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DISCOVERING THE 'TRUE FORM:' HOOKE'S *MICROGRAPHIA* AND THE VISUAL VOCABULARY OF ENGRAVED PORTRAITS

by

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This essay uses Robert Hooke's *Micrographia* to examine the intersection of visual conventions for portraiture with the viewing of the microscopic world. In the preface to his *Micrographia*, Robert Hooke asserts that he has discovered 'a new visible World' through the help of newly invented optical devices that add 'artificial Organs to the natural'. I claim that Hooke was also aided by the visual vocabulary developed by engravers for translating a three-dimensional world into a two-dimensional representation of it, and that his awareness of these conventions sets his illustrations apart from his predecessors.

Keywords: Robert Hooke; microscopy; visual culture; engraving; portraiture

> And therefore I never began to make any draughts
> before by many examinations in several lights,
> and in several positions to those lights,
> I had discover'd the true form.[1]

Robert Hooke (1635–1703) saw differently. When he looked through a microscope, he saw what others did not or could not.[2] For example, when John Wilkins, a founding Fellow of the Royal Society of London, looked through a microscope at deer hair, he saw a quill-like structure. Hooke, in contrast, saw a sponge-like form. Hooke was right.[3] I argue that seeing differently in this case was facilitated by his early training and lifelong interest in the arts. Hooke's understanding of line and particularly the engraved line allowed him to resolve the images he saw through his microscope in ways that others could not. Further, his working method, which involved numerous observations of the same subject, was critical to his seeing differently. Hooke struggled with discovering the 'true form' of his object of study, and this awareness, coupled with his familiarity with artistic techniques, allowed him to see the microscopic world differently from his predecessors and contemporaries.

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Expanding the brief anecdote just mentioned will help to establish what I mean. At a meeting of the Royal Society in 1663, Dr George Ent related to the Fellows that deer skins laid in the bottom of a boat would tend to float above the other animal skins laid with them when submerged in water.[4] This remark led Dr John Wilkins to relate his own observations of deer's hair with a microscope: he 'found them to be tubulous throughout, like quills; whereas the hair of other animals was like canes, full of pores, but not hollow; so that deer's hair being filled with more air than that of other animals, endeavoured, when put under water, to emerge to the top.'[5] Hooke was then 'desired to observe in his microscope some of the deer's hair, what cavities they have.'[6] Although Wilkins was a founding member of the Society and had served as an early patron to Hooke, his opinion was not sufficient proof for the Fellows that deer hairs were in fact 'tubulous'. Instead they called upon Hooke's expertise. Two weeks after this first mention of the nature of deer hair, 'Mr. Hooke produced a microscopical observation of the hair of an Indian deer, which represents it to be like a spunge, not like quills.'[7] The sponge-like form of the hair referred to its interior structure; it does not have a perforated exterior like a sponge. Hooke closely examined the sample of deer hair provided him by Mr Clayton[8] and then produced a drawing that allowed the Fellows to see what he saw.

Although the drawing that Hooke showed at the meeting is not extant, he did include a description and image of deer hair in *Micrographia* (figure 1). In the accompanying text he further explicated his findings and the steps he took to reach his conclusion about the sponge-like nature of the hair: 'through the Microscope, it appears all perforated from side to side, and Spongie, like a small kind of spongy Coral, which is often found upon the English shores; but though I cut it transversly, I could not perceive that it had any pores that ran the long-way of the hair.'[9] Although Wilkins and Hooke would have been using comparable instruments, Hooke saw something different, and this ability set him apart from the other Fellows. By looking repeatedly at the same object, and by cutting and recutting his specimen, Hooke was able to see what others could not and thereby discover the 'true form'. By arguing that Hooke saw differently, I am not, however, arguing that he was exceptional, but instead that he had developed a new way of seeing and that he wanted to instruct others to follow his method.

In the preface to his *Micrographia*, Robert Hooke asserts that he has discovered 'a new visible World' through the help of newly invented optical devices that add '*artificial Organs* to the *natural*'.[10] My claim in this essay is that Hooke was also aided by the visual vocabulary developed by engravers for translating a three-dimensional world into a two-dimensional representation of it. In particular this argument brings together evidence from two seemingly disparate bodies of work: seventeenth-century portrait engravings and the 38 plates that illustrate Hooke's *Micrographia*. This juxtaposition of images from different genres highlights the debt that Hooke owed to the visual vocabulary of engravers in his attempts to discover the 'true form' of his object of study and how his ability to see differently was tied to his engagement with mid-seventeenth-century visual culture.

I am using the term vocabulary in this essay to connote the visual elements used by engravers to create the illusion of three dimensions in a two-dimensional medium. This illusion of three dimensions is produced through the manipulation of depth and contrast, which we will see were paramount concerns for Hooke. That is, the lines carved by the engraver create a sense of dimensionality both in the forms depicted and in the space they inhabit by manipulating the viewer's perceptions. Lines are used to alter how the viewer perceives the illusion of depth within the picture plane and how light strikes different

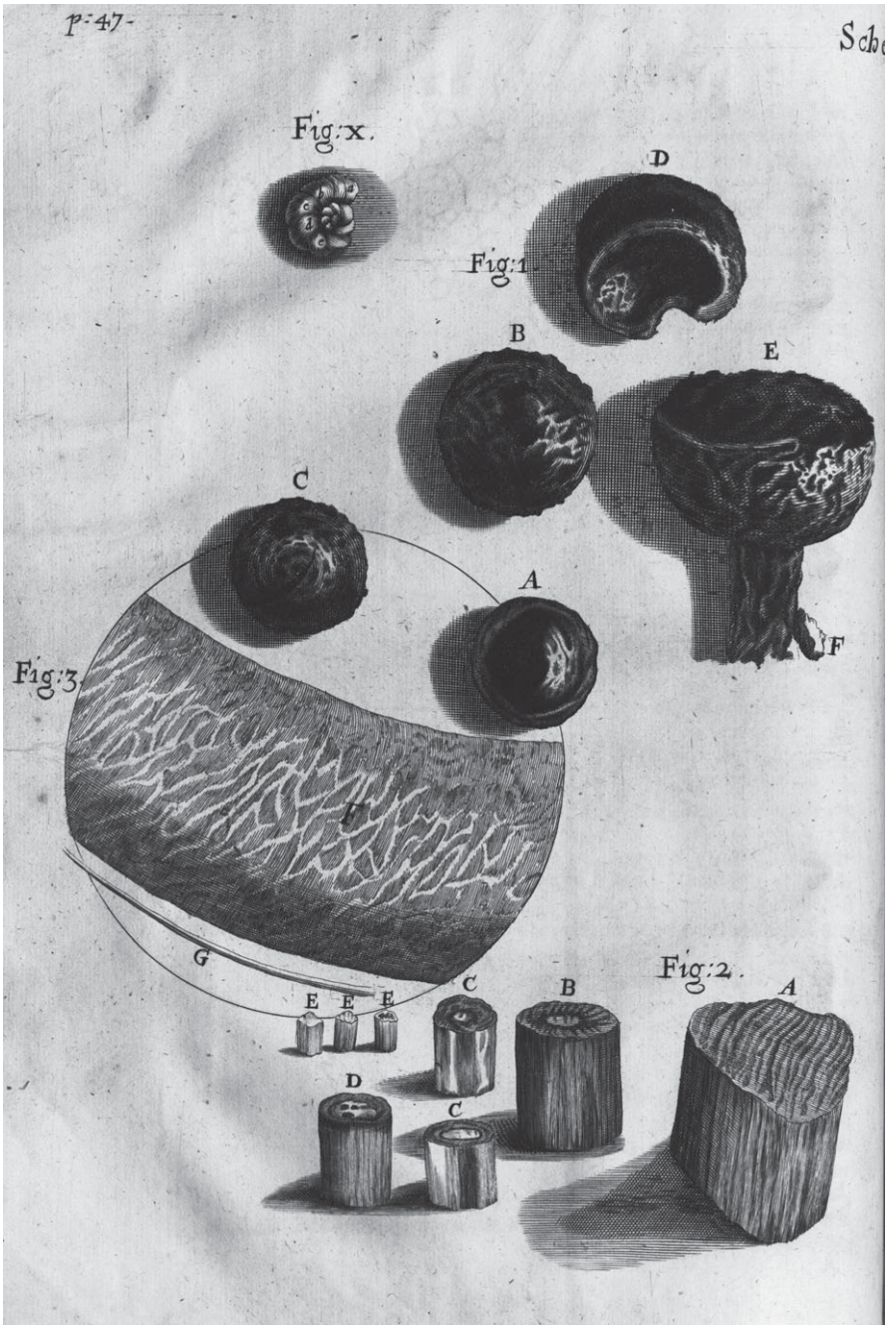


Figure 1. Scheme 5 from Robert Hooke, *Micrographia* (1665). (Gift of Daniel and Eleanor Albert; courtesy of the Department of Special Collections, Memorial Library, University of Wisconsin-Madison.)

areas within the space of the image in different ways to provide contrast. This essay explores how these terms of the visual vocabulary of engraving are not fully developed in the early visual culture of microscopy, but are mobilized in the illustrations in Hooke's *Micrographia* to create a compelling view of 'a new visible World'.

I argue that Hooke was presenting his readers with an accurate view of the object. This essay is part of my larger project, which investigates how artisans and experimenters created the visual effect of accuracy in printed images produced by and for the Royal Society, 1660–80.[11] I am using the term 'accurate' to describe these images for two reasons. The first is because it is a word that Hooke and his contemporaries would have recognized as important to their aims of reforming natural history and natural philosophy. 'Accurate' was coming into the English language at the same moment that the Society was being founded, and some of the earliest instances of the word and its derivatives in English are in writings of Fellows of the Society.[12] Second, I am using 'accurate' because of its closeness in the period to its Latin root, *accurare*, 'to perform with care'.[13] This paper examines the care that Hooke took in examining his microscopic subjects and the further care he took in depicting them. Whereas Lorraine Daston and Peter Galison have discussed the epistemic values of 'truth-to-nature' in the eighteenth century and 'objectivity' in the nineteenth century, I argue that accuracy was the guiding force in the creation of images for the Fellows.[14] I stress that Hooke and his contemporaries were striving to include images with their texts that recorded what they saw and how they saw it. These were images that were intimately tied to the act of looking.

