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Marieke M. A. Hendriksen

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# Boerhaave's Mineral Chemistry and Its Influence on Eighteenth-Century Pharmacy in the Netherlands and England

MARIEKE M. A. HENDRIKSEN 

*Utrecht University, The Netherlands*

In the eighteenth century, the use of mineral or fossil substances was relatively common in European medicine and pharmacy. However, this period also saw profound changes in ideas about the nomenclature, chemistry, and curative properties of minerals. Jonathan Simon has recently argued that an increasing orientation towards the mineral kingdom and the chemical transformation of minerals, and a rise in the number of mineral preparations demanded of the pharmacist, were characteristic for eighteenth-century chemistry within pharmacy. Yet in the Netherlands, and to a certain extent in England, another pattern is visible: although there certainly was an interest in the mineral kingdom and the chemical transformation of nonorganic materials, nothing suggests that this resulted in a strong increase in the demand for mineral-based pharmaceutical preparations – rather the contrary. Unlike English and French eighteenth-century pharmacy, Dutch pharmacy and its relation to academic medicine and chemistry have hardly received attention from historians of science thus far. This paper aims to fill that gap and argues that Herman Boerhaave's (1668–1738) view on mineral medicine was crucial in the development of a certain wariness of “mineral medicine” in the eighteenth-century Netherlands and England, especially among apothecaries.

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In the eighteenth century, the use of mineral or fossil substances – including metals, earths, salts, and (gem) stones – was common in European medicine and pharmacy. However, this period also saw profound changes in ideas about the nomenclature, chemistry, and curative properties of minerals.<sup>1</sup> Jonathan Simon has recently argued that an increasing orientation towards the mineral kingdom and the chemical transformation of nonorganic materials, and a rise in the number of mineral preparations demanded of the pharmacist, were characteristic for eighteenth-century chemistry within pharmacy.<sup>2</sup> Although this might be true for France, in the Netherlands a different pattern is visible: although there certainly was a strong interest in the mineral kingdom and the chemical transformation of minerals, there are no indications that this resulted in a strong increase in the demand for mineral-based pharmaceutical preparations – rather the contrary.

Unlike English and French eighteenth-century pharmacy, Dutch pharmacy and its relation to academic medicine and chemistry has hardly received attention from historians of science thus far. This article aims to start filling that gap and argues that the ideas about minerals and particularly metals of Leiden professor Herman Boerhaave (1668–1738), “teacher of Europe”, were crucial in the development of a certain wariness of “mineral medicine” in the eighteenth-century northern Netherlands, especially among apothecaries.<sup>3</sup> Moreover, I attempt to clarify why the distinction between Galenic and chemical pharmacy, which was still important at the beginning of the eighteenth century, disappeared in the course of that same century, and what this tells us about changing ideas about vegetable and mineral substances and the role of chemical processes in pharmacy.

Finally, an analysis of two English interpretations of Boerhaave’s work shows that the influence of his scepticism about mineral medicine reached well beyond the Dutch borders. John Powers has convincingly shown that Boerhaave restructured and reinterpreted various practices from diverse chemical traditions into a coherent organisational structure and philosophical foundation for an academic chemistry.<sup>4</sup> However, I take the argument a step further by showing that Boerhaave

<sup>1</sup> Marieke M.A. Hendriksen, “The Disappearance of Lapidary Medicine: Skepticism about the Utility of Gemstones in 18th-Century Dutch Medicine and Pharmacy,” in *Gems in the Early Modern World: Materials, Knowledge, and Global Trade, 1450–1800*, ed. Michael Bycroft and Sven Dupré (Basingstoke: Palgrave, 2018) (accepted chapter, forthcoming).

<sup>2</sup> Jonathan Simon, “Pharmacy and Chemistry in the Eighteenth Century: What Lessons for the History of Science?” *Chemical Knowledge in the Early Modern World, OSIRIS* 29 (2014): 293–97. I find Simon’s description of mineral substances as “nonorganic materials” somewhat confusing – supposedly he means inorganic materials in the modern sense of “molecules not containing carbon”, but this seems anachronistic. In this article, I therefore will only use the term “mineral” as an early to mid-eighteenth-century, shifting actor’s category, namely to designate substances other than vegetable and animal, found in or on the surface of the earth – including fossils. On these shifts see Susannah Gibson, *Animal, Vegetable, Mineral?: How Eighteenth-Century Science Disrupted the Natural Order* (Oxford: Oxford University Press, 2015). On the division of the three kingdoms, see Ursula Klein and Wolfgang Lefèvre, *Materials in Eighteenth-Century Science. A Historical Ontology* (Cambridge, MA: MIT Press, 2007), 11–14. On the anachronistic use of the terms organic and inorganic chemistry, see Frederic L. Holmes, *Eighteenth-Century Chemistry as an Investigative Enterprise* (Berkeley, CA: Office for History of Science and Technology, University of California at Berkeley, 1989), 61.

<sup>3</sup> For Boerhaave’s reputation as “teacher of Europe”, see G.A. Lindeboom, “Herman Boerhaave (1668–1738) Teacher of All Europe,” *JAMA* 206, no 10 (1968): 2297–301.

not just founded an academic chemistry; he and his students also profoundly influenced practical medicine and pharmacy with their chemical understanding of minerals.

### Boerhaave's chemistry book and his ideas on minerals

Boerhaave presented his ideas on chemistry in his lectures and in a book, the *Elementa Chemiae*. The first volume, almost nine hundred pages, discusses the history and theory of the art of chemistry. Here, Boerhaave defines chemistry as

an art which teaches the manner of performing certain physical operations whereby bodies cognizable to the senses, or capable of being render'd cognizable, and of being contained in vessels, are so changed, by means of proper instruments, as to produce certain determined effects; and at the same time discover the causes thereof; for the service of various arts.<sup>5</sup>

This sounds very general, and that was indeed Boerhaave's intention. Unlike contemporary textbook writers such as Lémery and Geoffroy, Boerhaave aimed to describe all available chemical theory and processes, rather than pharmaceutically oriented preparations, "as it is plain, that chemistry by no means administers to medicine alone, but to universal physics."<sup>6</sup> Yet Boerhaave did acknowledge that chemistry was very useful for medicine, not only for pharmacy or therapeutics as he called it, but also in physiology, pathology, semiotics (diagnosis), and dietetics. However, chemistry in his view should be seen as an aid to medicine, not as its principle guideline, and therefore he referred those interested in chemistry for medicine to his books on *materia medica* and the knowledge and treatment of diseases. In those books he had collected "such matters as chemistry affords, applicable without danger (...) in their proper places."<sup>7</sup>

Boerhaave was cautious about the use of mineral substances, and particularly metals in medicine. Only iron, he said "has great medicinal virtues, being nearer allied to the human body than any of the other metals, so as to be almost wholly dissolvable therein."<sup>8</sup> Boerhaave's understanding of all metals except iron as essentially

<sup>4</sup> John Powers, *Inventing Chemistry. Herman Boerhaave and the Reform of the Chemical Arts* (Chicago: University of Chicago Press, 2012).

<sup>5</sup> Herman Boerhaave, *Elementa Chemiae, Quae Anniversario Labore Docuit in Publicis, Privatisque Scholis* (Leiden: Isaak Severinus, 1732), vol. I, 65. The edition used for quotations here is Herman Boerhaave, *A New Method of Chemistry: Including the History, Theory, and Practice of the Art: Translated from the Original Latin of Dr. Boerhaave's Elementa Chemiae, as Published by Himself. To Which Are Added, Notes; and an Appendix*, transl. Peter Shaw (London, 1741), which is a reliable translation of the *Elementa*.

<sup>6</sup> Rina Knoeff, *Herman Boerhaave (1668–1738): Calvinist Chemist and Physician* (Amsterdam: Editia, 2002), 116. Boerhaave, *A New Method*, vol. I, 2. This stance forms a stark contrast to the French situation as described by Simon, "Pharmacy and Chemistry," 284–86, where repeated attempts were made to limit the definition of chemistry to the processes directly useful for pharmacy.

