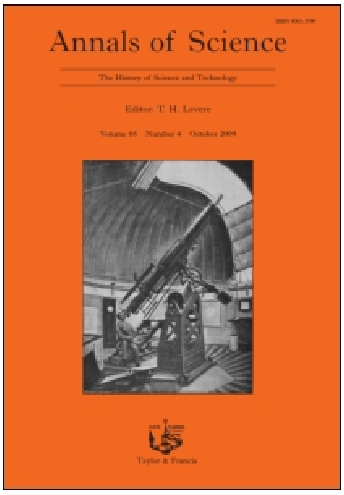

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The representation of insects in the seventeenth century: a comparative approach

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The representation of insects in the seventeenth century: a comparative approach

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Summary

The investigation and representation of insects in the seventeenth century posed huge problems: on the one hand, their size and texture required optical tools and fixation techniques to disentangle and identify their tiny parts; on the other, the esoteric nature of those parts required readers to make sense of images alien to their daily experiences. Naturalists and anatomists developed sophisticated techniques of investigation and representation, involving tacit and unusual conventions that even twentieth-century readers found at times baffling. This essay develops a comparative approach based on seven pairs of investigations involving Francesco Stelluti, Francesco Redi, Giovanni Battista Hodierna, Robert Hooke, Marcello Malpighi, and Jan Swammerdam. Seen together, they document an extraordinary time in the study of insects and reconstruct a number of iconographic dialogues shedding light on the conventions and styles adopted.

Contents

1. Introduction

The study of insects poses considerable problems to the investigator because of the softness and diminutive size of their body parts: just imagine tracing the digestive or the nervous system of a fly. These problems extend to the issue of representation: during the seventeenth century, with improvements in microscopes and techniques of microscopic investigation, researchers faced the issue of representing insects and their body parts that looked increasingly more remote and alien from the common perceptions of readers. Whereas in the first decades of the century readers may have been startled to see images of insects in unprecedented magnification and detail, but still in overall recognisable form, by the end of the 1660s many would have been unable to make sense of esoteric images displaying a silkworm's female genitalia or

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its silk-producing glands. While developing novel techniques of investigation, seventeenth-century microscopists invented novel techniques of representation as well, in the form of a visual language that could convey meaningful and decodable information to readers.

These issues are not simply the concern of present-day historians but were debated by seventeenth-century investigators as well, such as Robert Hooke, Marcello Malpighi, and Jan Swammerdam. Besides discussing the matter in words, microscopists also addressed the problem visually, responding to each others' images with new ones, seeking to correct or better their predecessors' in matters of accuracy and effectiveness, as in an iconographic dialogue; unlike Hooke, Swammerdam, for example, showed the posture of the water gnat in water, and corrected several features in Malpighi's figures of the silkworm. In some cases the objects of investigation were sufficiently prominent and obvious that microscopists studied them independently; yet these cases too prove exceedingly instructive in highlighting different interests and techniques of investigation and representation. Whether microscopists studied insects independently or not, a comparative study reveals a web of connections among images and texts. Focusing on pairs of closely related images can be a helpful tool of investigation enabling the viewer to make sense of problematic visual representations in an especially appropriate, focused, and circumscribed context. Many readers will be familiar with at least some of the figures I discuss; a comparative approach, however, enables the viewer to see them in a different light because the eye and the mind are constantly drawn back-and-forth to analyse features that at first sight one may have taken for granted. I often found myself in my rare books library armed with a panoply of magnification devices pouring over minute details of related engravings.[1]

I present seven cases dating from the beginning of insect microscopy in the second quarter of the century with Francesco Stelluti and Giovanni Battista Hodierna, to its maturity in the third quarter with Robert Hooke, Francesco Redi, Marcello Malpighi, and Jan Swammerdam. The images I study represent whole bodies and body parts and involve different investigations and printing techniques, from the usage of lighting effects to the exploitation of symmetry and from woodcut to copper engravings. The study and representation of insects go well beyond the few cases I have selected here, even for my focus on closely related images. Nonetheless, even the few cases I discuss highlight the fruitfulness of my approach: they document the struggle towards an effective visual language in the representation of insects and the emergence of a sophisticated art of representation that was to become the basis for future studies in the Enlightenment.

[1] The following items provide a useful introduction to the extensive literature on representation in the history of science: Caroline A. Jones and Peter Galison, eds, *Picturing Science, Producing Art* (New York: Routledge, 1998). Brian S. Baigrie, ed., *Picturing Knowledge* (Toronto: University of Toronto Press, 1996). Sachiko Kusukawa and Ian Maclean, eds, *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe* (Oxford: Oxford University Press, 2006). Focus section on *Science and Visual Culture* in *Isis*, 97 (2006), 75–220. Nancy Anderson, 'Eye and Image: Looking at Visual Studies of Science', *Historical Studies in the Natural Sciences*, 39 (2009), 115–25. Mario Biagioli, *Galileo's Instruments of Credit. Telescopes, Images, Secrecy* (Chicago: University of Chicago Press, 2007), 185. A striking case of iconographic dialogue is Yve Alain Bois, *Matisse and Picasso* (Paris: Flammarion/Kimbell Art Museum, 1998).

2. Stelluti (1630), Redi (1668), and the wheat weevil

In 1630 the member of the Lyncean Academy Francesco Stelluti published *Persio tradotto*, rendering into Italian six elegies by the first century Roman poet Aulus Persius Flaccus (Figure 1). It was in this unlikely setting that Stelluti included digression after digression on topics ranging from the announcement of the forthcoming *Dialogo* by the fellow Lyncean Galileo Galilei to the external anatomy of insects. Indeed, Stelluti's *Persio* is often referred to as the first book to include images of insects enlarged by optical devices. Bees were a focal point of attention under Urban VIII, since they figured in his coat of arms, and Stelluti duly devoted a celebrated plate to them in his book, developing an image he had produced five years earlier in a broadsheet, *Melissographia*. This, however, is not my main focus here: rather, I wish to discuss another plate depicting the wheat weevil infesting the Italian harvests, one that would have been familiar to most readers. Stelluti shows at top right the insect as it appears with the naked eye, whereas on the top left we see a detail of the rostrum. The shading does not add much to the figure, but rather disturbs the viewer; worse than that, the cleavage along the rostrum appears to be a misrepresentation due to lighting effect, since the rostrum is whole and is not for eating but for boring. As such, Stelluti's plate looks interesting enough, but we can appreciate it with different eyes in relation to another related plate.[2]

In the summer and fall of 1654 Francesco Redi, the naturalist and future Medici archiater, spent several months in Rome. Recent work has emphasised the significance of this episode for the contacts Redi is likely to have established with the secretary of Cardinal Francesco Barberini, Cassiano dal Pozzo, and his circle, including Stelluti. Given Redi's interests in microscopy and insects, it is likely that he was familiar with *Persio tradotto*. It is especially instructive to compare the engraving of the wheat weevil in Stelluti's *Persio* with Redi's in 1668 *Esperienze intorno alla generazione degli insetti*, his celebrated treatise in which he challenged spontaneous generation (Figure 2). A plate of his treatise shows a very closely related specimen, possibly of the very same species. Both images show the external features of the insect viewed from the top. Although the insects may appear broadly similar to the untrained eye, a closer look reveals striking differences that cannot be explained away in terms of different species: Redi's rostrum is not fissured; Stelluti's weevil has prominent eyes that seem totally lacking in Redi's; legs too appear quite different; the number of body parts differs, as does their overall appearance, with Redi's weevil displaying distinctive variations among the different segments, with grooves and pits, whereas Stelluti's looks more uniform.[3]

Microscopes underwent considerable improvements during the nearly four decades separating the two publications; moreover, Redi would have had at his disposal a number of top-of-the-range instruments available at the Tuscan court, including English microscopes and one by the leading Rome maker Eustachio Divini;

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[2] Francesco Stelluti, *Persio tradotto* (Rome: Mascardi, 1630), 127. David Freedberg, *The Eye of the Lynx* (Chicago: University of Chicago Press, 2002), 186–94.

[3] Luigi Guerrini, 'Contributo critico alla biografia rediana. Con uno studio su Stefano Lorenzini e le sue "Osservazioni intorno alle torpedini"', in *Francesco Redi. Un protagonista della scienza moderna,* edited by Walter Bernardi and Luigi Guerrini (Florence: Olschki, 1999), 47–69, at 50–1. Francesco Redi, *Esperienze intorno alla generazione degli insetti* (Firenze: All'insegna della Stella, 1668), plate 25. There is a modern edition with an introduction by Walter Bernardi, (Firenze: Giunti, 1996), 223.

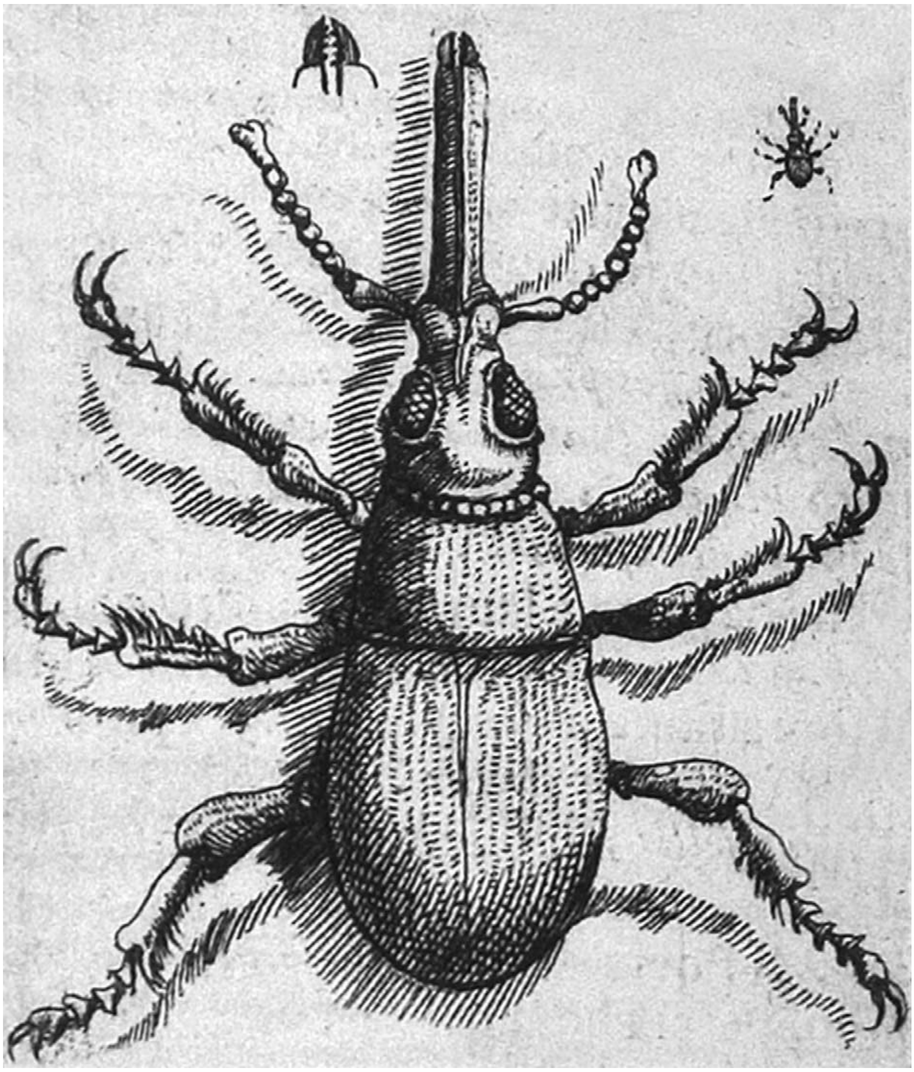

Figure 1. Stelluti, *Persio tradotto*, 'gorgoglione del frumento'.

