# Deconstructing Glass and Building up Shards at the Early Royal Society

RUTH EZRA, *University of St. Andrews*

*In 1662, the physician Christopher Merret presented his fellow members of the Royal Society with an English translation of Antonio Neri's "L'arte vetraria" (The art of glass, 1612). Central to the preparation and receipt of this book was a cache of objects relevant to glassmaking, now lost or dispersed. These* materia vitraria *served as a tangible appendix to Merret's written commentary. They also reified the society's interest in the development of domestic industry by offering a direct means by which fellows could appreciate the raw materials of contemporary glassmaking alongside evidence of the trade's longer history in the British Isles.*

## INTRODUCTION: MATERIAL TRANSLATION AND EKPHRASTIC FAILURE

**AT THE MEETING** of the Royal Society of London on 8 October 1662, it was "ordered that the Thanks of the Society be given to Dr Merrett for his paines in translating the Italian discourse de Arte Vitraria, upon the Motion and desire of the Society."[1] The text worthy of praise, *The art of glass*,[2] was a significantly expanded English rendering of *L'arte vetraria*, a recipe manual, or book of secrets, compiled by Antonio Neri (1576–1614) and published in Florence in 1612.[3]

My thanks to Sachiko Kusukawa and Sven Dupré for reading earlier versions of this text, and to Jessica Wolfe and my anonymous reviewers for their generous suggestions.

[1] Royal Society (hereafter RS), Journal Book Original (hereafter JBO)/1/99.

[2] Neri-Merret. The key publication on *The art of glass* is W. E. S. Turner, 1962. I follow his hyphenated bibliographic convention below. See also W. E. S. Turner, 1963; Charleston, 106–07, 115, 132; Dupré, 2017, 177–79.

[3] Neri, 1612. For a summary of the contents of *L'arte vetraria*, see W. E. S. Turner, 1962, 203–06; Dupré, 2017, 176–77. For Neri, see Mentasti, xli–lxix; McCray, 101–09; Douglas and Frank, 14–15; Beretta, 2004, 85–86, 177–83, 193. For Neri's text at the Medici court, within the Italian tradition of glassmaking, and in relation to alchemy, see Beretta, 2017, with further bibliography; for Neri's wider interests in pharmaceuticals and the Florentine Paracelsian chymical culture, see Dupré, 2014a, 307–11; Dupré, 2014b, 84–87.

*Renaissance Quarterly* 75 (2022): 88–135 © The Author(s), 2022. Published by the Renaissance Society of America.
doi: 10.1017/rqx.2021.331

Neri's translator, Christopher Merret, MD (1614–95), counted among the society's charter members.[4] Well connected with London's virtuosi, he was an avid botanist, keen natural philosopher,[5] and from 1654, first keeper of the Harveian collection at the Royal College of Physicians, where he had been a fellow since 1651.[6]

In preparing *The art of glass*, Merret had opportunity to exercise his wide-ranging curiosity. The 147 pages of "Observations" he appended to Neri's recipes testify to his having assumed the roles of bibliographer, commentator, experimenter, and confidant, all in an effort to make not just Neri's Italian but also his artisanal knowledge accessible to the society.[7] Merret took additional "paines" as a field collector and curator, assembling a cache of materials relevant to glassmaking.[8] These objects, integral to the interpretive project that bore *The art of glass*, later mediated the book's reception. That Merret amassed a physical archive did not escape the attention of his first readers. By October 22, the fellows desired that he "bring in his Materia Vitraria, spoken of in the booke he hath lately translated out of Italian into English."[9] One imagines that, as custodian of the Harveian collection, Merret well understood the role objects played in the acquisition of knowledge.[10] He certainly proved responsive to

[4] For Merret, see Allen; Dodds; V. Keller, 599; Koinm; Mauck; W. E. S. Turner, 1962, 206–08.

[5] Merret presented several reports on diverse subjects at early meetings of the society: RS, JBO/1/98, JBO/1/101. For those printed in the *Philosophical Transactions*, see Koinm, 26.

[6] The Royal College's library of books and specimens grew out of the personal collection of William Harvey (1578–1657), a friend and patron of Merret's. See Foley, 191; Mauck, 27.

[7] Neri-Merret, 205–352. Merret's comments on Neri's text (hereafter "Observations") are structured as textual references followed by anecdotal musings, suggested corrections, or new experimental findings. Also appended to the text is a report Sir Robert Moray (1608–73) delivered to the society in August 1661 upon receipt of Prince Rupert's glass drops, which Charles II had given the fellows to investigate. On Merret's role as commentator, see W. E. S. Turner, 1962. For the "Observations" as a learned format belonging to the epistemic genre of the medical *observationes*, see Dupré, 2017, 179.

[8] In the case of Merret's natural history, the *Pinax Rerum Naturalium Britannicarum* (1666), Albert Koinm has convincingly shown how the physician similarly relied on a store of domestic *naturalia*—flora, fauna, and fossils—to a greater extent than he did the authority of foreign texts or ancient sources like Pliny: Merret, 1666; Koinm, 24–27. Merret hired a former soldier in Cromwell's army, Thomas Willisell, as a field collector for this later project. For the preparation of the *Pinax*, estimated to have begun in 1660–61 and therefore concurrent with *The art of glass*, see Foley, 192–94.

[9] RS, JBO/1/99.

[10] On 3 October 1662, five days prior to depositing his translation at the Royal Society, Merret had taken John Evelyn (1620–1706) on a tour of the Royal College library and its "divers natural curiosities": Bray, 1:363.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

the call for an exhibition of his sources. Just two meetings later, on November 5, he "shewd the Society his Materia Vitraria: for which he received their thanks, being desired, to leave a part of each of the materials with the Society."[11]

Merret's collection of vitreous matter is now lost or dispersed.[12] This article sheds new light on its contents. Drawing from institutional records, personal correspondence, extant catalogues, and *The art of glass* itself, I recover a partial inventory of materials relevant to glassmaking that passed into Merret's hands and would in turn draw the scrutiny of his peers and later readers at the Royal Society. I show how these objects—raw ingredients, waste products, vessel fragments, archaeological finds—extended Merret's "Observations" on Neri's text. They participated first as corroborating illustration, then as material refutation, in what Sven Dupré calls the palimpsestic "codification of error" endemic to the translation of artisanal knowledge.[13]

Merret's object appendix manifests the "ekphrastic failure" of an otherwise ungraspable textual project.[14] The English physician found Neri's written descriptions of glass and its making insufficient to delineate what he knew—based on firsthand observation and the testimonies of craftsmen[15]—to be a visual and manual art, to say nothing of an aural and gustatory one.[16] Graphic representation proved similarly inadequate. *The art of glass* lacks figures

[11] RS, JBO/1/103. For "showing and telling" at the Royal Society, see Iliffe, 310–12. For a review of recent literature on how knowledge acquisition was mediated through objects, textual technologies, and collective practice, see Dietz and Dupré, esp. 114.

[12] No references to Merret's collection per se occur in the catalogues of the British Museum, where the society's repository moved in 1781. The Harveian once included a cache of minerals and metal samples, but much of the collection perished in the Great Fire of September 1666, and Heritage Centre staff at the Royal College confirmed in 2012 that no such items remain on site. Merret was blamed for what fire damage the Harveian sustained: Foley, 191–92; Mauck, 32.

[13] Dupré, 2017.

[14] I borrow this idea from classical rhetoric and mean by it the inability of the descriptive mode to conjure, or serve as surrogate for, a work of art. See Belting, 261–67.

[15] Typical is Merret's citation of an experiment "once shewed me by my neighbour a Refiner," a confidant whom he refers to as "the Copper-smith": Neri-Merret, 294. For Merret's interest in metallurgy, see Koinm, 27–28; Merrit [Merret], 1677.

[16] Sven Dupré arrives at a similar conclusion in regards to Johannes Kunckel's 1679 German translation of Neri, but Kunckel—and by extension Dupré—foregrounds sight in discussing the expert visual judgment (*Augenmaß*) required of glassmakers: Dupré, 2017, 184, 186. By bringing the *materia vitraria* to life as tangible, aural, and at times even tastable objects, my account of Merret's book rather highlights the contribution other senses made to an understanding of glass and its making. For sound as a property of glass, see Neri-Merret, 216, points 23 and 26; for "tast," the tongue, or teeth, see 2, 211, 279, 280–81.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

save for a single woodcut of a glass drop (fig. 1), an image that doubly illustrates the defiance of vitreousness in yielding to the black-and-white linear grammar of the print medium.[17] Not even diagrams of furnaces or scenes of laboring craftsmen punctuate the text as they do Giorgio Agricola's *De Re Metallica* (On the nature of metals, 1556), one source for Merret's commentary.[18] Only the *materia vitraria*, the things of the trade themselves, had eloquence enough to render glass and its making present before readers at the society.

Merret's collection contributes an instructive case study to a growing body of scholarship that demonstrates the limitations of early modern texts in conveying material properties and craft processes.[19] To this end, historians have increasingly construed reading as an embodied practice extending well beyond the page.[20] For Merret, the process of translating *L'arte vetraria* involved not just comprehending Neri's Italian and rendering it into English as best he could,[21] but also gathering objects, information, and vocabulary from artisans across London.[22] Such an assemblage of matter and practical knowledge allowed him, as Lorraine Daston puts it, to "re-experience the process of writing the work."[23] Merret in a sense re-staged the interactions with Venetian glassmakers that had informed Neri's work at the Medici court fifty years prior—even if the English physician did not always find it necessary to extend his reenactment to

[17] The image depicts one of Prince Rupert's explosive drops, subject of Moray's appended 1661 report. It falls outside either the main text of Neri's recipes or Merret's observations: Neri-Merret, 354.

[18] Chapter 12 of *De Re Metallica* in part concerns glassmaking, largely drawn from Pliny. Compare also the illustrations added to Neri, 1668; and Kunckel, which are not of glass material itself but rather of furnaces, tools, and labor. W. E. S. Turner, 1962, 211–13 (figs. 3–6).

[19] This work cuts across histories of medicine, science, art, and the book. One prominent research initiative is the Making and Knowing Project, whose recipe-testing fills the silences of a written record by recovering ephemeral, intermediary steps of craft processes that escaped linguisitic codification. On the limitations of glass recipes in particular, see Dupré, 2017.

