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Natural history in the physician's study: Jan Swammerdam (1637–1680), Steven Blankaart (1650–1705) and the 'paperwork' of observing insects

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Abstract. While some seventeenth-century scholars promoted natural history as the basis of natural philosophy, they continued to debate how it should be written, about what and by whom. This look into the studios of two Amsterdam physicians, Jan Swammerdam (1637–80) and Steven Blankaart (1650–1705), explores natural history as a project in the making during the second half of the seventeenth century. Swammerdam and Blankaart approached natural history very differently, with different objectives, and relying on different traditions of handling specimens and organizing knowledge on paper, especially with regard to the way that individual observations might be generalized. These traditions varied from collating individual dissections into histories, writing both general and particular histories of plants and animals, collecting medical observations and applying inductive reasoning. Swammerdam identified the essential changes that insects underwent during their life cycle, described four orders based on these 'general characteristics' and presented his findings in specific histories that exemplified the 'general rule' of each order. Blankaart looked to the collective observations of amateurs to support his reputation as a man of medicine, but this was not supposed to lead to any kind of generalization. Their work alerts us to the variety of observational practices that were available to them, and with what purposes they made these their own.

The portrait of a physician in his studio, dated around 1668, by Amsterdam painter Michiel van Musscher (1645–1705), offers a rare look into the workspace of a Dutch seventeenth-century physician (Figure 1). The physician, half-sitting in his chair behind a table, still dressed for making house calls, is examining a urine sample in

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Figure 1. The painting *Arts in zijn studeervertrek* or *Doctor in His Study* (Amsterdam, 1668), by Michiel van Musscher (1645–1705), depicts a Dutch physician surrounded by equipment for observing disease, medicines and the natural world more widely, including a lot of paperwork. Image with permission from the Rijksbureau voor Kunsthistorische Documentatie.

order to judge the condition of a patient. The picture's main theme of looking at urine in a flask against the light is common enough, but the picture is rare in the attention it draws to the entire observational practice of uroscopy.¹ The physician has his pen, ink and paper ready to record his findings, while holding the urine flask in his left hand, and a large folio book lies on the reading lectern farther to his right. This layout is exemplary of what Gianna Pomata and Nancy Siraisi have called early modern 'learned empiricism'; that is, the 'capacity for switching nimbly back and forth between book and direct observation'.² Showing texts as physical objects with all the other things in the physician's study, Van Musscher made visible a part of the scientific practice that has long remained unexplored, but has recently come into clearer

1 *Doctor in His Study*, c.1668, attributed to Michiel van Musscher, Amsterdam, cf. e.g. Evert Oudendijck, *A Doctor Inspecting a Flask of Urine*, Haarlem, 1650–1700; Gerard Dou, *The Physician*, Leiden, 1653; Dou, *A Doctor Examining Urine*, Leiden, 1653–75; Jacob Toorenvliet, *Doctor's Visit*, Leiden, c.1666–7. Michael Stolberg, Logan Kennedy and Lenhard Unglaub, trans., *Uroscopy in Early Modern Europe*, London and New York, 2016, pp. 105–13.

2 Gianna Pomata and Nancy G. Siraisi, 'Introduction', in Pomata and Siraisi (eds.), *Historia: Empiricism and Erudition in Early Modern Europe*, Cambridge, MA and London: MIT Press, 2005, pp. 1–38, 25.

focus. Paperwork prepared in the study brought reading, experiencing and reasoning about nature together.³ The objects that surround Van Musscher's physician imply that observational practices around diseases and the human body developed in close proximity to practices involved in observing the natural world more widely.

During the sixteenth and seventeenth centuries, the study developed from a space of book learning and contemplation into one in which naturalists all over Europe brought plants, different kinds of animals, *naturalia*, materia medica and the equipment to study and collect them as preserved specimens and on paper.⁴ This development is reflected in Van Musscher's painting. We find a mortar and an opened glass jar in the foreground, and on the table by the window a scale, flasks, folded pieces of paper called *huyskens* in which apothecaries packaged their goods, and a jar containing an eye remedy. A round bentwood band box on the table is suggestive of the physician's natural-historical activities. It is the kind of lightweight box in which people collected small animals and plants from gardens, wooded areas, marches, rivers, fields, ditches

3 See e.g. Simon Schaffer, 'Newton on the beach: the information order of *Principia Mathematica*', *History of Science* (2009) 47(3), pp. 243–76; Ann Blair, 'The rise of note-taking in early modern Europe', *Intellectual History Review* (2010) 20(3), pp. 303–16; Paul Nelles, 'Seeing and writing: the art of observation in the early Jesuit missions', *Intellectual History Review* (2010) 20(3), pp. 317–33; Volker Hess and J. Andrew Mendelsohn, 'Sauvages' paperwork: how disease classification arose from scholarly note-taking', *Early Science and Medicine* (2014) 19, pp. 471–503; Elizabeth Yale, *Sociable Knowledge: Natural History and the Nation in Early Modern Britain*, Philadelphia: University of Pennsylvania Press, 2016; Richard Yeo, 'Notebooks, recollection, and external memory: some early modern English ideas and practices', in Alberto Cevolini, *The Forgetting Machine: Knowledge Management Evolution in Early Modern Europe*, Leiden and Boston: Brill, 2016, pp. 128–54; Andrew J. Mendelsohn, 'Empiricism in the library: medicine's case histories', in Lorraine Daston (ed.), *Science in the Archive: Pasts, Presents, Futures*, Chicago: The University of Chicago Press, 2017, pp. 85–109.

4 Wolfgang Liebenwein, *Studiolo: Die Entstehung eines Raumtyps und seine Entwicklung bis um 1600*, Berlin: Mann, 1977; Steven Shapin, 'House of experiment: the house of experiment in seventeenth-century England', *Isis, A Special Issue on Artefact and Experiment* (September 1988) 79(3), pp. 373–404; Paula Findlen, 'Die Zeit vor dem Laboratorium: Die Museen und der Bereich der Wissenschaft 1550–1750', in Andreas Grote (ed.), *Macrocosmos in Microcosmo: Die Welt in der Stube. Zur Geschichte des Sammelns 1450–1800*, Wiesbaden: Springer Fachmedien, 1994, pp. 191–207; Maria Christina Tagliaferri, Stefano Tommasini and Sandra Tugnoli Pattaro, 'Ulisse Aldrovandi als Sammler: Das Sammeln als Gelehrsamkeit oder als Methode wissenschaftlichen Forschens?', in Grote, op. cit., pp. 265–81; Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy*, Berkeley: University of California Press, 1996; Klaus Mingos, *Das Sammlungswesen der frühen Neuzeit: Kriterien der Ordnung und Spezialisierung*, Münster: Lit, 1998, pp. 25–34; Dora Thornton, *The Scholar in His Study: Ownership and Experience in Renaissance Italy*, New Haven, CT and London: Yale University Press, 1997; Anke te Heesen and Emma C. Spary (eds.), *Sammeln als Wissen: Das Sammeln und seine Wissenschaftsgeschichtliche Bedeutung*, Göttingen: Wallstein, 2001; David Freedberg, *The Eye of the Lynx: Galileo, His Friends, and the Beginnings of Modern Natural History*, Chicago: The University of Chicago Press, 2002; Alix Cooper, 'Homes and household', in Katharine Park and Lorraine Daston (eds.), *The Cambridge History of Science*, vol. 3: *Early Modern Science*, Cambridge: Cambridge University Press, 2006, pp. 224–37; Brian W. Ogilvie, *The Science of Describing: Natural History in Renaissance Europe*, Chicago: The University of Chicago Press, 2006; Bruno J. Strasser, 'Collecting nature: practices, styles, and narratives', *Osiris, Clío Meets Science: The Challenges of History* (2012) 27(1), pp. 303–40, 312–13. On the paper involved in the study of insects by Ulisse Aldrovandi (1522–1605) see e.g. Christiana Scappini, Maria Pia Torricelli and Sandra Tugnoli Pattaro (eds.), *Lo studio Aldrovandi in Palazzo pubblico, 1617–1742*, Bologna: CLUEB, 1993; Fabian Krämer, 'Ulisse Aldrovandi's *Pandechion Epistemonicon* and the use of paper technology in Renaissance natural history', *Early Science and Medicine* (2014) 19, pp. 398–423.

and roadside hedges, to take home, keep and inspect. Next to the box is a stack of papers, loosely bound together between two thicker pieces of paper or board, demonstrating the paperwork involved in observation. There are quite a few stacks of loose papers, as well as books and bound manuscripts spread throughout the workspace.

But despite the equipment for doing natural history having been gathered, there was still no prescription for how to proceed. This can be illustrated by a look into the studies of two Amsterdam physicians, Jan Swammerdam (1637–80) and Steven Blankaart (1650–1705). While some seventeenth-century scholars, most prominently Francis Bacon (1561–1626), promoted natural history as the basis of natural philosophy, they continued to disagree about how it should be written, about what and by whom, and about how to mitigate its insufficiencies.⁵ Swammerdam and Blankaart are two of the many scholars across Europe who contributed to these debates by practising natural history. Both were educated as physicians, collected insects to examine them in their rooms, produced their own images and used magnifying glasses. Despite these similarities, the two approached natural history very differently, with different objectives, and relying on different traditions of handling specimens and organizing knowledge on paper. Emphasizing these aspects of their practices will help embed them in the wider history of natural history and view them as individual expressions of more long-term and international trends.⁶

Swammerdam arranged his life around investigating the generation of animals: how different kinds of animals produced offspring, offspring that grew and changed shape to produce their own offspring.⁷ Celebrated for his discoveries regarding the reproduction of insects, slugs and frogs, and for his skills in dissecting and preserving insects, he

5 Paula Findlen, 'Francis Bacon and the reform of natural history in the seventeenth century', in Donald R. Kelly (ed.), *History and the Disciplines: The Reclassification of Knowledge in Early Modern Europe*, Rochester: Boydell & Brewer Ltd, 1997, pp. 239–60; Peter R. Anstey, 'Locke, Bacon and natural history', *Early Science and Medicine* (2002) 7(1), pp. 65–92; Ian Maclean, 'White crows, graying hair, and eyelashes: problems for natural historians in the reception of Aristotelian logic and biology from Pomponazzi to Bacon', in Pomata and Siraisi, *Historia*, op. cit. (2), pp. 147–80; Peter R. Anstey, 'Experimental versus speculative natural philosophy', in Peter R. Anstey and John A. Schuster (eds.), *The Science of Nature in the Seventeenth Century: Patterns of Change in Early Modern Natural Philosophy*, Dordrecht: Springer, 2006, pp. 215–42; Michael Hunter and Peter R. Anstey, 'Robert Boyle's "Designe about Natural History"', *Early Science and Medicine* (2008) 13(2), pp. 83–126; Doina-Cristina Rusu, 'Francis Bacon: constructing natural histories of the invisible', *Early Science and Medicine* (2012) 17, pp. 112–33; Dana Jalobeanu, *The Art of Experimental Natural History: Francis Bacon in Context*, Bucharest: Zeta Books, 2015, esp. pp. 208–17.

6 Harold Cook, 'Physick and natural history in the seventeenth century', in Roger Ariew and Peter Barker (eds.), *Revolution and Continuity: Essays in the History and Philosophy of Early Modern Science*, Washington, DC: Catholic University of America Press, 1991, pp. 63–80; Cook, 'The cutting edge of a revolution? Medicine and natural history near the shores of the North Sea', in J.V. Field and Frank A.J.L. James (eds.), *Renaissance and Revolution: Humanists, Scholars, Craftsmen and Natural Philosophers in Early Modern Europe*, Cambridge: Cambridge University Press, 1994, pp. 45–61; Cook, 'Physicians and natural history', in Nicolas Jardine, James A. Secord and Emma C. Spary (eds.), *Cultures of Natural History*, Cambridge: Cambridge University Press, 1996, pp. 91–105; Cook, 'Natural history and seventeenth-century Dutch and English medicine', in Hilary Marland and Margaret Pelling (eds.), *The Task of Healing Medicine, Religion and Gender in England and the Netherlands, 1450–1800*, Rotterdam: Erasmus Publishing, 1996, pp. 253–70.