techniques of microscopic investigations too improved considerably between 1630 and 1668. Despite the correction to the rostrum, however, Redi's figure shows in other respects no overall improvement in rendering the weevil's features, such as the eyes and number of body parts, over Stelluti's, thus highlighting the problems of investigation and visualisation encountered by early microscopists.[4]

[4] Silvio A. Bedini, 'Seventeenth-Century Italian Compound Microscopes', *Physis*, 5 (1963), 383–422. Edward G. Ruestow, *The Microscope in the Dutch Republic* (Cambridge: Cambridge University Press, 1996), chapter 1. Redi, *Esperienze*, Bernardi's edition, 117, 155, 170, 196.

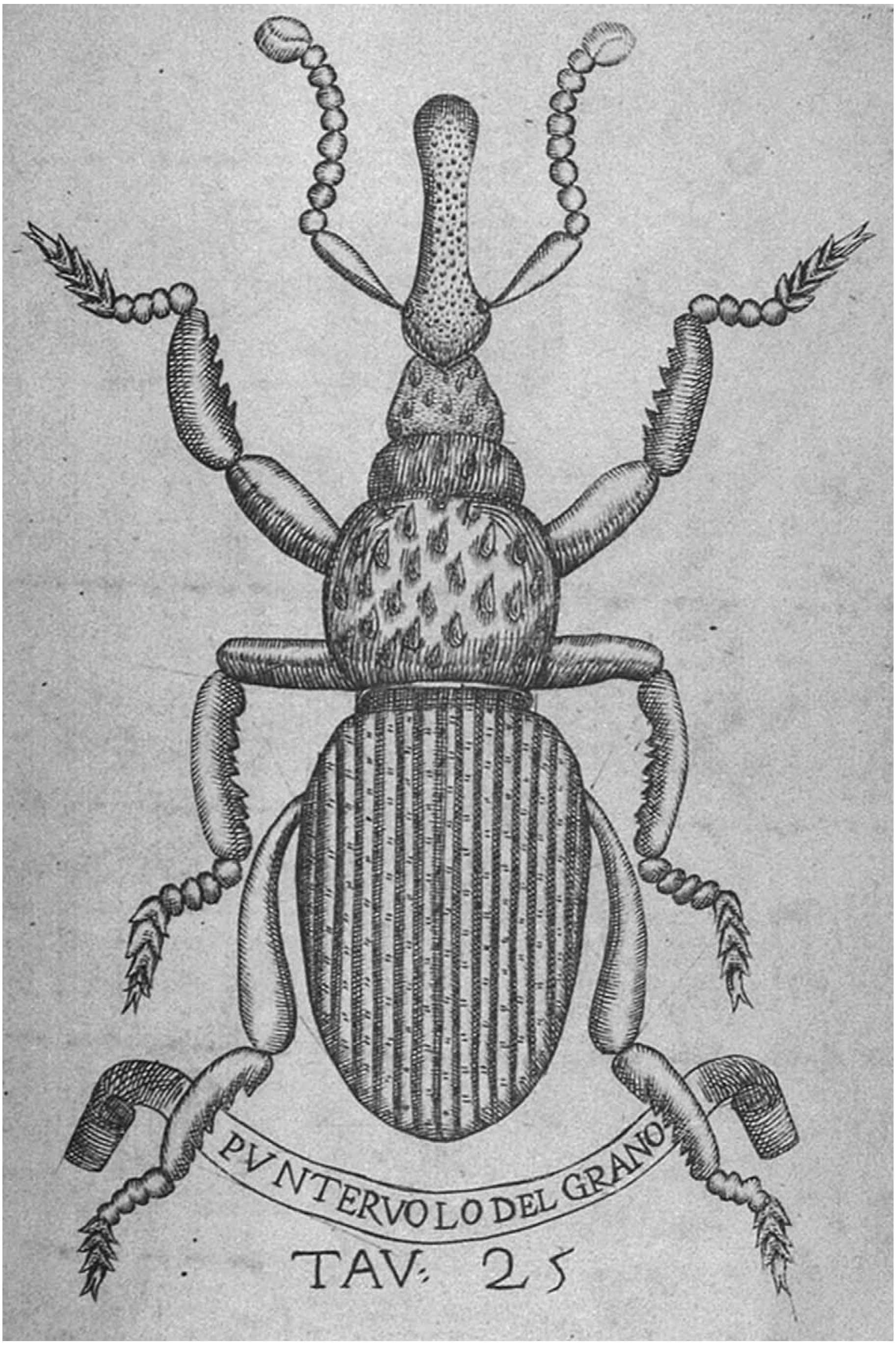

Figure 2. Redi, *Esperienze intorno alla generazione degli insetti*, 'punteruolo del grano'.

3. Hodierna (1644), Hooke (1665), and the eye of the fly

Giovanni Battista Hodierna was a priest at the court of the Barons of Lampedusa in Southwestern Sicily. Hodierna was interested both in astronomy and microscopy and published distinguished works in both areas. Although Palma di Montechiaro, in the province of Agrigento, is an unlikely site in the seventeenth-century world of learning, it was there that Hodierna carried out his pioneering investigations.[5]

In 1644 Hodierna published a collection of studies of *Opuscoli*, including one on the eye of the fly, *L'occhio della mosca*. Hodierna relied on a compound microscope or *occhialino* with two semispherical or convex lenses, thicker than a lentil. However, he also claimed that a good single lens as large as a chickpea would be suitable. He provided a brief account both of his optical devices and of the techniques he had employed. For example, he stated that he mounted his device on a tripod to keep it at the right distance from the object and tested the accuracy and focus of the instrument with poppy and lettuce seeds. Hodierna further described the pioneering techniques he employed to dissect the eye: first he boiled it, then he let it dry in the sun, and finally he sectioned it with a very sharp knife, starting from removing the cornea. His innovative preparation enabled him to investigate the internal structure of the eye. Similar techniques were adopted by later microscopic anatomists such as Malpighi in his study of the tongue, for example.[6]

In his description of the eye, Hodierna relied on analogies with the vegetable world, such as a white mulberry, a pomegranate, or a strawberry, using them as a bridge between common experience and esoteric microscopic images: his woodcut—an exception in my essay, since all other images I discuss are engravings—shows at far left (marked E) a white mulberry and at far right (marked F) a strawberry (Figure 3). Hodierna displayed a less than firm grasp of insect anatomy: he failed to see the optic nerve from the eye to the brain of the fly, but noticed instead what he identified as

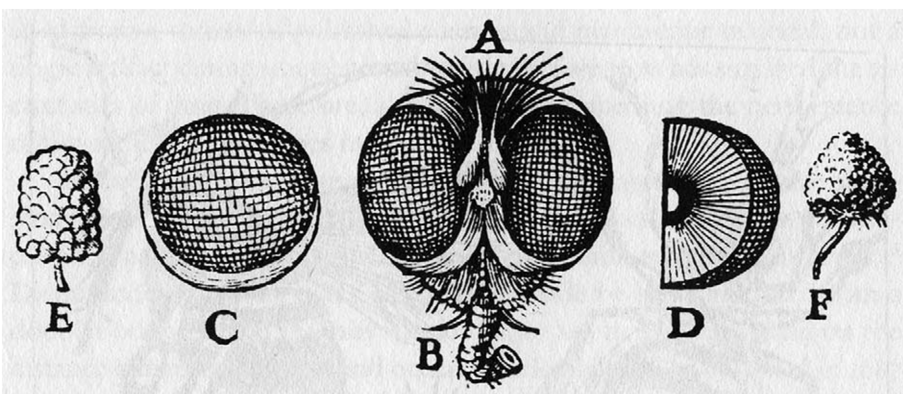

Figure 3. Hodierna, *L'occhio della mosca*, eye of the fly.

[5] Mario Pavone and Maurizio Torrini, eds, *G.B. Hodierna e il 'Secolo cristallino'* (Florence: Olschki, 2002).