<sup>7</sup> Boerhaave, *A New Method*, vol. II, 174–7.

<sup>8</sup> Boerhaave, *A New Method*, vol. I, 94. Also see Boerhaave, *A New Method*, vol. I, 68: "Iron. ♂Likewise denotes gold at the bottom, but attended with a great proportion of sharp corrosive, sometimes amounting to half of the whole; whence half the character expresses acrimony, which accordingly both alchemists and physicians observe of iron. And hence that common opinion of the adepts; that the *aurum vivium*, or gold

corrosive is based on much older alchemical ideas, and is reflected in the chemical symbols he used for metals too, which were basically alchemical symbols and still in common use: in those for copper, tin, lead, and mercury (☿, ♃, ♁, ☿), we see the sharp, corrosive element in the form of a cross, which is missing from the symbols for gold, silver, and iron (☉, ☽, ♂).<sup>9</sup> This understanding of the nature of metals as corrosive is reflected in Boerhaave's ideas about their usefulness as *materia medica*.

Quicksilver for example, was seen as strongly acid, sharp and corrosive, and in Boerhaave's opinion should only be used in medicine in processed form, and even then only be prescribed by an experienced physician in cases where all vegetable and animal-based cures had failed.<sup>10</sup> Because of their mercurial nature, Boerhaave believed metals in general to be unchangeable and indigestible in animals and vegetables, and foreign and noxious to the body. He argued that the exception was iron, because the earth in iron is similar in nature to that of plants and animals, which is why it can be absorbed by them. Like all the metals, iron had mercury as its basis, but because it contained lesser and less "acrimonious" mercury than the other metals it could be used in medicine relatively safely. Of the other metals, he wrote that they are corrosive and *insuperable* by the vital powers, which implies they are stronger than those powers, and thus may influence them and therefore one's health.<sup>11</sup> As has been noted by others, Boerhaave also always warned his students about the danger of universal doctrines and stressed the importance of knowledge of particulars.<sup>12</sup> Although he was fascinated by chemistry and the possibilities mineral substances offered for pharmaceutical preparations, he was always cautious about them in his printed works. For example, in his treatise on the treatment of venereal disease, he observed concerning the use of mercurial cures:

It is not to be wonder'd at, that I should wholly omit Mercury in Method of Cure, when almost every Practitioner is confident that Mercury, and Mercury alone, is sufficient to this Purpose. ( ... ) What Quicksilver acts in a Cure I shall by and by declare: In the mean Time I shall never be reconcil'd to the hardy Proceedings of such, who, when they are consulted in this Disorder, presently prescribe Quicksilver, which ever does Mischief to the Body, and is oftentimes needless.<sup>13</sup>

It must be noted that all Boerhaave's original publications were in Latin, which clearly indicates that they were aimed at an audience of learned peers who were

<sup>8</sup> *Continued*

of the philosophers, is contained in iron; and that the universal medicine is rather to be sought in this metal than in gold itself."

<sup>9</sup> For Boerhaave's discussion of the use of symbols for metals and their corrosive nature see Boerhaave, *A New Method*, vol. I, 67–70.

<sup>10</sup> "[Turbit of Mercury] seems an extraordinary medicine in stubborn and obstinate cases; but it requires a skilful physician, and should not be used when safer remedies may suffice." Boerhaave, *A New Method*, vol. II, 311.

<sup>11</sup> Boerhaave, *A New Method*, vol. I, 486.

<sup>12</sup> Knoeff, *Herman Boerhaave*, 183.

<sup>13</sup> Herman Boerhaave, *A Treatise on the Venereal Disease* (London: T. Cox and J. Clarke, 1729), 50–51.

capable of understanding the nuances and uncertainties in this knowledge – his works were not meant for use by those looking for quick, simple, or straightforward instructions. Only in his private letters to men he considered his peers, like Bassand, did Boerhaave dare to discuss mineral-based cures that he had not yet tried and tested, and aired ideas about possible new uses.<sup>14</sup> Although Boerhaave never categorically condemned the use of minerals in medicine, such as sulphurs and (gem) stones, and metals, in general, he appears to have preferred vegetable- or animal-based cures over mineral- and especially metal-based ones.<sup>15</sup> Salts were less problematic, because these are a natural part of the bodies of plants and animals, including man.<sup>16</sup> Although metals may influence the vital powers in the human body, it is better to avoid using any except iron in medicine because of their dangerously corrosive nature. Other mineral substances should be used cautiously too. Finally, Boerhaave was sceptical about the possibility of metallic transmutation, and he did not believe there was such a thing as a universal panacea or a Philosophers' Stone, the aims of traditional transmutational alchemy.<sup>17</sup> What was most important was that only an experienced physician should prescribe drugs, based on critical assessment of a particular case.<sup>18</sup>

Overall, cures based on botanical ingredients remained to be preferred over those based on mineral ingredients according to Boerhaave. Unlike the strong mineral orientation found in Lémery's *Course of Chemistry*, Boerhaave's preference for animal and vegetable substances is also reflected in the division of the *Elementa*.<sup>19</sup> The second volume, just over 500 pages long, lists 227 chemical processes, divided over the classical three kingdoms of bodies – fossils or minerals, vegetables, and animals. Although it describes eighty-eight chemical processes in regard to vegetable matter against 100 concerning mineral matter, the number of pages devoted to each category show that the vegetable-based chemical processes are discussed more extensively: these cover 279 pages, against 158 pages on mineral-based processes (Figure 1).

<sup>14</sup> Gerrit Arie Lindeboom and Herman Boerhaave, *Boerhaave's Brieven aan Bassand* (Haarlem: Erven F. Bohn, 1957), 212–13, 246.

<sup>15</sup> This point of view is reflected in numerous remarks Boerhaave made throughout his work. On Boerhaave's ideas about the limited medicinal use of (gem) stones, see Hendriksen, "The Disappearance of Lapidary Medicine."

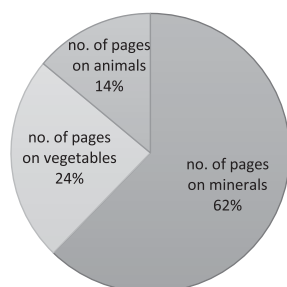
<sup>16</sup> Boerhaave, *A New Method*, vol. I, 152.

<sup>17</sup> John Powers has demonstrated that Boerhaave's increasing scepticism about the possibility of metallic transmutation was at least partly founded in practical experimentation. Lawrence Principe has suggested, and I substantiated, that the rhetoric with which Boerhaave and other Dutch academics rejected the "excesses of chemistry" was not only empirically, but also at a morally and socially motivated. See John Powers, "From Alchemy to Chemistry," in *Inventing Chemistry. Herman Boerhaave and the Reform of the Chemical Arts*, ed. John Powers (Chicago: University of Chicago Press, 2012), 170–91. Lawrence Principe, "The End of Alchemy? The Repudiation and Persistence of Chrysopoeia at the Académie Royale des Sciences in the Eighteenth Century," *Osiris* 29 (2014): 96–116. Lawrence M. Principe, *The Secrets of Alchemy* (Chicago: University of Chicago Press, 2013), 84–89. Marieke M.A. Hendriksen, "Criticizing Chrysopoeia? Alchemy, Chemistry, Academics and Satire in the Northern Netherlands, 1650–1750," *Isis* 109, no 2 (2018): 235–53.

<sup>18</sup> Herman Boerhaave, "Praefatio studioso," *Materia Medica* (London, 1718). This is most likely also the reason Boerhaave only published in Latin.

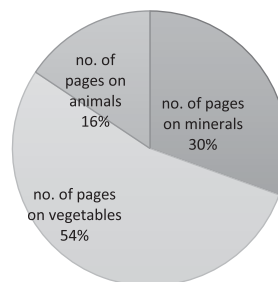
<sup>19</sup> Simon, "Pharmacy and Chemistry," 288.

