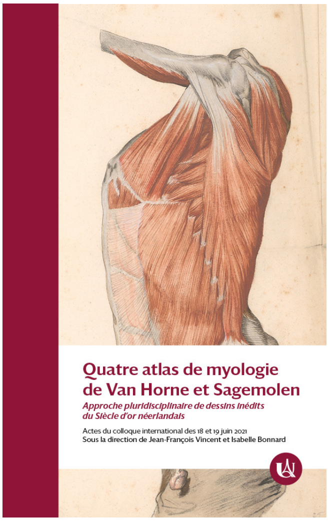

Sous la direction de Jean-François Vincent
et Isabelle Bonnard

Quatre atlas de myologie de Van Horne et Sagemolen

Université Paris Cité

Nicolaus Steno's Myology in Light of Johannes Van Horne's Muscle Atlas

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Nicolaus Steno's Myology in Light of Johannes Van Horne's Muscle Atlas

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In 1667, in Florence, Nicolaus Steno (1638-1686) wrote a book about a new geometrical model of muscle motion.[1] Steno's main claim was that no animal spirits were needed for muscle contraction to happen. Animal spirits were central to most theories of animal motion since the time of Galen (129-c. 210 AD) up to Steno's own time, with authors such as René Descartes (1596-1650) and Giovanni Alfonso Borelli (1608-1679) still relying on them.[2] Steno did not deny the existence of animal spirits *per se*, but he manifested a strong skepticism towards them and, therefore, towards most contemporary theories of animal motion. Indeed, in his book, Steno was also critical of the state of anatomy more generally. In the book's preface he wrote that 'if those who joined an entire lifetime to anatomical exercises did not hand on to posterity anything except things that were certain, then our knowledge would be less

1. Steno, Nicolaus, *Elementorum myologiæ specimen*, Florence, 1667. For a full English translation see Kardel, Troels and Paul Maquet, *Nicolaus Steno: Biography and Original Papers of a 17th Century Scientist*, 2nd ed., Berlin: Springer, 2018 (hereafter BOP). All translations are the authors' unless otherwise noted.
2. See Conforti, Maria, 'Succo Nerveo e Succo Seminale nella Macchina del Vivente di Giovanni Alfonso Borelli,' *Medicina nei Secoli Arte e Scienza* 13 (2001): 577-595; Cobb, Matthew, 'Exorcizing the animal spirits: Jan Swammerdam on Nerve Function,' *Nature Reviews Neuroscience* 3 (2002): 395-400. https://doi.org/10.1038/nrn806; Smith, C.U.M. *et al.*, *The Animal Spirit Doctrine and the Origins of Neurophysiology*, Oxford: Oxford University Press, 2012. https://doi.org/10.1093/acprof:oso/9780199766499.001.0001

wide but also less dangerous.'[3] Ahead in the book, when commenting on intercostal muscles, he also acknowledged that these muscles were 'so diverse and complex' that no anatomists agreed on how to describe them.[4]

Amidst this general criticism of the state of anatomy, Steno saved space to praise a particular group of people who, in his opinion, contributed to a better understanding of the anatomy of muscles, namely 'those who have drawn the muscles.'[5] Steno said that painters 'often have been more exact than those who described them [*i.e.*, the muscles] in words.'[6] Steno also praised 'the industry with which painters have approached nature's skill [*facilitas*]' to the point of stating that the first step of anatomical investigation is the ability to 'admire such a work of art [*artificium*].'[7] It was almost as if, for Steno, painters knew more about muscles than anatomists. The idea behind this claim was that an anatomist should repeatedly observe the organs just like a painter observed multiple times what he wanted to paint. Indeed, Steno was part of a generation of anatomists who greatly relied on dissections and vivisections for their research, building upon the legacies of anatomists from the first half of the seventeenth century such as William Harvey (1578-1657) and Gaspare Aselli (1581-1626).[8]

However, for Steno, the comparison between painting and making observations was more than just a metaphor. The recent discovery of Johannes van Horne's (1621-1670) muscle atlas at the Bibliothèque interuniversitaire de santé (BIU Santé médecine) in Paris opened new landscapes to study Steno's admiration of painters and the epistemic role of his