[6] Clelia Pighetti, 'Giovan Battista Odierna e il suo discorso su *L'occhio della mosca*', *Physis,* 3, (1961), 309–35, at 329, 331–2. Marcello Malpighi, *Opere scelte*, edited by Luigi Belloni (Torino: UTET, 1967), 13–4.

tenuous and lubricated tendons. He also located at the centre of the eye a white substance resembling the brain, leading him to argue that perception occurs in the eye itself. Moreover, the proboscis at B bears a striking resemblance to that of an elephant.[7]

We now move from the recesses of Sicily in the mid-1640s to London in the early 1660s. In his celebrated *Micrographia* of 1665, Robert Hooke too described his optical tool verbally and through an image, and then proceeded to discuss a number of observations accompanied by striking illustrations, including one of the eye of the fly (Figure 4). It is unlikely that Hooke would have been familiar with Hodierna's treatise, since he did not refer to, or employ, any of the preparation techniques described therein. Both, however, much like Galen in the *Epode* concluding *On the*

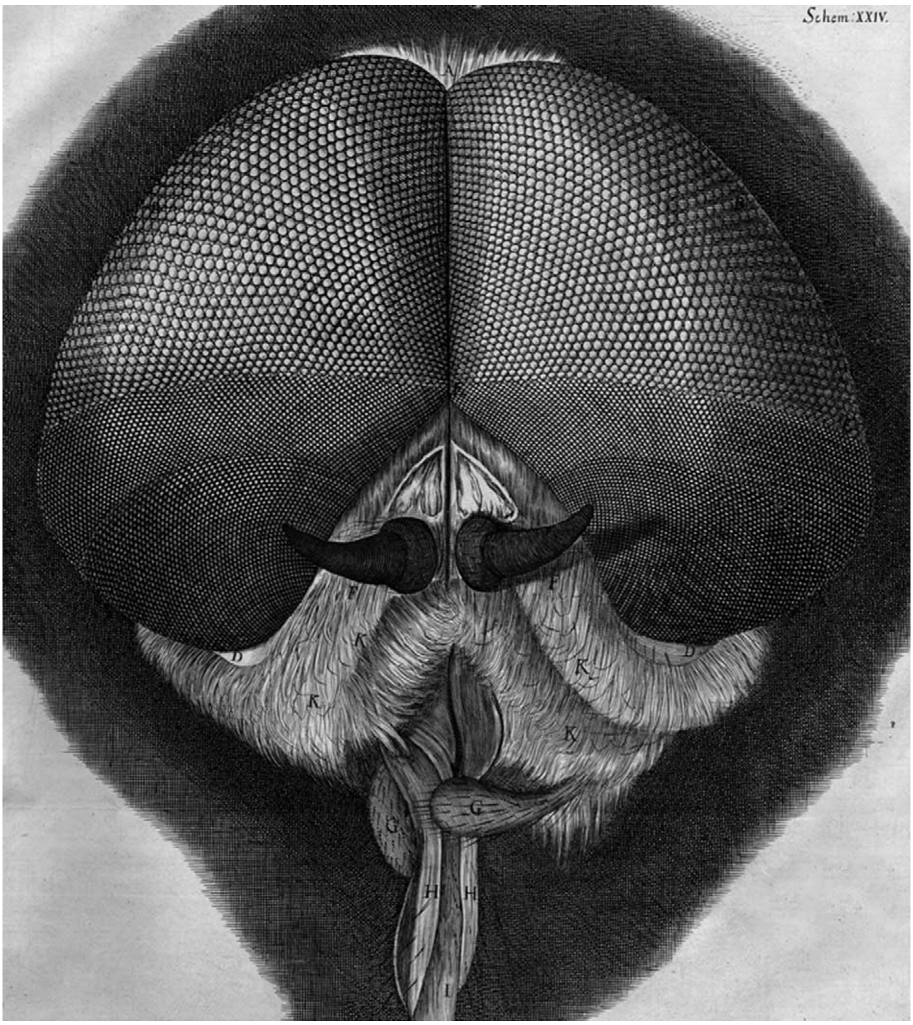

Figure 4. Hooke, *Micrographia*, eye of the fly.

[7] Pighetti, 'Hodierna', 326–7.

Usefulness of the Parts of the Body, highlighted the role of finalism in nature: Hooke specifically challenged Epicurus and his followers, arguing instead for the role of a 'highest Wisdom and Providence'. The high organisation revealed by the microscope supported the role of God's design.[8]

Micrographia was an epoch making publication whose images or 'schemes' arouse admiration even today, several centuries after its first appearance: in terms of scale, detail, and at times dramatic effect, Hooke's skill remained unsurpassed at the time. Hooke did not focus on a single discipline but rather presented a broad selection of microscopic images ranging from the blade of a razor to seeds and moss. Insects played quite a prominent role, as one would expect from their diminutive size.[9] I shall focus on his study of the eye of the gray drone fly.

Hooke selected this particular fly in view of the large size of its eyes and because of the variety occurring in their 'cluster', visible as different horizontal bands (Figure 4), with devilish horns creating a rather disquieting image. Whereas Hodierna tried to familiarise the reader with an unusual image by establishing analogies with common objects such as fruit, Hooke exploited the unfamiliar appearance of the drone eye to dramatic effect. The case of the grey drone is not the only instance in which he relied on the study of a body part in a species in which that part is especially large and accessible. His descriptions are astoundingly vivid and perceptive: especially memorable is his account of dust particles falling into the eye: how does the fly cope, given that those particles would be the size of a large stone for us? Lacking eyelids, the fly periodically wipes its eyes with its legs and then wipes the front legs against each other, in order to clean them. He was able to remove the cornea and found it very similar to that of humans; however, he was unable to gain direct access to the internal structure of the eyes of the fly and reasoned by inference from different animals, such as crustaceans, hypothesising the existence of a retina, for example. This way or proceeding suggests that Hooke did not limit his investigation to the outside of the eye because his interests did not go further: on the contrary, he was unable to go further because of the technical problems involved, such as the lack of consistency of portions of the eye. Thus, despite its unsurpassed dramatic effect, Hooke's figure highlights also a weakness in his techniques. This is a notable difference with respect to Hodierna's, which looks by comparison considerably less striking, although his technique of boiling and drying enabled him to fix its soft or gooey parts and penetrate its interior.[10]

4. Hooke (1665), Swammerdam (1669), and the water gnat

Problems of a different nature occur with the representation of the water gnat. This insect growing in rainwater is of special interest in that it is semi-transparent; in

[8] Pighetti, 'Hodierna', 320, 328. Robert Hooke, *Micrographia* (London: John Martin and James Allestry, 1665), 175–80, at 177. Nick Wilding, 'Graphic Technologies', in *Robert Hooke. Tercentennial Studies, edited by Michael Cooper and Michael C.W. Hunter (Aldershopt: Ashgate, 2006), 123–34. Gerard L.E. Turner, 'The Impact of Hooke's Micrographia* and its Influence on Microscopy', in *Robert Hooke and the English Renaissance,* edited by Paul Kent and Allan Chapman (Gracewing: Anthony Rowe Ltd, 2005), 124–45.

[9] John T. Harwood, 'Rhetoric and Graphic in *Micrographia*', in *Robert Hooke. New Studies*, edited by Michael Hunter and Simon Schaffer (Woodbridge: Boydell, 1989), 119–47. Allan Chapman, *England's Leonardo: Robert Hooke and the Seventeenth-Century Scientific Revolution* (Bristol and Philadelphia: Institute of Physics Publishing, 2005).

[10] Hooke, *Micrographia*, 175–80.

view of the difficulties of dissecting insects due not only to their size but also to the lack of consistency of their body parts, the water gnat offered a rare window into their inner structure. William Harvey had relied on the transparency of some shrimps in the Thames in order to examine the heartbeat without interfering with the animal. Hooke too could detect a beating heart in his specimens and, in addition, the gut—the darker portion in the middle of the body extending from the head to the tail—moving with a peristaltic motion with a black substance moving up and down through it (Figure 5). Hooke's engraving in *Micrographia* shows the water gnat as it appears in different stages of development: the plate is dominated by the diagonal Figure (1 in his scheme) of the larval stage, which, Hooke tells us, is slightly lighter than water and hangs from its surface with the head down and the tail up. Hooke then mentioned that he saw some specimens fly away, leaving their empty husks behind, and this prompted him to seek their intermediate transformation. Notice that Figures 3 and 4 have to be seen rotated by 90°. Hooke's Figure 2 shows another stage in the insect's life, with the dotted line highlighting a different stage of development.[11]

Four years later, the Dutch anatomist Jan Swammerdam published *Historia insectorum generalis*, an ambitious treatise in which he sought to provide a new taxonomy of insects based on their life cycles (Figure 6). Hooke's astounding figures must have left a deep impression on Swammerdam at several levels.

Swammerdam too became interested in the water gnat and referred to Hooke's figures as 'admirable', acknowledging that Hooke was the first to have seen the motion of food and excrements down the digestive tube, for example. However, he also pointed out some problems, as if to imply that the figures of the curator of experiment at the Royal Society were not always reliable. Swammerdam pointed out that Hooke's representation of the water gnat's tail was inaccurate and the nymph (numbered 2 in Hooke's scheme, my Figure 5 above) differed so much from the correct one that Hooke probably had mistakenly taken that of a different species. Swammerdam's own plate (Figure 6) corrects Hooke's and, in addition, shows the different stages of development of the insect: crucially, whereas Hooke had shown the various stages of the water gnat arranged so as to fit on the page with no regard to the actual posture of the insect in water, even rotating one to make it fit into the picture, Swammerdam showed the insect both life-size and under magnification in its environment, with its peculiar stance under the water surface. It was probably the combination of its anatomical features and posture in water that prompted Swammerdam to produce his plate in response to Hooke's.[12]

[11] Hooke, *Micrographia*, 185–91. William Harvey, *Exercitatio anatomica de motu cordis et sanguinis in animalibus* (Frankfurt: Wilhelm Fitzer, 1628); translated by Kenneth J. Franklin with introduction by Andrew Wear as *The Circulation of the Blood and Other Writings* (London: Everyman, 1993), 29. Janice Neri, 'Between Observation and Image: Representations of Insects in Robert Hooke's *Micrographia*', in *The Art Of Natural History: Illustrated Treatises and Botanical Paintings, 1400–1850,* edited by Therese O'Malley and Amy R.W. Meyers (New Haven: Yale University Press, 2008), 83–107, at 90.

[12] Swammerdam's treatise was originally published in Dutch. I refer to the French translation, *Histoire generale des insectes* (Utrecht: Guillaume de Walcheren, 1682), 101–5. See also Observation 54 in Hooke, *Micrographia*, 211–3, and the accompanying plate of a louse, which is shown grasping a hair. Marian Fournier, *The Fabric of Life. Microscopy in the Seventeenth Century* (Baltimore: Johns Hopkins University Press, 1996), 62–72.