Lémery - Course of Chemistry (1675)



■ no. of pages on minerals   ■ no. of pages on vegetables  
 ■ no. of pages on animals

Boerhaave - Elements of Chemistry, vol. 2 (original Latin edition, 1732)



■ no. of pages on minerals   ■ no. of pages on vegetables  
 ■ no. of pages on animals

FIGURE 1 Division between vegetable, animal, and mineral substances in Lémery and Boerhaave's work respectively.

Not all of the processes in the *Elementa* result in pharmaceutical preparations – some serve primarily to illustrate a chemical transformation, while others produce a substance that is more generally useful, such as a preservative. However, many of Boerhaave's students and readers were indeed apothecaries, so it is interesting to know how his work influenced their thinking about chemistry and mineral-based cures. The *Elementa* has a long and complex reception history – for example, the Othmer Rare Book Library at the Science History Institute in Philadelphia alone holds seventeen different editions of the *Elementa*. There is the official, signed, 1732 Leiden edition, spurious editions that predate it, an English translation authorised by Boerhaave, illegal copies of the official edition in Latin, and different versions of spurious translations of the official edition. The books are in Latin, English, and French, and they were printed in a variety of places, such as Venice, London, Paris, Leipzig, and probably in Tübingen – some editions appear to have a false Leiden imprint, given by printers who wanted to increase the credibility and value of their edition.<sup>20</sup> However, the reprints in Latin, although not legal, did not contain any changes to the original texts. Such reprints list all 227 chemical processes in the exact same order as the original, and the division of pages between vegetable, animal, and mineral processes is almost exactly the same too – the variations are less than 1% and can be explained from the use of different typefaces and layouts (Figure 2).

Apart from the Latin reprints, there are numerous books aimed at apothecaries that contain translated sections and heavily abridged and reinterpreted fragments

<sup>20</sup> Compare Herman Boerhaave, *Elementa Chemiae: Quae Anniversario Labore Docuit, in Publicis, Privatisque, Scholis*, 3 vols. (Lugduni Batavorum: Isaac Severinus, 1732) to Herman Boerhaave, *Elementa Chemiae: Quae Anniversario Labore Docuit, in Publicis, Privatisque, Scholis*, 1 vol. (Lugduni Batavorum: Joannis Rudolphi Imhof, 1732).

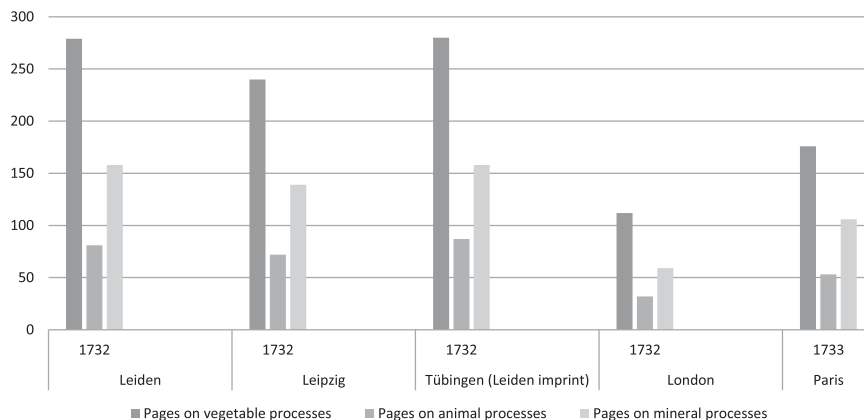


FIGURE 2 Number of pages devoted to chemical processes for each kingdom in various Latin editions of Boerhaave's *Elementa*.

of the *Elementa*, in various vernacular languages rather than the original Latin. Sometimes their authors explicitly refer to Boerhaave in the title of their work, although this frequently appears to have been more of a marketing strategy than a serious attempt to disperse Boerhaave's ideas. Interestingly, such spurious editions and derivatives are often a smaller size than the official edition. Many such works – translated, abbreviated, or only loosely based on the original – are sextodecimo or octodecimo size, like pocket books, whereas the official edition is a respectable octavo – not too big to handle, but definitely not a pocket book either.<sup>21</sup> Size and language matter in this case, as it shows that the authors, unlike Boerhaave, intended these books as *manuals* for professionals rather than academics, to be carried around and kept at hand as reference books during their work in the apothecary shop (Figure 3).<sup>22</sup> The focus here is on such apothecary handbooks in Dutch, and comparison with some English counterparts is made to gain a better understanding of how Boerhaave's influence varied between different countries.

This is important and interesting because while English and French eighteenth-century pharmacy have been studied quite extensively, Dutch pharmacy has thus far received little attention from historians of medicine. It was a heterogeneous field, with wildly varying rules and regulations per city or region. The trade was learned through apprenticeship and protected by guild examinations, but many apothecaries attended lectures in medicine, chemistry, and botany at universities,

<sup>21</sup> Compare Herman Boerhaave, *Elementa Chymiae: Quae Anniversario Labore Docuit, in Publicis, Privatisque, Scholis*, 3 vols. (Lugduni Batavorum: Isaac Severinus, 1732) to Herman Boerhaave, *Institutiones et Experimenta Chymiae* (Paris, 1724), Herman Boerhaave, *Institutiones et Experimenta Chymiae*, 2 vols. (Venetiis: Sebastianum Coleti, 1726), and Julien Offray de la Mettrie and Herman Boerhaave, *Abregé de La Theorie Chymique / Tiré Des Propres Ecrits ... Par M. de La Mettrie. Auquel on a Joint Le Traité Du Vertige* (Paris: Lambert & Durand, 1741).

<sup>22</sup> The noun "manual" originally referred to the size of a book rather than to its contents.





FIGURE 3 The book on the left is the original 1732 Leiden edition of the *Elementa*, the book on the right is the translated and abbreviated 1732 London edition of the same book.

and some even went on to take a medical degree. Most cities forbade the selling of medications by physicians, and the prescription of them by apothecaries, yet in some places the same person could practice the two trades simultaneously. In many cities, apothecaries were required to make all medicines themselves, while in others the preparation of chemical drugs could also be done by a specialist “chymist.”<sup>23</sup> Yet most apothecaries made almost everything themselves; both Galenical and chemical drugs, something reflected in the titles of many apothecary handbooks.

### A note on the distinction between Galenical and chemical pharmacy

As Simon notes, Lémery by the late seventeenth century distinguished Galenical from chemical pharmacy by observing that

Galenic pharmacy remains at the level of a simple mixing together, without making the effort to seek out the substances that naturally compose each of the drugs. Chemical pharmacy is concerned with the analysis of natural bodies in order to separate out the useless substances and to make more exalted, more essential remedies out of them.<sup>24</sup>

The distinction between Galenical and chemical drugs thus appears to have referred to the mode of preparation and the end product, not to the ingredients: Galenical

<sup>23</sup> Henriette A. Bosman-Jelgersma, *Poeders, Pillen En Patiënten: Apothekers En Hun Zorg Voor de Gezondheid Door de Eeuwen Heen* (Amsterdam: Uitgeverij Luitingh-Sijthoff B.V., 1983), 74.

<sup>24</sup> Nicolas Lémery, *Pharmacopée Universelle contenant toutes les compositions de pharmacie qui sont en usage dans la Médecine, tant en France que par toute l'Europe; leurs Vertus, leurs Doses, les manières d'opérer les plus simples & les meilleures* (Paris, 1697), 1. Translation taken from Simon, “Pharmacy and Chemistry,” 289.

drugs could be based on minerals and chemical drugs on vegetable substances. However, Simon goes on to argue that despite the numerical superiority of plant products in pharmacopoeia, the range of manipulations aimed at bringing about chemical transformations in the French context was much greater in the mineral kingdom, and the rise in pharmaceutical chemistry was tied to an increasing interest in the transformations of minerals.<sup>25</sup>

But why was this divide initially important for pharmacy, why did it disappear in the eighteenth century, and what does this tell us about ideas on vegetable- and mineral-based drugs? Finally, as we will see in the analysis of Dutch and English apothecary handbooks, there definitely was an interest in chemical drugs as well as in mineral-based drugs among eighteenth-century Dutch and English apothecaries too – but did this indeed mean the number of chemical and mineral preparations demanded of the pharmacist grew, as Jonathan Simon has argued was the case in France?