7 Elizabeth B. Gasking, *Investigations into Generation 1651–1828*, Baltimore: Johns Hopkins University Press, 1967; G.A. Lindeboom, *Het Cabinet van Jan Swammerdam (1637–1680): Catalogus met Inleiding*, Amsterdam: Rodopi, 1980; Matthew Cobb, *Generation: The Seventeenth-Century Scientists Who Unraveled the Secrets of Sex, Life, and Growth*, New York: Bloomsbury Publishing, 2006.

experienced a crisis of faith in his thirties from which he never recovered fully, leaving his final opus, *Bybel der Natuure*, to be published posthumously.⁸ Swammerdam's efforts have been considered part of the histories of generation and entomology, comparative anatomy, the growing appreciation for empiricism in science and the search for divine law in nature.⁹ However, these takes on Swammerdam's research leave his observational practice and especially its underlying principles unexplored. By considering the paperwork involved in his practice, a more comprehensive view of Swammerdam's project will emerge.

In 1975, historian F.J. Cole characterized animal anatomy between William Harvey (1578–1657) and John Hunter (1728–1793) as a period in which 'a vast reserve of facts which were one day to be pieced together' were accumulated, without 'any instructed attempt being made to collate the results so obtained'. Cole discussed Swammerdam as a representative of this period, treating his main work on insects, *General History of Insects or General Treatise of Bloodless Animals* (1669), as a loose collection of dissections of various kinds of small animals, including the honeybee, mayfly, louse and frog.¹⁰ The work of later historians has suggested that this characterization of Swammerdam's work as one of accumulation rather than collation missed the mark.¹¹ Indeed, as I will argue below, Swammerdam's observational practice integrated a tradition of collating individual dissections into histories, and writing general and

8 Jan Swammerdam, *Bybel der Natuure, of Historie der Insecten*, 2 vols., Leiden: Isaak Severinus, Boudewyn van der Aa, Pieter van der Aa, 1737–8; Rob P.W. Visser, 'Jan Swammerdam (1637–1680) "... het komt uyt een saatken of uiyt een ey"', in A.J. Kox (ed.), *Van Stevin tot Lorentz: Portretten van Nederlandse Natuurwetenschappers*, Amsterdam: Uitgeverij Bert Bakker, 1990, pp. 61–70; Luuc Kooijmans, *Gevaarlijke Kennis: Inzicht en Angst in de Dagen van Jan Swammerdam*, Amsterdam: Bert Bakker Uitgeverij, 2007; F.J. Cole, *A History of Comparative Anatomy: From Aristotle to the Eighteenth Century*, New York: Macmillan and Co., Ltd, 1975, pp. 273–5; Cook, 'The cutting edge', op. cit. (6), pp. 51–4.

9 Gasking, op. cit. (7); Cobb, op. cit. (7); Abraham Schierbeek, *Jan Swammerdam: Zijn Leven en zijn Werken*, Lochem: De Tijdstroom, 1946; Max Beier, 'The early naturalists and anatomists during the Renaissance and seventeenth century', in Ray F. Smith, Thomas E. Mittler and Carroll N. Smith (eds.), *History of Entomology*, Palo Alto: Annual Reviews, Inc., 1973, pp. 81–94, 90; Cole, op. cit. (8), pp. 270–305; G.A. Lindeboom, 'Het Collegium privatum Amstelodamense (1664–1673)', *Nederlands Tijdschrift voor Geneeskunde* (1975) 119(32), pp. 24–5; Rob P.W. Visser, 'Theorie en praktijk van Swammerdams wetenschappelijke methode in zijn entomologie', *Gewina: Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek* (1981) 4(2), pp. 63–73; G.A. Lindeboom, 'Swammerdam als microscopist', *Gewina: Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek* (1981) 4(2), pp. 87–110; Edward Ruestow, *The Microscope in the Dutch Republic: The Shaping of Discovery*, Cambridge: Cambridge University Press, 1996, pp. 109, 111–12, 132; Erik Jorink, *Reading the Book of Nature in the Dutch Golden Age, 1575–1715*, Leiden and Boston: Brill, 2010, pp. 244–7, 255; Marian Fournier, 'Jan Swammerdam en de 17e eeuwse microscopie', *Gewina: Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek* (2012) 4(2), pp. 74–86; Jens Loescher, 'How to see through Swammerdam's microscope', *Monatshefte* (2016) 108(1), pp. 1–22.

10 Jan Swammerdam, *Historia insectorum generalis, ofte Algemeene verhandeling van de bloedeloze dierkens*, Amsterdam: Meinardus van Drevnen, 1669; Cole, op. cit. (8), pp. 177, 278–304.

11 Marian Fournier, *The Fabric of Life: Microscopy in the Seventeenth Century*, Baltimore: Johns Hopkins University Press, 1996, p. 66; S.L. Tuxen, 'Entomology systematizes and describes: 1700–1815', in Smith, Mittler and Smith, op. cit. (9), pp. 95–118, 106–7; Cobb, op. cit. (7), pp. 144–5; Domenico Bertoloni Meli, 'The representation of insects in the seventeenth century: a comparative approach', *Annals of Science* (2010) 67(3), pp. 405–29, 413; Charlotte Sleight, 'Jan Swammerdam's frogs', *Notes and Records of the Royal Society* (2012) 66, pp. 373–92; Brian Ogilvie, 'Order of insects: insect species and metamorphosis between

particular histories of plants and animals, with new ways of thinking on inductive reasoning, in his words *optelling* or *inductie*. He thus identified the essential changes that insects underwent during their life cycle and described four orders of insects with these ‘general characteristics’. Using induction he placed insects he had not examined ‘specifically’ in one of these orders and reasoned by analogy from bigger insects to smaller ones. He presented his findings in his collection of specimens, in series of images, in a comparative table and in specific histories that exemplified the ‘general rule’ of each order.

Swammerdam’s efforts show that natural history was very much a project in the making by the second half of the seventeenth century. Swammerdam borrowed from predecessors and contemporaries to develop his own observational practices and write ‘true histories’ of insects. Comparing his practices with those of a near contemporary, the lesser known Blankaart, will make evident that others were shaping natural history along different lines in the same period. In contrast to Swammerdam, Blankaart is only a minor figure in histories of entomology, primarily mentioned to confirm the popularity of the study of insects in the Dutch Republic, as well as for some of his original observations.¹² As a practising physician, Blankaart accepted Swammerdam’s stance on where insects came from and how they developed, but did not adopt his observational practice. Rather, he looked to the collective observations of amateurs on the lives and behavior of insects, loosely gathered as individual accounts, to support his reputation as a well-connected and observant man of medicine. This was not supposed to lead to any kind of generalization or systematization as Swammerdam’s paperwork did: indeed, rather the opposite. Thus an analysis of the contrasts between the work of these two men brings to light the variety of observational practices in seventeenth-century natural history, as well as the different aims natural historians intended these practices to serve.

Collating dissections into histories

In 1667, after studying in Leiden and Paris for two years and graduating as a medical doctor, Swammerdam moved to the attic room of his father’s apothecary shop in Amsterdam.¹³ He had decided not to practice medicine, but to commit himself to anatomical research in general and the study of insects in particular. He had already developed an international reputation in this well-populated field.¹⁴ Philosophers and

Renaissance and Enlightenment’, in Ohad Nachtomy and Justin E.H. Smith (eds.), *The Life Sciences in Early Modern Philosophy*, Oxford: Oxford University Press, 2014, pp. 222–45, 236–9.

12 Beier, op. cit. (9), p. 92; Jorink, op. cit. (9), pp. 244–7.

13 Referring to his room, Swammerdam, op. cit. (8), vol. 2, pp. 522, 825; Kooijmans, op. cit. (8), pp. 35–7, 50, 103, 108–13.

14 Jan Swammerdam, *Tractatus physico-anatomico-medicus de respiratione usuque pulmonum*, Leiden: Danielem, Abraham and Adrian à Gaasbeck, 1667; Swammerdam, op. cit. (10); Jan Swammerdam, *Ephemeris Vita, of afbeeldingh van ’s menschen leven*, Amsterdam: Abraham Wolfgang, 1675; Cobb, op. cit. (7), 140–2; Kooijmans, op. cit. (8), 51–3, 60, 71, 73–4, 105, 108, 110–14; Ogilvie, op. cit. (11); Mary Terrall, *Catching Nature in the Act: Reaumur and the Practice of Natural History in the Eighteenth Century*, Chicago: The University of Chicago Press, 2014.

physicians had studied the development of animals from eggs into adults, but it was not until 1651 that William Harvey dedicated a treatise to the subject. His *Exercitationes de generatione animalium* inspired further work by Swammerdam and some of his contemporaries.¹⁵ Harvey's teacher Hieronymus Fabricius (1533–1619) had included images of bird eggs from two days up to twenty-four days after fertilization in his *De formatione ovi et pulli*, showing different phases in the dissection process of each egg.¹⁶ However, the text that these images accompanied was structured around the earlier writings of Aristotle and Galen on generation. Fabricius pointed to his own experiences, but also to his close reading of these authors to agree or disagree with them on certain points, arguing, for example, that many more animals developed from eggs than Aristotle had suggested.¹⁷ In contrast, Harvey put 'anatomical inquiry', the dissections of eggs on consecutive days after fertilization, at the core of his treatise. He expressly presented this 'method of investigation' as new and less likely to lead to error.¹⁸ He explained that 'because somethings – are much otherwise than hath been yet delivered, I shall declare to you what dayly progress is made in the egg, and which parts are altered'.¹⁹ Several times he pointed out that these changes corresponded with the images in *De formatione ovi et pulli*. In addition, he discussed his own observations of the reproductive organs of cocks and hens, intermingled with those of other reputable anatomists, reflecting on their functions in producing the egg, followed by 'certain deductions' about the function of the egg's parts in the development of the chick.

Harvey recounted what changes he had observed on days one to six, and day ten and fourteen of the chick's development, describing both the egg and the chick as if the same individual were being continuously observed during this period. Occasionally, these descriptions were interpolated by his own judgements and opinions. One such interjection made particularly clear that he had dissected many eggs on different days of their development, under different circumstances. He commented that 'the season of the year, the place where the fertilization is carried on, the sedulousness with which it is performed, and other accidents, have undoubtedly great influence on this diversity of result'.²⁰ Much like his teacher Fabricius had done, Harvey acknowledged all of the

15 Cobb, op. cit. (7); e.g. Ulisse Aldrovandi, *Ornithologiae est de avibus historiae*, 3 vols., Bologna: Franciscum de Franciscis Senensem, 1599–1603; L.R. Lind, trans., *Aldrovandi on Chickens: The Ornithology of Ulisse Aldrovandi (1600) vol. II, Book XIV*, Norman: University of Oklahoma Press, 1963, pp. 76–91; Hieronymus Fabricius, *De Formatione Ovi et Pulli*, Padua: Aloysii Bencii Bibliopolae, 1621; William Harvey, *Exercitationes de Generatione Animalium*, London: Octavianum Pulleyn, 1651; René Descartes, *De la Formation de l'Animal* (1647–1648), published as *De Formation du Foetus*, Paris: Charles Angot, 1664; Findlen, op. cit. (4), pp. 211; William Harvey, 'Anatomical exercises on the generation of animals; to which are added, essays on parturition, on the membranes, and fluids of the uterus; and on conception', in *The Works of William Harvey*, trans. Robert Willis, Philadelphia: University of Pennsylvania Press, 1989, pp. 145–588.