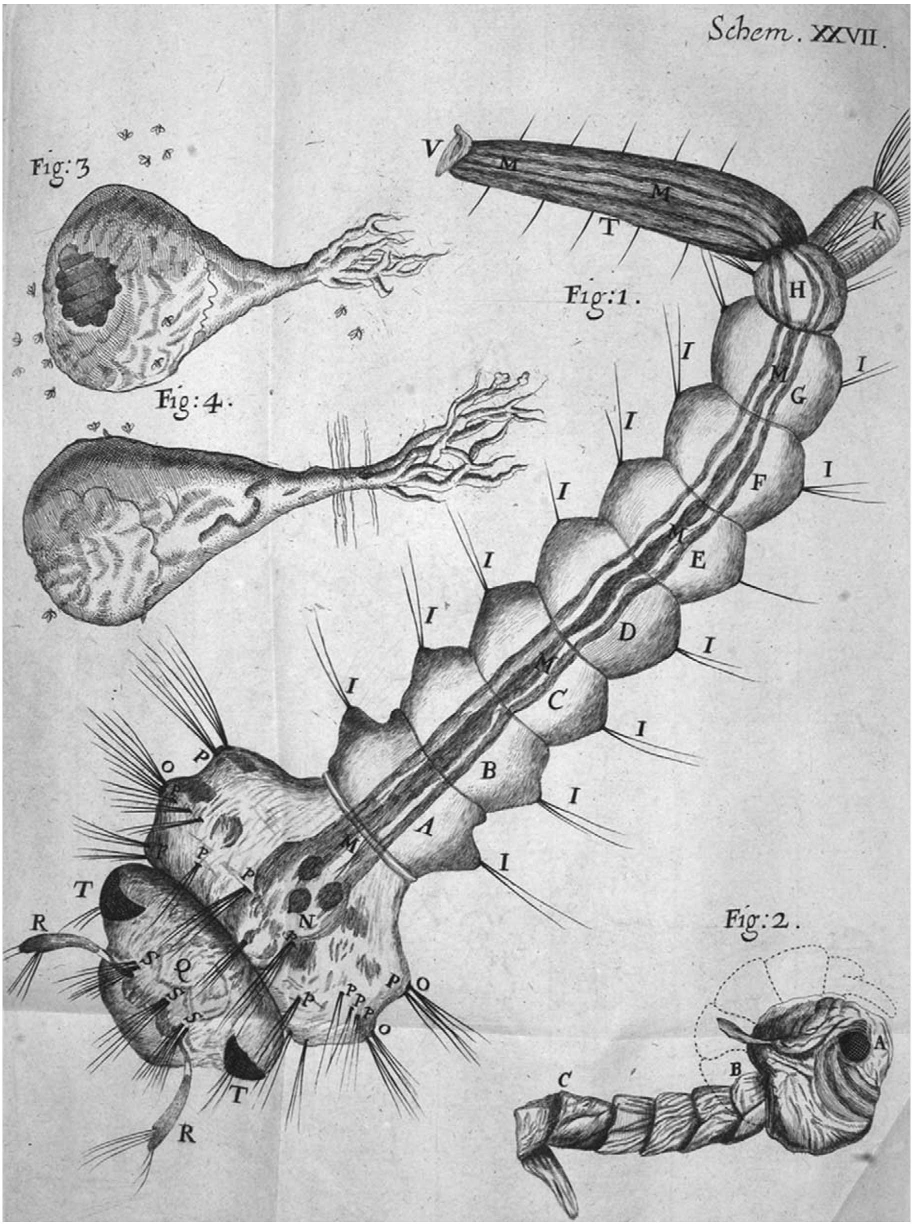

Figure 5. Hooke, *Micrographia*, water gnat.

In Swammerdam's response to Hooke we can identify and reconstruct not only a textual but also an iconographic dialogue.

5. Hooke (1665), Swammerdam (1669), and the usage of lighting effects

I am now going to discuss a different aspect of the approach I have adopted in this paper: this time I am not comparing insects of related—or the same—species and

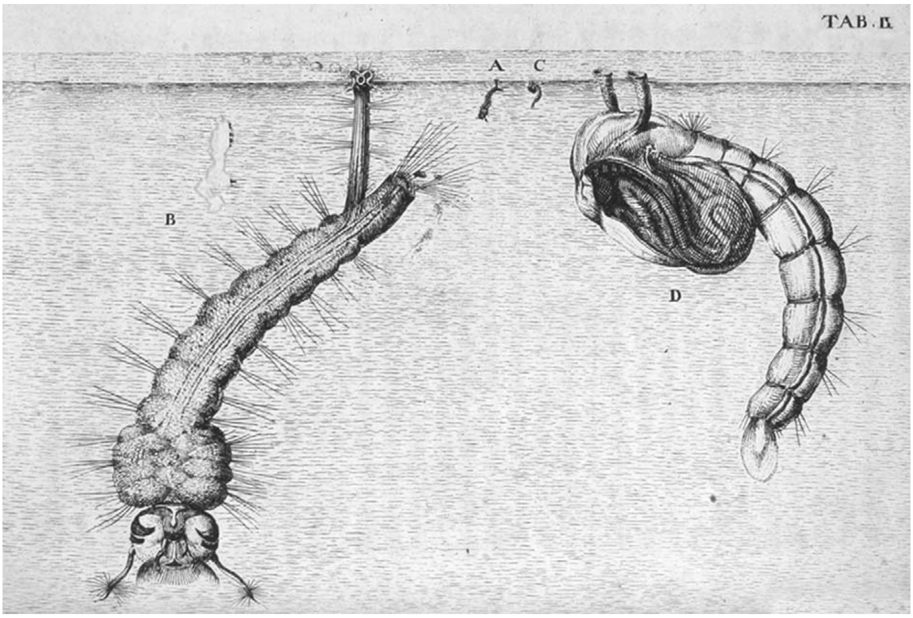

Figure 6. Swammerdam, *Historia insectorum generalis*, water gnat.

their body parts, but rather insects that are best investigated and represented in peculiar lighting conditions, such as white or diaphanous specimens. Such cases require careful handling because some of their surface features, such as hairs and filaments, for example, may be hard to see against a traditional white background and are best shown against a dark one, as if seen in a dark night. Similar techniques of representation had been used in other instances in the past, of course.

Hooke exploited this technique in several cases, such as the celebrated one of moss. But even with regard to insects he produced striking images, such as that of the vine bug: not only did Hooke show the insect from different angles, in order to highlight its front and back, but he also chose a dark background to highlight the white hairs on the insect's body (Figure 7). Here it seems likely that the technique of representation went hand in hand with the technique of investigation, especially lighting effects that would enable the investigator to see as well as represent the object in such dramatic fashion, or possibly placing the specimen on a dark surface for observation.[13]

In *Historia insectorum generalis* Swammerdam discussed this very problem of representation and argued on two grounds against the Dutch artist Johannes Goedaert, who had recently published a book on insects: Goedaert had his plates coloured by hand and had shown insects exclusively against a white background, thus missing details such as white hairs. Although Swammerdam did not mention Hooke at this juncture, he adopted the same technique of his English predecessor (Figure 8); thus it is likely that he was inspired by Hooke in this regard. In his illustration of the life cycle of the different orders of insects he had identified, Swammerdam relied on

[13] Hooke, *Micrographia*, 125 and scheme 12.

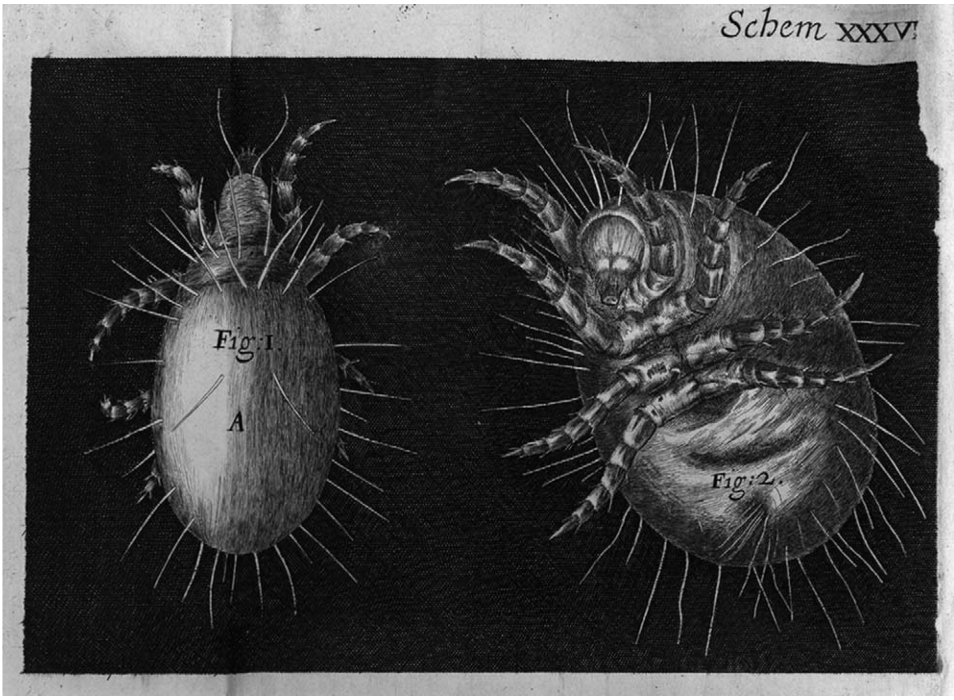

Figure 7. Hooke, *Micrographia*, vine bug.

black-on-white and white-on-black images on the same plate, though as to visual impact his work has nowhere near the dramatic effect achieved by Hooke (compare Figures 7 and 8). As to techniques of investigation, Swammerdam explained that in order to study the water flea, for example, he placed the insect in tiny half globes of glass specially blown for the purpose, or placed them in drops of water on white or coloured paper; he designed this technique of investigation to highlight the contrast of the insect's contour. Swammerdam's technique of investigation had its counterpart in his technique of representation: we witness here a significant correlation between these two aspects.[14]

6. Hooke (1665), Malpighi (1669), and silkworm eggs

Despite his astounding artistic talents and creativity, Hooke never achieved great results in microscopic anatomy going beyond the surface of his specimens. Thus the contrast with Hodierna's work is especially significant: the Sicilian investigator reached where Hooke did not. A similar contrast can be established between Hooke and Marcello Malpighi; indeed, it is likely that Malpighi learnt of Hodierna's

[14] Swammerdam, *Histoire*, 171. Ruestow, *Microscope*, 131n.101, 134. Abraham Schierbeek, *Jan Swammerdam. His life and Works* (Amsterdam: Sweets & Zeitlinger, 1974), 132–73, at 148. Matthew Cobb, 'Malpighi, Swammerdam, and the Colorful Silkworm: Replication and Visual Representation in Early Modern Science', *Annals of Science*, 59 (2002), 111–47, at 131, 135, 145n129.