To start with the issue of the distinction between Galenical and chemical pharmacy: this first occurred in the course of the sixteenth and seventeenth centuries, when traditional, Galenical pharmaceutical practices were increasingly combined with new chemical preparation methods, or *chymiatría*, into a more chemical medicine. The introduction of *chymiatría* to European medicine was rooted in medical alchemy of the medieval period. Epistemologically and methodologically opposed to the Scholastic tradition that formed the basis for university medical curricula and medical practice, chemical medicine was initially controversial, but gradually became an integral part of medical curricula and pharmaceutical practice.<sup>26</sup> In the seventeenth-century Spanish-speaking world this led to a pharmaceutical laboratory practice in which alchemical substances and techniques were combined with a thoroughly Galenic medical theory.<sup>27</sup> The many books that appeared between 1650 and 1750 on “Galeno-chemical” pharmacy in various European languages suggest that this pragmatic approach was adopted elsewhere too.

By the eighteenth-century, very few authors paid explicit attention to the distinction, and neither did Boerhaave, suggesting its origins and importance were, at least initially, still clear to most medical men. However, as chemistry and pharmacy started to develop as independent academic disciplines in the course of the eighteenth century, the distinction between Galenical and chemical pharmacy became more confused, eventually leading to a rejection of this divide. For example, the

<sup>25</sup> Simon, “Pharmacy and Chemistry,” 289.

<sup>26</sup> Allen Debus, “Chemists, Physicians, and Changing Perspectives on the Scientific Revolution,” *Isis* 89, no 1 (1998): 66–81; Allen Debus, *Chemistry and Medical Debate van Helmont to Boerhaave* (Canton, MA: Science History Publications, 2001), 25–26. Bruce Moran, *Distilling Knowledge: Alchemy, Chemistry, and the Scientific Revolution* (Cambridge MA: Harvard University Press, 2005), 86, 107.

<sup>27</sup> Ruth Hill, *Sceptres and Sciences in the Spains: Four Humanists and the New Philosophy (ca. 1680–1740)* (Liverpool: Liverpool UP, 2000), 160–62. Paula De Vos, “From Herbs to Alchemy: The Introduction of Chemical Medicine to Mexican Pharmacies in the Seventeenth and Eighteenth Centuries,” *Journal of Spanish Cultural Studies* 8, no 2 (July 1, 2007): 135–68.

consulting chemist Robert Dossie (1717–1777) stated in his 1761 *Theory and Practice of Chirurgical Pharmacy*:

Pharmacy in its present state is distinguished into two branches: GALENICAL and CHEMICAL. The *Galenical* consists in separating and extracting the proper matter of the simples from other heterogeneous substances, with which they may be commixt; — in altering their form or texture, without intending any change in the nature of their qualities and medicinal powers, so as to render them fit to be administered or applied; — and in conjoining them in compositions of various forms, in which, nevertheless, each simple is supposed to remain its original properties. The *chemical* consists in many operations on various bodies, (in most of which fire is a principal medium); by which extracts are made of the more elementary parts of simples, that in their separate state may have qualities different from those of the entire body of which they were a part; and combinations are formed in different simples, in which qualities, not found in any of the constituents, are produced.<sup>28</sup>

From this fragment it appears that by the mid-eighteenth century, Galenical drugs were still basically understood as purified naturally occurring substances that retained the properties ascribed to them in their natural form, prepared exclusively through separating and extracting processes, such as boiling, grinding, powdering, and mixing. By contrast, chemical drugs were made through transformative processes like distillation, crystallisation, and regeneration, and resulted in end products in which the original ingredients could often no longer be detected, and which had properties the original ingredients did not have. Although this may appear to be a sliding scale, in the first half of the eighteenth century it was still a commonly used distinction, probably not in the least because chemical drugs tended to be more concentrated and powerful, which meant smaller quantities were needed. This in turn meant many people found them more agreeable, as they were generally easier to ingest, and many medical practitioners believed them to be more effective.<sup>29</sup>

However, William Lewis (1708/14–1781), a brewer's son who gained an MD from Oxford in 1745, described how the distinction between Galenical and chemical pharmacy became contested and was eventually rejected.<sup>30</sup> A practicing physician, Lewis published frequently on medicine, pharmacy, and chemistry, mostly handbooks aimed at apothecaries. In the opening lines of the first chapter of his 1778 *New Dispensatory*, Lewis stated boldly that “no rational principle of distinction between them [Galenical and Chemical pharmacy] has yet been fixed on,” and that “the Galenical forms are by no means independent of chemistry; and that this science extends to mixtures of the most simple kind.”<sup>31</sup> He went on to

<sup>28</sup> Robert Dossie, *Theory and Practice of Chirurgical Pharmacy: Comprehending a Complete Dispensatory for the Use of Surgeons. With Explanatory and Critical Notes on Each Composition, and an Introductory Inquiry Concerning the Particular Intentions of Cure, in Which Remedies Are Applied or Administered; and the Nature and Medicinal Efficacy of the Several Simples Subserving to Them* (Dublin: G. and A. Ewing, 1761), 2–3.

<sup>29</sup> Bosman-Jelgersma, *Poeders, pillen*, 76–77; Wouter van Lis, *Gualtheri van Lis Pharmacopoea Galeno-Chemico-Medica ... = Meng- Schei- ... / Wouter van Lis Meng- Schei- En Geneeskonstige Artseny-Winkel* (Amsterdam: Jan Morterre, 1747), 2.

<sup>30</sup> The *Dictionary of National Biography* in 1893 gives 1714 as Lewis's birth year, yet in WorldCat identities it is 1708. <https://www.worldcat.org/identities/lccn-n82041022/>

explain that the distinction was “apparently derived from prejudice and superficial knowledge, and which has been continued only in compliance with custom,” and that the Royal College of Physicians of London – a professional and regulatory body that, amongst others, issued the city pharmacopoeia – had rejected the division between Galenic and chemical pharmacy. Pharmacy, Lewis wrote, is nothing more than a branch of chemistry, and even the simplest pharmaceutical preparations are chemical. If a distinction was to be made, it was between theoretical and practical pharmacy – the former focusing on the knowledge of the properties and qualities of medicinal substances, the direct result of experiment and observation, whereas the latter described mere manual labour.<sup>32</sup> Lewis' discussion of the obsolete distinction between Galenic and chemical pharmacy was copied in a posthumous 1786 Edinburgh edition of this work, but a similar work from 1805 shows that the rejection by then had apparently been so generally accepted that this explanation was no longer deemed necessary.<sup>33</sup> Similarly, in the Low Countries only one more apothecary handbook referring to Galenic pharmacy appeared after the 1760s: an unrevised 1790 reprint of Kornelis Elzevier's 1755 *Lexicon Galeno-Chymico-Pharmaceuticum*.<sup>34</sup>

That Boerhaave never paid explicit attention to the divide between Galenic and chemical pharmacy was part of his strategy in advocating the cautious use of chemistry and minerals in medicine and pharmacy. His *Elementa* was meant as an overview of chemistry, not as a pharmaceutical handbook. That some of the students and successors influenced by his work still felt the need to qualify their pharmaceutical chemistry as “Galeno-chemical” shows that at least until the middle of the eighteenth century, this was a manner of demonstrating that they were aware of the dangers of chemical medicine and mineral-based pharmaceutical preparations, and of the importance of the Galenic tradition.