In his overview of the history of scientific illustrations, Brian Ford notes in his chapter on microscopic images that microscopes pose problems of interpretation for the scientist that are not present when an object is viewed with the naked eye.[15] Questions arise pertaining to texture and colour in particular. How does the user of the microscope separate optical artefacts created by the instrument from the 'true form', as Hooke called it? This essay argues that Hooke's early training in the arts and his lifelong interest in prints and printing techniques aided him in the visual decision-making that is involved in looking through a microscope. Accuracy is not just something that the viewer perceives in the images, but also something that is demonstrated in Hooke's writings about his own process of image making.

In the preface, Hooke forswears the role of the imagination in his work and more broadly in the reformation of natural philosophy. Instead, he stresses the importance of sensory evidence:

> I hope, they [my endeavors] may be in some measure useful to the main Design of a *reformation* in Philosophy, if it be only by shewing there is not so much requir'd towards it, any strength of *Imagination*, or exactness of *Method*, or depth of *Contemplation* . . . as a *sincere Hand*, and a *faithful Eye*, to examine, and to record, the things themselves as they appear.[16]

While Hooke claims that his images are a record of 'the things themselves as they appear', they in fact look quite different from earlier images produced as a result of looking through a microscope. This essay shows that the images included in *Micrographia* are the product of more than 'a *sincere Hand*, and a *faithful Eye*', and that they are in fact embedded in and indebted to the visual vocabulary used in portrait engraving of the seventeenth century.

I am singling out portrait engraving for this argument because in both genres the goal of the image is to represent the individual characteristics of the object of study. This was also true of early telescopic images, such as those included in Galileo's *Sidereus nuncius*.[17]

It should be noted that the visual vocabulary discussed in this essay was not unique to portraiture, but rather was widespread throughout the visual culture of seventeenth-century London. Although it might be assumed that Hooke was depicting an ideal specimen that would help others looking through a microscope to identify what they were seeing, he was in fact depicting very particular specimens. For example, in Scheme 31, which shows the back, eyes and belly of a long-legged spider, the upper part shows the spider from above and it has only four legs (figure 2). In the lower part, which depicts the spider from below, all eight legs are still intact. I would argue that these two images show the same spider over the course of Hooke's examinations. It is entirely likely that during manipulation of the spider to turn it over, some of the legs broke off.[18] This pair of images then shows that Hooke's plates, like portrait engravings, recorded what his objects of study looked like at a given time. Portrait engravers also sought a balance between an idealized portrayal and a veristic one as the artist had to weigh a sitter's desire to be seen as attractive against the reality of his or her actual features.[19]

The act of looking is not a benign act. These views of a spider highlight the fact that the act of representing an object alters it. Instead, looking and inspecting yield an object that is different from the one that was initially under consideration. Although the case of the spider is a very literal example of this, the traces of how looking through the microscope changed the object of study can be seen in other images as well. Hooke's image of deer hair, discussed above, creates the illusion that the viewer of the image is looking through the eyepiece of the microscope at the object of study on the stage. In this image and others like it, the resulting representation presents the object of study as being contained within a perfect circle, therefore limiting the scope of the object to that which can be seen in a single viewing. Although the part of the specimen that is cut off by the physical limitations of the instrument is still a part of the object, unlike the spider's legs, all that exists for the viewer is what fits within the scope of the lens. What the viewer is presented then is a view of an object that is not what was put on the stage of the microscope, but rather what resulted from the act of looking through the microscope.

Although other scholars have noted in passing some of the facts of Hooke's multi-faceted life that I will discuss here, none have brought them into conversation with the production of his *Micrographia*.[20] In this essay I stress the importance of viewing Hooke's involvement with the arts and the development of modern science as inextricably linked. Jim Bennett has argued that Hooke's connections to instrument makers made him more successful at integrating developments in the mechanical arts into those in natural philosophy.[21] I am building on his work to argue that Hooke's involvement in the visual arts was crucial to his work with the microscope. Neither his dedication to the work being done by the Society nor his active engagement with the arts alone could have led to the production of *Micrographia*. Rather, the two together resulted in a book that changed the way in which the microscopic world was understood.

I begin by highlighting Hooke's connections to the artistic community and artistic practice in London in the middle of the seventeenth century. This is followed by an examination of the components of the visual vocabulary of portrait engraving that would have been familiar to Hooke and contrasts them with the vocabulary of the early visual culture of microscopy. Finally, I discuss and show how this vocabulary forms the basis of how Hooke saw this 'new visible World'. Through his understanding and appreciation of the arts of drawing and printing, Hooke created images that changed how the microscopic world was viewed and captivated audiences for generations.

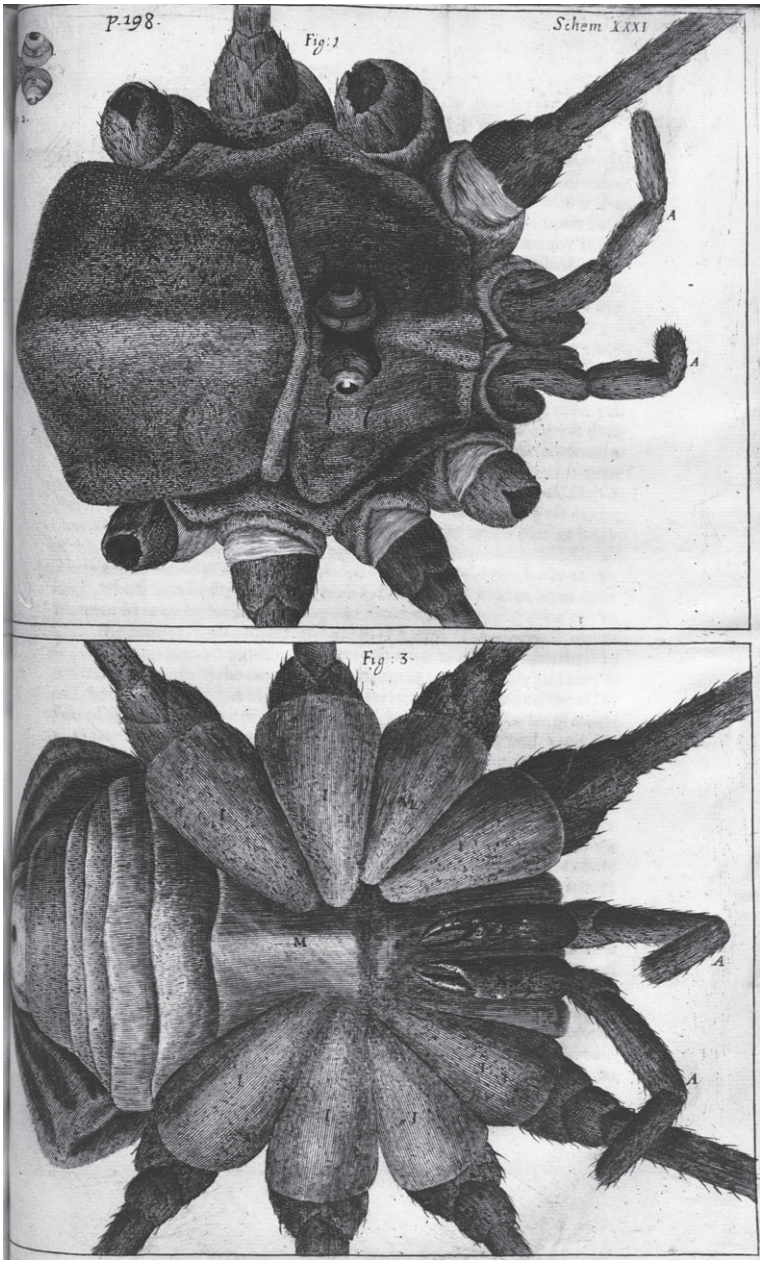


Figure 2. Scheme 31 from Robert Hooke, *Micrographia* (1665). (Gift of Daniel and Eleanor Albert; courtesy of the Department of Special Collections, Memorial Library, University of Wisconsin-Madison.)

Developing a 'sincere Hand and a faithful Eye'

This section re-evaluates Hooke's connection with the arts to obtain a better understanding of the context in which *Micrographia* was produced. In addition, I wish to highlight the

multifaceted nature of Hooke's interests in artistic practice. Using evidence from Birch's *History of the Royal Society* and Hooke's diary,[22] this section presents a more nuanced version of Hooke's biography that takes his interest in the arts as seriously as he did. This section further emphasizes the value placed on Hooke's expertise as a draughtsman by the Fellows of the Society.

Hooke's formal involvement in the arts began at a young age; in 1648, after the death of his father, he was sent to London from his home on the Isle of Wight and apprenticed to Peter Lely (1618–80).[23] Lely, a Dutch painter, was active in England by 1643 and had completed his obligations to the Painter–Stainers' Company in London in 1647.[24] Although it is unclear how long Hooke remained in Lely's studio, he was there at a time when Lely was working to establish himself as artistic heir to Anthony van Dyck and becoming the predominant portrait painter in England.[25] After the Restoration in 1660, his place as painter to Charles II was secure.