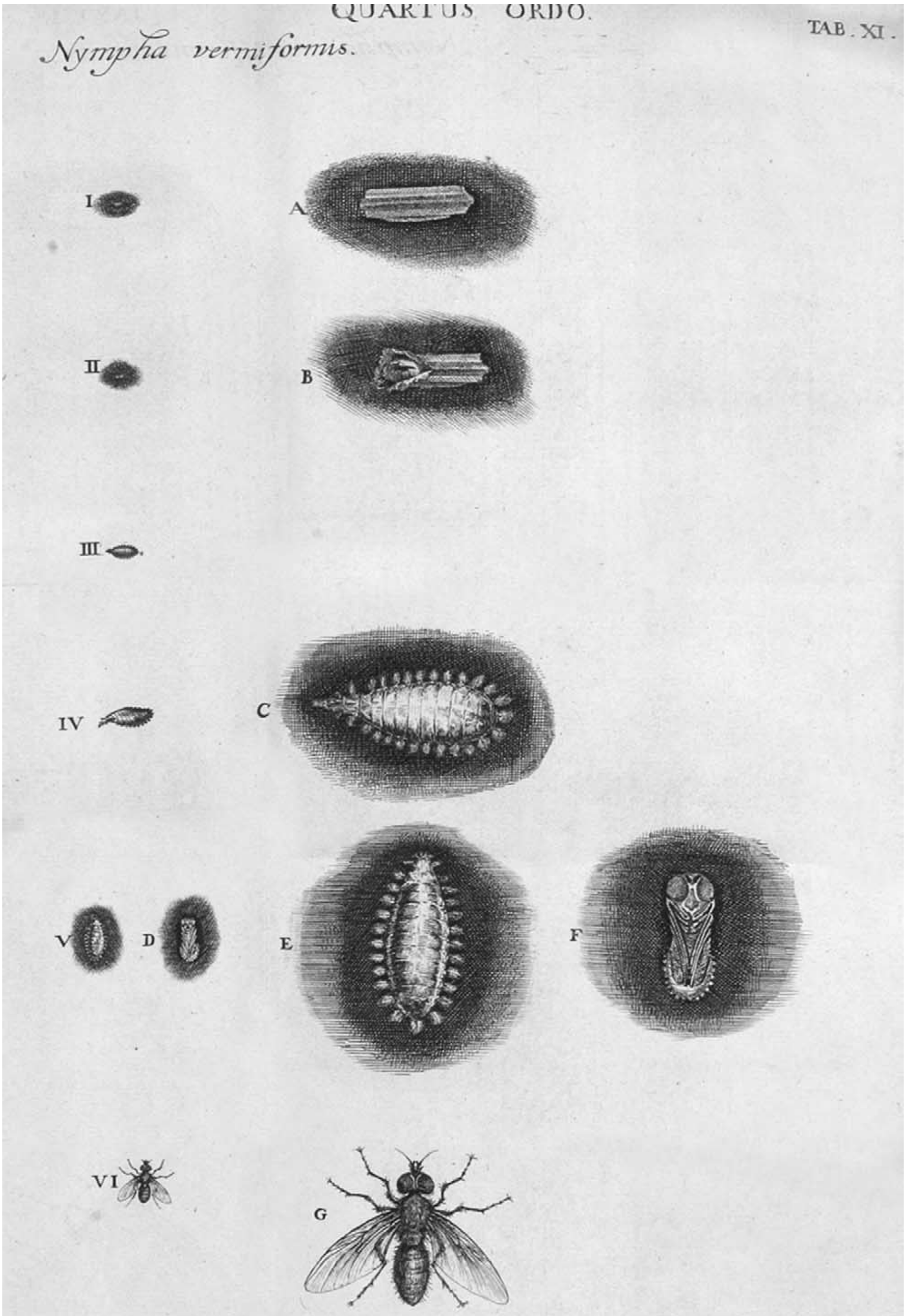

Figure 8. Swammerdam, *Historia insectorum generalis*, life cycle of insects.

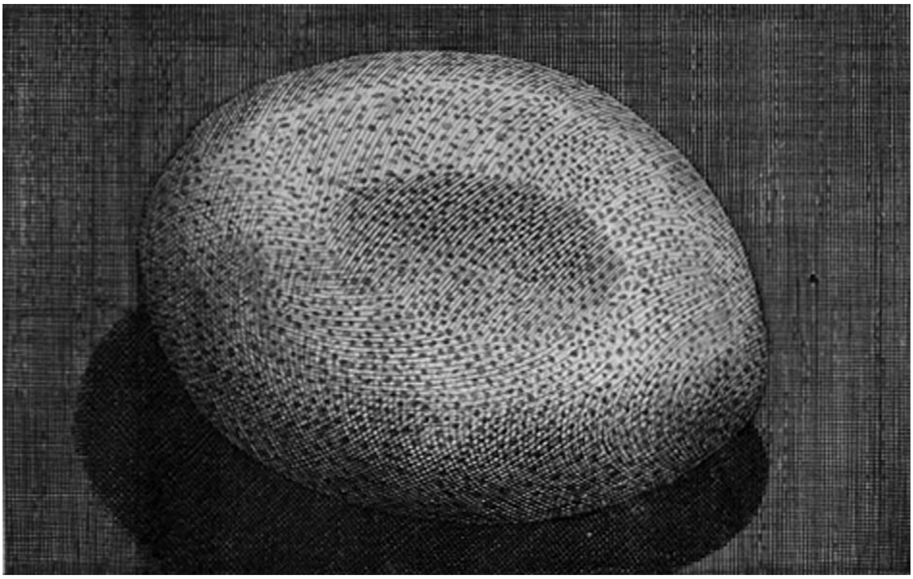

Figure 9. Hooke, *Micrographia*, silkworm egg.

microscopic techniques—possibly through Giovanni Alfonso Borelli—and developed them. It seems especially instructive to compare *Micrographia* and Malpighi's contribution to insect anatomy, his 1669 *De bombyce*, an entire treatise devoted to the silkworm published by the Royal Society thanks to Hooke's approval; it was as a result of that work that Malpighi gained his membership to that august body. Malpighi, however, was unaware of Hooke's work. Only in 1671 did Malpighi receive an account of *Micrographia* by his friend Silvestro Bonfiglioli in Rome, who had Adrien Auzout translate the English for him.[15]

Hooke first. In *Micrographia* Hooke provided a splendid figure of the silkworm egg: this is his only image of any part of the silkworm in that work and it provides a useful term for comparison with Malpighi. Hooke showed the silkworm egg in isolation, as if it were a hen egg. He described it as indented on the sides and covered with pits or cavities (Figure 9). Curiously, Hooke compared it to a poppy seed, the same object with which Hodierna had tested his microscope.[16]

Although Marcello Malpighi's *De bombyce* is generally considered a landmark in insect microscopy, it has been largely ignored by historians of science as to its contents, techniques of investigation, and iconography. Thus it seems appropriate to begin with a few words of explanation. Taking up a suggestion by Henry Oldenburg, in the summer of 1668 Malpighi embarked on the study of the silkworm, an insect with considerable economic implications. His treatise is part natural history and part anatomy, though it is certainly in the latter that he displayed his most innovative

[15] Howard B. Adelmann, *Marcello Malpighi and the Evolution of Embryology* (Ithaca: Cornell University Press, 1966), 5 vols, vol. 1, 338–44 and 669–76. Marcello Malpighi, *Correspondence*, edited by Howard B. Adelmann (Ithaca: Cornell University Press, 1975), 5 vols, vol. 2, 577–9, Bonfiglioli to Malpighi, Rome, 21 March 1671, at 578–9. At 577 Bonfiglioli reports that he had ordered microscopes from Eustachio Divini, which Malpighi had requested in a previous letter.

[16] Hooke, *Micrographia*, 181–2.

skills: he investigated the internal organs of an insect as no one else before him had been able to do, unraveling structures so elaborate as to destroy the belief that the inside of insects was simple or undifferentiated. Malpighi removed different body parts from the silkworm, placed them on a glass, wet them, and ostensibly showed what he saw through the microscope. But of course matters were not so simple and in some cases his figures resulted from a study of many specimens, as when he reconstructed an entire system of the insect, such as the respiratory vessels, for example, or the nervous system. He extended his investigation to other insects too, such as locusts, crickets, and bees.[17]

An important portion of *De bombyce* is devoted to reproduction; among the many figures, one is fortunately devoted to the egg. Malpighi studied the male and female organs of generation. Figure 10 reproduces Malpighi's plate with the complex female genitalia, showing the ovary consisting of eight branches terminating in the anus A at the top. Malpighi was at pains to describe the features he had observed and explain their purpose: comparative anatomist and historian Francis Cole found this portion 'The most impressive part' of his treatise. I will not follow either Malpighi or Cole in their description of the parts they identified, but focus primarily on the eggs. Each branch contains sixty or more eggs marked D. While the depression in the silkworm eggs in the ovary is rendered with a spiral line, this technique is not maintained in the isolated egg shown on the right as Figure IV, where the indentation is rendered by hatching. The eggs have a shell unlike that of hens because it is diaphanous and flexible. Malpighi argued that its external surface is not smooth but covered with tiny protuberances, like the skin of the fish *squatina*, whereas according to Hooke intriguingly they were pitted or covered with cavities. Hooke was very interested in the artefacts of microscopy and especially the issue of pits versus warts, which he discussed in the preface of *Micrographia* in relation to the eye of the fly: in the silkworm eggs, however, both accounts appear legitimate because the pits/protuberances are so dense that no univocal description is privileged.[18]

Whereas Hooke provided an individual portrait of an egg to satisfy curiosity and to show the power of the microscope, Malpighi focused on the silkworm's internal anatomy and provided a much more ambitious figure of the ovary in which the actual shape of the egg takes visually and conceptually second place. The images suggest that Hooke could possibly attain greater magnification, whereas Malpighi could muster superior skills with preparation techniques.

7. Malpighi (1669), Swammerdam (1737), and the silkworm's nervous system

We can gain a sense of the link between Malpighi's methods of investigation and representation by looking at the figure of the male genitalia of the silkworm (Figure 11):

[17] Marcello Malpighi, *De bombyce* (London: John Martin and James Allestry, 1669). I refer to the edition in *Opera Omnia* (London: Robert Scott and George Wells, 1686, reprinted in Hildesheim: Olms, 1975), 2 vols, vol. 2, 1 (wrongly numbered 64)–44.

[18] Malpighi, *De bombyce*, 35. The eggs appear to us shaped like red-blood cells. Adelmann, *Embryology*, 343. Francis Joseph Cole, *A History of Comparative Anatomy* (London: Macmillan, 1944), 194–6. Hooke, *Micrographia*, preface. Willem D. Hackmann, 'Natural Philosophy Textbook Illustrations 1600–1800', in *Non-Verbal Communication in Science prior to 1900,* edited by Renato Mazzolini (Florence: Olschki, 1993), 169–96, at 182–3. Y. Kawaguchi, Y. Banno, K. Koga, H. Doira, H. Fujii, 'Polygonal Patterns on Eggshells of Giant Egg Mutant and Large Eggs Induced by 20-Hydroxyecdysome in *Bombyx mori*', *Journal of Insect Physiology*, 39 (1993), 437–43, at 440 figure A.