3. Steno, *Elementorum myologiæ specimen*, p. v: 'si, qui totam ætatem in exercitiis anatomicis contribuere, non nisi sola certa posteritati tradidissent. Minus ampla esset cognitio nostra, sed et minus periculosa.'
4. Steno, *Elementorum myologiæ specimen*, pp. 43-44: 'Musculi ita varii et complicati sunt, ut non sit mirum, si anatomici scriptores inter se concordes non erunt.'
5. Steno, *Elementorum myologiæ specimen*, p. 65: 'qui musculos delinearunt.'
6. Steno, *Elementorum myologiæ specimen*, p. 65: 'naturæ facilitati accedentem pictoris industriam.' Translation from BOP, p. 696.
7. Steno, *Elementorum myologiæ specimen*, p. 65: 'miror tamen, qui musculos delinearunt, sæpius iis, qui eosdem descripserunt, exactiores fuisse, nec potuisse naturæ facilitati accedentem pictoris industriam ad tanti artificii admirationem, investigationis parentem, illos invitare.' Translation from BOP, p. 696.
8. Guerrini, Anita, 'Experiments, Causation, and the Uses of Vivisection in the First Half of the Seventeenth Century,' *Journal of the History of Biology* 46 (2013): 227-254. https://doi.org/10.1007/s10739-012-9319-7

anatomical illustrations.[9] Steno most likely had Van Horne's atlas in mind when he praised the activity of painters, especially painters like Marten Sagemolen (d. 1669), who not only painted Van Horne's atlas but also dissected muscles in order to paint them better.[10] Steno also wanted to make his observations visible to a wide community of scholars by means of images. This was especially important when his arguments were controversial, such as his mathematical theory of muscle contraction. But Steno's early anatomical works, such as his research on the glands of the head, also show his desire for images.

In research we conducted together, we argue that Steno not only shared Van Horne's interest in illustrating the muscles, but also that he deviated from Van Horne precisely because of the importance observations had in his anatomical research. Our findings were first presented at the International Symposium 'Four unpublished Myology Atlas from the Dutch Golden Age' at the BIU Santé médecine, and were recently published in a special issue on 'Picturing Life in the Early Modern Age' in the *Notes and Records: The Royal Society Journal of the History of Science*.[11] The following is a summary of our findings. We redirect our readers to our research paper for more details.

Anatomical illustrations in Leiden

Nicolaus Steno enrolled at the University of Leiden in July 1660, after medical studies in Copenhagen for three years, and a few weeks in Amsterdam.[12] As an anatomy student, Steno was familiar with the usage of images in anatomical books. Then as now, anatomy textbooks were filled with images of bodily parts. The *Institutiones anatomicæ*, which was republished with updates by Steno's Copenhagen mentor Thomas

9. The atlas was discovered in November 2016, see Vincent, Jean-François and Chloé Perrot, 'Johannes van Horne and Marten Sagemolen's myology,' Paris: Bibliothèque interuniversitaire de santé, 2016. https://hal.archives-ouvertes.fr/hal-03768364

10. Huisman, Tim, *The Finger of God: Anatomical Practice in 17th-Century Leiden*, Leiden: Primavera Pers, 2009, p. 80.

11. Castel-Branco, Nuno and Troels Kardel, 'Drawing muscles with diagrams: how a novel dissection cut inspired Nicolaus Steno's mathematical myology (1667),' *Notes and Records* (2022). https://doi.org/10.1098/rsnr.2022.0005

12. Steno enrolled in 27 July 1660, see Leiden University Library, ASF 10, fols. 585; as quoted in *Album studiosorum Academiæ Ludguno Batavæ* (The Hague, 1875), p. 482.

Bartholin (1616-1680), is one among many examples.[13] The important role of images in anatomy was reinforced by Johannes van Horne, who was Steno's professor of 'anatomy and surgery' at Leiden.[14]

In April 1661, Steno visited Van Horne's home with Ole Borch (1626-1690), Steno's former teacher in Copenhagen who also stayed in Leiden for some time.[15] Borch wrote in his journal that they saw at Van Horne's place 'all the muscles of the human body most accurately painted in their original colors.'[16] Van Horne himself told them that 'he made sure that they [*i.e.* the images] were made by an extraordinary craftsman with great effort' and that he 'believed that nowhere else in the world has such a work of art existed.'[17] Indeed, in a letter to Copenhagen, Borch further described these plates as 'most elaborate' and 'splendid.'[18] These plates were likely the images of the anatomical atlas of muscles that Van Horne had worked on together with the painter Marten Sagemolen.[19]