16 Howard B. Adelman, *The Embryological Treatises of Hieronymus Fabricius of Aquapendente*, Ithaca, NY: Cornell University Press, 1942, pp. 444–59.

17 Adelman, op. cit. (16), pp. 87–9, 116, 140–2, 167–9, 205.

18 Harvey, 'Anatomical exercises', op. cit. (15), p. 151.

19 Harvey, 'Anatomical exercises', op. cit. (15), p. 226.

20 Harvey, 'Anatomical exercises', op. cit. (15), p. 256.

variation in the eggs that he had encountered.²¹ In contrast to Fabricius's account, though, this 'history of the egg', the product 'of such painstaking, of such careful observation', formed the basis of Harvey's 'theorems' about the 'generation of all other animals'.²² As historian Bertoloni Meli has pointed out, such generalization in anatomical investigations depended on a belief in fundamental uniformity in the operation of nature. In his words, an anatomist like Marcello Malpighi (1628–94) saw every variation that he observed as a subtle modulation on a fundamentally homogeneous pattern.²³ Swammerdam would express his belief in the uniformity of nature too, writing, for example, that 'all of God's works are based on the same rules', even while acknowledging the enormous variety that existed in nature.²⁴

Swammerdam's good friend and one-time collaborator Nicolas Steno (1638–86) partly followed Harvey's example, by making dissection of chicken eggs the core of one of his treatises, *In ovo & pullo observationes*. Steno clearly did not attempt to write a history the way Harvey had, however. As if the reader was watching over his shoulder, Steno described in detail how he had opened eggs, at different ends, in different stages of development over the course of twenty days. On each consecutive day, he recorded different details regarding these eggs and the embryos inside. He collated his observations into a chronological account of the development of an egg into a chick, speaking mostly in the first person singular, occasionally in first person plural, and about individual eggs.²⁵ Swammerdam adapted precedents such as these to his own purposes.

Swammerdam's position in the ongoing discussions about generation in *General History* and the elaborated version, the posthumously published *Bible of Nature*, has received special attention from historians. Contrary to what Aristotle had suggested, insects did not appear spontaneously from decaying matter; instead, said Swammerdam, they came from eggs. Similarly and more controversially, adult butterflies did not appear spontaneously from the decay of the caterpillar either. Instead, the adult was already present in the caterpillar in rudimentary form and with all its parts present, and slowly developed from this form. Since insects did not substantially change during this process, metamorphosis was a misnomer, according to Swammerdam. Rather they underwent 'natural changes'.²⁶ His writing suggested that

21 Fabricius had included images of differently shaped bird eggs as having the same parts, and discussed the variety and commonalities of different such 'perfect eggs' in a separate chapter called a *historia*, or 'description of the egg'. See Adelman, op. cit. (16), pp. 166, 169–75, Part 2, pp. 401–9.

22 Harvey, 'Anatomical exercises', op. cit. (15), 270.

23 Domenico Bertoloni Meli, 'Of snails and horsetails: anatomical empiricism in the early modern period', in Claire Crignon, Carsten Zelle and Nunzio Allocca (eds.), *Medical Empiricism and Philosophy of Human Nature in the 17th and 18th Century*, Leiden and Boston: Brill, 2014, pp. 111–28, esp. 113.

24 Fournier, op. cit. (11), pp. 68–71; Cobb, op. cit. (7), pp. 143–4, 151–2; Ogilvie, op. cit. (11), p. 236; Swammerdam, op. cit. (10), pp. 23, 69, 106, 121, esp. *Naa-reeden*, 5; Swammerdam, op. cit. (8), pp. 65, 169, 533.

25 Nicolas Steno, 'XIX Observations on egg and chick: *In ovo & pullo observationes*', in Troels Kardel and Paul Maquet (ed. and trans.), *Nicolaus Steno: Biography and Original Papers of a 17th Century Scientist*, Berlin and New York: Springer, 2013, pp. 529–36.

26 E.g. Swammerdam, op. cit. (10), pp. 1, 8, 24, 26, 55, 56; Gasking, op. cit. (7), pp. 43, 47, 63, 113; Cobb, op. cit. (7), p. 141.

the incremental changes described would always occur in every individual specimen of a particular kind of insect. Throughout his writings, he consistently distinguished between recounting the variation he had observed and the key changes that he believed all similar animals underwent.²⁷

Swammerdam claimed that all bloodless animals reproduced and developed in four main ways or orders. As a consequence, he ordered together some unexpected creatures. In the first order, for example, we find 'spiders, mites, lice, fleas, woodlice, worms, scorpions, leeches, centipedes and snails', since they all hatched from an egg 'in a form that closely resembled the adult' except for its size. Animals in the second order underwent several moults. Those in the third group came from an egg as a caterpillar, which developed into a pupa (chrysalis) when its adult limbs had grown under the skin. From the chrysalis it emerged without this skin, with the ability to procreate. This third order he subdivided into two 'ways' or 'kinds'. Animals in the fourth group underwent the same changes as animals in the third order, without forming a chrysalis.²⁸ Swammerdam thus defined the 'general characteristics' of each order through comparison, outlining the stages where each order was similar to or different from the others. Swammerdam then further subdivided the animals that he collected into smaller groups and described some of their physical characteristics under the order he had placed them in by enumerating them 'in general'.²⁹

Finally, in *Bybel* he added detailed descriptions of typical species belonging to each order, such as the louse, snail and water flea belonging to the first order; the stonefly and dragonfly to the second; the ant, night-butterfly, bee and a type of carabus beetle and day-butterfly to the third order; and the fly and gadfly for the fourth.³⁰ These descriptions, which he called 'specific' or 'particular' 'examples' or 'histories', served as examples for the development of all the animals belonging to that order.³¹ He trusted that these histories could count as a 'general rule' by which all changes in insects could be checked and examined. By providing the same number of images to his accounts of the louse, stonefly, day-butterfly and fly, and describing them by the same 'fixed rule', the orders to which they belonged could be compared.³² It was primarily in these series of images that the successive changes could be traced, throughout the development of these animals.³³ Like the collated dissections of Harvey and Steno, these histories and images left the impression that an individual animal underwent a continuous development, as Swammerdam believed it did, identical to others of its kind. However, despite appearances, these specific histories were necessarily constructed from series of dissections of many different individual animals.

27 Swammerdam, op. cit. (10), pp. 62, 85, 113, 125, 133–4, 146, 155; Swammerdam, op. cit. (8), p. 621.

28 Swammerdam, op. cit. (8), pp. 64, 551.

29 See e.g. Swammerdam, op. cit. (10), pp. 65, 89–98, 104–27, 155; Swammerdam, op. cit. (8), p. 69.

30 Cobb, op. cit. (7), pp. 144–5; Ogilvie, op. cit. (11), pp. 236–7; Swammerdam, op. cit. (8), p. 64.

31 Swammerdam, op. cit. (8), pp. 63–4, 603, 616, 627, 629, 637, 641, 644, 738.

32 Swammerdam, op. cit. (8), pp. 65–6, *1.

33 Swammerdam, op. cit. (8), p. *1. For a comparative study of Swammerdam's image making see Bertoloni Meli, op. cit. (11), pp. 405–29.

Swammerdam studied generation by performing series of dissections, just as his predecessors had done. He did this systematically, as can be seen from a specific history prepared for publication in *Bible of Nature*.³⁴ On 15 August, he identified a group of caterpillars, which he determined to be of an animal whose appearance Dutch fine painter Johannes Goedaert (1617–68) had described, but that he himself had not encountered previously. Swammerdam studied the development of its pupae by intermittently opening one up, thereby killing it, while letting the others develop further towards maturity. He studied the development of these in the same way over seventeen days. On the basis of this examination he sorted this ‘common and coloured day-butterfly’ into the third of his four orders.³⁵ From this exercise it is clear that Swammerdam already knew what to look for to place the insect in the correct order. In defining his four orders he had apparently decided which characteristics of the insect were significant to tracing its development. It was far from self-evident how such characteristics should be identified, however, as will become clear in the next sections. While relying on the observational practices of anatomists like Fabricius, Harvey and Steno to study the uniformity of nature, Swammerdam engaged in broader strategies for ordering the great variety found in nature. These issues became more pressing as more and more kinds of plants and animals were investigated.³⁶

Accidental and essential characteristics

Because of his interest in dividing insects into distinct orders, Swammerdam’s work has been characterized as part of seventeenth-century efforts to classify insects.³⁷ His ordering of insects through comparing their features and writing histories also indicates the tradition of taxonomy. One debate that had received particular attention during the previous century concerned the possibility of defining and identifying a plant or animal by describing its morphological features. Very simply put, some argued that such features were only accidental – that is, changeable, independently of the substance of something – and not essential – that is, inherent to its substance. Therefore they were not suited to defining or identifying a plant or animal. Importantly, others developed the notion of ‘inseparable’ or ‘native’ accidents to argue that, indeed, plants could legitimately be identified by describing some of their accidents, like their colour and the shape of their parts.³⁸ While varieties of plants and animals could be organized through a listing of accidental properties, the question still remained which accidents should be included to properly describe and organize them. Naturalist Conrad Gessner (1516–65) had

34 This in contrast to his contemporary Van Leeuwenhoek. Jorink, op. cit. (9), p. 241.

35 Swammerdam, op. cit. (8), pp. 571–88, 778.

36 Bertoloni Meli, op. cit. (23), p. 114.

37 Ogilvie, op. cit. (11); Bertoloni Meli, op. cit. (11).

38 Kristian Jensen, ‘Description, division, definition: Caesalpinus and the study of plants as an independent discipline’, in Marianne Pade (ed.), *Renaissance Readings of the Corpus Aristotelicum*, Copenhagen: Museum Tusulanum Press, 2000, pp. 185–206; Ian Maclean, *Logic, Signs and Nature in the Renaissance: The Case of Learned Medicine*, Cambridge: Cambridge University Press, 2002, pp. 140, 142–3, 168, 170; Sachiko Kusakawa, *Picturing the Book of Nature: Image, Text, and Argument in Sixteenth-Century Human Anatomy and Medical Botany*, Chicago and London: The University of Chicago Press, 2012, pp. 102–7.

dealt with this issue in *Historiae animalium* (1558) inter alia by occasionally including descriptions of animals *in genere*, besides descriptions of particular animals in that group, *privatim* or *speciatim*. These 'general' descriptions included the characteristics that a group of different species or varieties had in common, whereas 'particular' descriptions included those features typical of a species or variety. This meant that varieties of animals could be grouped depending on their similarities and differences, while saving space on the page.³⁹ Ulisse Aldrovandi (1522–1605) had distinguished between descriptions *in genere* and *in particulari* with the same purpose in his works on birds.⁴⁰ This distinction between general and specific descriptions helped Swammerdam to order the insects he had observed and was aware of, within the limitations of a book, albeit a very large one, and it also helped him to limit the number of observations that he needed to make.