### The influence of Boerhaave's mineral medicine in Dutch apothecary handbooks

We have seen in Boerhaave's work that the processes aimed at chemically transforming minerals that were dominant in the tradition of French chemistry were perceived different in the low countries. Can we extrapolate that to the prescription of mineral-based pharmaceuticals in the Netherlands? Unfortunately, it is very difficult to discern how often and in which quantities drugs were prescribed and sold by eighteenth-century physicians and apothecaries. Prescriptions and sales were hardly registered systematically, and if they were, these records are mostly lost.

<sup>31</sup> William Lewis, *The New Dispensatory* (Dublin: James Potts, 1778), 1–2.

<sup>32</sup> Lewis, *New Dispensatory*, 1–2.

<sup>33</sup> Compare William Lewis, *The Edinburgh New Dispensatory* (Edinburgh and London: Printed for Charles Elliot, Edinburgh; and G.G.J. and J. Robinson, London, 1786), 2–3 to Andrew Duncan, *The Edinburgh New Dispensatory* (Worcester: Isaiah Thomas, Jun., 1805).

<sup>34</sup> Kornelis Elzevier, *Lexicon Galeno-Chymico-Pharmaceuticum, of Apothekers Woordenboek*, 1st ed., 2 vols. (Amsterdam: Nicolaas ten Hoorn, 1755) was reprinted as Kornelis Elzevier, *Lexicon Galeno-Chymico-Pharmaceuticum, of Apothekers Woordenboek*, 2 vols. (Amsterdam: by H. Gartman, W. Vermandel en J. W. Smit, 1790).

Pharmacopoeia, the official books that most apothecary guilds published and that contained a list of all the ingredients an apothecary should keep in his shop, are not representative of the actual use of ingredients.

City pharmacopoeias in the Low Countries were revised very infrequently and are therefore hardly reflective of how popular particular ingredients were in everyday practice. These books served primarily to regulate the drug trade, to establish the minimum of ingredients and preparations apothecaries should have in store, and to prevent inadvertent poisoning.<sup>35</sup> By the 1780s, in many Dutch cities the most recent pharmacopoeia dated from the beginning of the century. In Amsterdam, for example, the *Pharmacopoea Amstelaedamensis renovata* that appeared in 1726 was only fully revised and replaced with the *Pharmacopoea Amstelodamensis nova* in 1792.<sup>36</sup> Another problem was that these books usually appeared in Latin, and although it was a formal requirement, many apothecaries only had a very basic grasp of that language. This could have disastrous effects – something openly acknowledged by Boerhaave’s successor as professor of chemistry Gaub, who pleaded for the use of apothecary handbooks in the vernacular, rather than reliance on city pharmacopoeia.<sup>37</sup>

Therefore, we have to rely on state-of-the-art medical and pharmaceutical ideas reflected in books such as those by Boerhaave, combined with widely used apothecary handbooks. The number of times and the locations in which an apothecary handbook was reprinted, and the marginalia and signs of wear found in remaining copies give an impression of which books were widely used. Although libraries tend to prefer “clean” copies of books, in copies of Boerhaave’s work it is not unusual to find traces of use. At Utrecht University Library, a copy of his 1720 *Institutiones medicae* is bound entirely interleaved with note paper, which has been intensively used by the owner (Figure 4). A copy of the English translation of the *Elementa* in the library of the New York Academy of Medicine with an ex libris of New York Hospital Library (established 1769) has a piece of paper with a dried skein of tangled herbs, possibly thyme, between pages eighty and eighty-one of the first volume. The surrounding pages describe the chemical process to produce essential oil from rosemary and other herbs (Figure 5).

If we shift our attention to commonly used apothecary handbooks in the mid-eighteenth-century Netherlands, there are two frequently used books in particular that can give us a reliable impression of Boerhaave’s influence. The first Dutch apothecary handbook in which Boerhaave’s influence is clearly visible is Wouter van Lis’s *Pharmacopoea galeno-chemico-medica*, originally published in 1747 and reprinted in 1764 by an Amsterdam printer. Van Lis is an interesting case because he started his career as an apothecary and brewer in Rotterdam, then gained a medical degree at

<sup>35</sup> Also see Hendriksen, “The Disappearance of Lapidary Medicine.”

<sup>36</sup> Anton Wiechmann, *De Verzameling Medicijnen van Een Amsterdamsche Stadskokter* (Leiden: Museum Boerhaave, 1992), 12.

<sup>37</sup> See Hiernoymus David Gaub, “Voorreden”, in *Medicina Pharmaceutica, of Groote Algemeene Schatkamer Der Drögberedende Geneeskunst*, ed. Robertus de Farvacques and Johannes Schröder (Leiden: Isaak Severinus, 1741).



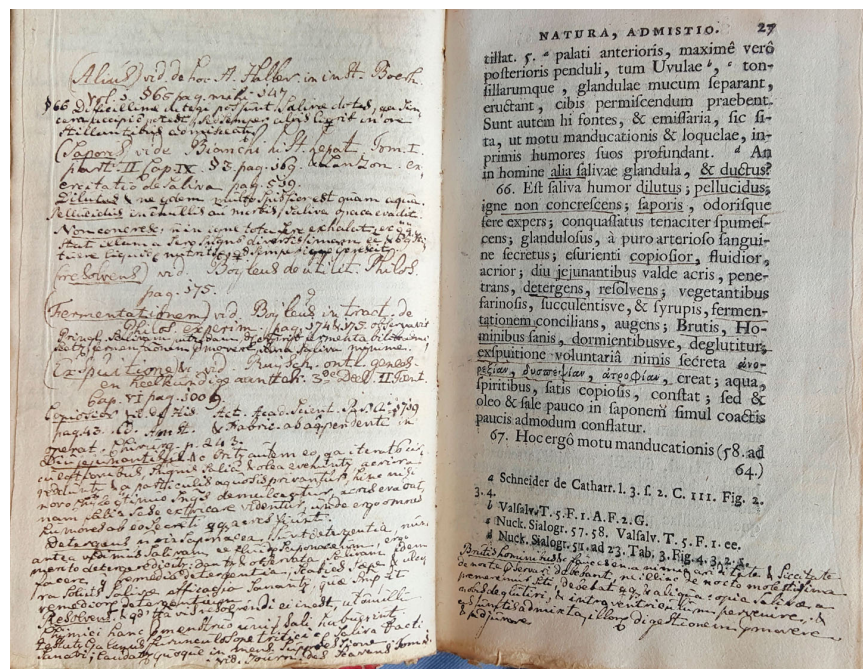


FIGURE 4 Herman Boerhaave, *Institutiones Medicae in Usus Annuae Exercitationis Domesticos* (Leiden: Johannes van der Linden, 1720), annotated copy at Utrecht University Library special collections, call number MAG: O OCT 1664.

Utrecht University with a former student of Boerhaave in 1745, and subsequently set up practice as a physician and apothecary in Bergen op Zoom, a city in the Austrian Netherlands where this combination was allowed.<sup>38</sup> His dissertation, on the medicinal applications of Aloe, shows that Van Lis had great respect for Boerhaave and his work, and that although he did not agree with him on everything, he did subscribe to his position on the use of mineral substances – namely that their use in medicine was limited, and the virtues of vegetable-based pharmaceuticals much greater.<sup>39</sup> Moreover, although as the title of the book suggests it covers both Galenical and chemical pharmacy, the main focus is on Galenical preparations.

This is reflected in the number of pages Van Lis devoted to the various topics in his pharmacopoeia. In the first part, which discusses simples, we find fifty-three pages on vegetable substances, five on animal substances, two on sea crops, and eleven pages on minerals. So almost 75% of basic ingredients are vegetable, and less than 16% are mineral (compare to Figure 1). If we move on to the discussion of the preparation of Galenical versus chemical compositions and their application,

<sup>38</sup> F.H.A. Peeters, "Wouter van Lis: Apotheker, Bierbrouwer En Stadsmedicus," *Kring Voor de Geschiedenis van de Pharmacie in de Benelux*. Bulletin 73 (1988): 1–13.