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13. Bartholin, Thomas, *Institutiones anatomicae* (Leiden, 1641, 1645, 1651; The Hague, 1655, 1660), also published in French (Paris, 1646), German (Copenhagen, 1648), Italian (Florence, 1651), and Dutch (Leiden, 1653). For more on images in the history of science, especially the history of anatomy, see Lefèvre, Wolfgang, Renn, Jürgen and Urs Schoepflin (eds.), *The Power of Images in Early Modern Science*, Basel: Birkhäuser Verlag, 2003; Roberts, K. and J. Tomlinson, *The Fabric of the Body: European Traditions of Anatomical Illustrations*, Oxford: Oxford University Press, 1992; and Bertoloni Meli, Domenico, *Visualizing Disease: The Art and History of Pathological Illustrations*, Chicago: University of Chicago Press, 2017.
14. Steno, *Observationes anatomicæ* (Leiden, 1662), pp. 80-81: 'Professoribus… D. Johanni Van Horne, anatomiæ et chirurgiæ.'
15. For Steno's pre-university studies see Gustav Scherz's biography as translated in BOP, pp. 25-32. On Borch see his autobiography as translated in Schepelern, H. D. (ed.), *Olai Borrichii Itinerarium 1660-1665*, 4 vols., Copenhagen: C. A. Reitzles Forlag, 1983 (hereafter OBI), vol. 1, xv-xxi. For more on Steno and Borch's early stay in the Netherlands, see Jorink, Eric, '*Modus politicus vivendi*: Nicolaus Steno and the Dutch (Swammerdam, Spinoza and Other Friends), 1660–1664,' Andrault, Raphaële and Mogens Laerke (eds.), *Steno and the Philosophers*, Leiden: Brill, 2018, pp. 13-44.
16. OBI, vol. 1, 8 April 1661, pp. 96-97: 'omnes humani corporis musculos acuratissime depictos. nativis suis colorib[us].' Steno mentions this visit briefly in a letter to Thomas Bartholin, 30 December 1661, in Bartholin, Thomas, *Epistolarum Medicinalium Centuria III* (Copenhagen, 1667), pp. 262-266 (translated in BOP, pp. 501-503).
17. Borch to Thomas Bartholin, 21 April 1661, in Bartholin, *Centuria III*, p. 394: 'quas magna industria se per insignem artificem hic ait curasse perfici; creditque nusquam gentium tale opus artis extare.'
18. Borch to Bartholin, 21 April 1661, in Bartholin, *Centuria III*, p. 394: 'musculorum omnium corporis humani elaboratissimas figuras, colore nativo splendidas.'
19. Huisman, *The Finger of God*, pp. 80-82.

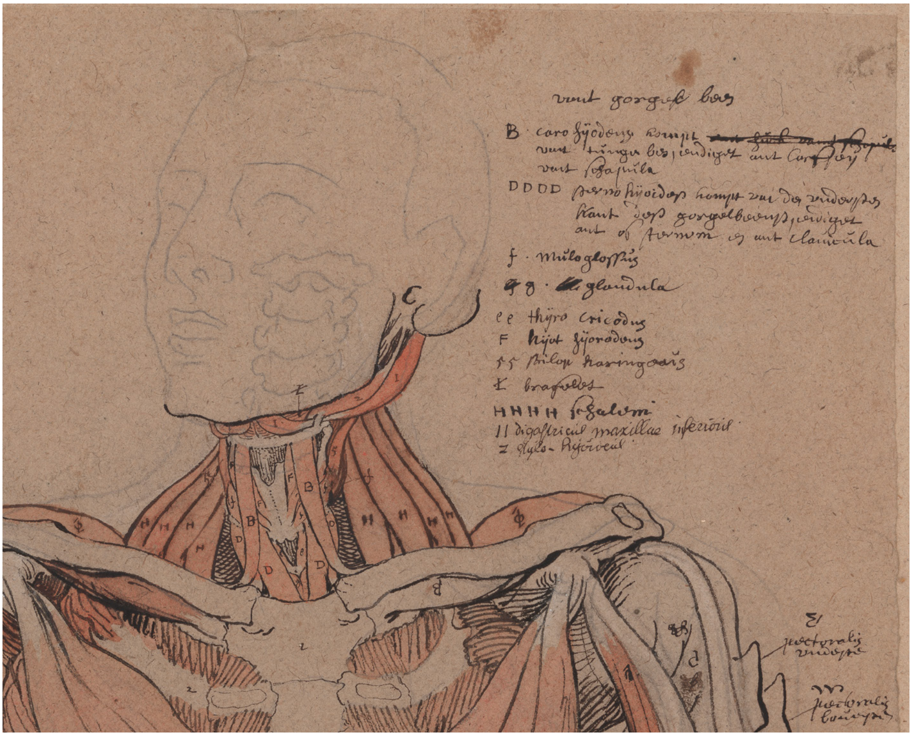

Figure 1.