There has been some doubt as to the aptness of the title of Swammerdam's first book on insects, *Historia insectorum generalis*.⁴¹ Indeed, it hardly contains the names or descriptions of all insects that were known to exist by the last quarter of the seventeenth century, only those that he had examined and collected as specimens in various boxes.⁴² In what sense, then, was it a 'general' history? Actually, remarkably few general histories about the natural world had been published by 1669.⁴³ Earlier general histories concerning plants help us to better understand the title of Swammerdam's book and the distinction between specific and general histories that apparently helped him to classify insects. One such *Historia generalis plantarum* (Lyon, 1586), by physician and botanist Jacques Dalechamps (1513–88) had the encyclopedic aim of covering nearly all plants mentioned by Greek, Latin and Arabic classical authors and exhibiting those newly discovered in the East and West, in twenty-eight books. The 'general' in the title appears to refer to this all-encompassing aim, only permitted by the impressive size of the publication.⁴⁴

39 See, e.g., on bulls and cows and on dogs, Conradus Gesnerus, *Historiae animalium lib. I de Quadrupedibus viviparis*, Zurich: Christoph Froschauer, 1551, pp. 235–69. On tortoises, Gesnerus, *Historiae Animalium liber IIII de Piscium*, Zurich: Christoph Froschauer, 1558, pp. c2v, 1130–43. On Gessner's use of shared morphological characteristics in his taxonomy of fish see Sophia M. Hendrikx, 'Monstrosities from the sea: taxonomy and tradition on Conrad Gessner's (1516–65) discussion of cetaceans and sea-monsters', *Anthropozoologica* (2018) 53(11), pp. 125–37, esp. 126–7; and Hendrikx, 'Gessner's taxonomical skill exhibited in his discussion of Felchen', in U.B. Leu and P. Opitz (eds.), *Conrad Gessner (1516–1565): Die Renaissance der Wissenschaften/The Renaissance of Learning*, Berlin and Boston: De Gruyter Oldenbourg, 2019, pp. 607–38, esp. 607.

40 Aldrovandi, op. cit. (15).

41 Cobb, op. cit. (7), p. 143, called it deceptive.

42 Swammerdam, op. cit. (10), p. 65; Swammerdam, op. cit. (8), p. 45.

43 Many concerned a full description of a particular territory and were particularly popular as a title in France, e.g. Gonzalo Fernández de Oviedo y Valdés, *L'Histoire Naturelle et Générale des Indes*, Paris: Michel de Vascosan, 1555; Thomas de Fougasse, *Histoire Générale de Venise depuis la fondation de la ville*, Paris: Abel l'Angelier, 1608; Girolamo Franchi di Conestaggio, *Histoire Générale de Portugal et des Indes Orientales*, Arras: Baudouin, 1617; Gabriel du Moulin, *Histoire Générale de Normandie*, Rouen: Jean Osmont, 1631; Jean-Baptiste du Tertre, *Histoire Générale des Isles de S. Christophe, de la Guadeloupe, de la Martinique et autres dans l'Amérique*, Paris: Jacques Langlois, 1654.

44 Jacques Dalechamps, *Historia Generalis Plantarum*, Lyon: Gulielmum Rouillium, 1586; Andrea Cesalpino, *De Plantis Libri XVI*, Florence: Giorgio Marescotti, 1583, was also supposed to contain all plants.

In creating his large, one-volume herbal, *The Herbal or General History of Plants* (1597), surgeon and botanist John Gerard had problems fitting in all the varieties of plants that he was aware of. As he expressed it, ‘to write of Peares and Apples in particular, woulde require a particular volume: the stocke or kindred of Peares are not to be numbred’. His solution for these two cases was to

set downe the figures of some fewe with their severall titles, as well in Latine and English, and one generall description for that, that might be saide of many, which to describe apart, were to send an Owle to Athens, or to number those things that are without number.⁴⁵

This also meant that ‘sorts’ of plants of which no images existed and which could not be discussed in detail could still be known sufficiently from a general description of the genus and its common uses.⁴⁶ All known plants could thus be included ‘in general’, without describing all of them ‘apart’.⁴⁷ This formulation of general descriptions of a genus, before discussing that genus’s different varieties or ‘kinds’, comes close to the sense in which Swammerdam’s general history should be understood. Whereas Gerard’s general histories provided ‘generall descriptions’ of species of plants, Swammerdam described ‘the general characteristics of each’ of the four orders of animals that he differentiated.⁴⁸ Focusing on orders rather than species or genera further limited the number of animals that Swammerdam described specifically and expanded the number of animals captured under the general descriptions.

With the changes that Thomas Johnson made to the 1633 and 1636 editions of Gerard’s herbal, it became especially clear that providing ‘general’ descriptions of genera, rather than separate descriptions of varieties, like the apple or pear in the herbal, solved issues of order and construction. After mentioning that there are ‘some twenty foure or more varieties’ of the iris in Gerard’s account of the plant, the editor Thomas Johnson added that

it is a thing no more pertinent to a generall historie of Plants, to insist upon these accidentall nicities, than for him that writes a historie of Beasts to describe all the colours, and their mixtures, in Horses, dogs, and the like.⁴⁹

In other words, the generality of this history of plants meant that not all the ‘accidental’ characteristics of irises needed to be included. Indeed not all varieties of irises, tulips or fox-stones known at the time needed to be described in the herbal. For these many other varieties, Johnson referred to other publications.⁵⁰ Swammerdam’s general history could justifiably be called general in this sense. His differentiation between general and specific histories developed from an endeavour, as Stolberg has described the efforts of some sixteenth-century naturalists, ‘to assemble the countless new

45 John Gerard, *Herball or Generall History of Plants*, London: John Norton, 1597, pp. 1267, 1270, 1273.

46 Gerard, op. cit. (45), pp. 30, 161, 1078, 1324.

47 Gerard, op. cit. (45), pp. 472, 475.

48 Swammerdam, op. cit. (10), pp. 155, 165; Swammerdam, op. cit. (8), 3, 6, 75, 275.

49 John Gerard, *The Herbal or General History of Plants*, London: Adam Islip, Joice Norton and Richard Whitakers, 1636, pp. 101–2.

50 Gerard, op. cit. (49), pp. 102, 140, 145, 212.

empirical observations of natural particulars in a certain field such as zoology and botany'. Importantly, Swammerdam did not arrive at general histories from assembling a large amount of 'individual observations' or histories and working out on paper how to generalize from them.⁵¹

Swammerdam was exceptionally concerned with deciding what changes in the animals were, *toevallig* or *totvallig* – that is, as with Johnson, accidental – and which were *wesentlijk*, *essentieel*, or *reëel* – that is, essential. It was important to get this right because this would form 'the ground and certainty on which the entire building of all the different changes of bloodless animals' depended.⁵² How could these essential changes be identified? To Swammerdam this was primarily a cognitive, embodied process, supported by his exceptional dissection skills and experience. This answer was in tune with contemporary philosophy and partly explains why there is only limited evidence of this part of his observational practice. René Descartes (1596–1650) has been viewed as providing the inspiration behind Swammerdam's search for 'rules and theorems', or even divine law, in insect generation.⁵³ However, Swammerdam's endeavour to arrange dissections into histories that sorted insects into different orders, together with his belief in the fundamental uniformity of nature, and his distinction between accidental and essential changes, tied him to the work of classifiers and anatomists, such as Gessner, Aldrovandi, Gerard, Fabricius, Harvey and Malpighi, rather than to the mechanics of Descartes.

When Swammerdam did express his appreciation for Descartes, it was by drawing on the empirical side of the philosopher's work.⁵⁴ Swammerdam mentioned in his *Historia generalis* that the great Descartes 'appreciated more the reasons drawn from the experiences of regular workmen, than the reflections of scholars that have no effects'.⁵⁵ Without referring to Descartes, he later reminded his readers that reasoning was useless without practical experience of nature: 'See so one strays, if one takes the mind and reason as his teacher, and sitting and speculating in his study room, one neglects the glory of God's works, that are the true teachers of our ignorance!'⁵⁶ In these references to experience, and to the type of experiences that would be most useful to gather, Swammerdam most evidently showed his debt to Descartes. In his use of induction, too, he appears indebted to Descartes, as well as to other seventeenth-century philosophers and physicians.

51 Michael Stolberg, 'Medical note-taking in the sixteenth and seventeenth centuries', in Alberto Cevolini (ed.), *Forgetting Machines*, Leiden and Boston: Brill, 2016, pp. 143–264.

52 Swammerdam, op. cit. (10), pp. 8, 14, 20; Swammerdam, op. cit. (8), pp. 64, 621.

53 Jorink, op. cit. (9), p. 255.

54 This side of Descartes's work has received particular attention from historians in more recent years. M. Dobre and T. Nyden (eds.), *Cartesian Empiricisms*, Dordrecht: Springer, 2013; Swammerdam, op. cit. (10), *Naa-reeden*, p. 7.

55 Swammerdam, op. cit. (8), p. 634; Swammerdam, op. cit. (10), p. 154: 'Ten welken aansien ook den grooten Cartesius ergens segt, meer te agten de reedenen uyt de ondervindingen van de gemeene werklieden getrokken, als de bespiegelingen der geleerden die geen uytwerkingen voort en brengen'.

56 Swammerdam, op. cit. (8), p. 580. 'Siet so dwaalt men, als men het verstant en de reeden, tot syn leermeester neemt, en dat men in syn studeerkamer sittende ende speculeerende, de heerlykheid van de werken GODS versuymt, die de waare leermeesters onser onwetenheid syn'.

Induction according to physicians and philosophers

As part of his inquiry into generation, Swammerdam famously built a large collection of dried and embalmed animals at various stages of their development. By the late 1670s, it consisted of around 1,200 pieces. These dried and embalmed animals showed their true shape, Swammerdam wrote, in a way the images and descriptions could not. Kept in boxes, this collection would provide ‘visible proof’ of what he wrote.⁵⁷ Some of these animals he had investigated ‘particularly’, yet not all had been examined in this way. Instead, they were placed in one of the four orders through, in Dutch, *optelling* or *inductie*, translated as *enumeratio*, *recensio*, *inductio* or *analogia* in Latin.⁵⁸ While he argued that his work was supported by ‘our own experiences, as on an unshakable ground’ and that ‘certain conclusions, stable positions and regular Orders’ were taken from them, *optelling der deelen* or ‘induction of parts’ came into play where these experiences fell short.⁵⁹ Induction had been a much-discussed topic in the work of philosophers and physicians earlier in the seventeenth century. While Swammerdam does not explicitly mention the source of his ideas on the topic, these earlier discussions did provide him with a context and justification for how he studied insects.

Harvey had presented induction as a new method of investigation, but he also grounded it in Aristotelian and Platonic philosophy. Referring to Aristotle’s *Physics* and *Analytics*, he argued that it was ‘advisable from singulars to pass to universals’, because what was derived from induction was more ‘perspicuous’ than what was known through syllogism. This passing from singulars to universals was a faculty of the human mind, which Harvey called ‘the understanding’, ‘imagination’, ‘the internal sensorium’ or ‘the fancy’. Harvey explained that ‘the comprehension of universals by the understanding is based upon the perception of individual things by the senses’. When an external sensory ‘impression comes to be made an abstraction, and to be judged of and understood by the internal sensorium, it is a universal’. Referring to Platonic philosophy, he argued that immediately after the perceived object was removed, ideas, types or *forma informans* were formed in a person’s imagination or memory, and the object was no longer ‘apprehended as a particular’. Though this idea was ‘a real entity’, ‘without the due admonition of the senses, without frequent observation and reiterated experiment our mind goes astray after phantoms and appearances’. Harvey then advised his readers ‘to strive after personal experience, not to rely on the experience of others’. Generation could only be fully understood ‘by repeated dissection’. Otherwise, ‘we shall but come to empty and unstable opinions; solid and true science will escape us altogether’.⁶⁰

57 Lindeboom, op. cit. (7); Swammerdam, op. cit. (10), pp. 50, 65, 110, 224, 265; Swammerdam, op. cit. (8), p. 45.

58 Swammerdam, op. cit. (10), pp. 2, 95, 155; Swammerdam, op. cit. (8), pp. 634, 807, 866–7.

59 Swammerdam, op. cit. (10), pp. 5, 48, 52, 56, *Naa-reden*, 5; *Noodig bericht*, **2r: ‘Op onse eygene ervarentheeden, als op een onvervrikbaare gront, sullen steunen; ende daar seekere beslyuten, vaste stellingen ende geregelde Ordenen, uyt maaken’.