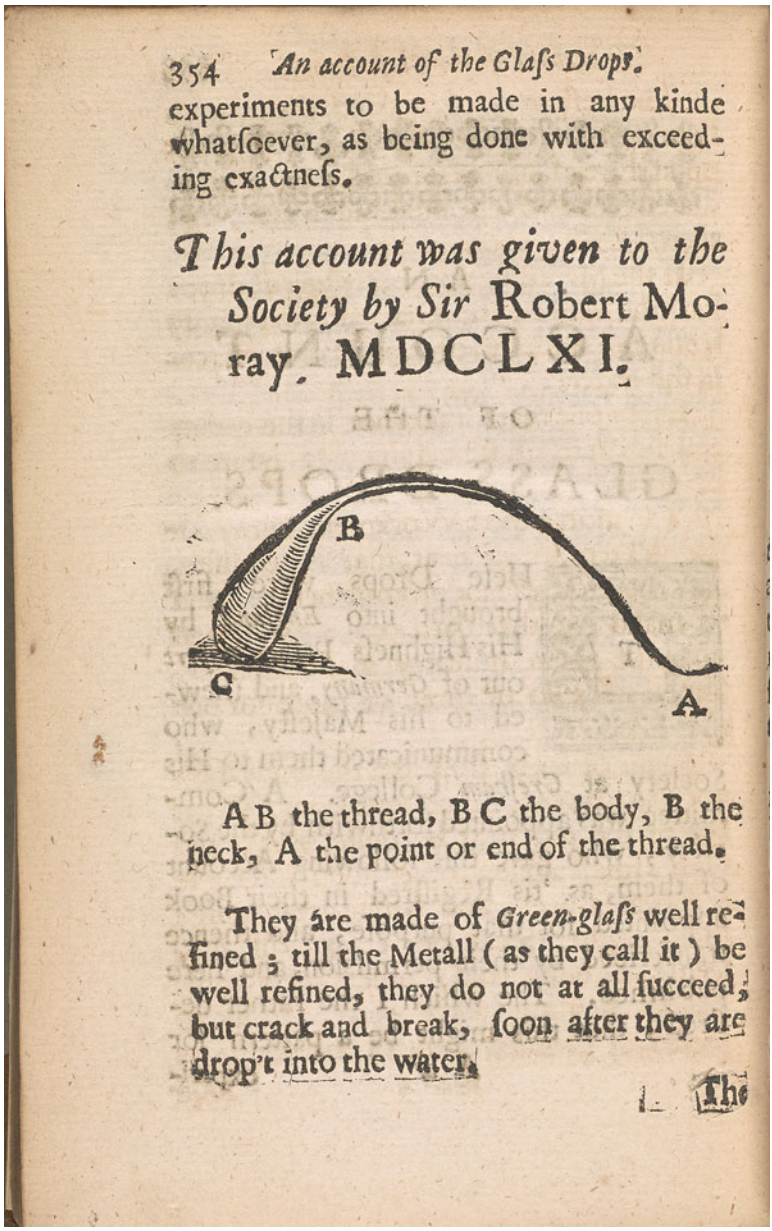
[20] Blair; Blair and Yeo; Daston; Smith, 2010; Neven. For an overview of the recent literature, see Leong.

[21] On Merret as translator, including his errors, see W. E. S. Turner, 1962, 208–09. For a general introduction to translation and its practice in the history of science, with further bibliography, see Dupré, 2018. For a comparison of the multilingualism of Kunckel and Merret's respective efforts, and the epistemic significance of untranslated terms in the former, see Dupré, 2017, 181–82.

[22] Merret often includes parenthetical asides in his commentary to indicate terms drawn from a workman's vernacular, referring to calcified *Lapis calaminaris* as "Calamie (as the workmen call it)" and to deteriorated *Calcarii* stones as "weary," "as they [brass-makers] call it": Neri-Merret, 294, 303. He includes similar asides in his report on refining: Merrit [Merret], 1677, 1050.

[23] Daston, 447.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press


354 *An account of the Glaſs Drops.*
experiments to be made in any kinde whatſoever, as being done with exceeding exactneſs.

*This account was given to the Society by Sir* Robert Moray. MDCLXI.



A B the thread, B C the body, B the neck, A the point or end of the thread.

They are made of *Green-glaſs* well refined; till the Metall (as they call it) be well refined, they do not at all ſucceed, but crack and break, ſoon after they are drop't into the water.

The

Figure 1. Antonio Neri. *The art of glass*. Trans. Christopher Merret. London, 1662, page 354. Beinecke Rare Book and Manuscript Library, Yale University.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

testing the recipes Neri himself recorded.[24] Fellows at the Royal Society in turn required that a close reading of the translated text involve their equally close proximity to the source material on which the author drew: truly grasping the contents of *The art of glass* would entail handling Merret's collection.[25]

Elusive as the *materia vitraria* remain, recent scholarship on *The art of glass* has centered not on this lacuna in today's archive but rather on what Merret himself lacked access to in the seventeenth century: malleable glass, a "storied object" of ancient legend debated among antiquaries, chymists, physicians, and natural philosophers.[26] In an account of malleable glass as both prestigious *deperdita* (lost objects) and subject of reconstruction in the Royal Society's circle, Vera Keller draws particular attention to Merret's doubt about the existence of such a ductile material.[27] The present article complements Keller's work at conjuring absence. And while I focus on early modern *materia* instead of ancient *deperdita*, my study is no less engaged with the Roman world, albeit its northern reaches. I show how the fellows' pursuit of late classical archaeology fed into and came to be informed by their shared familiarity with Merret's text. The circulation among virtuosi of Roman shards excavated in Restoration England speaks to the role that an antiquity at once tangible and local played in the late seventeenth-century study of glass at the society.

Yet the fellows' initial interest in *L'arte vetraria* stemmed not from their regard for ancient wares or even, for that matter, from their engagement with the alchemical tradition in which scholars tend to locate both Neri's recipes and Merret's commentary.[28] A larger aim of this article is to reassess the place of the 1662 translation within the society's history of trades program, a Baconian initiative Merret went on to chair from 1664.[29] As I demonstrate, those virtuosi in Merret's London circle who encouraged his efforts sought to develop English glass manufacture by finding cheaper, local sources for foreign ingredients listed in Neri. I argue that the *materia vitraria* reified their shared concern with the development of domestic industry.

*The art of glass* has been held up as an exceptional success[30] within the context of the fellows' otherwise failed attempts to document contemporary trades.[31]

[24] For recent attempts to follow recipes in Kunckel, see Hagendijk et al., 323–45.

[25] For early modern note-taking as part of a larger phenomenon of collecting that included the accumulation of natural and artificial objects, see Blair, 310; Leong, 53.

[26] V. Keller.

[27] V. Keller, 618–20.

[28] Beretta, 2017; V. Keller, 615; Smith, 1994 and 2004; Dupré, 2014a, 2014b, and 2017.

[29] Ochs, 1981 and 1985.

[30] Hall, 1983, 27; Ochs, 1981, 146; Ochs, 1985, 135.

[31] Ochs, 1981; Hanson, 75–80; Houghton; Hunter, 1981, 87–112.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

Along with Walter Charleton's *Mysterie of the vintners* (1667), it was one of only two monographic histories to result from the program.[32] Kathleen Ochs argues that the singularity of these works can be attributed to the individual efforts of their authors (Merret's "skill and perseverance"[33]) and not, rather, to what she calls the "auxiliary programmes" that supported the larger project, such as the endeavor to organize the society's repository.[34] Ochs goes so far as to claim, "Collective experiments and collection of natural histories . . . contributed little because, although the history of trades programme was designed to be a cooperative project, little corporate work was completed."[35]

As the exhibition and acquisition of *materia vitraria* make clear, however, not just translating, but also reading and revising *The art of glass*, were remarkably collective enterprises. Merret relied on cooperative endeavor—namely, note-taking in the "field"[36]—as much as the readers of his text who depended on the consultation of samples as a group for their understanding and improvement of it. International networks were also a vital source of information on the glass trade, dispatching materials relevant to glassmaking that enacted a physical *translatio*, or movement of knowledge, from one place to another.[37] The institutional records and personal letters I cite below attest to the myriad glass shards, waste products, and raw ingredients that reached England from the Continent, often serving as points of comparison for local industry. Here, as elsewhere in the early modern period, the *respublica litteraria* functioned both as a network of correspondence per se and as a system of connected channels through which objects passed, on loan or as gifts, for the purpose of collective scrutiny.[38]

What emerges from the present article, then, is a picture of collaboration and crowd-sourcing at the early Royal Society not unlike that which Deborah Harkness captures in her lively account of experts, practitioners, and go-betweens doing "Big Science" in Elizabethan London.[39] But glassmaking had come a long way since the days when William Cecil (1520–98) visited furnaces

[32] Ochs, 1985, 135.
[33] Ochs, 1981, 146.
[34] Ochs, 1985, 134.
[35] Ochs, 1985, 135.
[36] Leong, 93–94.
[37] For this definition of translation, see Dupré, 2018, 303.
[38] Grafton. On samples in letters, see the numerous examples in Browne, 1946, especially in correspondence from the 1660s.
[39] Harkness, esp. 15–56, 142–80.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

outside Aldgate or Cripplegate.[40] Before turning to Merret and his milieu, I will briefly summarize the seventeenth-century development of the industry, the better to locate *The art of glass* in its wider economic landscape.

## GLASS IN SEVENTEENTH-CENTURY ENGLAND

Scholars generally split the history of seventeenth-century English glassmaking into two distinct chapters.[41] The first chronicles the shift, beginning in the 1610s, from wood-fueled to coal-fired furnaces.[42] What followed was the rise of a patent-protected monopoly, centered in London and Newcastle, that saw naval administrator-turned-entrepreneur Sir Robert Mansell (1570/71–1652) exploit the technical expertise of migrant workers—many of them transplants from France, the Low Countries, and Northern Italy[43]—in pursuit of quality crystal glass.[44]

As the winds of conflict began to sweep through the British Isles, Mansell lost what control he exerted over the sector. In 1640, Scotland's victory in

[40] Harkness, 160. Merret's published observations on glasshouses are thought to relate mainly to time he spent at a single glass factory in London, Goodman's Yard at the Minories, which was run by the Racket brothers from Altare, Italy. Goodman's Yard was located within the route of what is now Prescott Street, and operations at the site appear to have survived the Great Fire in 1666. Sir Bevis Thelwell (1641–51) and next Robert Batson and Edmund Lewin (1651–ca.1676) acted as early proprietors, with green-glass bottles as the primary product from 1651 until at least 1691: Sue and Colin Brain, email message to the author, 22 February 2012. See also Brain, 112. Thomas Birch (1705–66), historian of the Royal Society, cites glasshouses at Woolwich, Rosemary Lane, and Radcliffe as well as the Minories as sources for the equipment fellows used to conduct experiments and demonstrations in the institution's early days. The glasshouse at Woolwich was active in the range of 1624–1701, while the works at Rosemary Lane—between modern Ensign Street and Dock Street—almost certainly postdate *The art of glass*, with documentation from 1677–78 onward. The works at Cock Lane, Ratcliff (the specific location of which remains unknown) were also a later addition to the capital's industrial map, active from 1680 until 1800. Birch, vol. 1; W. E. S. Turner, 1962, 207; Tyler and Willmott, 12–13; Charleston, 123.

[41] Charleston; Powell; Willmott, 2002 and 2005.

[42] For the end of glassmaking in the Weald see Clark, 79–84. For the late medieval Wealden industry, see Kenyon.

[43] Charleston; Godfrey; Willmott, 2005, 71–107; J. Turnbull, 58–61. Such practitioners had been arriving in England in large numbers since the late sixteenth century. For foreign workmen in "Big Science" projects and the glass industry, see Harkness, 144, 157.