The sternohyoid muscles of the neck labeled with 'D'. BIU Santé médecine, Ms 27 (6) (plate no. 4)

Van Horne's atlas was more than just an illustration of muscles and seems to have served as a way to think about new ways of cataloguing muscles. For instance, in January 1661, Ole Borch mentioned a dissection led by Van Horne of a female corpse in Leiden.[20] Among other things, Van Horne renamed a muscle of the neck usually known as 'sternohyoid,' with the different name of 'cleptohyoid,' 'because the muscle originates not in the sternum but in the clavicle,' he said. In the atlas, the name of this muscle is still related to the sternum, but its caption points to the possible origin in the clavicle (Figure 1).[21] This and other examples show that Van Horne's images of the muscles were linked to what he saw in dissection.[22]

20. OBI, vol. 1, 27 January, pp. 69-71.
21. Paris, BIU Santé médecine, Ms 27 (6) (plate no. 4): 'DDDD: strenohyoides… aut ab sternum … aut clavicula.'
22. See Castel-Branco and Kardel, 'Drawing Muscles with Diagrams,' *Notes Rec.* (2022). https://doi.org/10.1098/rsnr.2022.0005

At the time, Steno had been studying the glands of the head.[23] Among other things, Steno discovered a new salivary duct connected with the parotid gland, which Van Horne first named as 'Steno's duct' [*ductus stenonianus*], the name it still has today.[24] After several months dissecting, Steno concluded that the salivary fluid was produced in different glands around the mouth, including the parotid and the maxillary glands. When Thomas Bartholin learned of Steno's discoveries, he wrote to Steno, encouraging him to publish his discoveries. Yet, rather than asking directly for a text, Bartholin asked Steno to 'publish an image of the external salivary duct.'[25] Not unlike Van Horne, Steno's images of glands were more than just merely illustrative and reflect the observational techniques he had developed as a researcher in anatomy. Steno's discovery of the parotid salivary duct occurred when Steno inserted a probe through the gland, into the duct. Thus, Steno's image highlights an enlarged parotid salivary duct, almost as if with the probe inside it. Steno also used probes to identify new paths and vessels in the tongue. Therefore, these paths are particularly visible in Steno's images: not just the salivary duct, but also the little holes through which saliva arrived at the mouth through the cheeks and the palate (Figure 2). Less than a year later, in January 1662, Steno released a study of the glands of the eye with even more images. These images are similar in style to the glands of the head. But as Steno's research moved further, his illustrations also changed.

Early research on muscles

Steno started doing dissections of muscles in 1662. He mentions dissecting the muscles in a letter to Thomas Bartholin, adding later that Van Horne was present when he opened the leg of a rabbit.[26] Steno's dissections

23. Moe, Harald, 'When Steno Brought New Esteem to Glands,' *Nicolaus Steno 1638-1686: A Re-consideration by Danish Scientists*, Poulsen, J. and E. Snorrason (eds.), Gentofte, Denmark: Nordisk Insulinlaboratorium, 1986, pp. 51-96.

24. Van Horne, *Mikrokosmos seu brevis manuductio ad historiam corporis humani*, Leiden, 1662, p. 23.

25. Steno to Bartholin, 22 April 1661, in Bartholin, *Epistolarum III*, 87: 'Cum vero ut ductus salivalis exterioris iconem edam in eadem epistola author mihi sis.'

26. Steno to Bartholin, 26 August 1662, in Bartholin, *Epistolarum Medicinalium Centuria IV* (Copenhagen, 1667), pp. 103-113 (translated in BOP, 519). On Van Horne as witness, see Steno, 'Ex variorum animalium sectionibus,' *Acta Medica Hafniensia*, Bartholin, Thomas (ed.), vol. 2, Copenhagen, 1675, p. 144 (BOP, p. 556).