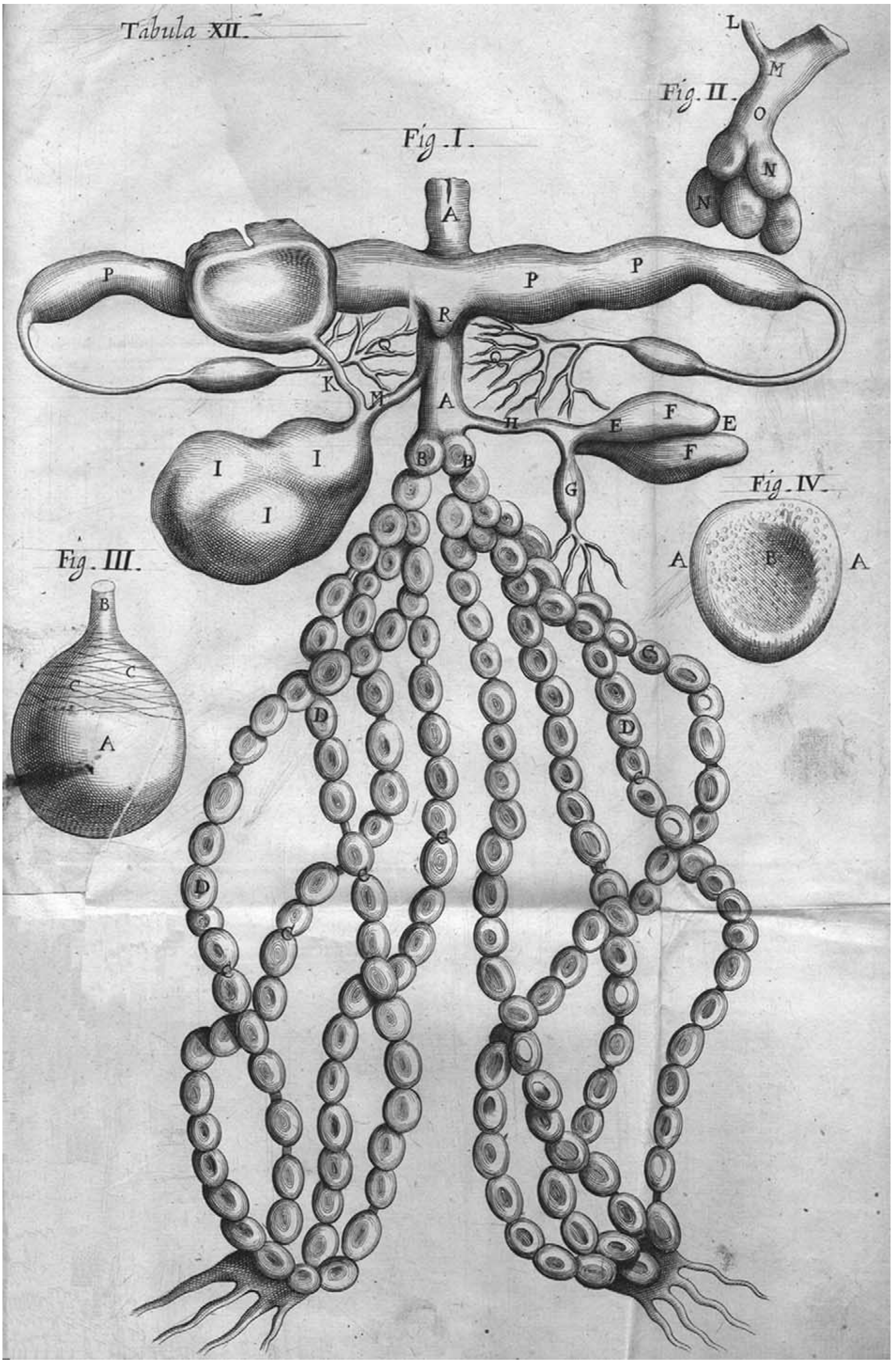

Figure 10. Malpighi, *De bombyce*, silkworm ovary and egg.

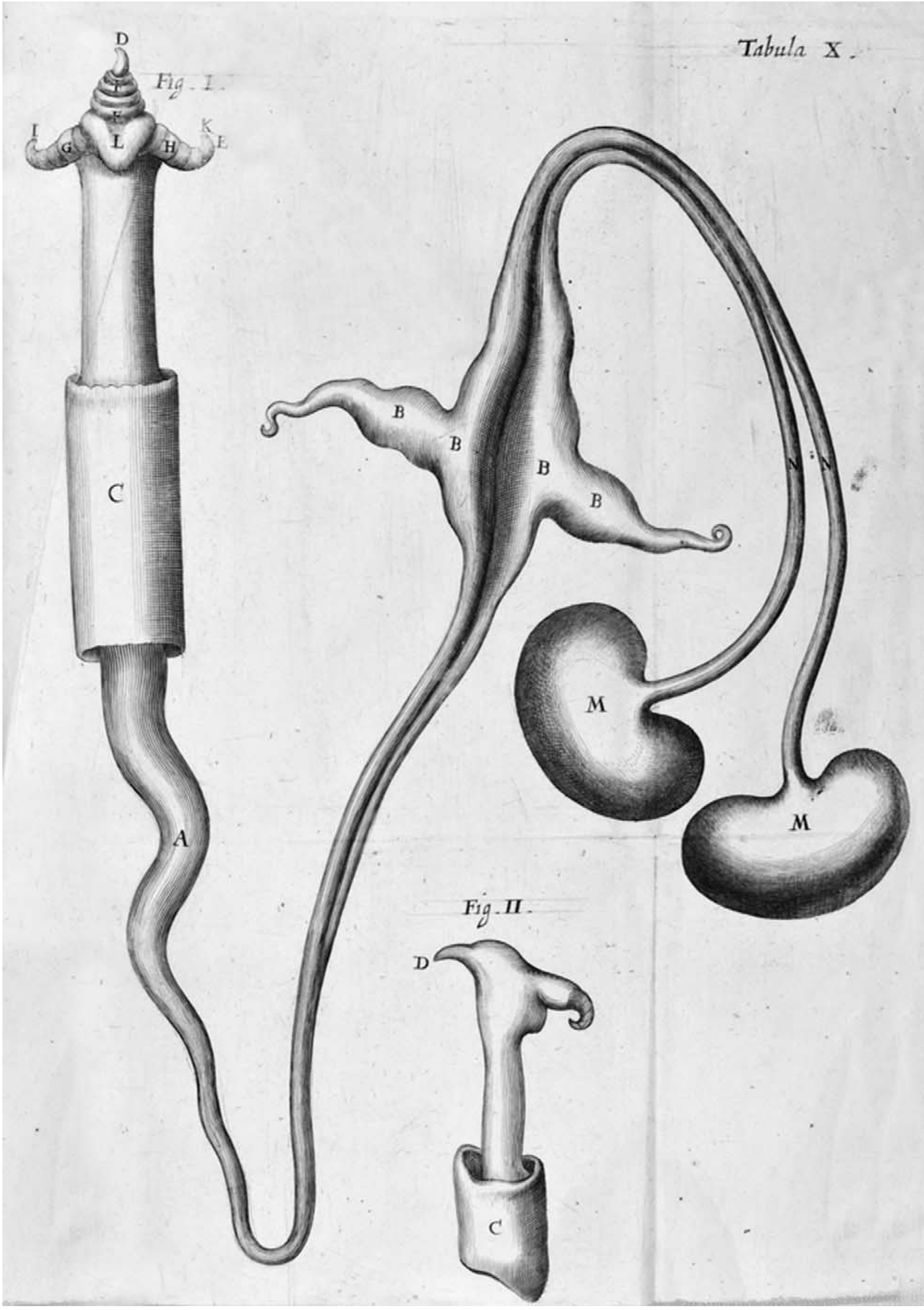

Figure 11. Malpighi, *De bombyce*, male genitalia.

Malpighi seems to have extracted them from the silkworm's body and placed them on a glass plate for microscopic observation, distorting the original arrangement of the parts. As we are going to see, the male genitalia could be treated in a much more sophisticated way.

We can gain a better sense of the challenges and difficulties faced by early insect microscopists by studying the peculiar structure of the nervous system of the silkworm. Malpighi produced an astounding image showing the nerve chain and ganglia or, as he called them, 'globules', visible in his Figure II on the right (Figure 12). The spinal cord is shown to be double in Figure II and in the text, though not in Figure I on the left, showing a globule under greater magnification. In this instance Malpighi said something about his techniques of investigation, namely that he traced the bifurcation of the spinal cord by means of ink staining. Running along the right and left sides of the spine he showed the nine spiracular openings, which are visible from the outside. Figure I shows the branches P of the breathing vessels and their ramifications, connecting the breathing vessels to the nervous system. Thus in his plate Malpighi attempted to show the nervous systems of the silkworm in relation to the respiratory system.[19]

Swammerdam was astounded by Malpighi's achievement, which he saw when his own *Historia insectorum generalis* was in press, but was unhappy with Malpighi's failure to disclose more fully his techniques of investigation as well as with the details of some figures; indeed, although Malpighi did provide some details about his methods, overall what he provided was insufficient to allow replication by others. By contrast, Swammerdam provided more details: for example, he stated that he put caterpillars in a bottle filled half with lees of wine and half with vinegar, a combination that, while killing the animal, hardened its members. Later he was to develop techniques of injection of various substances, staining, drying, using coloured glass as a background, and insufflation through a tiny glass pipette, a technique still used by entomologists today.[20]

The nervous system and male genitalia became an object of contention between the two rivals: in the 1672 *Miraculum naturae* Swammerdam attacked Malpighi for having represented the testicles in an unlikely position, for having failed to show the interconnections between the nervous and reproductive systems, and for having omitted the brain of the silkworm. He went as far as to charge Malpighi with having conceived the figure with his mind ('figuram mentem concepisse') rather than seen it with his eyes. In fact, Malpighi's figure looks very much like the result of his method on investigation, of extracting the body part, wetting, and placing it on a glass plate.[21]

Due to his religious crises, Swammerdam temporarily abandoned the investigation of nature, not before entrusting to Nicholas Steno some coloured drawings of the silkworm for Malpighi. They can still be found among Malpighi's papers and testify to the significance of iconographic dialogues among microsopists: the images were not accompanied by textual elucidations because Swammerdam knew that Malpighi would understand them and grasp their implications. Swammerdam, however, completed a major work that was published posthumously in 1737, *Biblia*

[19] Malpighi, *De bombyce*, 20–1. Cole, *Anatomy*, 190–1.

