage butterflies, and other delicate objects had become acknowledged tools to assess the performance of different microscopes.

Indeed, the practice of testing the microscope's performance with standard objects swiftly transgressed the circle of London microscope enthusiasts and spread as far as the Continent. In 1829, the French instrument makers Chevalier and Sons approached their British colleagues,



Fig. 4. The two sets of teeth and jaws of the cheese mite, viewed through a lens of the 20th of an inch focus. Reproduced by permission of the Syndics of Cambridge University Library, from plate III of [21].

requesting to be furnished with the 'very difficult test objects' of which they had heard. Gill obliged the Chevaliers with various kinds of object, among them the scales of the cabbage butterfly brassica. The Chevaliers responded with drawings of the scales' appearance when viewed with their microscope [14]. In the same year, the Viennese microscopist Jacquin publicly commended 'Dr. Goring in London' on having introduced test objects as measures for the performance of microscopes [15]. Instrument makers like Andrew Pritchard in Britain, Plössl in Vienna and Amici in Italy had then already begun selling their instruments together with sets of test objects, and writers began commenting on the quality of the tests that were provided with the different devices, marvelling at their extraordinary beauty or objecting to the way in which they were prepared.

Reshaping microscopical practice

The introduction of test objects into microscopical practice was consequential in many ways. First of all, the practice of testing served as a convenient means of drawing distinctions among groups of microscopists. Goring, never at a loss for graphic expressions, thundered that 'nothing exasperates me more than to hear some half-taught booby bragging of the goodness of a microscope because it shows objects so wonderfully magnified, when, in all probability, it will be found completely inert and ineffective when called upon to show them with a reasonable working power: thus converting what is really a proof of its worthlessness into an argument for its supposed superiority' [16]. Thus, Goring erected clear boundaries between

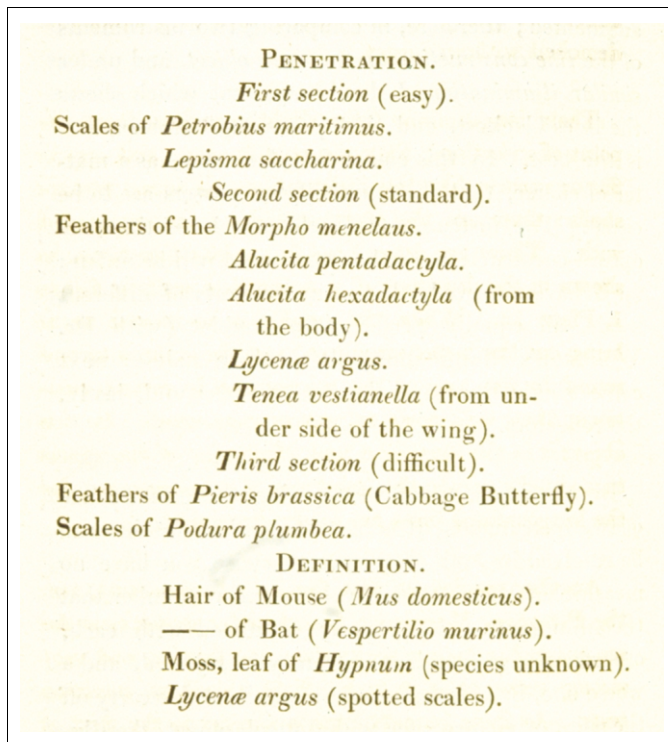


Fig. 5. Pritchard's list of test objects, sorted into different kinds and levels of difficulty. Reproduced from [17], courtesy of the British Library.

professional pursuits and amateur pastimes. To the genuine researcher, strong magnifying power was not desirable and indeed harmful, for it diminished the quality of the image. The serious investigator did not grope for exceptional sensational increments but aimed at a well-balanced, well-attuned, compromise between magnification and penetrating power, thus securing effective research.

In fact, the introduction of test objects prompted some more drastic changes in the practice of microscopy itself. For the application of tests required the 'utmost tact' in handling the object and managing the concrete investigative setting, so much so that, as Pritchard related, 'artists with instruments of the very first quality spend much time before they could exhibit an object' [17]. The application of test objects redirected the microscopists' attention to the complex conditions of successful observation: the correct illumination, the absence of vibrations, and so forth; and the extent to which an observation depended on these conditions became apparent.