<sup>39</sup> Wouter van Lis, *Dissertatio Medica Inauguralis de Aloë* (Utrecht: Johannes Broedelet, 1745), 2, 18.

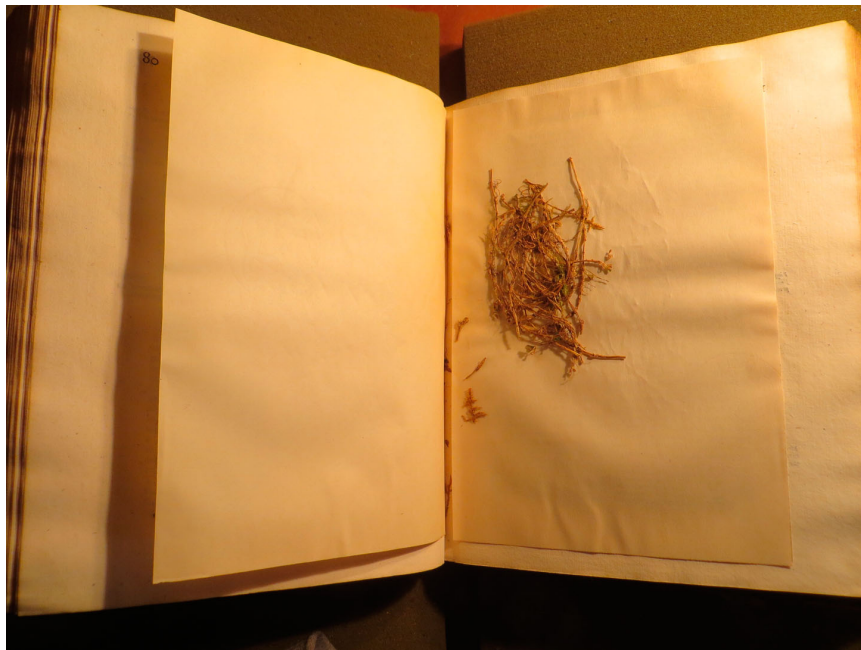


FIGURE 5 Dried herbs (possibly thyme) in the New York Academy of Medicine's copy of Boerhaave, *A New Method of Chemistry*, between pages 80 and 81.

we find 176 pages devoted to the former against ninety-one to the latter. The majority of the Galenical preparations and more than half of the chemical preparations are vegetable-based. So for the modern apothecary-physician Van Lis, trained in the Boerhavian tradition, vegetable preparations and Galenical pharmacy were still dominant by the mid-eighteenth century.

Another example we find in the anonymously published *Nieuwe Nederduitsche apotheek* of 1753, with a reprint in 1766, which claimed to be based on insights from the work of Boerhaave and Geoffroy. This book does not distinguish clearly between Galenic and chemical pharmacy, but 275 pages are devoted to preparations based on vegetable and animal ingredients, against 133 on “diggable bodies.” Given the remaining number of copies and the fact that this book, together with Van Lis's *Pharmacopeia*, were still considered to be among the best apothecary handbooks available in Dutch by an apothecary in 1793, we can assume that the use of these books in practice was considerable, and that the amount of attention that was given in these books to particular materials to some extent reflects the frequency with which they were prescribed or demanded.<sup>40</sup>

<sup>40</sup> E. Grendel, “De Opleiding van Apothekers in Het Eind van de 18e En Het Begin van de 19e Eeuw,” *Kring Voor de Geschiedenis van de Pharmacie in de Benelux*. *Bulletin* 55 (1977): 19–22, 19.

Of course, the question remains whether the number of pages devoted to certain categories of remedies and preparation methods in these handbooks reflect how frequently they were prescribed and sold. Although it is impossible to answer this question with certainty, a survey of manuscript prescription notes from the same period gives a similar impression: these too list predominantly vegetable-based, Galenical remedies.<sup>41</sup> Moreover, if we do a qualitative analysis of what is written about particular substances in these books, reflects the hypothesis that mineral substances were treated critically. For example, Wouter van Lis discussed silver in its pure form as an essentially harmless, but also completely useless material in pharmacy, using Boerhaave's argument that the heat of the body could not dissolve it. He did point out, however, that it could be used decoratively, for instance, to make pills and such more attractive to the eye.

However, there are exceptions to the dominance of vegetable preparations too. For example, a much rarer booklet, the *Laboratorium Chymico Pharmaceuticum, de Productis Chymicis Humidis et Siccis* or "Chemical-pharmaceutical Laboratory of Wet and Dry Chemical Products" was published in Amsterdam by a certain Jean George Riga in 1769.<sup>42</sup> By the middle of the eighteenth century, the concept of a wet and a dry way were common in mainstream, non-transmutational chemistry. For example, the Swedish chemist Torbern Bergman (1735–1784) created enormous affinity tables in the 1770s, which listed the affinity series for reactions in the wet or moist way (aqueous reactions) and the dry way (heated reactions).<sup>43</sup> Yet Riga's work was outright transmutational in nature: the wet and the dry way were also common processes in traditional transmutational alchemy. The wet way stipulates the use of watery solvents to dissolve gold in preparation of making the Philosophers' Stone, while the dry way maintains that the Philosophical Mercury is a metallic solvent prepared from common mercury, "the water which does not wet the hands." The moist way, wet way, or *via humida* hailed back to Basil Valentine, while the *via sicca* was practiced by alchemists following pseudo-Geber, the so-called Mercurialist school.<sup>44</sup>

Riga's work shows that he indeed firmly believed in metallic transmutation – his list of definitions in the back of the book contains a serious definition of the

<sup>41</sup> Anonymous MS, "Recepten," MUSEUM BOERH a 322, Anonymous MS, "Recepten," MUSEUM BOERH a 323, Anonymous MS, "Receptenboekje," MUSEUM BOERH a 313, "Manuscript [Medicament Boek: Met Een Recept van Boerhaave Tegen Koorts ] Jaar: 17XX", 17XX, Leiden University Library, MB: a 308.

<sup>42</sup> Jan George Riga, *Laboratorium Chymico Pharmaceuticum, de Productis Chymicis Humidis et Siccis: Of Het Chymische Werkhuys Der Apotheekers* (Amsterdam: J. Schuring, 1769). Riga was baptised in Mobach, Mainz, in 1737, married in Amsterdam in 1767, and is listed as having obtained his PhD in the same year and practicing as an apothecary near the Rokin in Amsterdam in 1768. See "Deutschland Geburten und Taufen, 1558-1898," database, FamilySearch (<https://familysearch.org/ark:/61903/1:1:V4BW-9WQ>: 28 November 2014), Joannes Georgius Riga, Oct 1737; FHL microfilm 949,601), *Huwlyks-zang, ter bruilofte van den heere Joannes Georgius Riga, en mejufrouwe Anna Catharina Gerôme* (Amsterdam: T. Crajenscot, 1767), 3, and *Lyste der naamen en woonplaatzen van de apothekers* (Amsterdam: Petrus Schouten en Reinier Ottens, 1768), 11.

<sup>43</sup> Tobern Bergman, *A Dissertation on Elective Attractions* (London: J. Murray, 1775). Also see Frederic L. Holmes, "Analysis by Fire and Solvent Extractions: The Metamorphosis of a Tradition," *Isis* 62, no. 2 (1971): 128–48, 131. I would like to thank the anonymous reviewer who pointed out Bergman's work to me.

<sup>44</sup> See Lawrence M. Principe, *The Aspiring Adept. Robert Boyle and His Alchemical Quest. Including Boyle's "Lost" Dialogue on the Transmutation of Metals* (Princeton, NJ: Princeton University Press, 1998), 153.