60 Harvey, ‘Anatomical exercises’, op. cit. (15), pp. 154–8; Walter Pagel, ‘Harvey and European thought in the seventeenth century’, in *William Harvey’s Biological Ideas: Selected Aspects and Historical Background*, Basel and New York: Karger Medical and Scientific Publishers, 1967, pp. 15–47, 35–6.

Like others writing about induction, Swammerdam was not much concerned with 'the mental process of induction'.⁶¹ But rather than regarding the imagination as the function of the mind that produced universals, Swammerdam instead warned his readers about imagination's power to deceive. 'If experiences are lacking, the further knowledge drawn from our reasoning or induction, arise not from Nature, but from our imagination.'⁶² According to Swammerdam, Goedaert had been a victim of his own imagination regularly, since he had portrayed several animals incompletely or incorrectly and his description of some insects read more like a novel than a 'true history'.⁶³ Even the 'most diligent investigators of nature' who preceded Swammerdam in studying insects, such as the Italian Ulisse Aldrovandi (1522–1605), the English Thomas Moffet (1553–1604) and the German Andreas Libavius (d. 1616), had been led astray by prejudice to reject what experience had shown them regarding generation.⁶⁴ For Swammerdam, reason based on extensive experience, not the imagination, allowed for induction. Thus while Swammerdam and Harvey attributed contrary roles to the imagination in the process of induction, they both emphasized its reliance on repeated, personal experience of nature to counteract the mind's tendency to stray. Induction had allowed Harvey to present his 'history of the egg' as a basis for 'theorems' about all eggs in his *Exertationes*.⁶⁵ Swammerdam extended this use of induction to define four orders of generation from a limited number of observations and to justify his use of specific histories to exemplify the development of all animals belonging to each of those orders.

Swammerdam needed to decide which amongst the countless possible observations and dissections that could be performed on insects would be most useful to understanding generation. In some animals it was more difficult to see their different parts than in others, either because they stuck together, or because the animals were especially small.⁶⁶ He addressed these issues in a key passage. He argued that though there were still

innumerable miracles of nature surrounding the changes of these animals to be experienced, it would be much more useful to have naturally described one single change of a caterpillar, as example for all other caterpillars, than to depict all the changes of caterpillars, with their colours.⁶⁷

Swammerdam's suggestion that in such cases a description of one single change of a caterpillar could be used as an example for all other caterpillars comes strikingly close to Descartes's discussion of enumerative induction. In his early work *Regulae ad*

61 Robin Buning, *Henricus Reneri (1593–1639): Descartes' Quartermaster in Aristotelian Territory*, Zutphen: Zeno Institute of Philosophy, 2013, p. 132.

62 Swammerdam, op. cit. (10), pp. 6, 7, 19, 21, 45, 56, 83, 103; Swammerdam, op. cit. (8), pp. 38, 148, 634. 'Want anders, als de ondervindingen ons komen te ontbreken, so is de vordere kennis die we uyt onse reedenen of door optelling putten, niet uyt de Natuur, maar uyt onse herssenbeelden voortkomen'.

63 Swammerdam, op. cit. (10), pp. 47, 50; Swammerdam, op. cit. (8), p. 487; Swammerdam also referred to 'fabels' in *Bybel*, 708, *Tarantula*, 56, 941, *Slakken*, 98, 938, *Kreeften*, 147–8, 934, *Bijen*, 397, 398, 477, 530, 931.

64 Swammerdam, op. cit. (10), pp. 18, 29, 256.

65 Harvey, 'Anatomical exercises', op. cit. (15), p. 165.

66 Swammerdam, op. cit. (10), pp. 2, 5, 15, 48, 63, 71, 85, 166, *Naa-reden*, 4.

67 Swammerdam, op. cit. (8), p. 553.

directionem ingenii (1628), not published until 1684, the philosopher outlined rules for attaining knowledge and included a discussion of what, according to him, can be called ‘enumeration or induction’. One example of *enumeratio* that he provided is as follows:

To give one last example, say I wish to show by enumeration that the area of a circle is greater than the area of any other geometrical figure whose perimeter is the same length as the circle’s. I need not review every geometrical figure. If I can demonstrate that this fact holds for some particular figures, I shall be entitled to conclude by induction that the same holds true in all the other cases as well.⁶⁸

A few years after Descartes, the Dutch philosopher Henricus Renerius (1593–1639) had written about this kind of reasoning through analogy as well. In his 1635 disputation *De natura et constitutione physicae*, Renerius had described what he thought scientific knowledge was and how to build it. The first step in the scientific process was to collect observations in a natural history, which should be a collective effort. Things that were too far away or too small to be seen with the naked eye could be observed by means of a telescope or a microscope. Anatomical section and chemistry could help to uncover things hidden from view. Importantly for Swammerdam’s problem, Renerius stated that reason could be used to derive conclusions from the analogous effects and associated phenomena that were better visible.⁶⁹

To these later philosophers, the process of induction was not as immediate and natural as Harvey had described. Another author with whom Swammerdam was familiar had discussed induction ten years after Harvey published his exercises. Swammerdam referred to the work of Henricus Regius (1598–1679), professor of theoretical medicine, botany and anatomy at the University of Utrecht, who was an admirer of Descartes and adapted his ideas. Regius had included a discussion of the way in which spiders move from tree to tree in his very popular *Philosophia naturalis* (1661).⁷⁰ In this book and its earlier edition of 1654, Regius provided an overview of nature from the principles that constituted it, through to the human body. At the end of the section on animals, Regius included a short chapter entitled ‘Of beasts’, which grouped insects under reptiles.⁷¹ In the 1661 version of this chapter, the section on reptiles was expanded by a discussion of the way some caterpillars develop from eggs into adult moths and butterflies.⁷² It seems that in this short section, Swammerdam had his work cut out

68 J.R. Milton, ‘Induction before Hume’, in Dov M. Gabbay, Stephan Hartmann and John Woods (eds.), *Inductive Logic: Handbook of the History of Logic*, vol. 10, Amsterdam et al.: Elsevier, 2011, pp. 1–41, esp. 29; Robert C. Miner, ‘The Baconian Matrix of Descartes’s *Regulae*’, in Nathan D. Smith and Jason P. Taylor (eds.), *Descartes and Cartesianism*, Newcastle: Cambridge Scholars Press, 2005, pp. 1–20, 10.

69 Buning, op. cit. (61).

70 Swammerdam, op. cit. (10), p. 71; Henricus Regius, *Philosophia naturalis, in qua tota rerum universitas, per clara & facilia principia, explanatur*, Amsterdam: Ludovicum and Danielem Elzevirios, 1661, pp. 517–18; Regius, *Fundamenta physices*, Amsterdam: Ludovicum Elzevirium, 1646; Theo Verbeek, ‘Regius’ *Fundamenta Physices*, *Journal of the History of Ideas* (October 1994) 55(4), pp. 533–51.

71 Henricus Regius, *Philosophia naturalis, in qua tota rerum universitas, per clara & facilia principia, explanatur*, Amsterdam: Ludovicum Elzevirium, 1654, pp. 330–3, ‘Caput XVII De Bestiae’.

72 Regius, *Philosophia naturalis*, op. cit. (70), pp. 352–97.

for him. Regius had included insects in his grand scheme of natural philosophy, but he still could not say much more about their development than previous authors.

As Delphine Bellis has shown, Regius also wrote about induction. He explained that universal notions about things

can be inferred from the collection of a few particulars observed by us. For those notions, which have been collected and acquired through induction from the observation of some particulars, are universal insofar as we judge them to agree with all other similar particulars because of a similarity that we believe they have with all the other particulars that have not been perceived by us.⁷³

In other words, collecting particulars and finding similarities between them was a basic part of induction. Though this retained induction as a natural function through which the mind produced universals, it qualified Harvey's ideas about repeated experience to some extent, indicating that it required a conscious search for similarities. Like Descartes and Renerius, Regius allowed for making statements about what had not been 'reviewed' or 'perceived' by induction.⁷⁴ Swammerdam offered the same solution. Using induction, he was justified in classifying animals that he had not investigated 'particularly' and in taking his description of a caterpillar's transformation as an example for all other caterpillars. As he wrote, 'And having all the science that we can have of the fabric of animals, we find nothing else to do but an induction of parts, which we had seen previously in bigger animals.'⁷⁵ When using the word *inductie* in *Bybel*, Swammerdam clarified that he had not actually seen that a body part existed in other animals, but that he judged them to be present in a similar shape and situation by induction.⁷⁶

Renerius's biographer, Robin Buning, has pointed out that Renerius's induction 'comes down to simple enumeration'.⁷⁷ In his *Novum Organum Scientiarum* of 1620, Bacon dismissed this type of induction as immature and a potential path to error. Instead, he outlined a complex procedure of setting up a succession of tables (tables of presence, of absence in approximation, of degrees, and of exclusion or rejection of natures) to be interpreted through induction by exclusion.⁷⁸ Though scholars in the Dutch Republic generally received Bacon's work, particularly *Silva Silvarum*, enthusiastically, its reception was mixed and its impact remains difficult to estimate.⁷⁹ No paperwork as part of

73 Delphine Bellis, 'Empiricism without metaphysics: Regius' Cartesian natural philosophy', in Dobre and Nyden, op. cit. (54), pp. 151–83, 158.

74 Bellis, op. cit. (73), pp. 156–7. Quoted from Regius, op. cit. (71).

75 Swammerdam, op. cit. (10), p. 2.

76 Swammerdam, op. cit. (8), pp. 77, 83.

77 Buning, op. cit. (61).

78 Francis Bacon, 'The true method of discovering forms; illustrated by an example in the form of heat', in *The Philosophical Works of Francis Bacon*, 3 vols. (ed. Peter Shaw), London, 1733, vol. 2, pp. 433–66.