Test objects and the dynamics of microscopy

The test objects were effective in the immediate context of their introduction in that they helped bring about significant improvements in microscope design. But in the course of these pursuits, the test objects themselves became objects of scrutiny. In the late 1820s, the overabundance of cheese mites, mouse and bat's hairs, scales of brassica, and flies' feet came to be tamed and rearranged. The cheese-mite's career as a test was rather short, and other objects were dismissed as well, some because they were hard to procure, other because they were difficult to handle. The remaining objects came to be sorted into groups. The essay on test objects that Pritchard published

in 1832 illustrates this process of ordering and classifying. Pritchard now delineated different sets of test objects. Some were best suited to test the penetrating power of an instrument; others were better suited to test the instrument's definition (Figs 5,6). The concept of 'definition' or 'defining power' – inversely proportional to the aberrations of the optical parts – was itself an outcome of the very practice of testing. The list contained easier and more difficult objects, up to the most difficult, 'requiring the most rigorous perfection in every respect for their resolution. When an instrument shows the last class properly, it may be at once pronounced superlative' [18].

This development shows that by the early 1830s, microscopes and test objects had entered into peculiar dynamics: while test objects stimulated technical innovation, the practice of testing instigated refinements of the tests – and these, in turn, made different aspects of the microscope's performance apparent.

In the mid-1840s, the German engineer Friedrich Nobert devised a technique to make artificial test plates

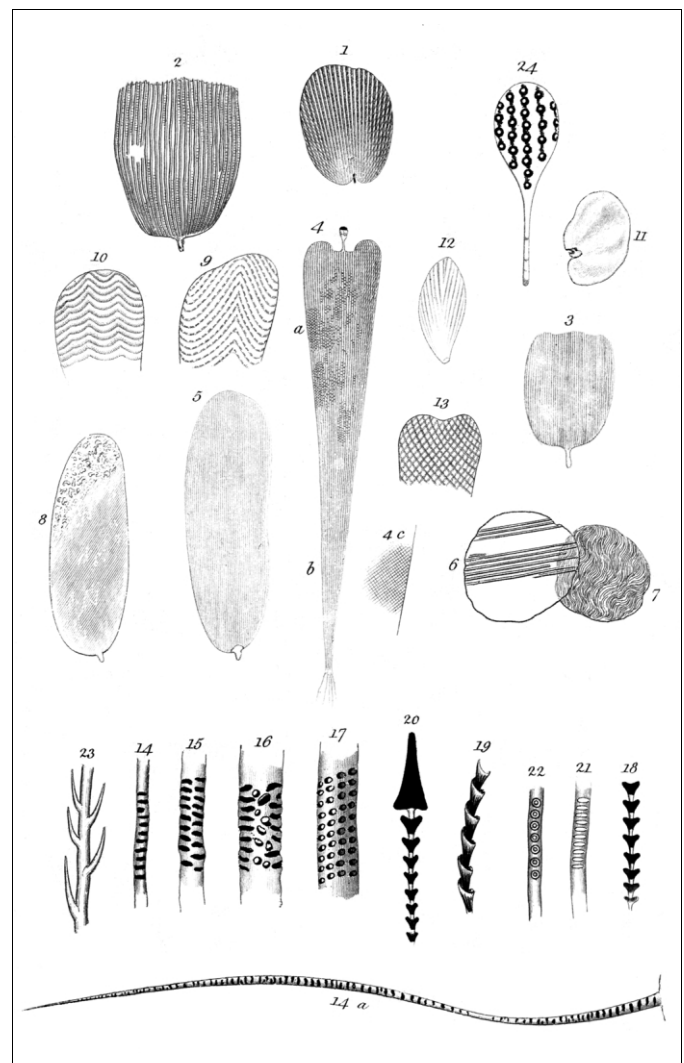


Fig. 6. This plate illustrates Pritchard's list of organic test objects. The upper part shows various feathers and scales from the wings of insects, which can be used to assess the penetrating power of a microscope; the figures at the bottom depict magnified portions of animal hair, useful for the test of the instrument's definition. Reproduced by permission of the Syndics of Cambridge University Library, from plate III of [22].

for microscopes, which he hoped to be less variable than organic test objects. Gerard L'E. Turner has pointed out that mechanical test plates had a considerable effect on the technical advancement of microscopy: the finest gratings Nobert produced always exceeded the resolving power of available instruments, thus challenging the microscope makers to improve the performance of the instrument. Every time the lines could be resolved, Nobert produced even finer ones [19]. Without doubt, Turner's observation is correct. Certainly, the mechanical production of standard test plates accelerated the advancement of microscope technology. However, in many ways, the earlier concerns with organic test objects were pivotal for this process. The culture of comparison and competition that had developed in the 1820s made the application of the mechanical tests meaningful in the first place.

The application of these tests continued to play a part in the advancement of microscope technology. In his reminiscences, Bowerbank related how every new improvement on combinations was 'carefully and critically examined by us; with Mr. A. White and Mr. J. Page we measured their angular apertures, and tested their centering and definition with minute globules of mercury, and other test objects, and so did our best to incite the makers to aspire to the greatest possible perfection in the construction of their object-glasses.' [20] Bowerbank's recollections elucidate the mechanisms through which the test objects helped bring about and accelerate technical developments.