[20] Swammerdam, *Histoire*, 74–5, 212. Ruestow, *Microscope*, 30–1, 61, 112, 127n87, 143; Fournier, *Fabric*, 147. Matthew Cobb, 'Reading and Writing 'The Book of Nature': Jan Swammerdam (1637–1680)', *Endeavour*, 24 (2000), 122–8.

[21] Jan Swammerdam, *Miraculum naturae, sive uteri muliebris fabrica* (Leiden: apud S. Matthaei, 1672), 16–7.

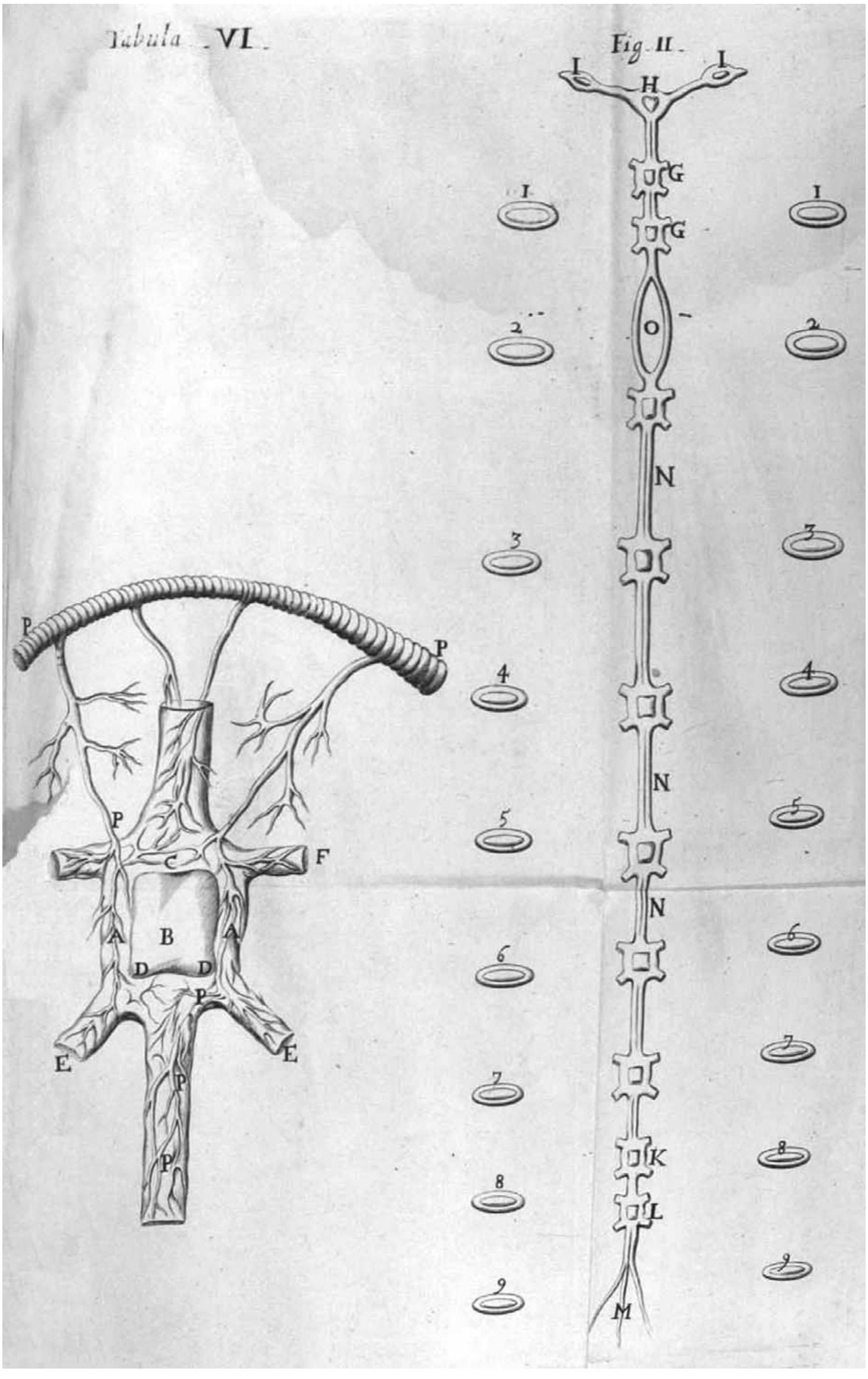

Figure 12. Malpighi, *De bombyce*, nervous system of the silkworm.

naturae. There one finds his public response to Malpighi in the form of a plate which encompassed the result of the drawings he had sent previously, corrected his rival's inaccuracies, and provided a more refined representation of the arrangement of the parts (Figure 13). Swammerdam's figure is quite detailed: notice in particular the interconnections between the nervous system and the genitalia and the position of the testicles, which appears far more convincing than in Malpighi's plate, since Malpighi had not tried to show them *in situ*. Swammerdam showed the connections among three systems; in addition to the nervous and respiratory apparatus—like Malpighi— he included the reproductive one as well. His plate includes a curious feature: unlike Malpighi, he showed only the spiracular openings of the respiratory system on the left side, since those on the right side are symmetrical and provide redundant information. This feature is a useful introduction to the next section.[22]

8. Malpighi (1669), Swammerdam (1675, 1737), and the exploitation of symmetry

In this final example I have found it useful to open up the notion of 'comparison', going beyond the object of investigation to the techniques of representation, even if they were applied to different insects and their body parts.

One of the most puzzling images in Malpighi's *De bombyce* was that of the silk-producing apparatus—which he later identified as glandular—on the right (Figure 14). In the same plate, on the left, he shows the stomach and digestive apparatus. It is quite helpful to see them side by side because Malpighi relied on the figure of the stomach to locate the silk-producing glands in the silkworm's body: the noodle-like structures can be found on the sides of the body, alongside the stomach. Even with this explanation, as in the case of the male genitalia, Malpighi's figure remains cryptic in that we have no sense of relative size, actual spatial relation to other body parts, and—despite his efforts—location within the body; once again, we are confronted with individual portraits out of context. Matters are even worse because Malpighi tacitly adopted a convention that even a distinguished twentieth-century comparative anatomist found baffling: Francis Cole apparently failed to grasp Malpighi's method of representation and charged him with having shown the organ to be asymmetrical, since the left side shows folds and convolutions whereas the right side appears disentangled. Even a reader untrained in comparative and insect anatomy may feel uneasy about the lack of symmetry in Malpighi's figure: could a silkworm really be so weird? Of course not! In the text Malpighi described the difficulty in tracing and disentangling the fragile structures and claimed that the length of a silk-producing filament was one Bolognese foot. In order to measure the filament he had to unravel it and this is precisely what the image shows. Thus Malpighi tacitly exploited symmetry to provide additional information: since the two sides are symmetrical, why not show them in different fashions so as to avoid redundant information? A manuscript preserved among his papers at the Bologna University Library with a corresponding drawing states that he unravelled the right side, thus providing an explicit—though unpublished—statement on this issue.[23]

[22] Bologna, Biblioteca Universitaria, Ms 936, I, K. The sheet is reproduce in black and white in Malpighi, *Opere scelte*, plate II. Jan Swammerdam, *Biblia naturae* (Leiden: Apud Isaacum Severinum, Balduinum vander Aa, Petrum vander Aa, 1737–8), 2 vols.

[23] Malpighi, *De bombyce*, 19–20. Francis Joseph Cole, *A History of Comparative Anatomy* (London: Macmillan, 1944), 190. Cobb, 'Malpighi', 115. Bologna, Biblioteca Universitaria, Ms. 2085 II, f. 63r.

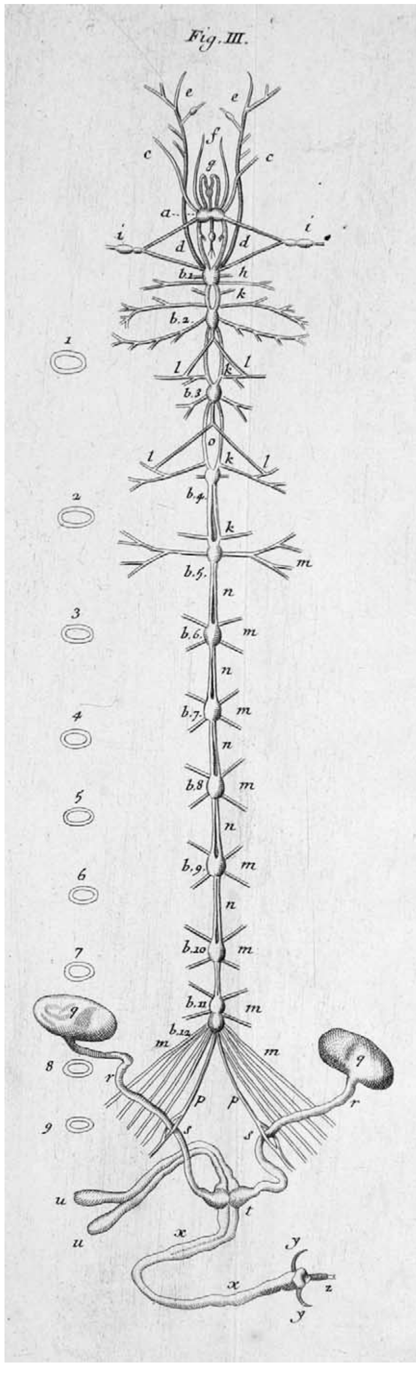

Figure 13. Swammerdam, *Biblia naturae*, nervous system of the silkworm.