[44] The Italian workmen at Mansell's London furnaces manufactured glass *à la façon-de-Venise*, a practice introduced to England by Jean Carré, a Flemish merchant, in 1567. These glasshouses were attempting to reproduce Venetian crystal glass, known as *cristallo*, without access to the secret recipe. Janssens et al., 539–40, 544; Douglas and Frank, 7, 14–15.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

the Bishops' Wars rattled production at his Newcastle glassworks; the skirmish at Newburn also cut off a vital coal supply to his London furnaces.[45] Two years later, in June 1642, Parliament finally stripped him of his almost thirty-year monopoly.[46] Despite these setbacks, Mansell continued to operate Tyneside for at least a decade longer.[47] It is thus his death, rather than the cessation of his monopoly as such, that some scholars view as having precipitated a renewal of interest in the English glass trade—a zeal arguably reflected in the society's eagerness for a translation of Neri.[48]

Yet histories of the trade all but skip over the Interregnum, instead picking up after the Civil War with the resumption of patent grants at the later Stuart court; the consolidation of plate and vessel production under George Villiers, second Duke of Buckingham (1628–87); the charter of the Company of Glass Sellers in 1664; and the increased protectionism for which this body lobbied to stave off competition from Venice.[49] The denouement comes in 1674 or thereabouts when English furnaces, again reliant on foreign workers, succeed in manufacturing colorless lead crystal (called "flint glass")—a process patented, and later tweaked, by the London merchant George Ravenscroft (1632–83).[50]

Did Merret's text provide the impetus for Ravenscroft's venture?[51] Considering the state of the trade in 1662, Merret famously remarked, "glass of lead, 'tis a thing unpractised in our furnaces";[52] by 1670, Ravenscroft's workmen were experimenting with recipes for "crystalline glass resembling rock-crystal."[53] Ravenscroft himself was no craftsmen, surely not the chymist-inventor scholars once assumed him to be, so the fact that he could access Neri's recipes in the vernacular likely mattered little to batch production at his furnaces. He was, however, a canny and persistent entrepreneur who, if he read Merret's commentary, must have sensed a

[45] Thrush.

[46] Thrush; Godfrey, 126–38; Willmott, 2005, 107.

[47] Thrush; Willmott, 2005, 108.

[48] For the climate of renewed interest, see Hartshorne, 203.

[49] MacLeod, 1988, 24–27; Willmott, 2002, 11; Willmott, 2005, 109–11.

[50] For a reconstruction of the gradual development of lead glass and the role of other actors such as Johan van Barmont Baptista da Costa, Jean Guillaume Reinier, and John Odacio Formica, all formerly of Nijmegen, the Netherlands, see MacLeod, 1987; Moody; Francis, 49–50; Dungworth and Brain, 2009, 111–12; Willmott, 2005, 117–20. As Noble has recently argued, Ravenscroft's original recipe used flints, not lead, with lead added later as a corrective: Noble, 194.

[51] This is a cliché in the literature. See W. E. S. Turner, 1962, 213; G. Turner, 403.

[52] Neri-Merret, 315–16.

[53] Great British Patent 176, 16 May 1674, as quoted in MacLeod, 1987, 777; G. Turner, 403. For the rapid implementation of changes in lead-glass production in the 1670s and 1680s, such as to prevent crizzling (corrosion), see Dungworth and Brain, 2013, 574–75.

business opportunity.[54] And indeed, Ravenscroft's purported invention—a long-sought-after domestic rival to Venetian *cristallo* (transparent glass that resembled rock crystal)—revitalized the London industry.[55]

The bifurcated history of seventeenth-century glass I have just outlined reduces the late 1640s and 1650s—the period of Merret and his circle's initial interest in the substance—to a mere postscript or prelude. To the extent that scholars of glass treat the Commonwealth era, they dismiss it as a time of contraction in domestic production.[56] Eleanor Smith Godfrey does suggest that the quality of English crystal glass, if not its quantity, improved during the Interregnum.[57] Her account of the industry stops short of the Civil War, however. Of Merret, she notes in passing, "Though [he] wrote the commentary in 1662, his knowledge of glassmaking methods went back at least to the 1640s when he was associated with experimentation at Gresham College."[58]

Picking up where Godfrey leaves off, I reconstruct a backstory to Merret's text that fills a gap in the broader literature on the development of English glass. By engaging with documentary sources from outside the industry rather than with the patents or rate books to which economic historians usually turn, I approach glass as it was experienced in the hands of those men—whether virtuosi, physicians, craftsmen, or natural philosophers—who bartered, gifted, created, and studied it. Complementing the well-told tales of Mansell's monopoly, Buckingham's privilege, and Ravenscroft's patent, my account of Merret's translation project, and of the subsequent collection of *materia vitraria* in the milieu of the early Royal Society, offers a microhistory of glass as both industrial commodity and tangible curiosity in early modern London.

[54] Francis, 49–50; Dungworth and Brain, 2009, 111–12; Hartshorne, 216. The recipe was not included in the patent; the workmen Ravenscroft employed likely prototyped the substance at furnaces in Northern Italy or Nijmegen before they immigrated to England, so they may have referenced later versions of Neri's Italian text or the Latin translation published in Amsterdam: Neri, 1668.

[55] English production of vessels, bottles, plate, and mirror glass had, per the archaeological record, been relatively low in the 1660s and early 1670s: Willmott, 2005, 114, 124.

[56] Evidence cited for this includes the import figures of rate books, the admittedly scant archaeological record, and the virtual cessation of patents: Charleston; Godfrey; Clark, 72–84; Willmott, 2002, 11; Willmott, 2005, 108–09. On Interregnum patents, see MacLeod, 1988, 16. For the concurrent mid-century stagnation of French and Venetian manufacturing, as compared to the flourishing of centers in the Low Countries and Central Europe, see Godfrey, 134. For the notion that the Commonwealth era saw a decrease in alcohol consumption and that there was very little local production of drinking glasses at this time, see Willmott, 2005, 110.

[57] Godfrey, 249.

[58] Godfrey, 250.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

## GLASS AND THE HARTLIB CIRCLE

Neri opens his 1612 treatise with a dedication to his patron, "the most Illustrious and Excellent Lord Don Antonio Medici."[59] Though Merret chose to include this citation in his translation, he follows it with an address to a contemporary, "the Honourable, and true Promoter of all solid Learning, Robert Boyle, Esq."[60] Merret credits Boyle (1627–91) as "the principal cause that this Book is made publick, by proposing and urging my undertaking of it, till it came to a command from that most Noble Society . . . meeting at Gresham College, whose desire I neither could nor ought to decline."[61] No documents survive detailing the proposal, but Boyle is thought to have encouraged Merret to begin work prior to the society's founding in 1660.[62] He was not the only one. Another figure in Merret's London milieu, Samuel Hartlib (ca. 1600–62), comes across on paper as an even stronger advocate for the project than Boyle.[63] Hartlib suffered a stroke in late 1660 and did not live to see *The art of glass* through to publication.[64] He did, however, have opportunity to make Merret's acquaintance, a meeting he records in his extant notebooks, the *Ephemerides*.[65] It is to Hartlib's interest in the manufacture of glass—a curiosity shared by many in his circle—that I will now turn.

### Mechanica *in the "Ephemerides"*

During the Interregnum, Hartlib, along with Boyle and John Evelyn (1620–1706), championed a Baconian history of trades program.[66] Hartlib couched his support for the project in Protestant notions of reform and the improvement of mankind.[67] He was more concerned with the practical, immediate outcomes of disseminating knowledge through written histories than he was with the theoretical underpinnings of technological innovation, an objective more in line with Boyle's philosophical tendencies.[68] In 1650, Hartlib in his notebook singles out Merret, listed as "Dr Merrick," for his involvement in the enterprise:

[59] On the audience for the text, see Beretta, 2017, 1059.

[60] Neri-Merret, unpaginated preface.

[61] Neri-Merret, unpaginated preface.

[62] Godfrey, 249–50; W. E. S. Turner, 1962, 207; Turner, 1963.

[63] For the connection between Merret, Hartlib, and *The art of glass* see G. H. Turnbull, 108, 123, 128.

[64] For Hartlib, see Greengrass; Webster.

[65] Hartlib.

[66] Hanson, 76–77; Hall, 1983, 23–26.

[67] Greengrass; Webster.

[68] The concurrent correspondence of Henry Oldenburg with Boyle and Hartlib reveals the diverging attitudes of the two men toward the history of trades projects: Hall, 1983, 23–26.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

"There is a Company or Society Dr Whustler Dr Merrick / That have p*ro*mised to make a Club for the perfecting of Mechanical Arts and to meete and correspond w*i*th Mr Worsl*ey* about it."[69]

A year earlier, Hartlib had identified Merret as having Neri's work in his possession. Observing that "they are yet very defective of making Glasse in Engl*and*," he notes, "There is an excellent little Tr*eatise* in Ital*ian wh*ich Dr Merrick as I take it is said to have De Arte Vitraria w*hi*ch if it were translated would bee a booke only of 3. or 6. d. price."[70] Hartlib evidently wanted to flag *L'arte vetraria* as potentially contributive to the trades project: in the tabular index for the entry, he jots down "Trades" alongside "Glasses" and "Libri select*i*." He uses the first of these marginal pointers ("Trades") alongside "Mechanica" throughout his notebooks whenever he categorizes information relevant to what Bacon called the "diverse Mechanicall Arts."[71]

Seven years later, in May 1656, Hartlib returned to the "Art of glasse making" in the *Ephemerides*. Recording a copy of Neri's treatise now in Boyle's custody, he insists once more on the necessity of a translation: "Mr Boyle hath a very rare Booke in Italian . . . De Arte Vitraria w*hi*ch should be Englished or Epitomized."[72] Hartlib's appeal to the vernacular here is consistent with his pragmatic vision for the trades project as a whole. The implied audience of non-Latinate readers also stands in contrast to the more learned market to which the Dutch publisher and bookseller Andreas Frisius (1630–75) later sought to cater with his own Latin translation of Neri-Merret, published in Amsterdam in 1668.[73]

As Hartlib's notes indicate, the first Italian edition of *L'arte vetraria* was rendered doubly inaccessible to London virtuosi by the small number of copies circulating in England. Not long after its printing in 1612, the treatise fell "into oblivion" in Italy and by extension the rest of Europe.[74] Merret himself counts the rarity of the book as a motivating factor for his translation, even more so

[69] Hartlib, 1650, part 4 (28/1/77A). Dates in citations to Hartlib refer to editions of the *Ephemerides*, though my transcriptions are drawn from the online edition cited in the bibliography. Any italics in quotations indicate where text has been de-abbreviated for readability. W. E. S. Turner does not cite this or the following reference. For Merret's involvement with virtuosi societies such as the so-called 1645 Group, Invisible College, and Comenians, see Mauck, 27–28.

[70] Hartlib, 1649, part 3 (28/1/37A).

[71] Bacon, 38.

[72] Hartlib, 1656, part 1 (29/5/70B).

[73] Neri, 1668. For the translation, see W. E. S. Turner, 1962, 211–12; Maclean, 309, 323, 331. Frisius (Fries) later declined to translate Benvenuto Cellini's *Due trattati* (1568) into Latin on account of the difficulty he experienced rendering Neri's terms of art: Maclean, 345.