Conclusion

A peculiar conjunction of optics, astronomy and natural history gave rise to the practice of using lined objects to estimate the efficiency of microscopes. This was a crucial incident in the history of microscopy, and productive in several respects. First, the test objects were instrumental in the advancement of the early achromatic compounds. The introduction of test objects transformed the practice of microscopical observation in that the microscopists' ability to manage the investigative environment came to play a much larger part in the observation: The actual setting had to be carefully monitored and controlled to allow the very application of the tests. Microscopes and test objects formed a productive partnership, in which the test objects stimulated the technical advancement of the optical device, which, in turn, helped organize, differentiate, and further refine the initial jumble of test objects.

The social practices of competing and comparing, of conversation, sharing and display were pivotal for the advancement of microscope technology. Test objects played a key role in this development.

References

- This article is an outcome of my current research on early 19th-century microscopy
- Herschel, W. (1800) On the power of penetrating into space by telescopes; with a comparative determination of the extent of that power in natural vision, and in telescopes of various sizes and constructions; illustrated by select observations. *Philosophical Transactions of the Royal Society of London* 90, 49–85
- In the coming decades, Goring's distinction was the subject of much debate. In the 1860s, researchers still discussed whether Goring had been correct in applying Herschel's notion of penetrating power to the microscope, whether the function of the microscope was not completely different, and whether the term 'penetrating power' was appropriate for the microscope's optical properties
- Goring, C.R. (1827) On achromatic microscopes with a description of certain objects for trying their definition. *Quarterly Journal of Science, Literature, and the Arts* 23, 410–434. pp. 418–419
- See, for example, Bradbury, S. (1967) The quality of the image produced by the compound microscope: 1700–1840. In *Historical Aspects of Microscopy* (Bradbury, S. and Turner, G.L'E., eds), 151–172 (p. 152), Heffer
- Lister, J.J. (1830) On some properties in achromatic object-glasses applicable to the improvement of the microscope. *Philosophical Transactions of the Royal Society of London* 120, 187–200
- Goring, C.R. (1827) On Mr. Tulley's thick aplanatic object-glasses, for diverging rays; with an account of a few microscopical test objects. *Quarterly Journal of Science, Literature, and the Arts* 22, 265–284. p. 271
- For details on Lister's work, see Bracegirdle, B. (1987) Famous microscopists: Joseph Jackson Lister, 1786–1869. *Proceedings of the Royal Microscopical Society* 22, 273–97
- See Hughes, A. (1959) *A History of Cytology*, p. 8, Abelard-Schuman
- Hodgkin, T. and Lister, J.J. (1827) Notice of some microscopical observations of the blood and animal tissues. *Philosophical Magazine, or Annals of Chemistry* 2, 130–138. p. 131
- Bowerbank, J.S. (1870) Reminiscences of the early times of the achromatic microscope. *Monthly Microscopical Journal* 3, 281–285. pp. 281, 284
- Gill, T. (1828) On the microscope. *Gill's Technological Repository; or, Discoveries and Improvements in the Useful Arts II*, 95–99 (p. 96)
- Gill, T. (1828) On the microscope. *Gill's Technological Repository; or, Discoveries and Improvements in the Useful Arts II*, 95–99 (p. 96–97)
- Gill, T. (1829) On the microscope. *Gill's Technological Repository; or, Discoveries and Improvements in the Useful Arts III*, 129–149 (p. 138)
- Jacquin, J.V. (1829) Bemerkungen über Mikroskope und ihren Gebrauch für Naturforscher. *Zeitschrift für Physik und Mathematik* 5, 129–160. p. 137
- Goring, C.R. (1827) On achromatic microscopes with a description of certain objects for trying their definition. *Quarterly Journal of Science, Literature, and the Arts* 23, 410–434. p. 419
- Pritchard, A. (1832) *The Microscopic Cabinet of Select Animated Objects; with a Description of the Jewel and Doublet Microscope, Test Objects, &c.*, p. 143, Whittaker, Treacher, and Arnot
- Pritchard, A. (1832) *The Microscopic Cabinet of Select Animated Objects; with a Description of the Jewel and Doublet Microscope, Test Objects, &c.*, p. 142, Whittaker, Treacher, and Arnot
- Turner, G.L'E. (1980) *The contributions to science of Friedrich Adolph Nobert in essays on the history of the microscope*, pp. 141–158, Senecia
- Bowerbank, J.S. (1870) Reminiscences of the early times of the achromatic microscope. *Monthly Microscopical Journal* 3, 281–285. p. 281
- Gill, T. (1828). On the Microscope. *Gill's Technological Repository; or, Discoveries and Improvements in the Useful Arts II*, 138–149
- Pritchard, A. (1833) Test objects. *London and Edinburgh Philosophical Magazine and Journal of Science* 2, 335–344