Even if Hooke's stay in Lely's studio was brief, it is clear that the two remained in contact after Lely's rise to fame in the Court of Charles II. Lely was one of several painters who agreed, in 1667, to meet with a committee of Fellows of the Royal Society, which included Hooke, to discuss their 'several curiosities and varieties of painting'.[26] Furthermore, on 27 December 1675 Hooke recorded in his diary that he went 'to Mr. Lelys. Discoursed of helping the sight and of picture box.'[27] Hooke, who was the Curator of Experiments at the Society, went to visit Charles II's Court Painter to discuss mechanical aids used in the creation of images. This was not the first mention of the 'picture box', or *camera obscura* in Hooke's diary: one had been brought to his house a year earlier.[28] In 1663 Hooke was required, as part of his duties as Curator of Experiments, 'To try the casting of a picture on a wall in a light room; and to bespeak a concave glass for it.'[29] He performed further experiments with variations on these optical devices dealing with adjustments in scale and righting the inverted image.[30] It should come as no surprise that Hooke and the Fellows of the Society were interested in the optical workings of the *camera obscura*. As Svetlana Alpers has shown, the *camera obscura* was central to discussions of the mechanics of sight and the picturing of the natural world, two topics in which Hooke was greatly invested.[31]

In addition to his interest in the *camera obscura*, Hooke recorded techniques used by artists in the practice of drawing in his diary. He transcribed a lengthy description of 'the way to coppy prints … with ease' that was transmitted to him by the same Mr Kirk who brought the 'picture box' to his house a few days later.[32] In the same passage of his diary, Hooke also records sharing his technique for drawing ovals.[33] He was not merely interested in theoretical problems related to drawing but also was a practising draughtsman. He showed many drawings of his experimental findings and instruments of his own invention at meetings of the Society.[34] In addition, he was often commissioned by the Fellows to produce drawings of specimens that were brought into meetings and of experiments performed by Fellows outside the scheduled meeting time, so that others could see the results.[35] Furthermore, Hooke served as an arbiter of the accuracy and usefulness of drawings that others sent in to the Society with their reports of observations.[36] Hooke's training and interest in drawing meant that he both contributed drawings to the Society's meetings and also determined which best served the Society's ends.

Hooke's practical interest in drawing extended to the books he read. In July 1675 he borrowed 'a book of limning' from William Faithorne, who sold prints and books

by himself and others.[37] Two weeks later, he records copying the book he had borrowed from Faithorne.[38] Although it is unclear exactly which book Hooke borrowed from Faithorne, because there were numerous books on the arts of drawing and limning available in London during the second half of the seventeenth century, we do know that Hooke owned a copy of the 1666 edition of Thomas Jenner's *A Book of Drawing, Limning, Washing or Colouring of Maps and Prints*.[39] Furthermore, Matthew Hunter has recently attributed a drawing at Tate Britain to Hooke that seems to be based on another mid-seventeenth-century drawing manual, Alexander Browne's *Ars Pictoria*.[40] Hooke was concerned both with mechanical aids for drawing and with manuals intended for young draughtsmen. This level of interest shows that he was not simply interested in aspects of drawing that were closely linked to questions of concern to natural philosophers, namely the *camera obscura*, but also with the more practical aspects of learning to draw.

Hooke's curiosity extended beyond drawing techniques into printing ones as well. He records in his diary numerous techniques he invented for improving printmaking and also gives reports of improvements for the art of printing suggested by others.[41] He even offered advice on the subject to his friend John Ogilby (1600–1676) a London publisher and geographer. Hooke writes that he 'shewd him [Ogilby] the way of Letters for marking his map and also the way of shadowing.'[42] This passage implies that Hooke was giving Ogilby tips for preparing drawings for printing, because the maps in question were probably part of one of Ogilby's atlases.[43] Of particular importance to my study of the images in *Micrographia* is that Hooke was giving advice on 'the way of shadowing', indicating that he believed he had a superior grasp of how to indicate the fall of light within a two-dimensional image. Hooke believed he knew the best ways of preparing drawings for printing.

In addition to sharing advice on printing techniques with his gentlemen friends, Hooke was on friendly terms with a group of London-based printmakers, and he purchased prints and books on art and architecture from several booksellers around London. Wenceslas Hollar is perhaps the most recognizable name among the list of Hooke's associates.[44] Hooke went to Hollar's on numerous occasions and records buying a number of his prints. He also bought works by Callot and Dürer, among others.[45] Along with buying prints, Hooke records buying books by Giorgio Vasari, a biography of Peter Paul Rubens[46] and a variety of books on the history of printing.[47] These are just a sampling of the interactions that Hooke had with artists and booksellers regarding prints and books on the arts. Hooke's diary is filled with references to meetings that attest to his accumulation of prints and books, and the auction of his books after his death contained more than 90 books related to the visual arts.[48]

All of these connections indicate that he was deeply involved in the visual culture of seventeenth-century England. Whether in discussions with painters or other Fellows of the Society, Hooke's diary shows that he was intrigued by different image-making strategies and conversed with both makers and consumers of images about technologies of vision and visualization. Further, Birch's *History of the Royal Society* is filled with references to Hooke's 'draughts' and 'schemes'. Beginning with his early education in Lely's studio and continuing throughout his life, Hooke was deeply involved with the production and consumption of images. These connections to the arts must be understood within the context of his advocacy of 'a *sincere Hand*, and a *faithful Eye*' as being essential to 'a *reformation* in Philosophy'.

Making 'a Plain Representation'

This section outlines how portrait engravings provided the visual lexicon that Hooke made use of in preparing his drawings to be engraved, and contrasts this lexicon with the one used by his predecessors. In describing his method for creating the 'draughts' that were used as the basis for the engraved plates in *Micrographia*, part of which served as the epigraph to this paper, Hooke makes it clear that he did not immediately draw what he saw upon looking through his microscope because of the difficulties of discerning what he saw:

> in making them [the draughts], I indeavoured (as far as I was able) first to discover the true appearance, and next to make a plain representation of it. This I mention the rather, because of these kind of Objects there is much more difficulty to discover the true shape, then of those visible to the naked eye, the same Object seeming quite differing, in one position to the Light, from what it really is, and may be discover'd in another. And therefore I never began to make any draughts before by many examinations in several lights, and in several positions to those lights, I had discover'd the true form.[49]

This passage shows that Hooke had to make a series of decisions about what exactly it was that he was seeing while preparing his drawings. These decisions were based on past experience of the visual world and required Hooke to make judgements 'to distinguish between a *prominency* and a *depression*, between a *shadow* and a *black stain*, or a *reflection* and a *whiteness in the colour*.'[50] In this passage, Hooke is particularly concerned with how to interpret and represent the depth and contrast he observed in 'these kind of Objects'.

Looking at an engraving from the period provides a better sense of what I mean by a visual vocabulary of engraving. A portrait of Charles II engraved by William Faithorne from the 1650s serves as an example of the portraits that were circulating in London at the time that Hooke was preparing the drawings for *Micrographia* (figure 3).[51] By studying Faithorne's likeness of the king we gain an understanding of the visual resources available to Hooke in the process of determining what he saw through the microscope.

First of all, how does Faithorne's engraving help us understand how 'to distinguish between a *prominency* and a *depression*?' In particular the king's hair gives us an opportunity to think about how engravers conveyed a sense of depth. The waves of Charles's hair are communicated through several methods: first, sinuous lines convey the overall contours of his hair; second, the depressions are made darker through a layering of hatched lines, the darkest areas being understood as the low points of the waves; and finally, the prominences of the waves of hair are indicated as the white of the paper shows through larger gaps in the engraved lines. The relatively sparse lines on the crests of the waves give the illusion of light hitting these high points. This combination of curving lines and varied density of lines creates an illusionistic representation of thick, wavy hair with definite prominences and depressions. The three-dimensionality of Charles's curls is depicted in two dimensions through variations in the shape and density of the engraved lines.

This vivid depiction of the prominences and depressions in Charles's hair is in stark contrast with early attempts at creating the illusion of depth in early microscopic images. For example, Giovanni Hodierna (1597–1660) in his *L'Occhio della Mosca*, published in Palermo in 1644, resorted to analogy to give a sense of the depth and texture of a fly's eye.[52] In this first account of microscopic dissections,[53] the 'true form' of the eye is

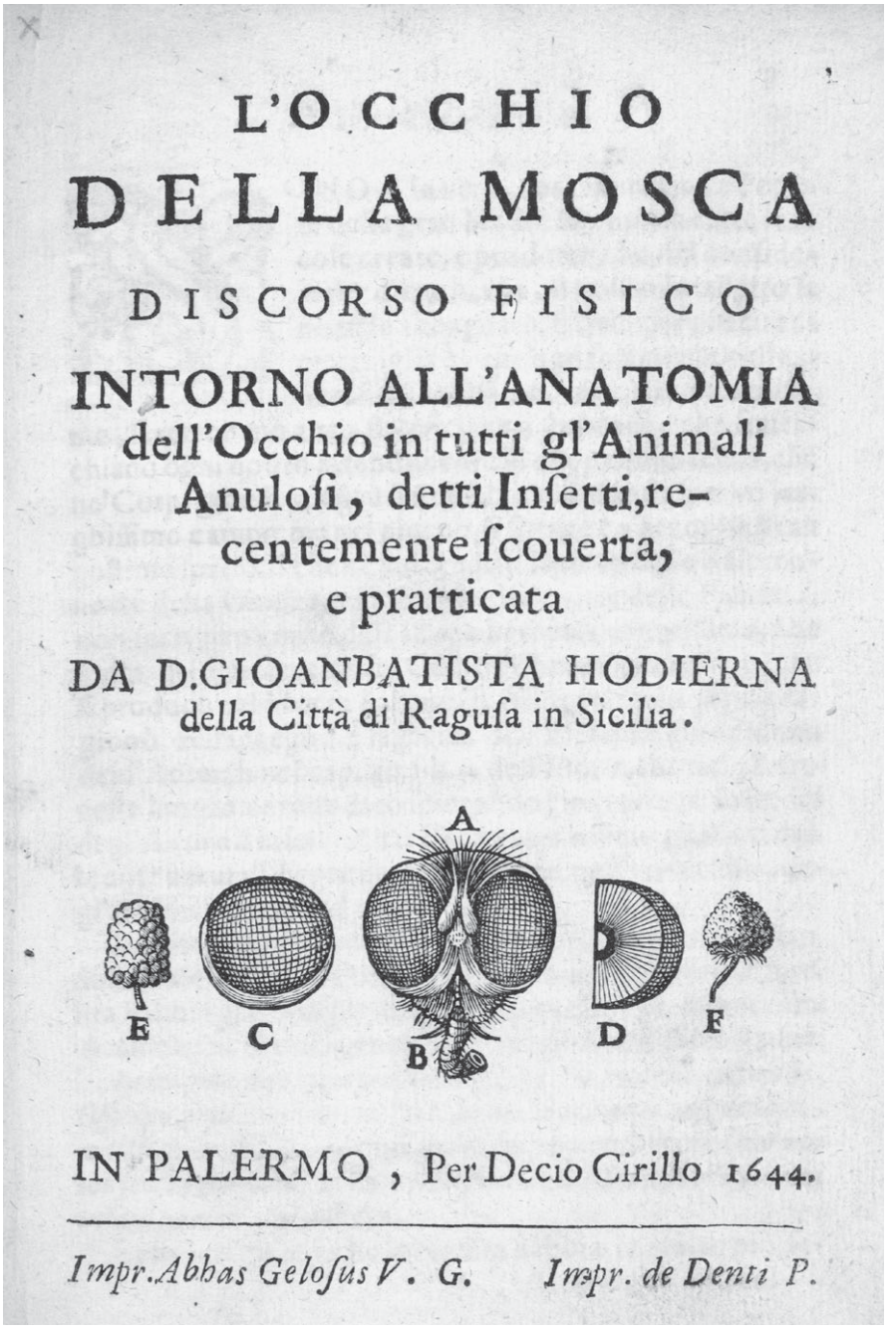
Figure 3. William Faithorne, Portrait of Charles II, 1650s. (Courtesy of the National Gallery of Art, Washington.)