[74] Mentasti, lix.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

than its language.[75] In his dedicatory remarks, he claims to have "satisfied [Boyle's] vast desire of communicating knowledge to others, who though intelligent of the Language could not procure Copies in the Original."[76]

The mid-century scarcity of copies can be attributed to the fact that no further edition was prepared in Italian until the Florentine printer Marco Rabbuiati reissued Neri's text in 1661, "corrected and expurgated of various mistakes."[77] A Venetian edition followed in 1663, with a second printing in 1678, by which point Merret's augmented English version was already in wide circulation.[78] The recipe palimpsest received a further translation into German at the hands of chymist Johann Kunckel von Löwenstern (1630–1703), who, having compared the Latin and Italian editions, added some improvements of his own, which he published in 1679.[79]

## *"Learn't in the Glasse-house"*

Hartlib's notebooks help elucidate the demand-side impetus for Merret's translation. If one looks beyond Hartlib's citations of *The art of glass* in particular and to his documented interest in glass and glassmaking in general, a fuller picture emerges of a voracious Interregnum virtuoso culture where samples, raw ingredients, waste products, and artisanal knowledge were both highly sought after and collectively gathered.[80] Against this background, Merret's work can be

[75] While no documents survive indicating whether or when Merret traveled to Europe, he may have spent some of his medical training in Italy, for example at the University of Padua, where Harvey is known to have studied: W. E. S. Turner, 1962, 208. In Merret's later book aimed at reforming the medical profession, *The accomplisht physician, the honest apothecary, and the skilful chyrugeon* (London, 1670), he recommends that would-be physicians conduct a grand tour with stops at Rome, Naples, Liverno, Lucca, and Milan, which could indicate his own familiarity with these cities. For the proposed itinerary, see Mauck, 43–44. If his medical education did include an Italian sojourn, Merret may have acquired his copy of Neri while abroad.

[76] Neri-Merret, unpaginated preface.

[77] Neri-Merret, unpaginated preface; Zecchin; Dupré, 2017, 182.

[78] Mentasti, lix.

[79] Kunckel, 1679. Mentasti, lxi; Stein; Harley, 36, 55–56. For the multilingual context for Kunckel's work and his decision to leave artisanal terms untranslated, see Dupré, 2017, 180–86. Kunckel would lead his reader to believe that he tried all of the recipes himself, commenting and improving upon the findings of his predecessor as he went. Among his notes is a repudiation of Merret's claim regarding the composition of zaffer, a contention that must have stemmed from his haptic knowledge of the material, which was then conveniently being mined in Saxony. Kunckel, 1689, 46–47; Harley, 55, 220n71. At the same time, scholars have recently learned from experiment that Kunckel, like Merret, neglected to try many of the Italian recipes. Hagendijk et al.

[80] As above, compare to the Elizabethan climate of cooperative investigation in London documented in Harkness, 142–80.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

viewed as one contribution to an ongoing, proto-institutional endeavor to understand the material properties of glass at a time when newly developing relationships between craftsmen and virtuosi led to the gradual revelation of what had previously been regarded—and withheld under the dictates of patent or privilege—as workshop secrets.[81]

As is well known, Hartlib's *Ephemerides* are rich with evidence of the mid-seventeenth-century exchange in craft knowledge.[82] Hartlib's interests in artisanal trades were wide ranging, and his preoccupation with glassmaking complemented a related curiosity about optics and the advancement of optical devices, much of which hinged on the quality of the glass (or its surrogates, mica and rock crystal) employed in instrumentation.[83] In 1659, he wrote to Boyle to request "some piece of glass, good and fine" in the hope that he might use it to barter with the French mechanician Étienne de Villebressieu (1626–59) for a reciprocal fragment of the craftsman's as yet proprietary optical workmanship.[84] Hartlib's notebooks also reflect his solicitation of expertise from jewelers and painters regarding several additional topics covered in Neri, such as the composition of pigments and the translucence of gems.[85]

For information on glassmaking specifically, Hartlib relied on an enterprising foreigner with Continental connections, Johann Brün (or Unmussig) (fl. 1648–68).[86] From the late sixteenth century onward, English glasshouses had seen an influx of workmen from France and the Low Countries. Hartlib singles out Brün—also a

[81] The literature on this transition is burgeoning. See in particular Eamon; Kavey; Smith, 2004; Dupré, 2017. For the role of Neri's 1612 book in making public recipes previously held in books of secrets, see Beretta, 2017. This is not to imply that information given out by craftsmen was always accurate or that those who shared it were above duplicity. For a case of Boyle's likely being misled by colormen, see Mactaggart and Mactaggart, 41. For Robert Hooke and Robert Plot's descriptions of ingredients employed in Ravenscroft's early trials with lead glass, and the disparity between these accounts and analytical testing of the extant archaeological record, see Dungworth and Brain, 2009, 111–12, 131. For Kunckel's withholding of the purported secret of gold ruby glass in his 1679 translation as a means of promotion, see Dupré, 2017, 175.

[82] For the Hartlib papers and artisanal practices, see Wilkinson. See also the discussion of Glauber and Hartlib in Smith, 2004, 173, 293n48, 294nn63–64, 297nn1–2; Young.

[83] On optics and glass in the early Royal Society, see Schaffer; G. Turner. For scientific equipment shipped in and out of London until 1640 see Godfrey, 244–50.

[84] Boyle, 4:135; Godfrey, 248–49. For de Villebressieu (or Bressieux) and other Frenchmen in the Hartlib circle and correspondence, see G. Turner, 144n5. Hartlib's close relationship with artisans and his attempts to extract trade secrets by exploiting connections to industry abroad is further evidenced in a record of a visit he received from a "vniversal Artist," the Flemand "Bernard Wasselin": Hartlib, 1653, part 1 (28/2/53B).

[85] Hartlib, 1648, part 2 (31/22/14A-20B).

[86] Hartlib, 1650, part 4 (28/1/77A).

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

confidant of Boyle—for his network. He cites his friend's knowledge as having been "learn't in the Glasse-house in Lond*on*" and goes on to recount how "The men in the Glass-house told Mr Unmus*sig* of a Glasse."[87] Among the contributions from Brün that Hartlib files away is a description of "Solda / in Ital*ian* et Latin," an "herbe brought out of Spaine being made or burn't into powder . . . the chiefe ingredient that makes glasse so cleere <and fine>. The Venetians keepe the best matter to thems*elves* and send the worst abroad."[88] Hartlib categorizes this information under the headings "Mech*anica*" and "Glasse making," the same designations he later uses in reference to Neri's treatise.[89]

Is this a first clue to an entry in Merret's *materia vitraria*? Hartlib's note refers to *Salsola soda* (glasswort or opposite-leaved saltwort) (fig. 2), a halophytic marine plant native to the Iberian Peninsula and wider Mediterranean basin that, when burned, yields an alkaline residue known as barilla.[90] The Venetians had begun importing burnt *Salsola soda* from Spain in the sixteenth century, thereafter controlling its trade. As Brün's confidants well knew, glassmakers in Murano were forbidden from exporting the plant's ashes to Northern European centers like Antwerp or London, cities where immigrant workers—many of them native to the Lagoon—had introduced sodic glassmaking (*façon-de-Venise*) to an industry otherwise dependent on wood-ash.[91]

[87] Hartlib, 1648, part 3 (31/22/39B); Hartlib, 1650, part 4 (28/1/77B).

[88] Hartlib, 1648, part 3 (31/22/39B). The production of glass requires fusing silica, a vitrifying agent, with an alkali flux, thereby lowering its melting point; in the case of English coal-powered furnaces of the seventeenth century, the silica was generally sourced from sand or quartz pebbles and the flux was either potash (potassium carbonate) or soda (sodium carbonate), both of which could be obtained by burning halophytic (salt-tolerant) plants. Lime added to or already present in the silica and alkali mix hardened the glass; another addition was cullet (broken glass), which further lowered the melting point of silica. The seventeenth-century glass I refer to below is either potash-lime-silica glass or soda-lime-silica, whose components are silica (usually about 60–75 percent), alkali ash (roughly 12–18 percent), and lime (5–12 percent). Even if the chemical composition of the ash was not yet understood in the early modern period, workers did appreciate the potential for variation based on provenance, season, climate, etc. For good summaries of the components of glass manufacture, see Chemistry of Glass, https://www.cmog.org/article/chemistry-glass; Velde, with further bibliography; Smedley et al., 147–50; and in the British Isles especially, J. Turnbull, 7–8; Clark, 162–87.

[89] Hartlib, 1648, part 3 (31/22/39B).

[90] Verità, 524; Hammer et al.

[91] Before they had access to Spanish halophytes, Northern Italian glassworkers relied for alkali salts on other marine plants, like *Salicornia herbacea*, sourced from the Levant. Even when *Salsola soda* became available from Spain, Muranese workshops continued to use sodic residues (*Alume catino*) leached from Eastern Mediterranean plants to flux batches for wares less expensive than *cristallo*. Ashes with an Egyptian or Syrian provenance were held to be of inferior quality to Spanish equivalents. Velde, 75; Verità, 524, with further bibliography.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press


Figure 2. *Salsola soda* (family Chenopodiaceae) from Alicante, Spain. Herbario del Real Jardín Botánico, CSIC. MA 00373529. © RJB-CSIC.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press


Figure 3. Barilla, donor J. W. Cumming. Economic Botany Collection, Royal Botanic Gardens, Kew. Cat. no. 45959.

By the early seventeenth century, though, some quantity of Spanish ash had, like Neri's recipe book, made its way to England (fig. 3).[92] In 1620—three decades prior to Hartlib's note—the mercantile agent James Howell

[92] The Spanish barilla industry attracted renewed attention in England in the late nineteenth century. In 1884, Jasper W. Cumming sent a sample of "plant, seed, and ashes" from Alicante to the Royal Gardens, Kew. See cat. no. 45959 and cat. no. 45964, Economic Botany Collection, Kew. For the correspondence, see "Barilla," 58.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

(ca. 1594–1666) wrote home to London from Alicante describing his purchase there of a "commodity called barilla . . . for making of crystal glass," a parcel of which he acquired from a Genoese merchant to "send . . . to Sir Robert Mansell."[93] Howell in his letter records that "the Venetians have it hence," and he proceeds to devote several sentences to the growth pattern, flowering, drying, and pit burning of this "strange kind of vegetable."[94] Even with limited access to the finest barilla, though, Mansell's London furnaces failed to produce genuine Venetian crystal.[95] One must assume that whatever alkali salts the workmen extracted from the Valencian plant-ash did not match the purity of *sale de cristallo* (crystal salts) prepared in the Veneto.[96] The failure to translate the proprietary Muranese purification process to London furnaces would have made Neri's treatise all the more valuable on the English market. *L'arte vetraria* opens by disclosing a "new and secret way" to pulverize and purify barilla, a process Merret renders as "the foundation of the Art of Glasswork."[97]

Did a sample of burnt "solda" make its way into Hartlib's hands as well as Howell's, and later into the society's collection? Judging by Merret's note-taking in the field, the variant sources of sodic ash used in the Venetian industry remained a point of confusion to at least some London workmen at mid-century. Commenting on book 1 of *L'arte vetraria*, Merret writes that "Rochetta"—the term Neri uses for the ashes of eastern Mediterranean halophytes, inferior to Spanish varieties—was a name "wholly unknown to our Glass-houses."[98]

## *The Search for Domestic Materials*

The shift in English glassmaking from wood-fired to coal-fueled furnaces spurred the quest for sodic ash that took Howell to Alicante. Previously, workers in need of potash could burn the same trees they relied on for fuel (e.g., beech or oak).[99] With the deforestation of the Weald and the introduction of the coal process, however, merchants and makers had to look beyond brushwood for their alkalis. One alternative source, kelp, grew on rocks in the northern reaches of the British Isles, where it also washed ashore. By 1621, the

[93] Howell, 63–64.