Philosophers' Stone – and he showed none of the Boerhaavian caution towards the use of mineral-based drugs. In fact, most of his book is devoted to chemical processes that create products from mineral substances – only small sections, about eighteen out of 180 pages, are devoted to processes that can be applied to vegetable and animal substances or that exclusively use vegetable and/or animal substances as their ingredients. An explanation for this might be that Riga was originally from Mainz in Rheinessen, and High German mid-eighteenth-century pharmaceuticals appears to have been rooted much more strongly in traditional (al)chemical knowledge, in which mineral materials and metallic transmutation played an important role, than Low German (i.e. Dutch) pharmacy. German travelling alchemists trying to sell topic cures, panaceas, transmuted metals, and even the Philosophers' Stone were a topic of both indignation and jest in eighteenth-century Dutch academic and popular culture, particularly in the 1730s.<sup>45</sup>

Riga's work is the only case I have encountered thus far in which an eighteenth-century apothecary in the northern Netherlands advocates mineral pharmaceutical preparations so strongly – all other eighteenth-century Dutch apothecary handbooks I have studied until now echo Boerhaave's caution about the use of mineral substances and his preference for vegetable-based cures to some extent. In Van Lis's book, for example, the majority of metal-based preparations are only listed for external use, and he is sceptical about the use of gold, silver, and tin. Similarly, Kornelis Elzevier, the author of the *Lexicon Galeno-Chymico-Pharmaceuticum, of Apothekers Woordenboek*, a Dutch apothecary's dictionary from 1755, was critical about the use of powdered stones, although he did list recipes containing them.<sup>46</sup>

### The influence of Boerhaave's mineral medicine on English authors

This critical stance towards the use of mineral matter in pharmaceutical preparations, let's call it the "Boerhaave-effect", was not restricted to the northern Netherlands, and continued for through much of the eighteenth century. For example, a 1755 English booklet entitled *Boerhaave's Materia medica, or the druggist's guide, and the physician and apothecary's table-book. Being a compleat account of all drugs in alphabetical order* has a preface by a Richard Goade. Goade states that this is an English translation of a Latin manuscript given to him by a Dr James Carroll, who allegedly had "taken [it] from the mouth of the great professor Boerhaave, in a course of Lectures." This edition is a completely different work than Boerhaave's original *Materia Medica*, which systematically lists recipes for specific diseases without discussing the characteristics of the individual ingredients or theoretical basis for applying them. Instead, this book, as the title promises, is more of a list of simples, an alphabetical enumeration of basic iatrochemical ingredients, listing their origins, characteristics, virtues, which diseases they cure, in what dose

<sup>45</sup> Hendriksen, "Criticizing Chrysopoeia?"

<sup>46</sup> Elzevier, *Lexicon Galeno-Chymico-Pharmaceuticum*.

they should be used, etc. Nonetheless, the applications and doses described largely adhere to Boerhaave's prescriptions and warnings. Goade repeats Boerhaave's warnings about the dangers of using metals too liberally, yet there are also remarkable differences, most notably the discussion of gemstones as *materia medica*.<sup>47</sup>

To illustrate this, I will discuss two examples of English works aimed at practicing apothecaries that clearly referred to Boerhaave's chemistry. The first is a book that first appeared in 1732 and saw a reprint in 1734, under the title *Dr. Boerhaave's Elements of chymistry: Faithfully Abridg'd from the Late Genuine Edition, Publish'd and Sign'd by Himself, at Leyden ... : To Which are Added, Curious and Useful Notes ... / by a Physician*. This physician was most likely Edward Strother (1675–1737), who had obtained his MD at Utrecht University in 1720, before settling in London.<sup>48</sup> As the title already suggests, the author had heavily abbreviated Boerhaave's original text – in the preface he explained that he felt that a lot of it was superfluous for the practice of pharmacy, and thus a waste of paper. As a physician, he was primarily interested in the medical application of chemistry, and in his opinion, more attention should have been paid to how the chemistry of pharmaceutical preparations influenced the human body. He lamented: “I wish this treatise had aim'd more at the Correlation between Animal and Chymical Actions; this is not the only Difference between the Author and me ... ”

Although Strother indeed faithfully maintained the same sections, chapters, and number and order of processes as the *Elementa*, he had deleted everything that was not useful for physicians and apothecaries. For example, under the headers “Its Uses” for each process, for the most part only the medical applications were listed in this edition. Moreover, the balance between the descriptions of processes on vegetable, animal, and what Strother calls “metal” rather than fossil matter differed from the original Latin of the *Elementa*: the vegetable and especially the animal processes get more space and the mineral processes less than in the original (Figure 6).<sup>49</sup> This results mainly from the fact that Strother was primarily interested in the medical uses of the chemical processes Boerhaave described, not because he was particularly worried about the dangers of using mineral medicine. Boerhaave simply wrote less about the medicinal use of mineral medicine, and hence that part of his work was of less interest to Strother. If we look, for example, at Boerhaave's discussion of Boyle's “silver pill,” a form of silver nitrate, we see that most of his text focuses on how silver nitrate can be used to suggest the

<sup>47</sup> Hendriksen, “The Disappearance of Lapidary Medicine.”

<sup>48</sup> E.I. Carlyle, “Strother, Edward (1675–1737),” rev. Patrick Wallis, *Oxford Dictionary of National Biography* (Oxford University Press, 2004) [<http://www.oxforddnb.com/view/article/26678>, accessed 5 April 2017]

<sup>49</sup> *Dr. Boerhaave's Elements of Chymistry: Faithfully Abridg'd from the Late Genuine Edition, Publish'd and Sign'd by Himself, at Leyden ... : To Which are Added, Curious and Useful Notes ... / by a Physician* (London: J. Wilford, 1732). The “physician” in the title was probably Edward Strothers (1675–1737). There is an identical 1734 reprint of this edition. Similarly, the English translator of a 1735 edition, although he stated in the *Author's preface* that he has stayed as close to the original as possible, and with the author's permission, pays much more attention to the vegetable and animal processes, and less attentions to the fossil processes than Boerhaave did. See Herman Boerhaave, *Elements of Chemistry, Being the Annual Lectures of Herman Boerhaave*. Translated from the Original Latin by Timothy Dallowe, 2 vols. (London: J. and J. Pemberton, 1735).

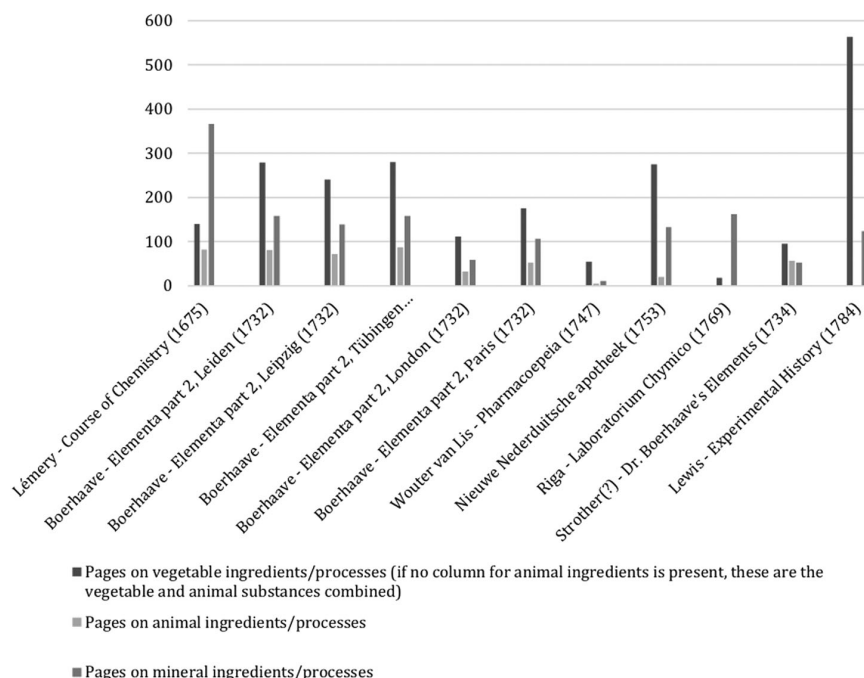


FIGURE 6 Division between the kingdom in chemistry and apothecary books.

transmutation of lead into silver, and how to debunk this. Only then does Boerhaave mention its application as an external medicine, and lastly as an internal medicine – with the explicit warning that it should be used very sparingly and mixed with other ingredients. Strother, by contrast, greatly abbreviates the part on the transmutation fraud, leaves out the external application almost entirely, and apparently heedlessly warns “have a care how you dose it.”<sup>50</sup> So even though Strother did definitely not agree with Boerhaave in all respects and wished for a much more pharmaceutically useful chemistry, he happily pirated his book. The fact that Boerhaave paid very little attention to the medical uses of mineral chemistry in the *Elementa* therefore also resulted in a very vegetable- and Galenic-medicine focused abridgement of his work by Strother.