Figure 2.

Parotid glands in the head of a calf. Steno, *Observationes anatomicae* (Leiden, 1662), p. 21. BIU Santé médecine, cote 32043-3

led to a series of important results that, once again, needed illustrations. But unlike what he saw in the salivary glands, his results on the structure of muscle fibers were not as easily illustratable. Therefore, his first publication on the muscles, the *De musculis et glandulis* (Copenhagen, 1664) had no illustrations, with the exception of a beautiful frontispiece. This lack of illustrations is particularly intriguing because Steno knew the important role of illustrations in books of anatomy. Moreover, one of his main goals with his theory of muscles was to criticize the recently-published editions of René Descartes' *Treatise on Man* (Leiden, 1662; Paris, 1664), which were filled with anatomical illustrations. Indeed, Steno commented that the illustrations in the Latin edition of Descartes' *De homine* were 'not inelegant,' but he doubted 'whether such images can be seen in any brain.'[27] In the *Discours sur l'anatomie du cerveau* (Paris, 1669), written in 1665 while in Paris, Steno used illustrations of varied dissection cuts of the brain as a way to argue against Cartesian neuroanatomy. And yet, even though the main elements of Steno's theory of muscle were already well-established in *De musculis et glandulis*, Steno did not include a single image inside the book. Why not?

Steno's decision not to publish images in 1664 highlights two important features of his anatomical research: the importance of a novel dissection cut of the muscles, and his increasing use of mathematics in anatomy.[28] In *De musculis et glandulis,* Steno suggested that muscle fibers form an 'oblique parallelogram or the figure of a rhomboid.'[29] This distinction was related to Steno's method of dissecting the muscles, in which he cut 'along the course of the fibers … not in a plane cutting everything transversely through the middle,' but in a plane in which 'the tendons remain intact with the flesh.'[30] Steno represented them with three images in a 1663 letter to Bartholin, but he did not include the drawings in his book.[31] This longitudinal cut was a major deviation from Van Horne's dissection practices, whose atlas drawings show a cut of the muscles in the extremities, in order to distinguish them. Van Horne's method was the typical way in which anatomists dissected muscles. Indeed, as far as we know, no one before Steno attempted to cut muscles longitudinally.

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27. Steno to Bartholin, 26 August 1662, in Bartholin, *Epistolarum IV*, p. 115: 'in quo figuræ conspiciuntur non inelegantes quas ex ingenioso cerebro prodiisse certum est, an vero tales in ullo cerebro conspiciendæ valde dubitarem' (BOP, p. 516).

28. Steno did not include images also possibly because, 'an unexpected event drew me away from my papers and dissections,' in Steno, *De musculis et glandulis*, p. 3: 'cum ecce casum inexspectatum, qui non à chartis modò et sectionibus me meis abstraxit, sed et…'

29. Steno, *De musculis et glandulis*, Copenhagen, 1664, p. 15: 'fibrae… parallelogrammum obliquangulum, seu rhomboideam exhibent figuram.'

30. Steno, *De musculis et glandulis*, p. 15: 'Binas musculus … sectiones juxta fibrarum ductum admittit, rectam alteram, alteram transversam, non quidem plano per medium transversim omnia secante, sed ita à latere ad lactus acto, ut tendines cum carne maneant integri.'

31. Steno to Bartholin, 30 April 1663, in Bartholin, *Epistolarum IV*, pp. 415-416.

Secondly, the more Steno researched the muscles, the more skeptical he grew of previous studies on them. Thus, as a way to reach a more accurate description, Steno increasingly used mathematics to study the muscles. For instance, he used mechanical analogies and geometry to speak of the abdomen and the intercostal muscles.[32] But how could Steno represent mathematical insights with illustrations? Even though Steno never states it explicitly, in light of his later diagrams, it is possible to conclude that Steno was looking for a way to incorporate mathematics in his illustrations. He wanted to combine mathematics with observations, almost as if he saw the geometrical structure of muscles. The ongoing difficulties in representing muscle fibers are confirmed by Steno's writings and the writings of those he met between the publication of *De musculis et glandulis* (1664) and the *Elementorum myologiae specimen* (1667), as we show in our article.[33]