[94] Howell, 63–64.

[95] Janssens et al., 539–40, 544.

[96] Modern archaeometry confirms that *cristallo*'s purity was due more to the purification of barilla than it was to its provenance: Verità, 523–36; Janssens et al.

[97] Neri-Merret, 1–6; W. E. S. Turner, 1962, 205.

[98] Neri-Merret, 250.

[99] Paynter and Dungworth, 133–34.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

Scottish glassworker James Ord had moved to secure the exclusive rights to prepare its ashes in Scotland.[100]

Surveying the glass-ingredients trade from London three decades hence, Hartlib became increasingly interested in how the exploitation of yet more domestic resources could advance manufacture in England.[101] In a notebook entry from 1653, he touches upon the three main components of a glass batch: alkalis, sand, and cullet. He lists in turn, "Potashes / Co*lonel* Wurtz promised to write downe the whole mysterie of making of Potashes"; "Glittering Sand, Glasse / Greene or white glasse beaten smal into Powder gives an excellent glittering sand. Also by it something may bee gained, they selling ordinary sand for 2 d. a pound"; and "Glasse broken / Broken glasse remelted makes a more excellent kind of glasse then before."[102] These last two entries demonstrate Hartlib's familiarity with a raw-materials market that extended beyond the shipment of sodic halophytes from Spain or seaweed from Scotland.[103] His comments on pulverization and reheating suggest that he was especially attuned to the glass recycling economy.[104] Hartlib's tradesmanlike regard for cullet as a commodity may in turn have informed the tastes of those in his circle who came to valorize shards.[105] The fellows in receipt of Merret's *materia vitraria* learned to look upon broken glass, as well as potash and sand,[106] with a

[100] J. Turnbull, 9–10. For kelp also used to wrap glass for transport, see Neri-Merret, 264.

[101] In the sixteenth and seventeenth centuries, the Venetians forbade the use of potash, but by the eighteenth century, when trade in *Salicornia* fell off with the Levant, they, too, sought a domestic source for their sodic ash. Attempts were made—with little success—to cultivate barilla-yielding halophytes in the Lagoon: Verità, 524.

[102] Hartlib, 1653, part 4 (28/2/82B).

[103] For the earlier movement of sand to the Weald and the trade in sand to glassworks, see Clark, 162–67. Clark cites a 1629 map of a site in West Sussex that contains an inscription, "diging of sand and the sellinge thereof to ye glasses makers." For the trade in cullet, see Godfrey, 160; J. Turnbull, 10.

[104] When successful, the glass recycling economy, like any industrial recycling economy, would be largely invisible to outsiders, so Harlib's appreciation for broken glass as a commodity is noteworthy. Broken glass was valuable to the trade not only as a solvent, in which capacity it was incorporated into new batches to lower the melting temperature, but also, as Harlib's last comment implies, due to its higher purity relative to raw ingredients like sand or ash. D. Keller, 65; Freestone, 29–30.

[105] The only broken glass that seems to have been collected in the early seventeenth century for purposes other than remelting was that preserved as evidence of iconoclasm. For Nehemiah Wallington's collection of "peeces of broken glace" from the London church of St. Leonard Eastcheap in October 1641, see Aston, 121–22.

[106] Merret in his commentary channels Hartlib's attentiveness to the sourcing and pricing of sand, assuring his reader that moving quantities of granular matter from the Kent coast to "our Glass houses in London" would "cost but little besides their bringing by water" down the Thames Estuary: Neri-Merret, 261.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

covetousness equal to that which Continental princes extended to the *cristallo* vessels they housed in courtly cabinets.[107]

What Colonel Wurtz divulged the *Ephemerides* do not reveal. In 1654, though, Hartlib, still on the hunt for viable alkalis, came across a contemporary whose knowledge of potash derived from Poland, where glassworkers followed the recipes of metalworker Johann Rudolf Glauber (1604–70).[108] Two years later, an encounter with yet another foreigner familiar with Glauber's preparations led Hartlib to reiterate his faith that an ash capable of producing quality sodic vessels might yet be leached from English plants.[109] To Hartlib, "outglassing" the Venetian competition was—like the development of steelworking he references earlier in his notebooks—a matter of locating and extracting natural resources previously unexploited in the British Isles.[110]

## *"Some advantage to our Countrey-men"*

Merret appears to have imbibed Hartlib's nativist economic position. In the introduction to *The art of glass*, he hazards, "I doubt not but [the book] 'twill give some light and advantage to our Countrey-men of that profession [glass making], which was my principal aim."[111] Such a Hartlibian objective surely motivated the expansive approach he adopted to the translation of Neri's work: contributing to the growth of domestic industry meant not only publicizing Italian recipes but also lessening the reliance of English furnaces on imported ingredients, many of them of dubious quality.[112] Arriving at vernacular raw materials was, like translating an Italian term of art, far from straightforward.[113] Neri in the first book of his treatise lists various sources for alkaline ash, which Merret elaborates upon in an extended gloss. He cites the botanist

[107] For glass in cabinets of curiosity, see Dupré, 2010; Van Elk.

[108] "Mr Smart learn't several secrets practised in a Glasse-house in Poland, who had taken their hints from Glaub*er's* writi*n*gs. As of making of sp*iritus* salis in great quantity etc the making of porcelaine glasse out of wheate-ashes etc Of making malleable glasse, of w*hi*ch hee p*ro*mised to p*ro*cure vs the discovery. . . . Of making salpeeter etc etc.": Hartlib, 1654, part 3 (29/4/26A). Glauber was active in the German-speaking lands and resident in Amsterdam from 1641. For Glauber and the dissemination of knowledge on glassmaking throughout Central Europe, see Loibl; Smith, 2004, 26, 165–81, 234–35, with further bibliography.

[109] "We having more plenty of those Materials could easily out-glasse them": Hartlib, 1656 (20/5/95A).

[110] For steelworking and domestic resources, see Hartlib, 1650, part 4 (28/1/77A).

[111] Neri-Merret, unpaginated preface. A similar view is manifest in the *Pinax*. Merret, 1670, 26–30; Mauck, 44.

[112] Crossley.

[113] For Kunckel's attempts to adapt local materials, see Dupré, 2017, 184.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

William Turner (d. 1568) in remarking that the Kali plant (fig. 4)—*Salsosa kali*, whose finely ground sodic ashes Neri terms *polverine*—"hath no name in English, and though it be very plenteous in many places of England, yet I could never meet with any man that knew it."[114] He goes on to caution based on "an experiment made at the Glass-house" that while "our river Thames, and Sea-coasts, affords [two sorts of Kali] in great plenty . . . ours will not make ashes for Crystall, or any other sort of Glass." Merret concludes that the plant is as yet better sourced from the Levant, noting that its "saltish" ashes could be purified to yield a strong white alkali.[115]

Merret clearly sought out examples for his *materia vitraria* of both efficacious Mediterranean alkalis and their unsuccessful English alternatives. He makes explicit reference to having "seen" and "had by him" a sample "taken from their Polverine bags call'd *Kali spinosum* by the Herbarists."[116] Of the plants themselves, Merret goes on to observe that "our Kali when gathered appears to the tast very brackish and salt, and will being laid in moisture, contract it self into a small dimension."[117] Physical inspection of these plant samples and prepared salts would have made the distinctions drawn in the text between local and foreign varieties of Kali all the more vivid to Boyle and company. Merret's 1662 performance of his collection may well have included a taste test of any alkalis presented.[118] He evidently cultivated gustatory discernment as part of his research. Elsewhere in *The art of glass*, he shares with the reader that "in old windows of French glass . . . you may manifestly discern, nay, pick out pieces of salt, easily discovering their nature to the tast."[119]

Merret's observations on the paucity of English equivalents for foreign sources of sodic ash anticipate what was to become a tired refrain for the history of trades program. The fellows repeatedly found geographic conditions to be among those "diverse circumstances" that complicated their attempts to

[114] Neri-Merret, 252. See discussion of Merret's botanical knowledge and glass in Koinm, 28. Sir Thomas Browne (1605–46), in his *Pseudodoxia Epidemica*, describes the "original ingredients of glasses" as "fine Sand, and the ashes of Chali or Fearn": Browne, 1646, 39.

[115] Neri-Merret, 253; Koinm, 28. For the provenance of sodic ashes see discussion above.

[116] Neri-Merret, 253. This variety of Kali grows in the south of France, likely sourced from Provence or Languedoc.

[117] Neri-Merret, 253.

[118] For the display of natural-historical curiosities as performance, see Delbourgo, 37–39, 50.

[119] Neri-Merret, 211. For other invitations to the tongue, see Neri-Merret, 279–81. One is reminded of the conversation regarding elements, geology, and glassmaking that Michael Cole imagines to have transpired when King Francis I and his virtuosi guests served themselves salt from Benvenuto Cellini's enameled *Saltcellar* (1543): Cole, 42; for salt in the writing of Cellini, Bernard Palissy, and Vannoccio Biringuccio, see Cole, 34–36.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press


Figure 4. *Salsola kali* (family Chenopodiaceae) from Alexandria, Egypt. Smithsonian Institute. Cat. no. 805895.

improve native industry using overseas models or translated texts.[120] Undeterred, Merret looked to another English trade, the "Button-mold-

[120] Cipolla; Hunter, 1981, 104–05. Kunckel, in his own translation and commentary on Neri, would similarly draw attention to the sensitivity of glass manufacture to the variant sourcing and processing of ingredients. Hagendijk et al., 327.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

makers," for local knowledge that could be brought to bear when sourcing components for a glass batch. From these men he learned "how much . . . the seasons of the year difference Vegetables."[121] No wonder Merret went on to chair the trades project at the Royal Society. That he cites mold-makers in his commentary as readily as he does glassworkers or refiners accords with Aaron Mauck's claim that to Merret, "virtually any trade could lead to improvements in natural knowledge."[122]

Merret met with more success as a field collector in England when he looked beyond halophytes for a source of alkaline ash.[123] Of potash derived from firs and pines, he first identifies "Poland, and Russia, and New-England" as points of origin. He goes on to describe these and other wood-ashes as easily mixed up on the domestic market: "For Green-glasses in England, they buy all sorts of ashes confused one with another, of persons who go up and down the Countrey to most parts of England to buy them."[124] Surveying the options within the British Isles, he then contends that "the best and strongest of all English ashes, are made of the common way Thistle, though all thistles serve well to this purpose."[125] For other sources of alkali salts, he suggests "Leguminous plants," noting that "Lentils . . . lately sown plentifully in Oxford-shire" have "been found by experience good to this effect."[126] English oak, ash, and hawthorn trees are also listed as "communicating in their Salts" when burnt.