The second English example is another book by William Lewis. One of his most successful works was his *Experimental History of the Materia Medica*, which saw three editions between 1761 and 1784, as well as a German translation. Although Lewis never studied with Boerhaave and did not refer to him in the title of his work, he mentioned him or referred to his work on at least 32 occasions in his 687-page book. Most of these references are to Boerhaave’s books on botanicals and *materia medica*, but there are five instances in which Lewis refers to Boerhaave’s

<sup>50</sup> Dr. Boerhaave’s *Elements*, 169.

critical discussion of mineral-based pharmaceuticals in the *Elementa*. For example, when discussing *pilula lunaris*, variations of silver nitrate pills already described by Boyle in the late seventeenth century, Lewis writes:

Pilula Lunaris. Boerhaave assures us, that two grains of this preparation, made into pills with crumb of bread and little sugar, and taken on an empty stomach, some warm water sweetened with a little honey being drank immediately after, purge gently without griping, and bring away a large quantity of water almost without the patient's perceiving it. He nevertheless cautions against too liberal or continued use of this medicine, and observes, that by its corrosive quality it weakens the bowels, particularly the stomach, and that therefore proper corroborants, as rob of juniper berries, ought to be interposed. Even with this assistance, however, it is at best a dangerous medicine, and as such deservedly stands excluded from practice.<sup>51</sup>

The phrase “Boerhaave assures us” is slightly ironical, given the fact that although Boerhaave did write about the *pilula lunaris* in the *Elementa* in Latin, he clearly did not mean to assure apothecaries and others who could not read Latin that it was safe to prescribe silver solutions – quite the contrary.<sup>52</sup> As appears from the rest of the fragment, Lewis did not explicitly or categorically speak out against the use of mineral-based pharmaceuticals, but like Boerhaave, he was cautious. Because his book is organised alphabetically rather than along the lines of the three kingdoms, it is more difficult to tell how much attention he paid to vegetable, animal, and mineral preparations. However, a count shows that of the 687 pages, only about 124 discuss mineral-based substances, so about 18%. When discussing cures based on silver, antimony, copper, mercury, and sal ammoniac, Lewis refers to Boerhaave and what he said about their use in the *Elementa*. These references were maintained in all editions, even in the 1784 posthumous edition, which demonstrates that almost half a century after his death, Boerhaave's chemistry was still influencing practical pharmacy.

## Conclusion

The examples I have discussed demonstrate that the increasing interest in the mineral kingdom and chemical transformation in eighteenth-century pharmacy and medicine did not result in an overall rise in the number of mineral preparations described in Dutch chemistry and apothecary handbooks (Figure 6). Although it might be true

<sup>51</sup> William Lewis, *An Experimental History of the Materia Medica: Or of the Natural and Artificial Substances Made Use of in Medicine: Containing a Compendious View of Their Natural History, and Account of Their Pharmaceutic Properties, and an Estimate of Their Medicinal Powers, so Far as They Can Be Ascertained by Experience, or by Rational Induction from Their Sensible Qualities*, 3rd ed. (London: J. Johnson, 1784), 93.

<sup>52</sup> Repeated or excessive ingestion of silver solutions can cause acute silver poisoning (argyria), which may cause haemorrhage and erosive intestinal lesions, but in small doses silver compounds are thought to be harmless despite widespread systemic deposition. However, the cosmetic disability can be psychologically traumatic, as systemic argyria can cause the skin to turn permanently greyish-blue. See R.J. Prescott and S. Wells, “Systemic argyria,” *Journal of Clinical Pathology: The Journal of the Association of Clinical Pathologists* 47, no 6 (1994): 556–57.

that the proportion of mineral ingredients and preparations in pharmacopoeia increased over time from the sixteenth century through the eighteenth, this says very little about their actual use in practice. Studying contextual evidence suggests a more nuanced situation, in which mineral-based drugs were still a last resort, rather than ubiquitously prescribed. Nor is there proof that the amount of mineral and chemical cures demanded of the pharmacist rose dramatically, certainly not in the Netherlands, and probably also not in England. The strong focus on mineral chemistry and pharmacy in the eighteenth century is possibly a particular French phenomenon.

As the realisation grew that all pharmaceutical preparations were in a sense chemical, and the distinction between Galenical and chemical pharmacy became obsolete in the course of the eighteenth century, it is impossible to tell whether the demand for pharmaceutical preparations that would previously have been understood as chemical (in the sense of non-Galenical) rose over the course of the eighteenth century, as by the end of the century the distinction between the two had disappeared and all pharmaceutical preparations were considered chemical. Moreover, although the absolute number of mineral ingredients and mineral-based preparations listed in English and French pharmacopoeia may have grown in the early modern period, this article shows that their actual use in everyday practice was probably rather limited.

This article has shown that the influence of Boerhaave's ideas on pharmacy, chemistry, and particularly the use of mineral substances on eighteenth-century pharmacy, at least in the Netherlands and England, can hardly be overestimated. It has been established that Boerhaave and many of his contemporaries were well aware of the dangers of using mineral-based, chemically produced pharmaceutical preparations. Although Boerhaave wrote his *Elementa* reluctantly and exclusively for an academic audience, the effect of the illicit reprints, translations, and abbreviated editions on eighteenth-century pharmacy should not be underestimated. As this article demonstrates, Boerhaave's written work, and especially his *Elementa Chemiae*, profoundly influenced pharmaceutical handbook writers within and outside the Netherlands for much of the eighteenth century. This raises the question to what extent changes in pharmaceutical chemistry were localised phenomena in early modern Europe, especially outside the relatively well-known Anglo- and Francophone realm.

The numerous explicit and implicit references to Boerhaave and his nuanced ideas about chemistry and the use of mineral-based substances in medicine and pharmacy in eighteenth-century Dutch and English apothecary handbooks show that the "teacher of Europe" not only restructured and reinterpreted various practices from diverse chemical traditions into a coherent organisational structure and philosophical foundation for an academic chemistry, but that he influenced a less academic audience too. Notwithstanding the traditional non-academic training structure in Dutch pharmacy, Boerhaave did not just found an academic chemistry; he and his students also profoundly influenced practical pharmacy with

their chemical understanding of minerals, at least in the northern Netherlands and England. Even though Boerhaave's chemical theory was not primarily intended for apothecaries, his recommendations were echoed in pharmaceutical handbooks for decades.

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### Note on contributor

Marieke M.A. Hendriksen is a historian of art and science and postdoctoral fellow with the ARTECHNE project, Utrecht University. Her research focus is the intersection of material culture and the history of ideas in medicine, chemistry, and art in the long eighteenth century. Previously, she worked at Leiden and Groningen universities, and was awarded grants and prizes by the National Maritime Museum London, the MPIWG Berlin, the Wellcome Trust, the Chemical Heritage Foundation, and the Society for the History of Alchemy and Chemistry amongst others. For more information, see [www.mariekehendriksen.nl](http://www.mariekehendriksen.nl). Email: [m.m.a.hendriksen@uu.nl](mailto:m.m.a.hendriksen@uu.nl)

### ORCID

Marieke M. A. Hendriksen  <http://orcid.org/0000-0001-7347-4432>