Mathematical diagrams in Florence

The *Elementorum myologiæ specimen* (Florence, 1667) was Steno's final and most important book on myology and was filled with geometrical diagrams. Steno first showed the traditional representation of a muscle as it was represented since antiquity (Figure 3). Yet, he wrote, 'it seems to me most trustworthy to represent the structure of muscles the way I found it in many simple muscles,' as well as in 'all compound muscles.'[34] Therefore, in his first new illustration, on the book's third page, Steno represented 'a muscle through a collection of motor fibers arranged in such a way that the middle flesh forms an oblique parallelepiped, but the tendons form two opposite tetragonal prisms' (Figure 4).[35]

32. For a survey of Steno's uses of mathematics in anatomy see Castel-Branco, Nuno, 'Dissecting with Numbers: Mathematics in Nicolaus Steno's Early Anatomical Writings, 1661-64,' *Substantia* 5 (2021): 29-42. https://doi.org/10.36253/Substantia-1276

33. Castel-Branco and Kardel, 'Drawing Muscles with Diagrams,' *Notes Rec.* (2022). https://doi.org/10.1098/rsnr.2022.0005

34. Steno, *Elementorum myologiæ specimen*, pp. 2-3: 'Mihi visum tutissimum eo modo fabricam musculorum repræsentare, quo in multis simplicibus musculis eam invenio, et in omnibus compositis me demonstraturum spero.'

35. Steno, *Elementorum myologiae specimen*, p. 3: 'musculum repræsento per *fibrarum motricium collectionem ita conformatam, ut mediæ carnes parallelepipedum obliquangulum constituant, tendines verò oppositi duo prismata tetragona componant.*'

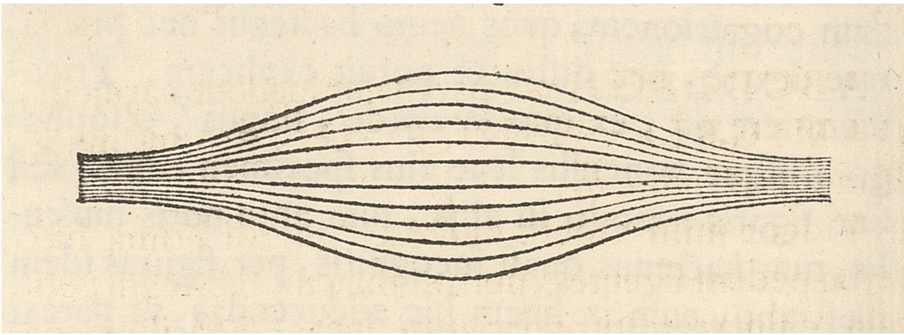

Figure 3.

Traditional representation of a muscle, in Steno, *Elementorum myologiæ specimen*, p. 2. BIU Santé médecine, cote 5530

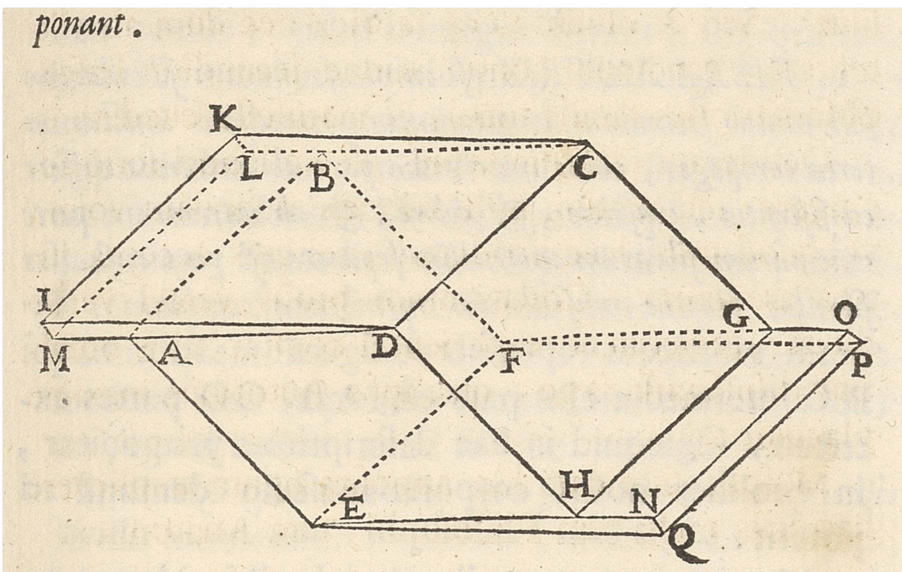

Figure 4.