79 For some of the great enthusiasm for the work of Bacon in the Low Countries see Paul Dibon, 'Sur la reception de l'oeuvre de F. Bacon en Hollande dans la première moitié du XVIIe siècle', in Paul Dibon, *Regards sur la Hollande du siècle d'or*, Naples: La Scuola di Pitagora, 1990, pp. 191–220. For some consideration of Bacon's influence on Regius and Renerius see Bellis, op. cit. (73); and Buning, op. cit. (61). For Isaac Beeckman's reading of Bacon see Benedino Gemelli, 'Isaac Beeckman as a reader of Francis Bacon's *Sylva Silvarum*', *Journal of Early Modern Studies* (2013) 2(1), pp. 61–81; and Gemelli, 'Bacon in

the induction process, such as described by Bacon, appears in what remains of Swammerdam's work. This would accord with his thinking of induction principally as an embodied process, founded on extensive experience in dissecting animals. Still, there are aspects of Swammerdam's work that demonstrate a similarly critical attitude towards simple enumerative induction. For example, he noted the importance of acknowledging counterinstances. While he admitted he had not studied every single insect that he had collected 'particularly', he was confident that all insects developed according to one of the four orders he defined. In the introductory text, he wrote that the only thing that would make him doubt this was if there were *tegenstrijdige bevindingen* or 'contradictory findings'. One would be wrong, for example, if 'from the induction of an infinite number of animals that one had found to be either male or female, one would conclude that male and female could never be found together'. Swammerdam himself had provided a counterexample to this conclusion by discovering that snails were hermaphrodites. He promised his readers that if he still found anything that spoke against his positions, he would impart it to his readers.⁸⁰

Swammerdam's critical attitude towards simple enumerative induction is also evident in his distinction between accidental and essential changes. Comparing animals to find both similarities and differences between them was central to Swammerdam's practice of observation and induction, as for other taxonomists and anatomists. Characteristics he considered essential to the development of various insects formed the basis of his four orders.⁸¹ As we saw in the quote above, he thought it 'useful' to leave some of the changes that a caterpillar underwent out of his description. This included characteristics such as colour, which were significant to other students of these animals. These, Swammerdam apparently had decided, were only accidental properties in his investigation of generation. The centrality of comparison and the identification of essential changes is also reflected in the title of the 'special treatise on frogs', 'comparison of the changes or, as I say, transformation of the limbs in the nymphs of frogs with those of the insects'.⁸² In addition, Swammerdam expressed the results of his enumerations in a table of 'general comparison and similarity of the changes or accretion, in parts and limbs'. It displayed the points of comparison between the animals and incorporated innumerable observations of individual animals, as did the self-produced images in his publications and the collected specimens in his study.⁸³ Swammerdam's induction did not consist in collecting similar or different instances or cases, but rather in identifying the essential characteristics of each order of change and claiming that those orders existed beyond what he had seen.

Although, clearly, Swammerdam could rely on recent developments in the philosophy of induction, he combined these with the observational practices of taxonomists and

Holland: some evidences from Isaac Beekman's *Journal*, *Journal of Early Modern Studies* (2014) 3(1), pp. 107–30.

80 Swammerdam, 'Noodig bericht aan den waarheid beiverende leeser', in Swammerdam, op. cit. (10), p. *(3).

81 See e.g. Swammerdam, op. cit. (80), pp. 7–16, 24, 56, 99–101, 103, 140.

82 Swammerdam, op. cit. (8), p. 789.

83 Swammerdam, op. cit. (8), p. 553; Swammerdam, op. cit. (10), pp. 63, 79, 155; incidentally, this table is nothing like those proposed and composed by Bacon.

anatomists to present his findings as 'on an unshakable ground' of 'our own experiences'. While the rules and guidelines outlined by Bacon, Descartes and Regius were directed at finding the causes of natural things, Swammerdam made it clear that the true causes or the real origin of God's works remained completely impenetrable to him.⁸⁴ His reliance on thorough and thoroughly personal experience, rather than on a collective effort to discover order and regularity in nature, further distinguished Swammerdam's observational practice from that proposed by Bacon and Renerius. It made sharing the task of observation of only limited use and sidelined the activities of many others in Dutch society who were interested in insects. By 1669 several Dutchmen possessed elaborate collections of insects, especially of butterflies and moths. The collectors had organized the animals according to various principles, from their size to their colour. At least one is known to have used Goedaert's publications as a template for the organization of his collection.⁸⁵ With his use of induction, collating dissections into histories and distinguishing accidental and essential characteristics, Swammerdam rejected this more haphazard approach to observing and categorizing insects, while Blankaart embraced it.

Paperwork and Blankaart's *Theatre of Caterpillars*

The notebook next to the wooden box in Van Musscher's painting appears similar in function to the original notes of Dutch physician–naturalist Steven Blankaart that remain in the Zeeland provincial archives. Quite badly damaged by water, these notes are some of the few that survive of those originally assembled by seventeenth-century Dutch naturalists. It consists of a few dozen quires loosely stacked together and held in a paper cover. Each quire is only pinned together, ensuring that more sheets can easily be added when desired. All notes and the images pertaining to one particular series of observations remained together in each gathering, which could easily be taken out of the stack and rearranged.⁸⁶

At first sight the resulting accounts of insects might appear similar to the histories constructed by Swammerdam and his fellow anatomists. After all, they are chronologically arranged accounts of an insect's development. Closer inspection, however, shows that they originated from very different kinds of observational practice. No sophisticated ideas on induction were involved in their composition. Blankaart noted down in detail where and when he had encountered the insects, how they behaved, how he had kept them and fed them, and how they had developed. Each time something notable happened to the insects in his study, or every time Blankaart made a follow-up observation, remembered an earlier encounter with such an insect or conducted some little experiment, he wrote it down following the other notes, within the same gathering, numbering

84 Ogilvie, op. cit. (11), p. 236; Swammerdam, op. cit. (10), *Naa-reeden*, 5, 8.

85 Minges, op. cit. (4); Ken Arnold, *Cabinets for the Curious: Looking Back at Early English Museums*, Aldershot: Ashgate Publishing, 2006, pp. 211–20 – there the interplay between collecting and ordering of objects and of writing is also addressed.

86 Steven Blankaart, 1137G2 'Aantekeningen over insecten', c.1695, Handschriftenverzameling Koninklijk Zeeuwsch Genootschap der Wetenschappen, 1400–1999, Zeeuws Archief.

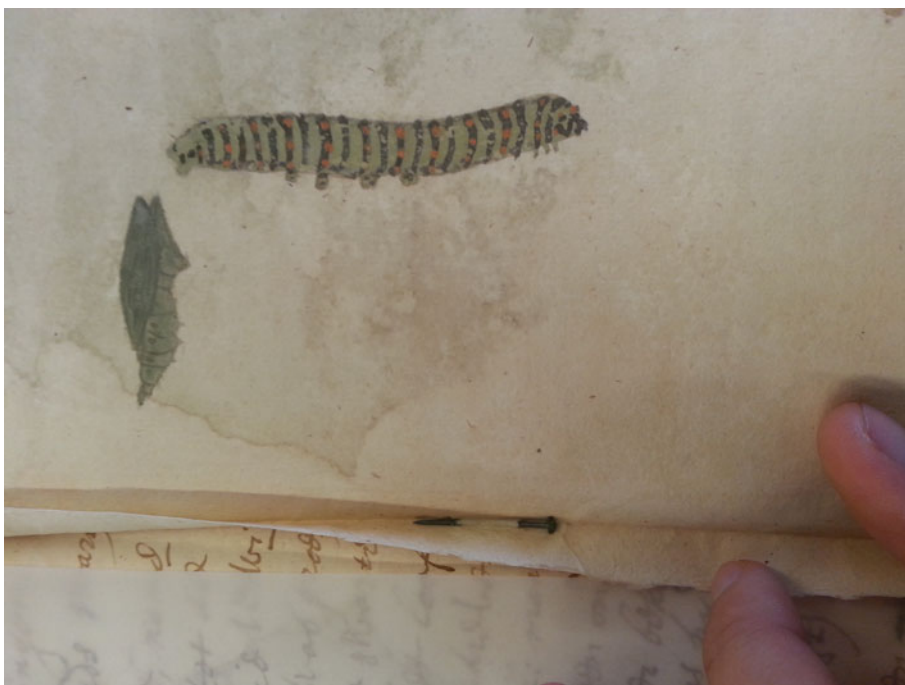


Figure 2. Blankaart's manuscript consists of a few dozen quires loosely stacked together and held in a paper cover. Each quire is only pinned together, ensuring that more sheets could easily be added when desired. The images are pinned to each quire, so that they could be detached to be engraved for publication or transferred to a neat copy. Image by the author with permission from the Collectie van het Koninklijk Zeeuwsch Genootschap der Wetenschappen (KZGW).

consecutive entries with roman numerals.⁸⁷ He dedicated a few chapters to animals he had only read about and consequently had made no images and observations of at a particular time or place.

Blankaart modelled his way of studying the development of insects on that of Goedaert, whom he knew from his youth in the Zeeland city of Middelburg.⁸⁸ Goedaert investigated insects over thirty years at his home, without dissecting them, before he was persuaded to publish his findings in three parts from 1660. His *Metamorphosis Naturalis or Historical Descriptions, and the Origin, Characteristics and Strange Changes of Worms, Caterpillars, Maggots, Flies, Butterflies, Bees, Moths and more such Animals*, in which he described the development of these animals in shape, colour and behaviour over time, made him internationally renowned. Scholar Johannes de Mey (1617–78) had added learned commentaries or annotations to

⁸⁷ Blankaart, op. cit. (86). Swammerdam included some of these details in his some of his 'particular' histories too, e.g. Swammerdam, op. cit. (8), pp. 110, 224, 265, 414, 522

⁸⁸ Steven Blankaart, *Schou-burg der rupsen, wormen, maden, en vliegende dierkens daar uit voortkomende*, Amsterdam: Jan ten Hoorn, 1688, pp. *3v–*4r.

Goedaert's accounts and translated his works into Latin. Though an admirer of the Dutchman's work, Martin Lister (1639–1712) disapproved of the lack of any order to the arrangement of Goedaert's 'historical descriptions', rearranging them into a systematic organization of his own.⁸⁹

Swammerdam had pointed out the differences between his practices and those of Goedaert. While in Swammerdam's practice many animals died at some point during their development, in Goedaert's and Blankaart's the animals were supposed to live into adulthood and so required care and feeding throughout their lifespan. Swammerdam thought this produced unnecessary labour for researchers.⁹⁰ While he paid plenty of attention to the particularities of the species he described, such as the different ways in which water fleas propelled themselves, or the changing colour of the louse's eyes, he clearly distinguished these from the 'general rules' in the development of insects that he had discovered.⁹¹ Goedaert and Blankaart found all details of an individual animal's behaviour or appearance of equal interest.

The ultimate organization of Blankaart's observations greatly differed from that of Swammerdam's as well. The gatherings that Blankaart assembled were designed to stand on their own as chapters in a publication. After two years, Blankaart printed a selection of forty-nine such bundles, as *Theatre of Caterpillars, Worms, Maggots and the Flying Animals that come forth from Them* (Amsterdam, 1688). While we can discern a loose order into butterflies, moths, spiders and lice in *Theatre*, this is not consistent. Another deciding factor for the organization of the book appears to have been the way Blankaart's painted images fitted together on the engraved plates. The size of the images was not adjusted to the size of the sheets they were printed on. The randomness that this introduced into the order of the insects included in the book emphasized the uniquely individual characteristics of each encounter.⁹² It is reminiscent of the collections of drawings of plants and animals of the previous century, but also of the drawings by some contemporary amateur naturalists such as Jan Velten.⁹³ As an insect collection on paper, Blankaart's book could easily fit alongside any collection of specimens, no matter the organizing scheme the collector had imposed on it.

The organization of the book is representative of the way the scholarly, amateurish and commercial coexisted in *Theatre*. After studying medicine in the northern city of Franeker, Blankaart began practising medicine in Amsterdam around 1674. One historian has called him 'a lover of the new' and in his publications he shared this love with an

89 Huib J. Zuidervaart, 'Het natuurbeeld van Johannes de Mey (1617–78), hoogleraar filosofie aan de illustere school te Middelburg', in *Archief: Mededelingen van het Koninklijk Zeeuwsch Genootschap der Wetenschappen*, Middelburg: Koninklijk Zeeuwsch Genootschap der Wetenschappen, 2001, pp. 1–40, 17–18; Brian W. Ogilvie, 'Nature's Bible: insects in seventeenth-century European art and science', *Tidsskrift for Kulturforskning* (2008) 7(3), pp. 5–21, 11–15.