conveyed through its likeness to strawberries and blackberries. The importance of the visual representation of Hodierna's discoveries is made immediately clear because the only image included in this short work appears on the title page, as well as on page 17 of the text

(figure 4).[54] The image is therefore the first thing you see on opening the book and is also embedded in Hodierna's discussion of the results of his dissections. A series of five images spans the width of the page and shows a magnified view of a fly's head, a view of a single eye, a dissection of an eye, and two comparative images of a blackberry and a strawberry. Modern scholars have estimated that Hodierna's microscope magnified 'no more than twenty to thirty times'.[55] Although it seems clear from the text that Hodierna had gained an understanding of the anatomy and physiology of insect eyes,[56] his images do not match the quality of his observations. The rough style of this woodcut presents the surface of the fly's eye as a flat grid, without visually presenting a sense of the faceted nature of the eye that he describes in the text. The depth and texture of the fly's eye are indicated not through the skill of the woodcutter, but instead through an analogy with the texture of a blackberry and strawberry. However, the depth of the individual components of the fruit is merely suggested in the blackberry by arcing lines piled one onto the other. The dimpled texture of the strawberry is even more vaguely suggested. The images of the berries do not in themselves convey a sense of the depth and texture of a fly's eye, but instead call to mind the actual fruits to aid the viewer in understanding the faceted nature of the fly's eye. These images alone are not sufficient; the viewer must rely on a knowledge of the visible world to understand the invisible. Although Hodierna had gained an understanding of the three-dimensionality of the fly's eye, this depth is not conveyed in the representation of either the eye or the comparative berries.

A comparison of Charles's armour with his collar indicates how 'a *reflection* and a *whiteness in the colour*' are distinguished with the visual vocabulary of engraving. In both cases the whiteness of the paper shows through, but it is quite clear in looking at this image that his armour is reflecting the light and his collar is white. What I am interested in is *how* this is made so clear to a viewer. An obvious answer is that it is unreasonable to think that his armour has a white stripe in it. However, there is more to it than that. The alternation of black and white, dark and light, in the area surrounding the highlight on his right shoulder visually adds up to a reflection. The area behind the hotspot on his shoulder is heavily shaded with a series of overlapping lines that taper down the shoulder and hug the bright spot. In addition the area around the hotspot gets gradually brighter at the edges of the reflection. It gets brighter through a decrease in the density of lines; the lines become both thinner and fewer. The irregularity of the shape of the white spot on his shoulder also adds to our sense that we are looking at a reflection. This is not a round white marking on the armour; instead the light plays off the curve of the metal as it bends around the form of his shoulder. The bright white of the paper combines with the dark shading on the upper part of the shoulder to give a clear indication that we are looking at a reflection, not a 'whiteness in the colour'. The contrast of light and dark gives a clear sense of the play of light on a three-dimensional object.

In contrast with the glaring white of the reflection, the whiteness of the collar is represented more evenly. The plain white section of it is indicated with regularly spaced lines that curve slightly and get thicker where there is a dimple in the fabric about halfway between the patterned section and his neck. The more shadowed side of the collar is also indicated with very even lines that are now crossed with diagonals indicating the shadow cast on the collar by the King's chin. Whiteness is not indicated through unadulterated paper. Instead, lighter lines with more space between them convey the whiteness of Charles's collar. Whereas reflections are shown through striking contrasts of dark and light, whiteness is expressed through an evenness and regularity of line.



L'OCCHIO
DELLA MOSCA
DISCORSO FISICO
INTORNO ALL'ANATOMIA
dell'Occhio in tutti gl'Animali
Anuloſi, detti Inſetti, re-
centemente ſcouerta,
e pratticata
DA D. GIOANBATISTA HODIERNA
della Città di Raguſa in Sicilia.

A
E C B D F

IN PALERMO, Per Decio Cirillo 1644.

Impr. Abbas Geloſus V. G. *Impr. de Denti P.*

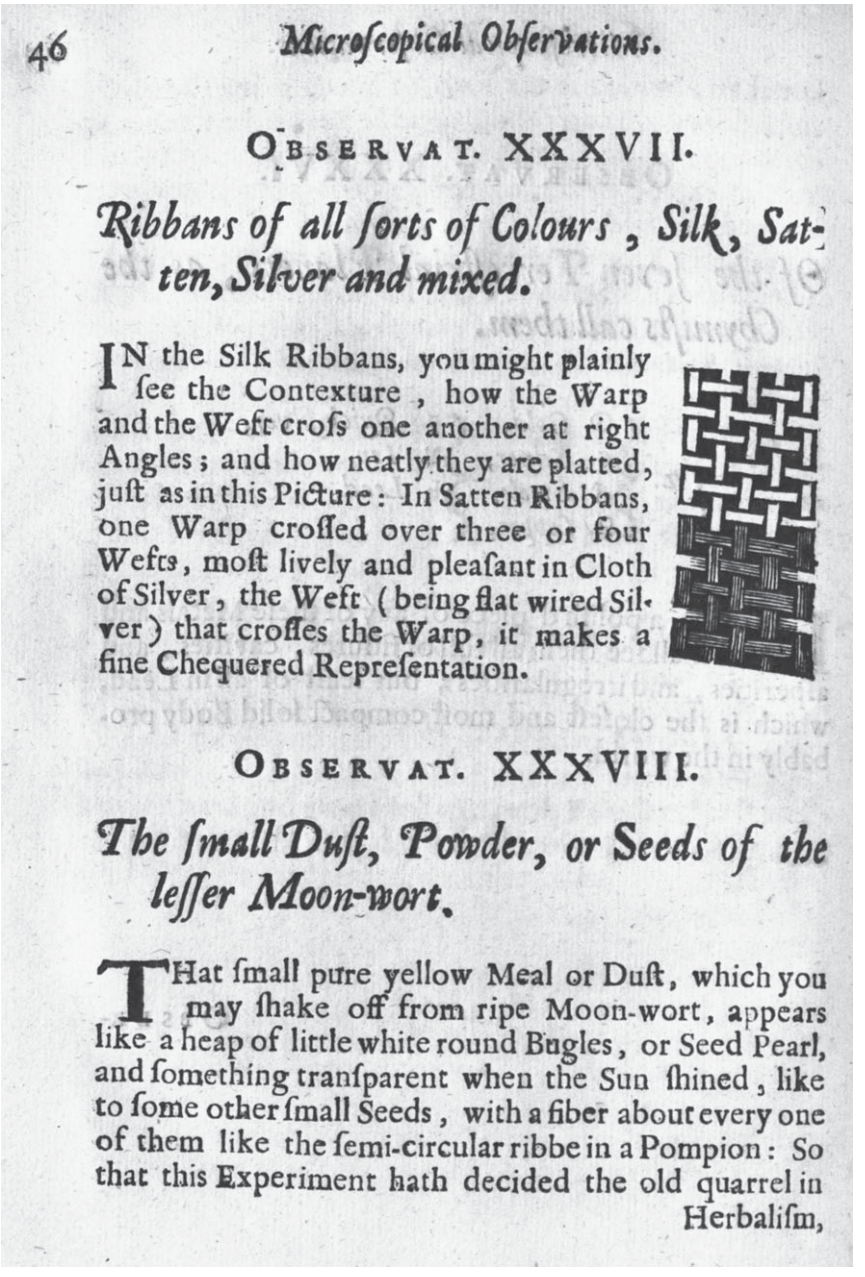
Figure 4. From Giovanni Hodierna, *L'Occhio della Mosca* (1644). (Copyright © British Library Board (537.c.15.(1.)).)

Even Hooke's closest contemporary, Henry Power (*ca*. 1626–68), struggled with finding a vocabulary for depicting the subtleties of the contrast of light and dark of the microscopic world in his *Experimental Philosophy*, published in London in 1664. Power's book is composed of three sections of 'new experiments: microscopical, mercurial, magnetical'.[57] There are three woodcut illustrations included in the first section of the book, treating 'experiments microscopical'. Power chose to illustrate his observations of the eyes of spiders, a piece of ribbon, and poppy seeds with small woodcuts. The illustration of the warp and weft of a silk ribbon only vaguely indicates how the light hits the different fibres (figure 5). The image gives a clear sense of the fibres meeting at right angles, which Power comments on in the text.[58] However, there is no subtlety in the shading of the image, either in the stark upper section, which gives no indication of the texture of the fibres, or in the more subtle lower section. At the points of intersection between the warp and the weft, the space around the crossed fibres is solid black. There is no sense of the gradual darkening of the appearance of one strand as it goes under another. An area that would appear shaded when you looked at it is simply rendered in black. The small woodcuts in Power's book do not convey a sense of the play of light off the silk ribbon that one would expect. Although Power's book and Hooke's shared the same publisher and they were both Fellows, they do not share the same vocabulary for depicting the microscopic world. Power's illustrations are much closer to Hodierna's in terms of medium and style than they are to Hooke's.