An oblique parallelepiped as a muscle as conceived by Steno, *Elementorum myologiæ specimen*, p. 3. BIU Santé médecine, cote 5530

Steno's contribution in this book was twofold.[36] First, he showed that muscle fibers looked like a two-dimensional parallelogram or a three-dimensional oblique parallelepiped, also called rhomboid. Then, Steno showed how the specific structure of a rhomboid functioned in a muscle, most especially that it does not increase in volume even though it looks inflated. This geometrical structure, with the addition of a few propositions of Euclid's *Elements*, allowed Steno to demonstrate that the variation of the oblique angles alone was enough to increase the muscle thickness [*crassities*].[37] Even though the muscle looked inflated, its volume remained constant. This was Steno's most important claim. Therefore, he said that 'it is amply demonstrated in every muscle, that when contracted, it reaches a swelling, even though no new matter arrives at the muscles.'[38] That is, no animal spirits were necessary: the inflated shape of a contracted muscle was caused by its geometry.

However, Steno's insight that muscle contraction relied on its shape alone was more complex than simply describing his observation of the muscle fiber structure. Indeed, Steno's text looked more like a mathematical treatise, filled with lemmas, propositions, and corollaries, than it looked like an anatomy book. His option for the images matched this mathematical approach. Steno's argument also included a time-dependent process. Thus, he opted to use multiple diagrams to guide the reader through the necessary geometrical steps, just like a treatise of mathematics. First, he began with definitions of what was a single fiber and a group of two-dimensional fibers and then moved to define three-dimensional fibers, like the muscles are supposed to be. Then, he drew a diagram for almost every step of his geometrical reasoning demonstrating the geometrical properties of the rhomboid.

36. See Kardel, Troels, *Steno on Muscles*, American Philosophical Society, 1994, pp. 17-24; Bertoloni Meli, Domenico, 'The Collaboration between Anatomists and Mathematicians in the mid-Seventeenth Century with a Study of Images as Experiments and Galileo's Role in Steno's Myology,' *Early Science and Medicine* 13 (2008): 665-709, esp. 696-706. https://doi.org/10.1163/157338208x362714; and Andrault, Raphaële, 'Mathématiser l'Anatomie : La Myologie de Stensen (1667),' *Early Science and Medicine* 15 (2010): 505-536. https://doi.org/10.1163/157338210X516305

37. Steno refers to one postulate, two axioms, and nineteen propositions from Euclid. For a list of all propositions see Kardel, Troels, *Steno on Muscles*, American Philosophical Society, 1994, p. 243.

38. Steno, *Elementorum myologiæ specimen*, p. 30: 'Atque ita quidem abunde demonstratum puto in omni musculo, dum contrahitur, tumorem contingere, etiamsi nulla nova musculo accederet materia.'

After extensive geometrical explanations and diagrams, Steno also said that he had 'to demonstrate their certainty with examples taken from Nature herself,' that is with observations.[39] Thus, he included 'figures of different muscles … displayed at the magnitude at which I have measured them in cadavers.'[40] Steno used several examples of animals, such as a calf, fish, lobsters and, most importantly, humans. Just like in Leiden, Steno's images helped the reader see what the dissector himself had seen. In fact, these images represent the new longitudinal cut of the muscles made by Steno in different animal species. Steno's goal was to link observations to his mathematical insights as much as possible. Only then could he describe muscle contraction in mathematical terms.

Conclusion

Our research shows that Nicolaus Steno's interest in images developed alongside an increasing interest in empiricism in anatomy shared by most of his professors and colleagues at the University of Leiden, such as Johannes van Horne. This attitude of having the images closer to the act of dissection is seen in Van Horne's atlas and also in Steno's book on the glands. Yet, precisely because of this link between images and observation, the geometrical diagrams drawn by Steno are particularly mysterious. Steno never saw a perfect three-dimensional geometrical shape in the muscles, but he still was convinced that the rhomboid was a good match for muscle fibers. Moreover, he wanted to bring his readers closer to this mathematical insight and have them see a muscle contracting like a parallelogram changes its shape by variation of its oblique angles. Recent biomechanical research has shown an impressive similarity between Steno's diagrams and ultrasounds of a contracted muscle, which confirms the rigor of Steno's observations.[41] However, Steno did not have ultrasound machines. Thus, to stress the importance of observations he had recourse to geometrical diagrams in parallel with life-size images of his longitudinal cuts.