Merret sought to provide additional information on domestic natural resources useful in coloring glass. His comments on Neri's recipes for achieving tincture concern metals mined locally. Take, for example, manganese, which, as a monoxide (MnO), gives a pink or purplish tint; manganese dioxide ($MnO_2$), on the other hand, serves as a decolorizer, acting on the iron found in siliceous sand to yield practically colorless glass.[127] Though Neri insists on the Northern Italian region of Piedmont as the best source for manganese, Merret claims "some few years since, the industry of our nation hath found in our own countrey at Mendip-hills (famous for Lead) in Somerset-shire, as good as any used at Moran."[128]

[121] Neri-Merret, 263.

[122] Mauck, 36.

[123] For various wood-ash compositions in Northern Europe, see Velde, 73–74.

[124] Neri-Merret, 264–65.

[125] Neri-Merret, 265.

[126] Neri-Merret, 266.

[127] Godfrey, 157; J. Turnbull, 10.

[128] Neri-Merret, 289. Charleston cites two Manganese-purple lead-glass bottles in the collections of the Victoria and Albert Museum and the Ashmolean Museum, Oxford, respectively, that have "a strong claim to be English made," suggesting the application of Merret's recipes in domestic workshops: Charleston, pl. 25d; Victoria and Albert Museum, cat. no. 122, pl. 6a. With thanks to Reino Leifkes, V&A.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

Of *Lapis calaminaris* (in the seventeenth century meaning zinc oxide, the ore of zinc and a component of brass, also used to color glass), Merret locates a source "in Sommersetshire, and the North of Wales" that he considers superior to Polish imports: "though some of it hath been brought from Dantzick, yet 'tis not of the same goodness with ours of England."[129] A few pages later, Merret reports on another domestic source of zinc ore, indeed a recent find: he observes that large stones of *Calcarii*, used in the manufacture of brass, were "formerly brought from Holland, but have been sometimes since found in the mountanous parts of Cornwall."[130]

On the subject of tincture, Merret was also cognizant that the slightest impurities (iron) in sand could impart a green hue to a batch of glass. He introduces for his readers' benefit three criteria—color, grain type, and size—with which to distinguish grains used for clear *façon-de-Venise* vessels from more ferruginous sands constitutive of green-glass bottles.[131] He writes, "Our Glass Houses in London have a very fine white sand (the very same that's used for Sand-boxes and scouring) from Maid-stone in Kent, and for Greenglasses, a coarser from Woolwich," which he describes as "harder and more gritty."[132] The distinction would have been all the more clear if performed at the Royal Society as part of the multisensory display of *materia vitraria*. Again, samples could well have ended up in fellows' mouths: when Merret elsewhere discusses sand as a possible component of zaffer (a cobalt compound), he assures his reader that "your tongue and teeth may easily discover it."[133]

At least one reader sought to experience the fineness of a Kent grain for himself. In the 1681 catalogue of the Royal Society's repository prepared by Nehemiah Grew (1641–1712), there appears among the "Earths" a donation from a "Mr. Evelyn" of "FINE SAND, from a Sand-Pit near Bruley in Kent."[134] Grew notes, "Of this is made the clearest and best English Glass" (fig. 5). With this entry in mind, I will turn to consider the collection and trade of *materia vitraria* in the society's milieu subsequent to Merret's translation.

[129] Neri-Merret, 299.

[130] Neri-Merret, 302; Koinm, 27.

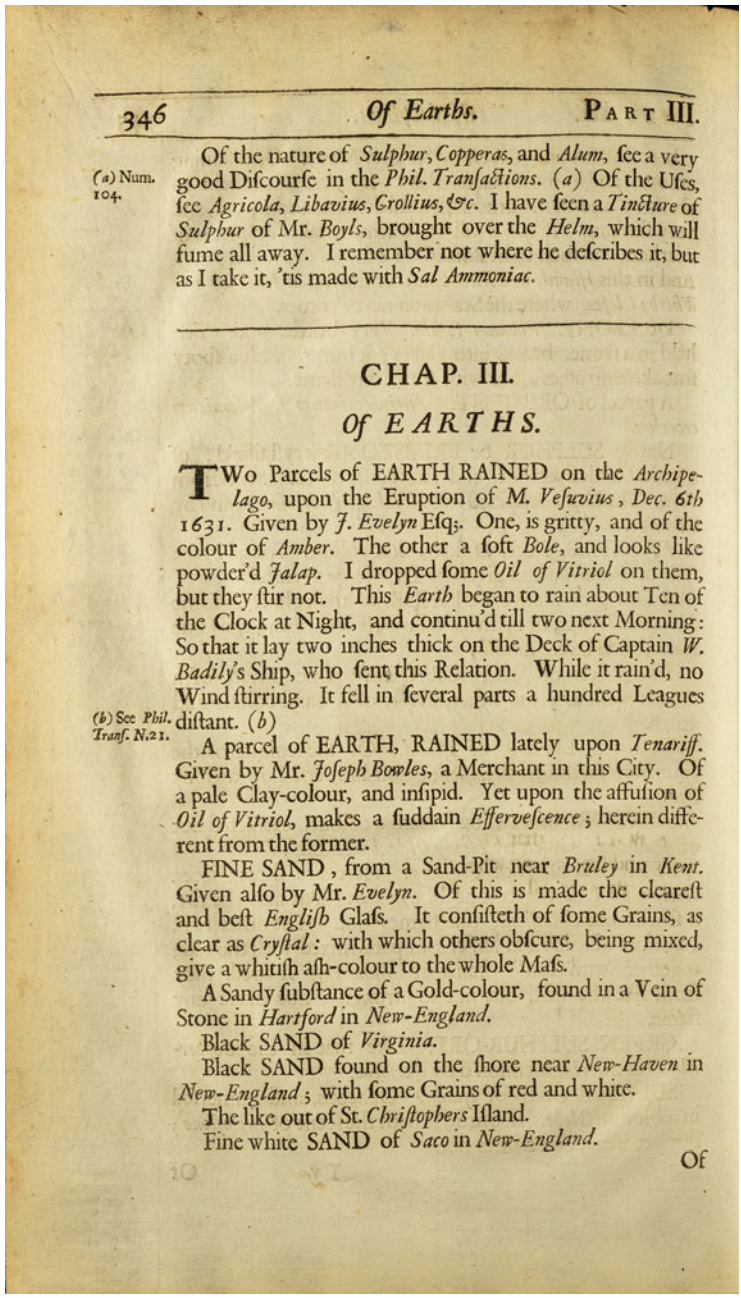
[131] Neri-Merret, 260; Clark, 162–63.

[132] Neri-Merret, 261.

[133] Neri-Merret, 280–81. He also explicitly advises the reader to test the brittleness of zaffer's "sandy gritty substance" not just with their fingers, but with their teeth as well: Neri-Merret, 279.

[134] Grew, 346. For Evelyn and Merret, see Foley, 192.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press



346 *Of Earths.* PART III.

Of the nature of *Sulphur*, *Copperas*, and *Alum*, ſee a very good Diſcourſe in the *Phil. Tranſactions*. (*a*) Of the Uſes, ſee *Agricola*, *Libavius*, *Crollius*, &c. I have ſeen a *Tincture* of *Sulphur* of Mr. *Boyls*, brought over the *Helm*, which will fume all away. I remember not where he deſcribes it, but as I take it, 'tis made with *Sal Ammoniac*.

(*a*) Num. 104.

## CHAP. III.

## *Of EARTHS.*

TWo Parcels of EARTH RAINED on the *Archipelago*, upon the Eruption of *M. Veſuvius*, *Dec. 6th* 1631. Given by *J. Evelyn* Eſq; One, is gritty, and of the colour of *Amber*. The other a ſoft *Bole*, and looks like powder'd *Jalap*. I dropped ſome *Oil of Vitriol* on them, but they ſtir not. This *Earth* began to rain about Ten of the Clock at Night, and continu'd till two next Morning: So that it lay two inches thick on the Deck of Captain *W. Badily's* Ship, who ſent this Relation. While it rain'd, no Wind ſtirring. It fell in ſeveral parts a hundred Leagues diſtant. (*b*)

(*b*) See *Phil. Tranſ. N.*21.

A parcel of EARTH, RAINED lately upon *Tenariff*. Given by Mr. *Joſeph Bowles*, a Merchant in this City. Of a pale Clay-colour, and inſipid. Yet upon the affuſion of *Oil of Vitriol*, makes a ſuddain *Effervеſcence*; herein different from the former.

FINE SAND, from a Sand-Pit near *Bruley* in *Kent*. Given alſo by Mr. *Evelyn*. Of this is made the cleareſt and beſt *Engliſh* Glaſs. It conſiſteth of ſome Grains, as clear as *Cryſtal*: with which others obſcure, being mixed, give a whitiſh aſh-colour to the whole Maſs.

A Sandy ſubſtance of a Gold-colour, found in a Vein of Stone in *Hartford* in *New-England*.

Black SAND of *Virginia*.

Black SAND found on the ſhore near *New-Haven* in *New-England*; with ſome Grains of red and white.

The like out of St. *Chriſtophers* Iſland.

Fine white SAND of *Saco* in *New-England*.

Of

Figure 5. Nehemiah Grew. *Musaeum Regalis Societatis; or a catalogue & description of the natural and artificial rarities belonging to the Royal Society and preserved at Gresham College*. London, 1681, page 346. © The Royal Society.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

## THE REPUBLIC OF GLASS AND LETTERS

The exhibition of natural and artificial curiosities was a frequent event at the meetings of the early Royal Society.[135] Grew's descriptive catalogue of the institution's repository attests to the variety of rarities acquired, with many items having been sent to fellows from afar.[136] Hartlib had previously espoused that collectors in his circle cast a wide geographic net for "didactica." In his notebooks, he recommends that those traveling to the "Oriente . . . should bee instructed what to observe and collect not only Book's and MS but likewise the History of Nature and Art."[137]

Following the publication of *The art of glass*, fellows venturing to the Continent, if not the "Oriente," seized the opportunity to collect samples of vitreous matter. The dispatch of these materials afforded members of the Royal Society a more holistic picture of the glass trade as it was practiced abroad. What evidence of contemporary manufacture they accumulated complemented the firsthand experience of London workshops one finds recorded in Hartlib's notebooks or Merret's commentary.

### *Oldenburg as Collector and Correspondent*

The correspondence of Henry Oldenburg (ca. 1619–77), the society's first secretary, reveals channels whereby information on glass manufacture and *materia vitraria* reached England.[138] When in 1666 Oldenburg wrote from London to Johann Hevelius (1611–87), a consul in Danzig, he included a list of "annexed queries" sent on behalf of the fellows. From Hevelius he sought "in all parts those things with which Nature enriches different regions."[139] Among his questions was whether "Signior Burattini" (Tito Livio Burattini [1617–81]), the master of the mint to the king of Poland, had "the Art (as has been written from Paris) to make such Glass, as is not at all inferior to Venice-glass, and exceeds any plate of Glass, hitherto made there, twice or thrice in bigness?"[140]

[135] Da Costa, 46–51; Hunter, 1985 and 1989.

[136] Grew.

[137] Hartlib, 1648, part 3 (31/22/40A). The literature on the seventeenth-century collections of natural philosophers is vast. For the expansion of cataloging practices tied to imperial pursuits, see especially Smith and Findlen.

[138] Oldenburg was also a member of Hartlib's Interregnum circle. For imperialism in the Oldenburg correspondence and the early *Philosophical Transactions*, see D'Amore.