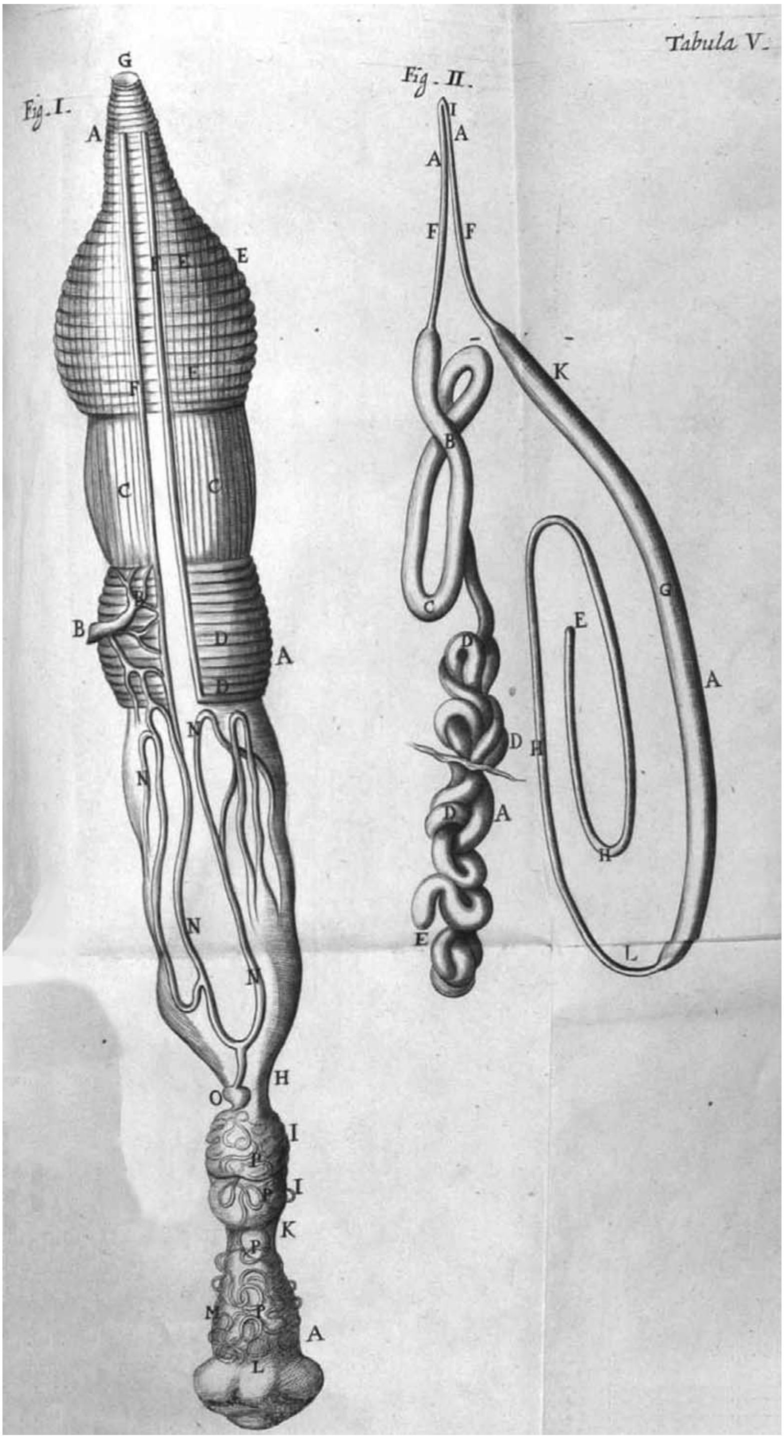

Figure 14. Malpighi, *De bombyce*, silk-producing apparatus.

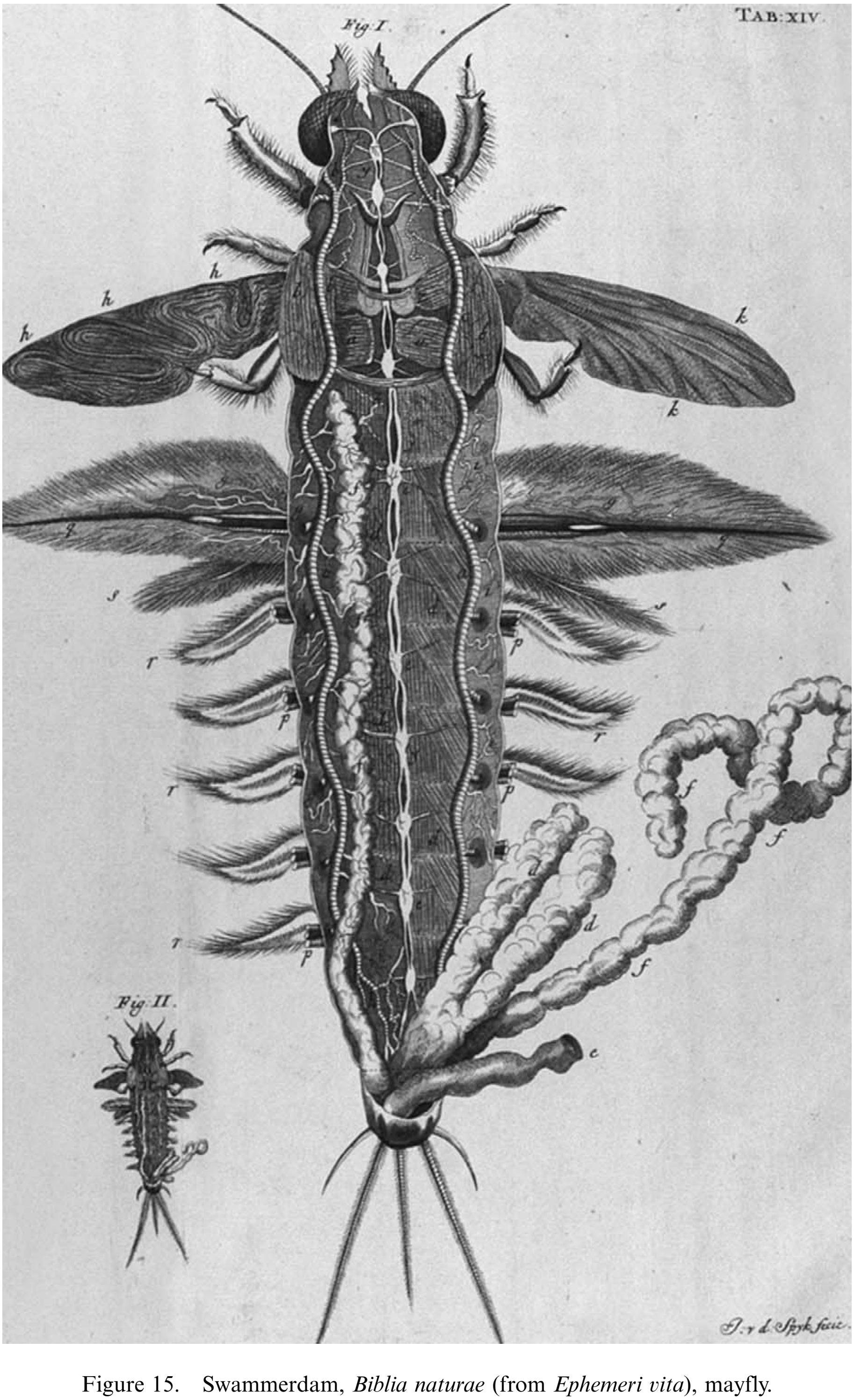

Figure 15. Swammerdam, *Biblia naturae* (from *Ephemeri vita*), mayfly.

In 1675, after extended periods of religious crises and about to join the circle of the mystic preacher Antoinette Bourignon, Swammerdam published *Ephemeri vita*, a treatise on the ephemeron, or mayfly, interspersed with prayers. His striking engraving of the ephemeron looks like a challenge and a response to Malpighi's decontextualised individual portraits of different organs: Swammerdam's superb and exceedingly complex image was unprecedented at the time in showing the internal anatomy of an insect all at once. Gone is Malpighi's way of rendering body parts in splendid but problematic isolation: now the body parts were shown in all their layered complexity. Curiously, however, his critical response to Malpighi relies on the same technique of representation adopted by his Italian rival: both exploited symmetry by breaking it. In Swammerdam's case this technique was not so much a desideratum as a necessity: only by having recourse to this technique could Swammerdam provide a meaningful image of the entire ephemeron. Notice (Figure 15) the medulla spinalis *yyy* with its 11 nodes, the muscle fibers *ddd*, the anus *e* removed from its natural position at the bottom, and air vessels *aaa* like tracheas running along both sides of the length of the body with their ramifications, such as *ppp*, in conjunction to the fins, truncated to show their structure. Swammerdam relied on the symmetry of the insect to show different parts, as the seminal vesicles *fff* of the male, shown on the left in their natural position and size and on the right, partly removed from the body and enlarged, thus offering a better view of the muscle structures underneath. Notice also the fine structure of the air vessels at bottom left, which is covered on the right side. Swammerdam could not have completed his study without a number of insects and a range of preparation techniques, since tracing a set of muscles or the breathing apparatus, for example, would have required destroying other fragile parts in the way. Whereas in his work on the silkworm (Figure 13) he had merely shown the peculiar interconnections between the nervous and reproductive systems, in *Ephemeri vita* he studied all the individual components before putting everything back together again in a composite picture of unprecedented complexity.[24]

9. Concluding reflections

In the course of the seventeenth century, microscopic anatomists created a visual language enabling them to represent tiny insects and especially their body parts that would have been inaccessible to most of their readers. Starting from the late 1660s, the investigation of insects had become so advanced as to render the problem of representation especially acute: plates no longer involved simply a specimen as large as a page, but included internal organs and entire systems unlike anything that had been seen before.

In some cases, investigators responded to each other not only verbally but also through images, as in an iconographic dialogue. The episode of Swammerdam sending his drawings of the silkworm and its organs to Malpighi in order to correct inaccuracies in Malpighi's work is emblematic in this regard, in that it documents an iconographic exchange involving microscopic images of insects. Swammerdam's drawings point to a practice that occurred with printed plates as well: by studying them we can reconstruct a dialogue as we do with written words. Documenting such

[24] Jan Swammerdam, *Ephemeri vita* (Amsterdam: Abraham Wolfgang, 1675). I reproduce the corresponding plate from Swammerdam, *Biblia naturae*.

dialogues is an important step in the early history of microscopy, enriching our views of seventeenth-century perceptions and representations of insects and of visual representations more broadly.

In other cases, as with Hodierna and Hooke for the eye of the fly, or Hooke and Malpighi for the silkworm egg, the pairs of images I have examined were produced independently: thus a comparative study highlights similarities and differences in the separate and individual concerns, techniques of investigation, and modes of representation of early microscopists. But whether the images were produced independently or not, a comparative study produces a result that is more than the sum of its parts. I hope that some of methods I have used in my research and some of my results will prove useful to scholars in different areas and periods.

No doubt, an entomologist would look at the images I discussed in this essay with a very different eye from an art historian: although I welcome different perspectives from which the figures I have selected could be further investigated, my aim has not been to provide a comprehensive analysis but rather to highlight the richness and problems of the investigation and representation of insects and to point to a useful way to investigate those problematic figures—and potentially others.

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