These examples show how engraved lines in portraits were combined to indicate differences in depth and in light and dark, and how this vocabulary was not used by Hooke's predecessors. The play of light on the undulating waves of Charles's curls and the bright reflection off his armour are indicated through variations in the shape and density of lines. Portraits of a wide range of individuals created by many different artists in the seventeenth century used this same vocabulary and, as we will see, so did Hooke.

Engraving 'the True Form'

Although the large-format plates depicting the minute details of insects are perhaps the best known in *Micrographia*, I wish to focus my discussion of the importance of the visual vocabulary of portrait engraving on a more humble topic: the poppy seed. As we saw earlier, this was one of the three objects that Henry Power illustrated in the section on microscopy in his *Experimental Philosophy* (figures 6 and 7). The contrast between Power's and Hooke's views of poppy seeds attests to the lengths that Hooke went to in depicting the 'true form' of his objects of study and in creating an illusion of accuracy. Although published within a year of one another by the same printers, these two representations give very different senses of the three-dimensionality of the microscopic world. It would be easy to dismiss the differences between the two images as being solely tied to the medium. That is, one could argue that because Power's illustration is a small woodcut, it is limited by the constraints of the medium. However, this argument would discount the existence of highly detailed and nuanced woodcuts that were published by artists such as Albrecht Dürer.[59] I argue, rather, that it was Hooke's involvement with the arts and his awareness of the techniques of draughtsmen and engravers that yielded such striking images.



46 Microſcopical Obſervations.

OBSERVAT. XXXVII.

Ribbans of all ſorts of Colours, Silk, Satten, Silver and mixed.

IN the Silk Ribbans, you might plainly ſee the Contexture, how the Warp and the Weft croſs one another at right Angles; and how neatly they are platted, juſt as in this Picture: In Satten Ribbans, one Warp croſſed over three or four Wefts, moſt lively and pleaſant in Cloth of Silver, the Weft (being flat wired Silver) that croſſes the Warp, it makes a fine Chequered Repreſentation.

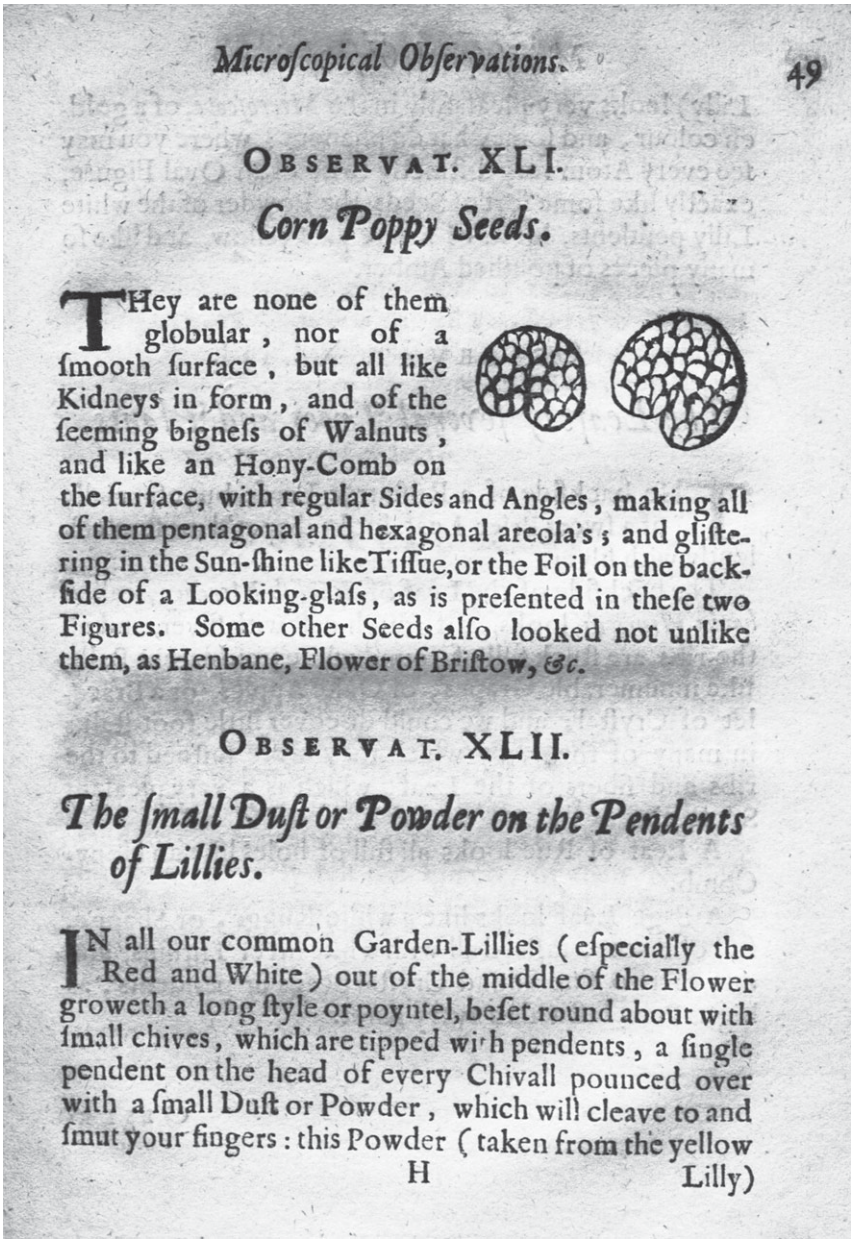
OBSERVAT. XXXVIII.

The ſmall Duſt, Powder, or Seeds of the leſſer Moon-wort.

THat ſmall pure yellow Meal or Duſt, which you may ſhake off from ripe Moon-wort, appears like a heap of little white round Bugles, or Seed Pearl, and ſomething tranſparent when the Sun ſhined, like to ſome other ſmall Seeds, with a fiber about every one of them like the ſemi-circular ribbe in a Pompion: So that this Experiment hath decided the old quarrel in Herbaliſm,

Figure 5. From p. 46 of Henry Power, *Experimental Philosophy, in Three Books* (1664). (Courtesy of the Department of Special Collections, Memorial Library, University of Wisconsin-Madison.)

The most noticeable difference between these two images is scale: Power's larger poppy seed is $\frac{3}{4}$ inch by $\frac{3}{4}$ inch, whereas one of Hooke's is 3 inches by $2\frac{3}{8}$ inches. However, I am less interested in the relative sizes of these images and more interested in how the images convey a sense of the microscopic texture of the poppy seed and the depth of the craters on the



Microſcopical Obſervations. 49

OBSERVAT. XLI.

Corn Poppy Seeds.

THey are none of them globular, nor of a ſmooth ſurface, but all like Kidneys in form, and of the ſeeming bigneſs of Walnuts, and like an Hony-Comb on the ſurface, with regular Sides and Angles, making all of them pentagonal and hexagonal areola's; and gliſtering in the Sun-ſhine like Tiſſue, or the Foil on the back-ſide of a Looking-glaſs, as is preſented in theſe two Figures. Some other Seeds alſo looked not unlike them, as Henbane, Flower of Briſtow, *&c.*

OBSERVAT. XLII.

The ſmall Duſt or Powder on the Pendents of Lillies.

IN all our common Garden-Lillies (eſpecially the Red and White) out of the middle of the Flower groweth a long ſtyle or poyntel, beſet round about with ſmall chives, which are tipped with pendents, a ſingle pendent on the head of every Chivall pounced over with a ſmall Duſt or Powder, which will cleave to and ſmut your fingers: this Powder (taken from the yellow

H Lilly)

Figure 6. From p. 49 of Henry Power, *Experimental Philosophy, in Three Books* (1664). (Courtesy of the Department of Special Collections, Memorial Library, University of Wisconsin-Madison.)

surface. Power's small woodcut image makes clear that the surface of a poppy seed is not as smooth as meets the naked eye. What is unclear from this image is whether the surface of the seed is made up of a series of overlapping scales, like those found on a fish, or whether there is some other explanation. Power's text provides more clues as to what he saw:

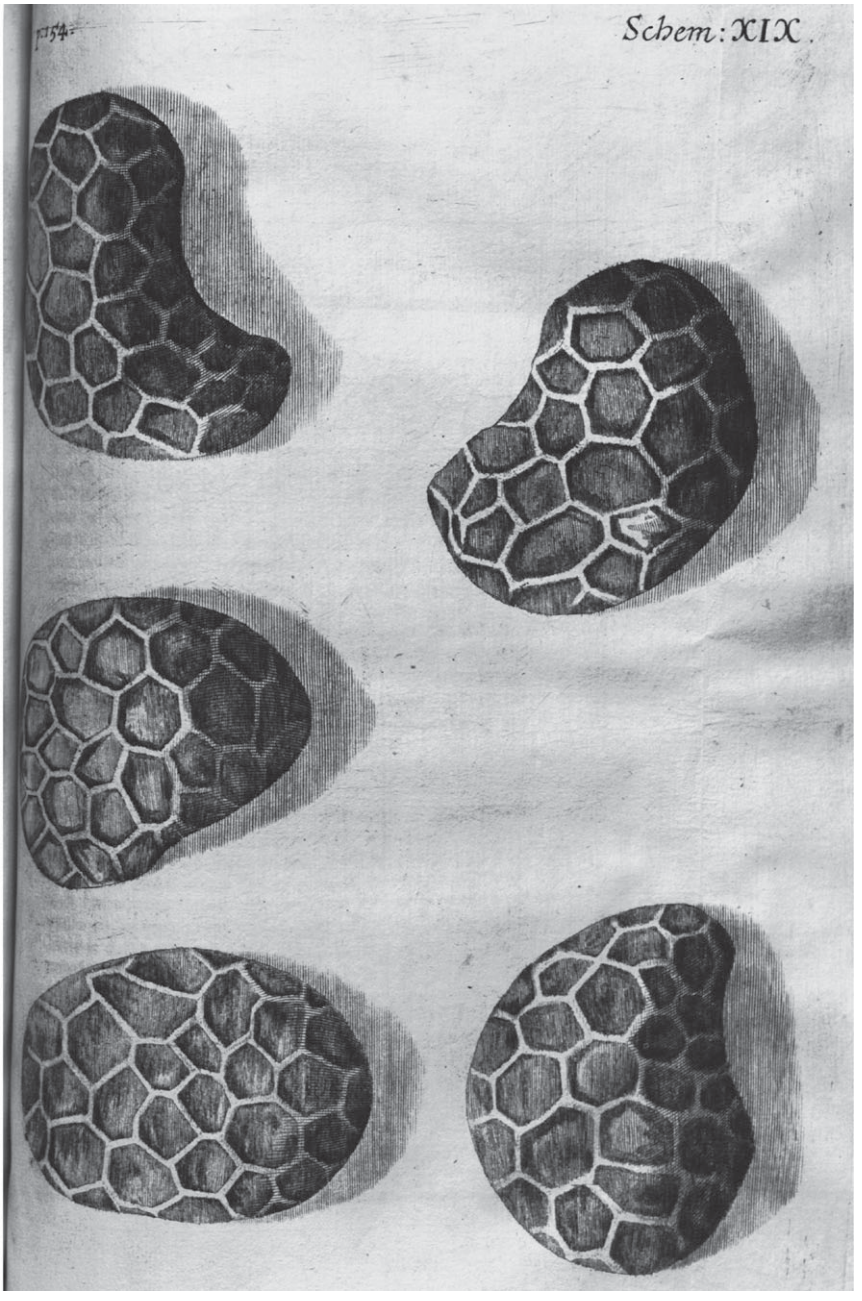


Figure 7. Scheme 19 from Robert Hooke, *Micrographia* (1665). (Gift of Daniel and Eleanor Albert; courtesy of the Department of Special Collections, Memorial Library, University of Wisconsin-Madison.)

like an Hony–Comb on the surface, with regular Sides and Angles, making all of them pentagonal and hexagonal areola's and glistering in the Sun-shine like Tissue, or the Foil on the backside of a Looking-glass, as is presented in these two Figures.[60]

The lines delineating the texture of the poppy seeds, however, do not meet at crisp angles that would bring to mind honeycombs. In addition, the uniform blackness of the lines gives no sense of the glistening of sunshine or the shimmer of mirrored glass. Although Power seems to believe that his image helps to clarify his textual description ('as is presented in these two Figures'), the woodcuts fall short of the standards of description established by the text. As we saw in Hodierna's *L'Occhio della Mosca*, for instance, this discrepancy between text and image was common. The images in Hooke's *Micrographia* close this gap by applying the visual vocabulary of portrait engraving to the representation of objects under microscopic investigation.

If we turn to Hooke's plate of poppy seeds, we can see the crisp angles of the honeycomb formations and the bright reflection of light glistening on the uneven surface of the seeds. Like Power, Hooke remarks on the grid-like structure of the surface of the seeds in his text, and, again like Power, he uses analogies to describe what he sees:

> curiously Honey-comb'd all over with a very pretty variety of Net-work, or a small kind of imbosment of very orderly rais'd ridges, the surface of them looking not unlike the inside of a Beev's [Beef's] stomack.[61]

Hooke's images, however, rise to the level of his textual description. In the images of each of these five seeds it is possible 'to distinguish between a *prominency* and a *depression*, between a *shadow* and a *black stain*, or a *reflection* and a *whiteness in the colour*.'[62]

As we saw in the hair in the portrait of Charles II, in this plate variations in light and dark indicated through differences in the density of the lines convey a sense of the depth of the 'imbosments' that Hooke saw. The ridges of each cell cast distinct shadows into the basin as the light falls onto each seed from the left. For instance, looking at the seed in the upper right-hand side of the plate, it is clear that the large oblong basin on this seed is particularly deep because the lines are so thick as to become almost black, and they fade out into the lit portion that is outside the shadow of the wall of the comb. The same visual techniques are used in the engravings in *Micrographia* as in Faithorne's portrait.

Whereas in Power's image any variation in the black lines that delineated the honeycombs was the result of the uneven way in which the paper took up the ink, in Hooke's plate the seeds do seem to be 'glistering in the Sun-shine like Tissue, or the Foil on the backside of a Looking-glass.'[63] This illusion is created through the same vocabulary that made the King's armour glisten. The bright white of the paper shines through on the tops of the 'rais'd ridges' and the sides of the ridges are heavily shaded, like the back of Charles's shoulder. In addition, in the same seed on the upper right, one of the combs is so directly in the light as to reflect back the light cast on it. We know from Hooke's description that the seeds are 'of a dark brownish red colour'.[64] In addition, we know from looking at Charles's armour that a bright white section of paper showing through does not indicate a white spot. Hooke's text combined with our understanding of the visual vocabulary of engraving clearly indicate that we are seeing a reflection and not 'a *whiteness in the colour*'.

Although this plate showing five poppy seeds is just one of the 38 included in *Micrographia*, it shows clearly how different Hooke's images were from earlier ones, and the comparison with Faithorne's portrait of Charles II helps us to understand *how* that difference is accomplished. It would be easy to dismiss this difference as dependent on the engravers and not on Hooke, but that would be underestimating Hooke's commitment to the visual component of his book. As we have seen, he spent a great deal of time looking at his objects of study before drawing them. In addition, he writes in the preface

that 'in divers of them the Gravers have pretty well follow'd my directions and draught'.[65] Although this may sound like slight praise, Hooke was well known in the period as being someone who was willing to openly express his displeasure should his ire be stoked, so this comment should be read as an endorsement for the engravings.[66]

There are very few extant drawings from Hooke's hand related to the production of *Micrographia*, but there are many drawings connected to other projects.[67] A leaf of drawings in a manuscript at the British Library includes several drawings of insects that have recently been attributed to Hooke.[68] One of the figures, of a stick-like bug, shows how the visual vocabulary of portrait engraving was incorporated into Hooke's drawing style (figure 8). We can see clearly in this drawing how the light was reflected off the insect's back. The pen strokes along the ridge of the back become sparser as they approach the high point and finally, on the highest section, the paper shows through as we saw on Charles's armour. Even though this particular insect does not appear in *Micrographia*, it provides concrete evidence that Hooke's drawings as well as the printed images in the book owe a debt to the visual vocabulary of portrait engraving.

Although Hooke's *Micrographia* was published only one year after Power's *Experimental Philosophy*, and John Martyn and James Allestry, Printers to the Royal Society, published them both, the images included in their books are markedly different. As this essay has shown, this difference is due in part to Hooke's connections to the artistic community in London and his interest in printing and the printed image. Further, the effect of accuracy was produced through visual references to other images. The plates in *Micrographia* shocked and fascinated viewers in the seventeenth century. Samuel Pepys records staying up until 'two o'clock in my chamber reading of Mr. Hooke's Microscopicall Observations, the most ingenious book that ever I read in my life.'[69] The book also circulated throughout Europe and was the basis of the illustrations in many other books on microscopy. Even those who disagreed with Hooke copied his images in their books, such as a text by a Jesuit priest published in 1691 arguing for an Aristotelian view of spontaneous generation.[70] Although Filippo Buonanni held markedly different views about the natural world from Hooke's, he still included copies of a number of Hooke's plates in his own book. Johann Griendel, who set out to create a new *Micrographia*, also copied Hooke plates, but without the same level of visual skill or detail.[71] In addition, Hooke's plates continued to be printed long after his death. In 1745 Henry Baker reprinted Hooke's plates along with new text explaining them.[72] A further edition was published in 1780.[73] Hooke's images became the standard point of reference for depicting the microscopic world.

For more than 100 years Hooke's remarkable plates provided viewers with a glimpse of the microscopic world that vividly called to mind a three-dimensional world using a visual vocabulary that clearly and coherently translated three dimensions into two. The use of this familiar vocabulary helped to construct an illusion of the act of looking at the visible world. That is, by using the visual vocabulary of engraving, Hooke's images present the microscopic world in a recognizable idiom that creates a sense of accuracy because the images appear to represent a three-dimensional world that can only be seen with the aid of 'artificial organs'. Their careful creation and the use of a familiar idiom yielded images that were accepted as representations of Hooke's 'new visible world'. These images were deeply embedded in the act of looking at a particular object. Hooke's discovery of their true form was informed by his own training and interest in the visual arts. Hooke filled the space between looking at an object and picturing one with his knowledge of artistic practice.