[139] Oldenburg to Hevelius, 30 March 1666, in Oldenburg, 3:76–78.

[140] Oldenburg, 3:77. The Halls use for their translation of the *Inquiries* the text Oldenburg himself published in *Philosophical Transactions*: Hevelius and Oldenburg, 344–46; the Latin original is presumed missing.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

Taking after Hartlib, Oldenburg probed Hevelius for details: "What is the way of making Pot-ashes in Poland?"[141]

Other of Oldenburg's letters attest to his correspondents' successful extraction of samples from European glasshouses. In August of 1668, Samuel Colepresse (d. 1669) of Devon, then stationed in the Netherlands, wrote to Oldenburg of opal glass, recalling its accidental manufacture at the Duke's Glasshouse in Woolwich, England.[142] He compared the chance incident at the English workshop with the more calculated preparation of the substance at Haarlem, where he recently observed "the experiement of this soe livelie-counterfeited Opall in Glass for wch. they now have their certain Rules."[143] Colepresse went on to explain the role of heat in yielding variant opacities of the substance. He assured Oldenburg that he had acquired "ye Specimina of the severall degrees: wch. with some curiositie & wonder I observed in ye operation."

The interest of both men in the opaque substance persisted, and on November 20, Colepresse again wrote to Oldenburg, this time including the aforementioned evidence: "You'le find herein (according to order) inclosed: I have added 4 little peices to it, all of ye very same mettall, & out of ye same pot, with ye great peice, * . . . I likewise adde, a peice of ye Red-glass, thoe not soe well mixt, as wisht, or probablie may on a second tryall: another peice shows you ye sedement of ye Red composition. . . . I shall let slip noe oportunitie of gaineing what glass-specimena & informations I can from ym; nor of sending ym you."[144]

Colepresse intended these imperfect samples not just as proof of the impact that variant heating and cooling methods had on opacity, but also as material testimony to his firsthand observation of the glassmaking process. In his gloss, he avows, "I was present at ye furnace ye [time] these peices of glass, I now send you were taken out, & diverslie cool'd. . . . I adde a fifth, wch. I had forgott, wherein lies ye greatest degree heat, & opacitie."[145] By the end of 1668, Oldenburg had received yet more samples from his man in the Netherlands. Writing from Leiden on December 14, Colepresse relates that "my Glass-Correspondent . . . has sent me a few specimena of their Glass-experiments, wch I carefully transmitt you."[146]

[141] Oldenburg to Hevelius, 30 March 1666, in Oldenburg, 3:77, 79.

[142] Samuel Colepresse to Oldenburg, 7 July 1668, in Oldenburg, 4:572–74; Brain, 112; Ochs, 1981, 142.

[143] Colepresse to Oldenburg, 7 July 1668, in Oldenburg, 4:572–74.

[144] Colepresse to Oldenburg, 10 November 1668, in Oldenburg, 5:140–41.

[145] Colepresse to Oldenburg, 10 November 1668, in Oldenburg, 5:140–41.

[146] Colepresse to Oldenburg, 14 December 1668, in Oldenburg, 5:247–48. For additional mention and movement of glass in the Oldenburg correspondence see the following letters from the French scholar Henri Justel (1620–93): Justel to Oldenburg, 3 October 1668, in Oldenburg, 5:76–79; Justel to Oldenburg, 18 November 1668, in Oldenburg, 5:179–81.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

## *Framing Glass in Archaeology's Window*

A similar practice of attaching samples to correspondence transpired in domestic mail, and the fellows augmented Merret's *materia vitraria* with objects they received, whether on loan or as gifts, from sites closer to home than the Continent—if temporally more removed. An entry in the Royal Society's *Letter Book* of 1684 documents an instance when medieval glass fragments sent from the east of England became the subject of collective interrogation. On 1 April 1684, "A letter of Mr. MUSGRAVE to Mr. ASTON was read, concerning some old painted glass brought from Wooburn abbey in Bedfordshire."[147] From the excerpt in the *Letter Book*, Musgrave reports: "We had an old piece of Glass, painted red & blow, shown us; it was brought from Wooburn-Abby in Bedfordshire."[148]

The reading of Musgrave's correspondence encouraged further discourse among the fellows on "the making of glass," whereupon a disagreement transpired between Lister and Robert Hooke (1635–1703) as to the consistency of sources for the tincture of Roman versus contemporary glass.[149] Again, it was the material properties of the substance, and not any blown or poured form, that members of the society found so compelling. Lister claimed that "magnesia from magnes . . . takes away the foulness of glass: that the Romans not knowing it, their glass and urns are therefore all of a different colour from our modern glass,"[150] whereas Hooke "remarked, that the Roman glass has this colour by age, because the glass in old abbies seemed to be of the same colour."[151]

The windows of at least some medieval English churches were in fact closer to Roman glass than either Hooke or Lister knew: modern analysis confirms the reuse of late classical material, such as tesserae, to color panes at York Minster.[152] Not all the Roman glass left in Northern England had been recycled in the medieval era, though. In the late seventeenth century, excavations in and around York uncovered fragments of ancient vessels and windows.[153] The

[147] RS, Letter Book Original (hereafter LBO)/10/25.

[148] RS, LBO/10/25. No such fragment exists in the collections of the Higgins Art Gallery & Museum, Bedford: Kristian Purcell, personal correspondence.

[149] Birch, 4:276–77.

[150] Lister says that magnesia, from magnes, the load-stone, "had been lately found in Mendip hills": Birch, 4:276–77.

[151] Birch, 4:277.

[152] Freestone, 36–37. This practice is described in the twelfth century by Theophilus, for whose recipes see Smedley et al. For the circulation of knowledge on stained glass on the Continent in the early modern period, namely the northern Netherlands, see Hendriksen.

[153] For the manufacture of glass in Roman York, see Jackson et al.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

close ties between the Royal Society and the so-called York Virtuosi facilitated the exchange of these finds among the scholarly circle.[154]

The correspondence of York-based glass painter Henry Gyles (ca. 1646–1709) reveals the interest contemporary artisans took in the coloration of Roman glass. Writing to Ralph Thoresby of Leeds (1658–1725) in 1699, he recalls "finding this morning . . . that small fragment of the glass urne I formerly told you of, have sent them to you, togeather with some specimens of my owne coloured glasse . . . and, Sr, I can tell you as to the ancient coloured glasse and these, I know no difference except that these exceed in greater varieties."[155] Gyles goes on to request of Thoresby, "When you come to Yorke . . . I must beg of you bring this peice of the glass urne with you, because then I expect a glassmaker to be in Yorke that I would shew it to for the hollow roule at the bottom is pretty and odd: besides, I wou'd examine with him the nature and temper of it, which seems to be a more fix'd mettle than . . . [illegible] use."[156] With archaeological finds such as this unearthed shard, Gyles could compare the composition of ancient glass with examples of his own enameling and perhaps even manufacture[157]—assuming, that is, that the circulation of Merret's text emboldened a painter such as he to experiment with glassmaking itself.[158]

Thoresby's repository, held in Leeds, included several exhibitions of *materia vitraria*.[159] Along with donations of antiquities from Gyles, the collection boasted additional vitreous gifts like "*Adder-Beads* . . . sent [from Wales] by Mr Lhwyd. . . . One is of blew Glass with white Snakes upon it. The other curiously undulated with blew, white and red."[160] Moreover, Thoresby's commentary on others of his ancient glass possessions indicates his familiarity with contemporary excavations in London: "With the *Roman* Urns are often found Fragments of Glass Viols, of that Sort which is commonly called *Lacrimatorys*. Of the *Roman* Glass Ware, I have from *London*, *Yorke, Aldbrough*, and the Station near *Alde*; the blewish Green, and some of the White are very thick, viz. above a Quarter of an Inch. Part of a Lacrimatory from *Isurium*, it hath been three Inches Square. The Handle (half a foot long) of a large Vessel, found at St. Paul's; thick white Glass from the same

[154] For the York Virtuosi, see Honour; Stacpoole, 856–59; Sloan.

[155] Henry Gyles to Ralph Thoresby, York, 4 March 1699: transcribed in Lancaster, 68; Brighton, 13, Appendix Letter 28.

[156] Lancaster, 69.

[157] For Gyles's materials and techniques, see Brighton, 13–16.

[158] Newton et al. refute Knowles's claim that "glass painters and glaziers could have no practical knowledge of glass making," citing Gyles. See Newton et al., 34; Knowles, 68.

[159] Thoresby. See Connell and Boyd, 31–40; Brears.

[160] Thoresby, 563, nn23–24.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

Place. A Piece remarkably thin for those Ages, found five or six Yards deep in the *Roman* Wall at *Aldbrough*."[161]

Samples held in his Leeds repository also documented failed experiments at historical glassworks. Thoresby records one such donation from Sir Godfrey Copley (1653–1709), a member of the virtuosi and friend of the collector Thomas Kirke (1650–1706).[162] Thoresby describes the item as "a Rim of one wrought Hollow; fluted or furrowed Glass . . . with a Lump of Metal that seems to have boiled out of a Crucible, from the Ruine of the said Wall [at Aldbrough]."[163] Was it Hartlib and Merret's shared regard for the waste products of contemporary industry that primed younger antiquaries like Copley to esteem finds as ostensibly worthless as this lump?

Back in London, a flurry of post-fire building unearthed Roman shards on several occasions, as well as the odd furnace. In his memoranda book John Conyers (ca. 1633–94), an apothecary and repeat guest at the Royal Society's meetings, describes watching excavations of the Fleet Ditch ("between the fleet gate & the bridg at Holbourne") that revealed small kilns with "a funnel to covey smoake wch might serve for glass forneses."[164] He surmises that "though not anny potts wth glass in it whole in the fornaces was there found yet broken crucibells or Vesls for Molteing of glasses togeather wth boltered glasse such as is to be seen remaining at glass housen amongst the broken Glass, wch was glasses spoyled in the makeing was there found . . . mostly such as for cruetts or glasses wth a lipp to dropp withall & that a grenish light blew collour."[165] A denizen of digs, Conyers also reported "ornamentall beads of Green blew like enamel" that turned up alongside "earthern ware with inscriptions & glass" at "gravel pitts . . . deep oposite & neere S$^{t}$ pauls Schoole in London."[166]

Conyers's ability to make sense of these findings likely stemmed from his direct familiarity with the operations of a glasshouse (for example, the nearby works at Savoy) and what knowledge of glass manufacture and related crafts he

[161] Thoresby, 560.

[162] For Copley, see Armytage.

[163] Thoresby, 560.

[164] British Library (hereafter BL), Sloane MS 958, fol. 106$^{r}$. Transcribed in Burnby, 68, 75, as Sloane MS 959. For Conyers, glass, and archaeology, see MacGregor, 188–89, 197n90.

[165] BL, Sloane MS 958, fol. 106$^{r}$, as transcribed in Burnby, 75.