90 Swammerdam, op. cit. (8), p. 32.

91 Swammerdam, op. cit. (8), pp. *2, 86–7.

92 Blankaart, op. cit. (88).

93 Florike Egmont, *Eye of Detail: Images of Plants and Animals in Art and Science, 1500–1630*, London: Reaktion Books, 2017; Florence F.J.M. Pieters and Huub Veldhuijzen van Zanten (eds.), *Wonderen der Natuur in de Menagerie van Blauw Jan te Amsterdam, zoals gezien door Jan Velten rond 1700*, Amsterdam: ETL, 1998.

audience of *liefhebbers* or amateurs.⁹⁴ Starting in 1678, he began what would be an enduring business partnership with publisher and bookseller Johannes Claesz. ten Hoorn (1639–1714). Sometime during 1685, the two conceived the plan to publish a book on insects. Blankaart presented his practices as imitable by telling his readers much about his habits of observation, experimentation and collection, such as the places where insects could be found, and by repurposing regular household objects. From 1686, Blankaart renewed his childhood activity, collecting insects in and around his home, in his garden, inside and outside the gates of Amsterdam, and after visiting patients further afield. He then brought them inside to ‘paint them off’, examine them with his magnifying glass, keeping them with a crystal cup put over them, in porcelain bowls, in sealed bottles, in wooden boxes such as we saw in Van Musscher’s painting, or reburied in earth.⁹⁵ Blankaart occasionally mentioned the various rooms where he kept these animals – for example, when telling of the time he dried a dead parrot in his attic and brought it to his room to examine what kind of ‘small animals’ were in it, or when a moth that had recently emerged from its pupa flew into his ‘book-room’, or when a visitor to this book room had let a spider out of the bottle where Blankaart had been keeping it.⁹⁶

The pleasure derived from handling these small animals, rather than a particular philosophical question, appears to have guided Blankaart’s work. His love for the new, but also wonder at nature, is reflected in *Theatre*’s frontispiece. The image very much emphasized personal experience of nature as a source of knowledge, to the exclusion of book learning and contemplation. In the frontispiece, the action has moved from the study in Van Musscher’s painting to a space half inside, half outside. One person at the table is wearing typical indoor clothing of the time. He is directing his visitor’s gaze to the caterpillar on the table and the visitor appears amazed. There are magnifying glasses on the table and an enlarged caterpillar in the foreground seems to be crawling off a rectangular plane, suggestive of a piece of paper. In the background, two men are admiring a landscape. We also see many of the boxes from Van Musscher’s painting in the frontispiece, where they are now used to exhibit a collection of butterflies on pins. Blankaart explains how to prepare insects in this way in the last chapter of *Theatre*, emphasizing that the collector had to take special care to preserve the animals’ exterior as well as possible, even if this meant damaging or even completely removing its insides.⁹⁷

In *Theatre*, Blankaart promised that if the current publication proved successful, he had much more such material ready to be printed.⁹⁸ Although proposed, a second volume was never published. Taking into account Ten Hoorn’s business acumen, we

94 Erik Dirk Baumann, *François dele Boe Sylvius*, Leiden: E.J. Brill, 1949, p. 196.

95 Blankaart, op. cit. (88), pp. *3v, 4–6, 11, 14, 17–18, 20–4, 27, 29, 32–3, 35–40, 42–4, 46–54, 57, 60, 71, 74–89, 92–5, 97–105, 112, 119–21, 125–7, 138, 146–7, 149, 151–2, 155, 160–4, 166–70, 181–9, 213–31; Blankaart, op. cit. (86), pp. 5, 21, 24.

96 Blankaart, op. cit. (88), p. 5, 37, 80, 125; Steven Blankaart, *Schouburg der rupsen, wormen, maden en vliegende dierkens daar uit voortkomende*, Amsterdam, 1688–95, Koninklijke Bibliotheek, 71 J 51–2, pp. 101, 105–8, 144, 153.

97 Blankaart, op. cit. (88), pp. 206–9.

98 Blankaart, op. cit. (88), p. *4r.



Figure 3. The frontispiece of Blankaart's *Schouburg der rupsen, wormen, maden en vliegende dierkens daar uit voortkomende* or *Theatre of Caterpillars, Worms, Maggots and the Flying Animals that come forth from Them* (Amsterdam, 1688), engraved by Jan Luyken (1649–1712), emphasized personal experience of nature as a source of knowledge and wonder. Image with permission from the Amsterdam Museum.

can only assume that the first volume had not been particularly commercially successful. Still, Blankaart's papers kept in the Dutch Royal Library include a bound first and second volume of *Theatre*. These demonstrate that for Blankaart himself, *Theatre* had a secondary function as a neater, more permanent version of his original notes.⁹⁹

⁹⁹ Blankaart, op. cit. (96); something that was not an unnecessary precaution considering the current state of his rough notes remaining in the Zeeland Archives.

Blankaart's copy of *Theatre* consisted of the pages of the printed book glued into a blank-page notebook together with the original images that Blankaart had made, instead of the book's engravings. The second volume of *Theatre* is a manuscript, the individual gatherings of chapters copied out in a blank book, also with the illustrations glued to the pages. Blankaart had apparently resigned himself to the fact that the second volume would not be published, otherwise he would not have permanently fixed his original images to the pages of the manuscript. A neatly written, bound manuscript was the next best thing to a printed text. The two volumes of *Theatre* thus remained in this form as part of Blankaart's library, as a neat copy of his notes, while he continued to accumulate new observations. He added to the second volume either by filling pages initially left blank, or by fixing additional pages into it. His own books and notes became part of his library and Blankaart would later refer to them in the notes now in the Zeeland archives, as he would to other authors such as Goedaert, Swammerdam, Moffet, Lister and Francesco Redi (1626–97). Comparing the animal he had in front of him with images and written descriptions, including his own, the circle of learned empiricism was complete.

Contemporaries of Blankaart, like naturalists Lister and James Petiver (1668–1718), also used pins and glue to attach images to paper, as well as insects to 'boxes' more or less permanently and to provide a (provisional) organization to their notes and specimen collections. Though this indicates the common historical roots and geographical spread of such practices, it likewise illustrates the extent to which such practices had been advanced in the hands of some, while those of Blankaart remained relatively unsophisticated.¹⁰⁰ As I will continue to explore in the final part of this paper, these practices seem to have served his purposes, however.

Insects and the art of medicine

Publishing his observations on insects appears to have supported Blankaart's reputation as a physician–naturalist. In *Theatre* and his remaining notes, he appears as the grateful recipient of both animals and letters from acquaintances, amongst whom there were many physicians, surgeons and apothecaries. By publishing some of these letters, discussing these gifts and sources, Blankaart publicly showed himself as a well-connected and respected man, a contributor of knowledge and a central person in amateur networks.¹⁰¹ In *Theatre* and his notes, Blankaart found other occasions to exhibit aspects of his medical occupation, such as his knowledge of plants, visits to patients and the fact that he prepared and distributed his own remedies.¹⁰² Indeed, on the title page of the publication, Blankaart announced himself as 'P. & M.Dr. Practitioner in Amsterdam'.

100 Anna Marie Roos, 'Fossilized remains: the Martin Lister and Edward Lhuyd ephemera', in Vera Keller, Anna Maria Roos and Elizabeth Yale (eds.), *Archival Afterlives: Life, Death, and Knowledge-Making in Early Modern British Scientific and Medical Archives*, Leiden and Boston: Brill, 2018, pp. 150–72; and Arnold Hunt, 'Under Sloane's shadow: the archive of James Petiver', in Keller, Roos and Yale, op. cit., pp. 194–221.

101 Blankaart, op. cit. (88), pp. *3v, 94, 213–31; Blankaart, op. cit. (86), pp. 2r, 10r, 11r, 19r, 22r–23v.

102 Blankaart, op. cit. (88), pp. 24, 29, 81, 84, 95, 97, 119, 162, 181–2, 186–9; Blankaart, op. cit. (96), 71 J 52, pp. 12, 21, 29, 31, 36–7, 153; Blankaart, op. cit. (86), p. 24.

In his 'address to the reader' Blankaart made an allusion that sheds more light on how his work on insects related to medicine.

Blankaart started his 'address to the reader' in *Theatre* by assuming that the subject of the book might be unexpected of him, since 'it appeared to be entirely outside of my art'; that is, the art of medicine. By 1688 the reading public would have been familiar with Blankaart as a translator and commentator of Latin medical works and author of compendia on human anatomy and chemical medicine.¹⁰³ Indeed, *Theatre's* subject would be outside his art, Blankaart wrote, had he not, since childhood, endeavoured to discover 'all that is hidden in the human body'.¹⁰⁴ These efforts had apparently helped prepare him for writing this book in some way. Blankaart's half-formed sentences do not do much to explain how the investigation of the human body was connected to the study of insects. Despite presenting *Theatre* as an extension of his youthful interest in discovering 'all that is hidden in the human body', Blankaart did not mention dissecting any animals himself, a practice that was central to Swammerdam's investigations. He does mention some of the anatomical curiosities he had seen in Middelburg in his other works, and had likely witnessed dissections performed in the anatomical theatre of that city. But unlike Swammerdam at Leiden, Blankaart's medical studies at Franeker did not equip him to dissect insects.¹⁰⁵ For Blankaart, the study of the human body and that of insects were not connected through the practice of dissection. Nor was understanding generation the principal point of his study of insects. Still, Blankaart's reference to investigating the human body appears to be an attempt to make a tenuous connection between studying insects and his 'art'.

While a rectangular plane is the only trace of paper in the frontispiece, Blankaart mentions on *Theatre's* first page that in accordance with this interest in the human body, he had kept accurate *aanteikeninge* or notes, as his readers could judge by leafing through the book. In her 2004 article 'Taking note(s)', Lorraine Daston pointed out that 'taking notes entails taking note – that is, riveting the attention on this or that particular'. While Daston relates this to the central role of reading practices in 'doing science', these reading practices involved writing as well. It seems that Blankaart evoked the parallel between taking notes and taking note, in referring to his 'accurate notes'. The accuracy of his notes showed his ability both to notice things and to record them properly on paper. It was his note-taking skills, in this double sense, that connected the study of the human body to the study of insects. Cook has argued that seventeenth-century physicians practised natural history as an alternative to 'philosophical disputations' as the 'foundations of medical learning'.¹⁰⁶ The tentative link that Blankaart established between discovering the insides of human bodies and studying insects points in this

103 A.J.J. Vandevelde, 'Bijdrage tot de studie der werken van Stephanus Blankaart', *Koninklijke Vlaamsche Academie voor Taal en Letterkunde*, 1924, pp. 453–94.

104 Blankaart, op. cit. (88), p. *3v.

105 Huib J. Zuidervaart, 'Het in 1658 opgerichte 'Theatrum Anatomicum' te Middelburg: Een medisch-wetenschappelijk en cultureel convergentiepunt in een vroege stedelijke context', *Archief: Mededelingen van het Koninklijk Zeeuwsch Genootschap der Wetenschappen*, Middelburg: Koninklijk Zeeuwsch Genootschap der Wetenschappen, 2009, pp. 73–140, p. 109.

106 Lorraine Daston, 'Taking note(s)', *Isis* (2004) 95, pp. 443–8, 445; Cook, 'Physicians and natural history', op. cit. (6), p. 91.

direction. In judging the accuracy of Blankaart's notes on insects, readers could also evaluate his skills in observing nature in general and the human body in particular. This becomes all the more evident when we compare the organization of *Theatre* to the genre of *Observationes*. Nance has argued that physicians increasingly adopted this new genre to defend themselves against vernacular critics.¹⁰⁷ Blankaart promoted his own *Collectanea Medico-Physica* as a gathering of 'accurate observations' that would provide an improved basis for medical practice, as well as bestow appropriate esteem on physicians.