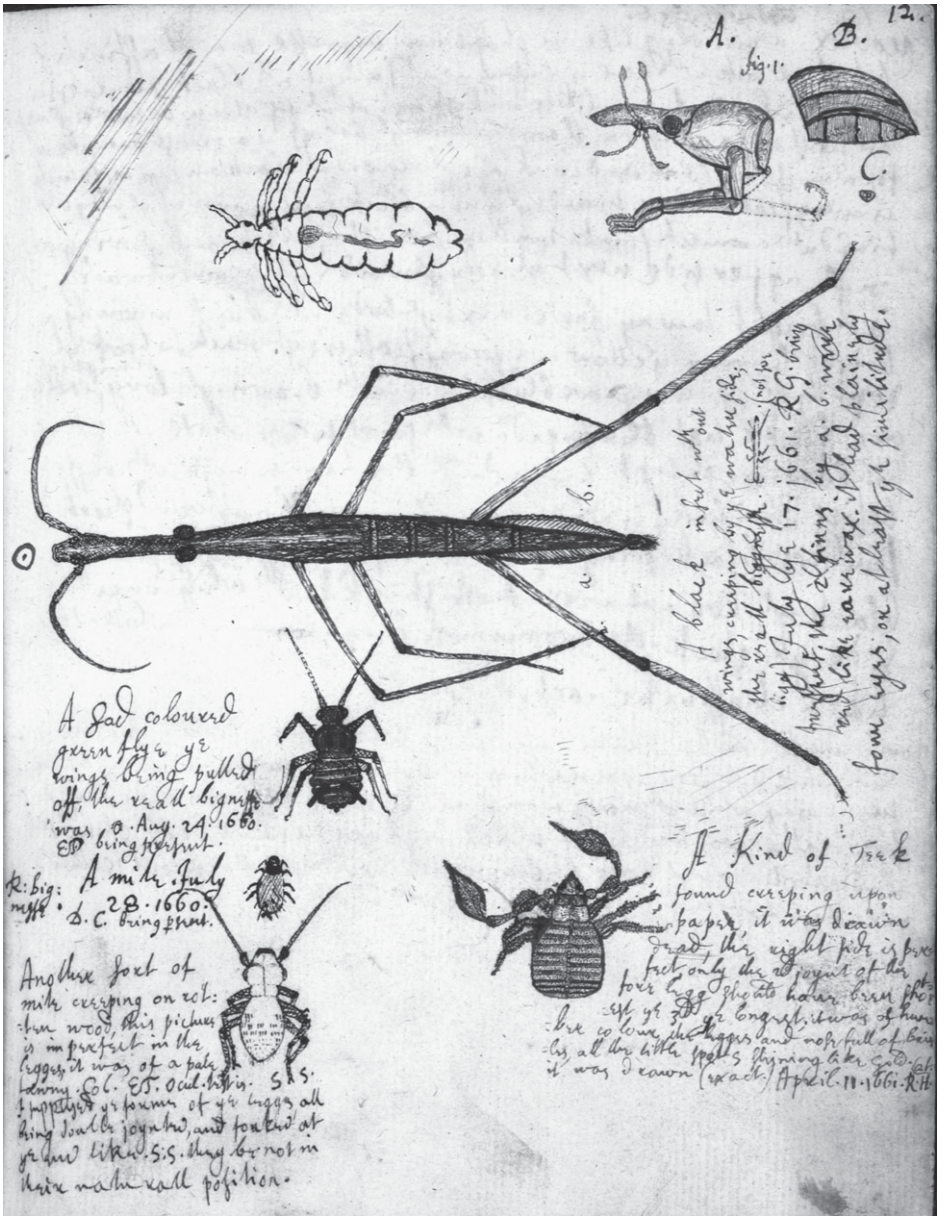


Figure 8. Robert Hooke, Drawing of an Insect from John Covel, *Natural History Notebook and Commonplace Book, 1660–1713*. (Copyright © British Library Board (Add. MSS 47495).)

Acknowledgements

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Humanities Dissertation Fellowship. An Andrew W. Mellon Foundation/ACLS Early Career Fellowship Program Recent Doctoral Recipients Fellowship allowed me time to revise the essay.

Notes

1 Hooke, *Micrographia, or, Some Physiological Descriptions of Minute Bodies Made* (printed by J. Martyn and J. Allestry, London, 1665), preface, f. 2v. Throughout this paper the spelling and punctuation of the original sources have been maintained.

2 Although historians of science may not find Edgerton's thesis about the geometrization of space compelling, the connections he makes between Galileo and Florentine *disegno* are informative for my own approach to Hooke and seventeenth-century visual culture. Samuel Y. Edgerton, 'Geometrization of astronomical space: Galileo, Florentine disegno, and the "Strange Spottednesse" of the Moon', in *The heritage of Giotto's geometry: art and science on the eve of the Scientific Revolution*, pp. 223–253 (Cornell University Press, Ithaca, 1991). For an example of a contemporary finding Galileo's view of the moon transformative of his own viewing see Terrie F. Bloom, 'Borrowed perceptions: Harriot's maps of the Moon', *J. Hist. Astron.* **9**, 117–122 (1978).

3 Examinations of deer hair with modern microscopes reveal the sponge-like form of the hair.

4 Thomas Birch, *The History of the Royal Society of London* (printed for A. Millar, London, 1756), vol. 1, p. 342 (9 December 1663).

5 *Ibid.*, vol. 1, p. 342 (9 December 1663).

6 *Ibid.*, vol. 1, p. 343 (9 December 1663).

7 *Ibid.*, vol. 1, p. 348 (23 December 1663).

8 'Mr. Clayton promised to furnish him with some deer's hair brought from the Indies.' Birch, *op. cit.* (note 4), vol. 1, p. 343 (9 December 1663).

9 Hooke, *op. cit.* (note 1), p. 158.

10 Hooke, *op. cit.* (note 1), preface, a2r–v.

11 Meghan C. Doherty, 'Creating standards of accuracy: Faithorne's *The Art of Graveing* and the Royal Society', in *Science in print: essays on the history of science and the culture of print* (ed. Rima D. Apple, Gregory J. Downey and Stephen L. Vaughn), pp. 15–36 (University of Wisconsin Press, Madison, 2012).

12 *Oxford English Dictionary*, s.v. 'accurate', definition 3, quotations.

13 *Oxford English Dictionary*, s.v. 'accurate', etymology.

14 Lorraine Daston and Peter Galison, *Objectivity* (Zone Books, New York, 2007). They argue (p. 67) that the impulses in the seventeenth century to depict the particulars of individual specimens 'represent an epistemic way of life that was as opposed to that of truth-to-nature as the latter was to objectivity.'

15 Brian J. Ford, *Images of science: a history of scientific illustration* (Oxford University Press, New York, 1993), p. 167. For a study of the place of observation in seventeenth century inquiry see Lorraine Daston, 'The empire of observation, 1600–1800', in *Histories of scientific observation* (ed. Lorraine Daston and Elizabeth Lunbeck), pp. 81–113 (University of Chicago Press, 2011).

16 Hooke, *op. cit.* (note 1), preface, a2v. Italics in the original.

17 Mary G. Winkler and Albert Van Helden, 'Representing the heavens: Galileo and visual astronomy', *Isis* **83**, 195–217 (1992). Winkler and Van Helden describe Galileo's drawings and the engravings made from them as 'portraits'.

18 I thank Steven C. Turner, Associate Curator, Medicine and Science, National Museum of American History, for his extraordinary efforts to help me understand what the world looks

like through a microscope. While we were studying a flea he had brought in for me to study, I inadvertently pulled off several of its legs while trying to get a better look.

19 Pointon discusses the balance that artists sought in creating likenesses, particularly in the eighteenth century: Marcia Pointon, *Hanging the head: portraiture and social formation in eighteenth-century England* (Yale University Press, New Haven, CT, 1993), esp. Chapter IIIi, 'Likeness and Genre'.

20 Hunter comes closest to the model I am proposing for understanding Hooke's visual output: Matthew C. Hunter, 'Robert Hooke fecit: making and knowing in Restoration London' (PhD thesis, University of Chicago, 2003). Hunter has further elaborated his argument about Hooke and representation in a recent article: Matthew Hunter, 'The theory of the impression according to Hooke', in *Printed images in early modern Britain: essays in interpretation* (ed. Michael Hunter), pp. 167–190 (Ashgate, Farnham, 2010). Although he is more concerned with broad, theoretical understandings of the act of representing ideas visually, my work considers the pragmatics of making images that pass as accurate. Iliffe also puts a great deal of emphasis on Hooke's connections to artisans: Rob Iliffe, 'Material doubts: Hooke, artisan culture and the exchange of information in 1670s London', *Br. J. Hist. Sci.* **28**, 285–318 (1995). Lisa Jardine, Margaret 'Espinasse and Michael Cooper all discuss Hooke's connections to artists and craftsmen but do not stress the formative role of these interactions: Lisa Jardine, *The curious life of Robert Hooke: the man who measured London* (Harper Collins, London, 2003), pp. 53–57; Margaret 'Espinasse, *Robert Hooke* (William Heinemann, London, 1956), p. 46; Michael Cooper, 'Hooke's career', in *London's Leonardo: the life and work of Robert Hooke* (Oxford University Press, 2003), pp. 1–62.

21 Jim Bennett, 'Hooke's instruments', in *London's Leonardo* (*op. cit.* (note 20)), p. 80. See also Michael Aaron Dennis, 'Graphic understanding: instruments and interpretation in Robert Hooke's *Micrographia'*, *Sci. Context* **3**, 309–364 (1989).

22 Birch, *op. cit.* (note 4). Gail Ewald Scala, 'An index of the proper names in Thomas Birch, *The History of the Royal Society* (London, 1756–1757)', *Notes Rec. R. Soc. Lond.* **28**, 263–329 (1974). Robert Hooke, *The Diary of Robert Hooke, M.A., M.D., FRS, 1672–1680, transcribed from the original in the possession of the Corporation of the City of London (Guildhall Library)* (ed. Henry W. Robinson and Walter Adams) (Taylor and London Francis, London, 1935). Felicity Henderson, 'Unpublished material from the Memorandum Book of Robert Hooke, Guildhall Library MS 1758', *Notes Rec. R. Soc. Lond.* **61**, 129–175 (2007).

23 'Espinasse, *op. cit.* (note 20), p. 46. John Aubrey in his account of Hooke's life also notes that he 'had some instruction in draweing' from Samuel Cooper, whom Aubrey described as the 'prince of limners of this age': John Aubrey, *'Brief Lives' Chiefly of Contemporaries, Set Down by John Aubrey, between the Years 1669 and 1696* (ed. Andrew Clark) (Clarendon Press, Oxford, 1898), p. 410.

24 Diana Dethloff, 'Lely, Sir Peter (1618–1680)', in *Dictionary of National Biography* (Oxford University Press, 2004).

25 Aubrey, *op. cit.* (note 23), p. 410; *Grove Dictionary of Art*, s.v. 'Lely, Sir Peter'.

26 Birch, *op. cit.* (note 4), vol. 2, p. 111 (22 August 1667). The group of painters included Lely, Robert Streater and Samuel Cooper. The prospect of visiting the painters was again raised in December of the same year. Birch, *op. cit.* (note 4), vol. 2, p. 230 (19 December 1667).

27 Hooke, *op. cit.* (note 22), p. 204.

28 'Mr. Kirk here saw Picture box [e.g. *camera obscura*] and Raritys.' Hooke, *op. cit.* (note 22), p. 142 (19 January 1674/5).