39. Steno, *Elementorum myologiae specimen*, p. 34: 'restat exemplis ex ipsa Natura depromptis eorundem certitudinem demonstrem, …'

40. Steno, *Elementorum myologiae specimen*, p. 34: 'figuras variorum musculorum ostendendo poitus…'

41. See BOP, pp. 198-203; and Kardel, Troels, 'Steno's Myology: The Right Theory at the Wrong Time,' *Steno and the Philosophers*, pp. 138-173. https://doi.org/10.1163/9789004360655_008

It is our hope with our research also to shed light on the visual aspects of mathematization in early modern science. Indeed, Steno used diagram illustrations and longitudinal dissections to argue that the body could be understood in geometrical terms, or in a mathematical language. That was, in fact, one of Steno's main goals with the *Elementorum myologiæ specimen.* He believed that anatomy should become a mathematical discipline, like those that fit under the early modern category of mixed or physico-mathematics. He wrote: 'why can we not give to the muscles what astronomers give to the sky, what geographers give to the earth and… what writers on optics concede to the eyes?'[42] For Steno, these writers 'treated natural things mathematically so that their knowledge may be more clear.'[43] Moreover, unlike a traditional drawing of muscles or glands, these diagrams allowed the reader to visualize with rigor a time-dependent process, such as muscle contraction, that they could not see otherwise.

Interestingly, Steno continued to rely on diagrams and mathematics to describe processes that were hard to observe. In his most famous book in the history of science, the *De solido intra solidum naturaliter contento* (Florence, 1669), Steno also used geometrical diagrams when explaining the time-dependent formation of mountains and fossils (Figure 5).[44] Besides listing all observations that he made in his tour of Tuscany, Steno drew the process of superposition of the Earth's strata with diagrams, making the first geometrical depiction of the Earth's history and of modern geology. That is, although diagrams were not as real as a muscle atlas nor as a mountain landscape, they were still intrinsically related to Steno's observations and they allowed to see things that were not easily observed such as the dynamics of muscle contraction and the formation of the strata.

42. Steno, *Elementorum myologiæ specimen*, pp. iii-iv: 'Et quidni musculis id daremus, quod cœlo astronomi, quod terræ geographi, et, ut ex microcosmo exemplum adducam, quod oculis rei opticæ scriptores concessere?'

43. Steno, *Elementorum myologiæ specimen*, p. iv: 'Res naturales mathematice tractarunt illi, quo distinctior earum esset cognitio.'

44. See also Kardel, Troels, 'Nicolaus Steno on Solutes and Solvents in Time-Related Structural Changes of Muscles, Fossils, Landscapes and Crystals, his Galilean Heritage,' *Substantia* 5 (2021): 43-57. https://doi.org/10.36253/Substantia-1277

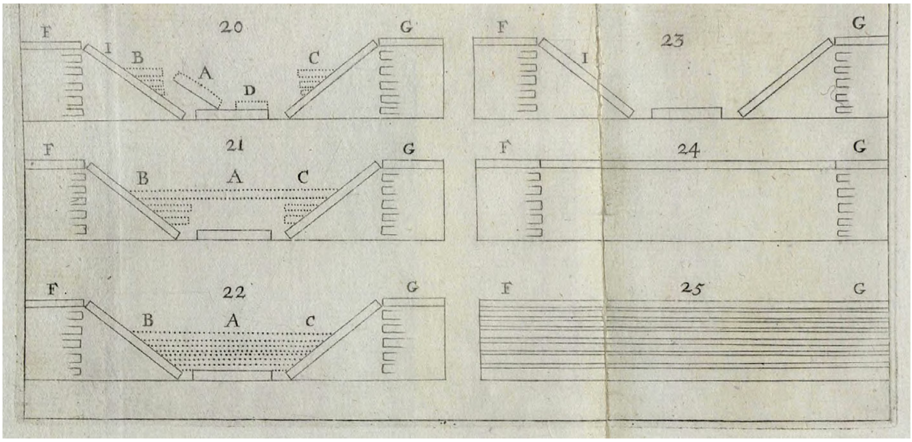

Figure 5.

Diagram of the geological formation of Tuscan mountains, in Steno, *De solido intra solidum naturaliter contento* (Florence, 1669). Courtesy of Biblioteca Nazionale Centrale di Firenze