By the 1680s a tradition of recording medical *observationes* was well established and thriving in the Dutch Republic. Like their foreign colleagues, Dutch physicians and surgeons recorded these medical case histories, and physical and anatomical *observationes*, in notebooks and on loose sheets of paper, as diaries, *adversaria*, *animadversione*, *collectanea medico* and other such titles. Sixteenth-century physicians tended to attach *scholia* to their observations and often arranged them into groups, for example, according to the parts of the body that had been affected in the cases. As the genre developed the *scholia* and organization became more uncommon. In their form as chronological descriptions of events and actions and especially in their stand-alone character, Blankaart's notes on insects are similar to the *observationes* traditionally recorded, exchanged and published by physicians.¹⁰⁸ In 1680 Blankaart reported that he had collected 'a fair number' of his 'own observations', which included one on cheese mites. To these he had added observations on surgical and medical cases, chemical experiments and natural occurrences from books and other publications, and imparted to him by patients, physicians, surgeons, aldermen and other interested citizens. Over the next six years he published these annually as *Collectanea Medico-Physica or Hollandsch year-register of medicine and physicks: Observations from entire Europe* (Amsterdam, 1680–6).

Blankaart mentioned foreign publications as models for his own.¹⁰⁹ Indeed, as the seventeenth century progressed, individual medical and physical *observationes* began to be collected and published communally. Though they also tended to focus on extraordinary and rare cases, there was a crucial difference between Blankaart's publications and the French, English and German journals to which he referred. The latter were the

107 Brian Nance, 'Wondrous experience as text: Vallerioli and the *Observationes Medicinales*', in Elizabeth Lane Furdell (ed.), *Textual Healing: Essays on Medieval and Early Modern Medicine*, Leiden and Boston: Brill, 2005, pp. 101–18.

108 Gianna Pomata, 'Sharing cases: the *Observationes* in early modern medicine', *Early Science and Medicine* (2010) 15, pp. 193–236; Pomata, 'Observation rising: birth of an epistemic genre, ca. 1500–1650', in Lorraine Daston and Elisabeth Lunbeck (eds.), *Histories of Scientific Observation*, Chicago: The University of Chicago Press, 2011, pp. 45–80; Katharine Park, 'Observation in the margins, 500–1500', in Daston and Lunbeck, op. cit., pp. 15–44; Cole, op. cit. (8), 150; Domenico Bertoloni Meli, 'Gerardus Blasius and the illustrated Amsterdam *Observationes* from Nicolaas Tulp to Frederik Ruysch', in Cynthia Klestinec and Gideon Manning (eds.), *Professors, Physicians and Practices in the History of Medicine: Essays in Honor of Nancy Siraisi*, Cham: Springer, 2017, pp. 255–97, 291–2; Bertoloni Meli, *Visualizing Disease: The Art and History of Pathological Illustrations*, Chicago and London: The University of Chicago Press, 2017, pp. 31–2, 36, 38–41, 72–3.

109 Steven Blankaart, *Collectanea medico-physica oft Hollands Jaar-Register der Genees en Natuurkundige Aanmerkingen van gantsch Europa etc.*, Amsterdam: Johan ten Hoorn, 1680, pp. *2r–v.

collective product of academies and societies. The distinguished members of these societies worked to develop editorial points of view, assessing contributions, adding learned commentaries and directing the efforts of amateurs and virtuosi towards particular ends, even into more standardized forms.¹¹⁰ Blankaart, however, published *Collectanea* under his own name and did not outline or apply any qualifications for contributions.

As in *Theatre*, Blankaart invited *liefhebbers* or amateurs to 'make common' their own observations. Then, he claimed, the republic – *het gemeene beste* – would enjoy the fruits of these shared experiences. He positioned these experiences as a nostrum against 'the systems of medicine that had long kept people blindfolded, being supported by few and idle speculation'. Physicians most of all should add their observations of anything rare and unusual to 'certify the knowledge to heal' and show the caution, prudence and wisdom of physicians in contrast with apothecaries.¹¹¹ Stolberg has proposed that early modern physicians collected observations in order to arrive at 'valid generalizations' that would improve their success as medical practitioners. In Blankaart's case, compiling individual observations was not supposed to lead to either generalization or systemization. Instead, it was important for physicians to accurately note the detailed peculiarities of each case, and to be free from any constraining organizational scheme in so doing. This was what Blankaart invited them to do in both *Theatre* and *Collectanea*. He argued that making these observations commonly known, by itself, would improve the practice of physicians and would facilitate the reconstitution of medical knowledge on the basis of empirical observation, as opposed to 'idle speculation'.

Blankaart was not the only practising physician in Amsterdam espousing this position. A few years earlier, Justus Schrader (1646–1720) had assembled observations and histories from anatomists such as William Harvey, as well as the most prominent anatomists working in the republic, including Swammerdam. The long introduction that Schrader included is echoed in Blankaart's talk against systems and plea for gathering observations. In medicine and natural philosophy there were two distinct ways of pursuing knowledge, Schrader claimed, that of systems and that of *historiae, observationes* and *experimenta*. He argued that there was no real middle ground between these two approaches, and for the superiority of the latter. In line with this manifesto, Schrader

110 E.g. Harold Cook, 'The new philosophy in the Low Countries', in Roy Porter (ed.), *The Scientific Revolution in National Context*, Cambridge: Cambridge University Press, 1992, pp. 115–49, 139–40; Michael Hunter, 'Robert Boyle and the early Royal Society: a reciprocal exchange in the making of Baconian science', *BJHS* (2007) 40(1), pp. 1–23; Marion Mücke, 'Between status attainment and professional dialogue: the significance of membership in the Leopoldina in 1750', in André Hollenstein, Hubert Steinke and Martin Stuber (eds.), *Scholars in Action: The Practice of Knowledge and the Figure of the Savant in the 18th Century*, Leiden and Boston: Brill, 2013, 1, pp. 173–93; Margaret D. Garber, 'Chemical curiosities and trusted testimonials in the Journal of the Leopoldina Academy of curiosi', in Karen Hunger Parshall, Michael T. Walton and Bruce T. Moran (eds.), *Bridging Traditions: Alchemy, Chemistry, and Paracelsian Practices in the Early Modern Era*, Kirksville, MO: Truman State University Press, 2015, pp. 79–100; Bertoloni Meli, *Visualizing Disease*, op. cit. (108), pp. 31–4, 38, 41–6. In Paris the *Journal des Sçavans* (from 1665), in London the *Philosophical Transactions* (from 1665) and in Leipzig the *Miscellanea Curiosa sive Ephemeridum* (from 1670).

111 Blankaart, op. cit. (109), pp. *2v–*3v; 'derhalve werden alle Liefhebbers, die yets raars by haar hebben berusten, of dagelijks observeren, genoodigt om ons dat gemeen te maken op dat het gemeene beste vrugt geniete uit d'ondervindingen van een yder quaal'.

excerpted the things that Harvey had seen himself from his *Exercitationes de generatione animalium* and rearranged them under different headings. This meant leaving out any mention of induction and reducing Harvey's 'history of the egg' to a series of inspections of the egg. Schrader's dedication of the book to his friend Swammerdam and the inclusion of some of his dissections of corpses in it demonstrate their shared preoccupation with observing nature, but also bring home where their practices and views on observation and natural history diverged.¹¹²

Conclusion

Despite having much in common, Swammerdam and Blankaart's practices of observation differed to a great extent. Swammerdam not only observed and dissected more and smaller animals than any of his contemporaries. He actually integrated the practices of anatomists, such as Fabricius, Harvey and Steno, who collated individual dissections into histories of development, and of taxonomists such as Gessner, Aldrovandi and Gerard, who wrote general and particular histories of plants and animals, with new thinking on inductive reasoning propounded by Bacon, Renenius, Harvey, Descartes and Regius, into his observational practice. It produced a practice of natural history by which he purposefully dissected a great many animals to identify the essential changes that insects underwent during their life cycle and described four orders of insects based on these 'general characteristics'. Moreover, he dissected animals to present his findings in a collection of specimens, series of images and a comparative table, and to write specific histories that exemplified the 'general rule' of each order. His extensive experience in dissection justified his use of induction to place insects he had not examined 'specifically' in one of these orders and to reason by analogy from bigger insects to smaller ones.

The individual, extraordinary characteristics of the insects he studied, rather than their essential similarities and differences, were the main object of Blankaart's interest. He recalled being taught how to observe the lives and behavior of insects in his youth by Dutch fine painter Johannes Goedaert and picking up the habit as a practising physician and medical author in Amsterdam. It suited his occupation since it did not require a great commitment of time and effort, but publishing on the subject also offered him an opportunity to show himself as a seller of his own remedies, a sought-after medical practitioner, a well-connected and respected man of medicine, and above all an accurate note taker.

By loosely gathering his observations on insects, medical cases and anatomy, and not including the kind of *scholia* that had traditionally accompanied such observations, he also emerged as an opponent of 'systems of medicine'. As for at least one other physician in the republic, there seemed no middle ground between such systems and the recording

112 Justus Schrader, *Omnes et singulae è Guiljelmi Harvei libello De Generatione Animalium excerptae, et in accuratissimum ordinem redactae*, Amsterdam, 1674, especially pp. *5v–*8r,*9r–v, **v, **2v, 22–41; Baumann, op. cit. (94), pp. 48–50; Gianna Pomata, 'Praxis Historialis: the uses of *Historia* in early modern medicine', in Pomata and Siraisi, *Historia*, op. cit. (2), pp. 105–46, pp. 121–2.

and compilation of individual observations. It appears that only a while later, by physicians such as François Boissier de Sauvages de Lacroix (1731–72) drawing from botany, did the collecting of individual case histories become instrumental in generalizing from particulars and classifying diseases.¹¹³ Additional research could provide more insight into ways that organizing knowledge on paper enabled generalization from medical observations before the eighteenth century and moved between the observational practices of natural history, medicine and natural philosophy.

Swammerdam and Blankaart's practices of observation illustrate the fundamental discussions about natural history they were aware of and contributed to. If we only pay attention to their insistence on observation as the proper basis of science, we overlook the different contentions that existed amongst practitioners of natural history about its aims and means. By the second half of the seventeenth century, there was little consensus over what natural history was and how one should practise it.¹¹⁴ Swammerdam and Blankaart's works alert us to the variety of observational practices and traditions that were available to natural historians, and with what purposes they made these their own.

113 Volker Hess and J. Andrew Mendelsohn, 'Fallgeschichte, Historia, Klassifikation: François Boissier de Sauvages bei der Schreibearbeit', *NTM: Zeitschrift für Geschichte der Wissenschaften, Technik und Medizin* (2013) 21(1), pp. 61–92; Hess and Mendelsohn, op. cit. (3).

114 Steven Shapin, 'Pump and circumstance: Robert Boyle's literary technology', *Social Studies of Science* (1984) 14(4), pp. 481–520; Cook, 'Physick and natural history', op. cit. (6); Cook, 'The cutting edge', op. cit. (6); Cook, 'Physicians and natural history', op. cit. (6); Cook, 'Natural history', op. cit. (6); Elizabeth Yale, 'Marginalia, commonplaces, and correspondence: scribal exchange in early modern science', *Studies in History and Philosophy of Biological and Biomedical Sciences* (2011) 43, pp. 193–202; Pomata, 'Observation rising', op. cit. (108); Dirk van Miert, *Communicating Observations in Early Modern Letters (1500–1675): Epistolography and Epistemology in the Age of the Scientific Revolution*, London and Turin: The Warburg Institute-Nino Aragno Editore, 2013; Richard Yeo, *Notebooks, English Virtuosi, and Early Modern Science*, Chicago: The University of Chicago Press, 2014.