29 Birch, *op. cit.* (note 4), vol. 1, p. 313 (October 12, 1663).

30 See, for example, Birch, *op. cit.* (note 4), vol. 2, p. 436 (26 May 1670).

31 Svetlana Alpers, *The art of describing: Dutch art in the seventeenth century* (University of Chicago Press, 1983), pp. 27–33. For a collection of essays on artists and the *camera*

obscura see Wolfgang Lefèvre (ed.), *Inside the camera obscura: optics and art under the spell of the projected image* (Preprint 333, Max Planck Institute for the History of Science, Berlin, 2007).

32 Hooke, *op. cit.* (note 22), p. 140 (6 January 1674/5).

33 *Ibid.*

34 For mentions of drawings of microscopical observations see, for example, Birch, *op. cit.* (note 4), vol. 1, p. 219 (22 April 1663), *ibid.*, vol. 1, p. 231 (29 April 1663) and *ibid.*, vol. 1, p. 234 (6 May 1663). For drawings of instruments see, for example, Birch, *op. cit.* (note 4), vol. 1, p. 287 (29 July 1663), *ibid.*, vol. 1, p. 295 (19 August 1663) and Henderson, *op. cit.* (note 22), p. 143 (11 July 1672).

35 Hooke was asked to draw the stones that were taken out of the Earl of Belcarres's heart; Birch, *op. cit.* (note 4), vol. 1, p. 292 (5 August 1663). He also presented drawings based on Hevelius's and Cassini's reports of comet sighting. Henderson, *op. cit.* (note 22), p. 142 (19 June 1672). Although many of these drawings have been lost, several of them do still exist in the Archives of the Royal Society, including that of the heart stones: Register Book Original, vol. 2, p. 66 (RBO/2i/66).

36 See, for example, Birch, *op. cit.* (note 4), vol. 2, pp. 31–32 (19 April 1665).

37 Hooke, *op. cit.* (note 22), p. 169 (12 July 1675).

38 *Ibid.*, p. 170 (24 July 1675).

39 Hooke's copy is now in the collection of the British Library (Shelfmark 536.l.21.(3.)). *A Book of Drawing, Limning, Washing or Colouring of Maps and Prints* (printed by M. Simmons for T. Jenner, London, 1666).

40 Matthew Hunter, 'Hooke's figurations: a figural drawing attributed to Robert Hooke', *Notes Rec. R. Soc.* **64**, 251–260 (2010), at p. 254.

41 On 29 June 1674 Hooke recorded that he had 'Invented the way of printing with the common press pictures made with Pinns. An Invention of Great use. Of this more elsewhere': Hooke, *op. cit.* (note 22), pp. 109–110. For notes on others' innovations see, for example, Hooke, *op. cit.* (note 22), pp. 17 (21 December 1672), 19 (3 January 1672/3), 24 (27 January 1672/3), 57 (26 August 1673), 65 (14 October 1673), 95 (3 April 1674) and 143 (22 January 1674/5).

42 Hooke, *op. cit.* (note 22), p. 65 (14 October 1673).

43 For a discussion of Hooke's connections with Ogilby and his atlas projects see E. G. R. Taylor, 'Robert Hooke and the cartographical projects of the late seventeenth century (1666–1696)', *Geogr. J.* **90**, 529–540 (1937).

44 Others in the list include William Faithorne, Mr Davys the Younger, Wat Dole (probably Walter Dole, Faithorne's apprentice) and Mr Lamb. These names appear throughout Hooke's diary (Hooke, *op. cit.* (note 22)): Hollar, pp. 54 (9 August 1673), 55 (16 August 1673), 108 (16 June 1674), 136 (15 December 1674), 249 (14 September 1676) and 379 (2 October 1678); Davys, pp. 112 (11 July 1674), 115 (31 July 1674), 116 (7 August 1674), 118 (22 August 1674) and 125 (6 October 1674); Dole, p. 95 (3 and 4 April 1674); Lamb, pp. 85 (6 February 1673/4) and 134 (7, 9 and 10 December 1674).

45 For works by Callot see Hooke, *op. cit.* (note 22), pp. 10 (17 October 1672) and 136 (15 December 1674); for works by Dürer see *ibid.*, p. 170 (23 July 1675).

46 Hooke, *op. cit.* (note 22), p. 38 (9 April 1673).

47 Hooke records owning copies of John Evelyn's *Sculptura* (Hooke, *op. cit.* (note 22), p. 90 (7 March 1673/4)) and Abraham Bosse's *Traicté des manières de graveur en taille douce* (*ibid.*, p. 291 (17 May 1677)), and recorded having 'Bought of Pits, *History of printing* 1sh' (*ibid.*, p. 121 (9 September 1674)).

48 Leona Rostenberg has analysed and published this catalogue. Leona Rostenberg, *The library of Robert Hooke: the scientific book trade of Restoration England* (Modoc Press, Inc., Santa Monica, CA, 1989), p. 133.

49 Hooke, *op. cit.* (note 1), f. 2v.
50 *Ibid*., f. 2v. The emphasis is in the original.
51 For more on Faithorne see Meghan C. Doherty, *op. cit.* (note 11). In all likelihood, the 'J.O.' who penned the verses below the image of Charles was John Ogilby, mentioned earlier as someone with whom Hooke discussed drawing techniques.
52 Giovanni Battista Hodierna, *L'Occhio della Mosca Discorso Fisico* (Per Decio Cirillo, Palermo, 1644).
53 Catherine Wilson, *The invisible world: early modern philosophy and the invention of the microscope* (Princeton University Press, 1995), p. 76. Marian Fournier, *Fabric of life: microscopy in the seventeenth century* (The Johns Hopkins University Press, Baltimore, MD, 1996), p. 26.
54 This is the case in the copy of this work that I consulted in the collection of the British Library (Shelfmark 537.c.15.(1.)).
55 Fournier, *op. cit.* (note 53), p. 14.
56 Fournier, *op. cit.* (note 53), pp. 26–27.
57 Henry Power, *Experimental Philosophy, in Three Books: Containing New Experiments Microscopical, Mercurial, Magnetical* (printed by T. Roycroft for John Martyn and James Allestry, London, 1664).
58 *Ibid.*, p. 46.
59 See, for example, his Apocalypse series: Matthias Mende, *Albrecht Dürer: zum Leben, zum Holzschnittwerk, Chronologisches Verzeichnis der Holzschnitte, Hinweise zum aktuellen Schrifttum, Zeittafel, Kondordanz*, nos 97–112 (Edition Tomas, Munich, 1976), and Walter L. Strauss, *Sixteenth century German Artists: Albrecht Dürer*, vol. 10 (*The Illustrated Bartsch*), nos 60–75 (Abaris Books, New York, 1980).
60 Power, *op. cit.* (note 57), p. 49.
61 Hooke, *op. cit.* (note 1), p. 155. I thank Sean Clark, Associate Professor of Agriculture and Natural Resources, Berea College, for pointing out to me that the reticulum of a bovine digestive system has a honeycomb-like surface and is sometimes referred to as honeycomb tripe.
62 Hooke, *op. cit.* (note 1), f. 2v.
63 Power, *op. cit.* (note 57), p. 49.
64 Hooke, *op. cit.* (note 1), p. 155.
65 *Ibid*., f. 2v.
66 See, for example, his conflict with Newton. Margaret 'Espinasse begins her biography of Hooke with an account of how Hooke's death in 1703 was the condition on which it was possible for Newton to become President of the Royal Society: 'Espinasse, *op. cit.* (note 20), p. 1. Similarly, Lisa Jardine begins her account of Hooke's life with his dispute with Newton: Jardine, *op. cit.* (note 20), pp. 1–19.
67 For a reproduction of one of the few drawings related to *Micrographia* see John T. Harwood, 'Rhetoric and graphics in *Micrographia*', in *Robert Hooke: new studies* (ed. Michael Hunter and Simon Schaffer), plates 9a and 9b (The Boydell Press, Woodbridge, 1989). Volume 20 of the Classified Papers in the Archives of the Royal Society comprises papers written by Hooke. Many of these papers include sketches by Hooke that clarify and augment the arguments he makes in the text.
68 The drawing is folio 113v in Add. MS 57495 at the British Library. Janice Neri has attributed this drawing to Hooke: Janice Neri, 'Some early drawings by Robert Hooke', *Arch. Nat. Hist.* **32**, 41–47 (2005); *idem*, 'Between observation and image: representations of insects in Robert Hooke's *Micrographia*', in *The art of natural history: illustrated treaties and botanical paintings, 1400–1850* (ed. Therese O'Malley and Amy R. W. Meyers), pp. 95–99 (National Gallery of Art, Washington DC, 2008); *idem*, *The insect and the image: visualizing nature in early modern Europe, 1500–1700* (University of Minnesota Press, Minneapolis, 2011), pp. 123–131.

69 Robert Latham and William Matthews (eds), *The diary of Samuel Pepys: a new and complete transcription* (University of California Press, Berkeley and Los Angeles, 1970), vol. 6, p. 18 (21 January 1664/5).

70 Filippo Buonanni, *Micrographia Curiosa sive Rerum Minutissimarum Observationes* (Typis Dominici Antonij Herculis, Rome, 1691).

71 Johann Franz Griendel, *Micrographia Nova, sive, nova et curiosa variorum minutorum corporum* (Sumptibus Johannis Ziegeri, Nuremberg, 1687). The book was presented by Hooke at a meeting of the Royal Society as described as 'giving the figures of several insects, seeds, &c. many the same with those in Mr. Hooke's *Micrograpphia*, but much worse designed': Birch, *op. cit.* (note 4), vol. 4, p. 541 (8 June 1687).

72 Robert Hooke, *Micrographia restaurata, or, The copper-plates of Dr. Hooke's wonderful discoveries by the microscope, reprinted and fully explained* (ed. Henry Baker) (printed for and sold by John Bowles, London 1745).

73 Robert Hooke, *Microscopic observations; or, Dr. Hooke's wonderful discoveries by the microscope, illustrated by thirty-three copper-plates, curiously engraved* (printed for John Wilkinson, London, 1780).