[166] BL, Sloane MS 958, fol. 113$^{v}$, as transcribed in Burnby, 77–78. The attention Conyers gives to ancient beads in this passage may reflect their contemporary currency. Merret identifies glass beads as a trading good with West Africa, noting, "Neither may I forget those Beads . . . which have procured us good store of Gold from Guiney, adorning the Noses, Ears, Lips, Rists and Legs of that nation": Neri-Merret, 229.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

gleaned from *The art of glass* or correspondents abroad.[167] When Roman pottery kilns were unearthed in 1677 at the building site of St. Paul's Cathedral, he likened the ancient ovens to those "at this day in use about Poland."[168] In addition to documenting find spots, Conyers acquired antiquities from excavations for his personal collection. He made pains to classify these objects, preparing them for open exhibition. In 1691, the *Athenian Mercury* published a summary inventory: ""For Natural things . . . Minerals, Mettals, Stones, Gemms, Petrefactions etc. in greaty plenty. For Artificial things . . . Urns, Lachrymatories, Lamps, Gemms, Meddals." The periodical affirms that the trove "may be in many ways useful to the Publick."[169] In Restoration London, then, shards of Roman glass would have been examined not just alongside contemporary wares but also besides the very *naturalia*—minerals, metals, stones—from which any reader of Merret would recognize their tincture and translucence as having derived.

## MATERIAL OVER FORM IN THE REPOSITORY

When Merret brought his *materia vitraria* before the fellows in November of 1662, they asked him to entrust a part of his collection to the society. Just where these donated materials would have initially been stored is unclear; mention of an official, institutional repository can only be found in records from the following year.[170] Merret's sources may have entered into the custody of Hooke, who acted as the inaugural curator of the collection until his death in 1703.[171] Hans Sloane (1660–1753) in his inventories[172] attributes several glass

[167] Burnby, 68. The Savoy works were located between Adam Street and Carting Lane and were active from 1673 to 1679 and again from 1681 onward. George Ravenscroft was the first proprietor, followed by the Glass Sellers' Company and Hawley Bishop after 1681. See Tyler and Willmott, 12; Charleston, 110–11.

[168] BL, Sloane MS 958, fol. 106$^{v}$, quoted in Burnby, 66.

[169] *The Athenian Mercury*, 21 November 1691, quoted in Burnby, 64.

[170] Thomas; Swann, 81–90.

[171] Thomas, 1.

[172] Sloane, "Catalogue of Miscellanies" (some items with dates 1730–38) and "Antiquities," British Museum (hereafter BM), Africa, Oceania and the Americas, Am,CUPBD2/SH.4. These are listed as catalogues 28a and 28b in Jones, and I follow these numbers (28a, 28b) in all references to inventory items hereafter. I have checked any transcriptions against the originals in the AOA and edited them with Marjorie Caygill's master copy, dated 20 May 2010. For a reconstruction of the "Miscellanies" in Sloane's cabinets with object tabulation, see Sloan and Nyhan. For Sloane's collections in general, see most recently Walker et al.; Caygill; Delbourgo; Marples and Pickering; Marples, 2018; and the Reconstructing Sloane website at https://reconstructingsloane.org.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

specimens to "Dr Hook," who, in his capacity as keeper, would have overseen the accumulation of any samples further to Merret's.[173] Conyers, Lister, the French chymist Étienne Geoffroy (1672–1731), and James Petiver (ca. 1663–1713), a London apothecary and member of the society, are likewise credited for contributions of glass materials.[174] Indeed, throughout the repository's history, the fellows relied for the expansion of the collection on what Jennifer Thomas terms "proactive methods" and "spontaneous donations."[175] The society continued to administer accessions until 1781, when the British Museum absorbed the contents of the store into its ever-deepening bowels.[176]

Recent scholarship has treated the repository variously as "a physical site of reciprocal identity formation for the Royal Society and its virtuoso supporters";[177] a three-dimensional analogue to the society's register books;[178] and a storehouse of objective "eyewitnesses" that "formed part of the Society's more general desire to authenticate written observations."[179] The last of these interpretations is particularly germane to the role the repository played as a tangible appendix to *The art of glass*. Thomas argues that the fellows used the repository to address the shortcomings and suspected dubiousness of secondhand accounts.[180] She views the institution's impulse to possess objects as indicative of a larger "desire for completeness" in the accumulation of natural knowledge. Fulfilling this ambitious aspiration thus entailed looking beyond the limited testimonies of any one author to the very sources of natural histories themselves, things which the fellows could interpret collectively.

## *Transparency Condescends to the Opacity of Text*

Writing the history of a trade in the late seventeenth century required the transposition of knowledge from the eyes and hands of practitioners to the graphic and written notes of chroniclers. The manufacture of glass is similarly characterized by the transition of materials between states. It is perhaps on account of the instability inherent in both processes that the endeavor to translate *The art*

[173] Items attributed to "Hook": BM, 28a/266, 331, 334, 335, 349, and 28b/86. Note also "Mr Boyles lead glasse from Dr Hook," BM, 28a/334. For Hooke and glass, see Gunther, 553, 596–97, 679.

[174] For Petiver as collector, see Swann, 90–91.

[175] Thomas, 3.

[176] Marples, 2019. For Sloane's collections, see most recently Delbourgo; Marples, 2018; Marples and Pickering; Sloan and Nyhan.

[177] Swann, 85.

[178] Johns, 476, 485, 499; Swann, 85.

[179] Thomas, 4.

[180] Thomas, 4.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

*of glass* offers a particularly conspicuous example of ekphrastic failure in the history of trades program.[181] The fellows' demands to inspect those *materia vitraria* "spoken of in the booke" confirms the inadequacy of the textual medium to convey what Merret implies was in essence an intuitive art. He cites a glassworker who "always puts in all his colours, not by weight, nor measure, but by little and little at a time, and then at each time mixeth them well with the metall, and taketh out a proof, and by his eye alone judgeth whether the colour be high enough, and when too low adds more of them till he attain the desired colour."[182]

Certain of the fellows may have enjoyed a familiarity with the corpus of Merret's not insignificant bibliography, but even reading *The art of glass* with its acknowledged precursors to hand was not enough to "re-experience" its writing.[183] In other words, Merret's appended commentary comprised more than an armchair literature review, with objects offering their own annotations on Neri. For example, in his remarks on the recipes the Florentine recorded for coloring glass balls with "gesso," Merret notes: "There's another pale earth with stony clots, which they use to scoure Brass, they call it Gessum. But it seems [Neri] knew not what it was."[184] Going on to describe the material properties of this substance in some detail, Merret concludes by citing the thing itself: "To the eye it much resembles Alablaster, and is brittle as it, for so is a large piece I have by me."[185]

The accessioning of samples like this into the repository, along with gifts from Continental glasshouses and finds from excavated Roman sites, represents one measure the Royal Society took to address the essential deficiency of a written history: its inability to record the multisensory observations intrinsic to craft practice.[186] No matter the language, Merret's commentary could not equal the eloquence of the thing beheld or tasted and, as a result, fell flat in conjuring such essential material properties as color, grain size, brittleness, and salinity, all of which I have glossed above. If the fellows were to acquire embodied knowledge of glass and its raw ingredients, only the direct observation and handling of *materia vitraria* would do.[187]

[181] Dupré, 2017, 184.

[182] Neri-Merret, 274.

[183] Daston, 447.

[184] Neri-Merret, 344.

[185] Neri-Merret, 345.

[186] For this point in regards to Kunckel, see Dupré, 2017, 184.

[187] Like Merret, the German alchemist Johann Becher (1635–82) appreciated the futility of writing down knowledge of glassmaking. He viewed the formation of Venetian glass to be "made in such a way that it cannot be communicated to [Germany] except by a long period of apprenticeship, for it is an art and consists in work of the hand." Given this impasse, Becher instead recommended "finding out the correct preparation of the material," which could be recorded in recipes. Becher, Kunsthaus Referat, 1676, as cited and translated in Smith, 1994, 209. See also Mádl, 104.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

## *A Fresh Appraisal of the Fragment*

While the contents of Merret's original collection are lost today, Birch's *History* and the entries of Sloane's extant inventories provide additional insight as to the direction in which the society chose to expand its cache of matter relevant to glassmaking. On 16 July 1663, the improvement of domestic crafts was back on the fellows' agenda, as was sand, recognizable to any reader of Merret as a component of a glass batch: "Mr. Pell produced a bag containing potter's sand . . . which then gave occasion to speak of our English materials. . . . Some of the members suggesting, that this sand might be capable of more noble uses than for ovens, and that it might perhaps be found useful for vitrification."[188]

In 1669, the repository received another donation of *materia vitraria*. Charles Howard (1630–1713) presented to the society on red glass, after which he was "desired to produce a piece of plate of that glass."[189] At the next meeting, "there was produced some fagots of red-streak glass sent by Mr. Read out of Herefordshire for the use of the society; which were distributed to several of the members."[190] A decade later, acquisition and appraisal continued apace: "Mr. Henshaw produced a paper containing the milk-white pieces of glass, which had been so made by the corruption of a menstruum contained therein. This substance was very brittle, and with one's fingers might easily be crumbled into sand. This was received from Mr. John Dwight of Fusha."[191]

Items listed among the "Miscellanies" and the "Antiquities" in Sloane's catalogues indicate that the collection of *materia vitraria* for the repository endured long after Merret himself was unceremoniously expelled from the society in 1685.[192] With its burgeoning object appendix, *The art of glass* became ever present to subsequent fellows in Merret's absence.[193] The fragmentary nature of much of the material that entered into Sloane's museum testifies to the society's continued preoccupation with the components and byproducts of a glass batch —this, in contrast to Continental collectors who prized luxury goblets.[194] Merret's "Observations" as to the composition of various vitreous species and his attention to raw ingredients appear to have steered the society's collecting practices in this direction: Sloane's catalogues reveal the amassing of objects that

[188] Birch, 1:276–77.
[189] Birch, 2:426.
[190] Birch, 2:426.
[191] Birch, 4:110–11.
[192] Allen; Mauck, 46.
[193] Jones.
[194] Cf. Dupré, 2010, and the engraved glass examples discussed in Van Elk.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

bore witness to Merret's "wayes to make and colour Glass, Pastes, Enamels, Lakes, and other Curiosities."[195]

That the Royal Society accumulated glass shards from botched manufacturing jobs (fig. 6), intermediary processes, and archaeological digs accords with what scholars now understand as the institution's appreciation of the singular and the rare in the production of knowledge, particularly in the early eighteenth century.[196] Already in Grew's 1681 catalogue, though, there is evidence that Merret's method of assembling a veritable archive of waste representative of glassmaking had been adapted to the study of tin mining, a trade centered around Cornwall and Devonshire.[197] Grew lists "a slag, remaining in the bottom of the Tin-Floate. Sent by Mr. Colepress" and "scum taken from melted tin."[198] For all its ostensible failure, then, the history of trades project left its mark on the society's collecting practices, inspiring the accession of objects otherwise lost to or rendered invisible by industrial recycling economies.[199]

Again, the tastes of Sloane and the other fellows diverge here from those of collectors on the Continent who traditionally favored the exhibition of finished glass produced in nearby workshops.[200] To be sure, some amount of fragmentary glass, previously thought "valueless" to those outside the trade, did enter into Northern European cabinets of curiosity in the seventeenth century.[201] Just as the unearthing of Roman glass in London and York expanded interest in industrial waste products among the society's milieu, the excavation of Roman sites, such as those in Luxembourg documented by the brothers Wilhelm and Alexander Wiltheim (1594–1636 and 1604–94), encouraged a new receptivity to the shard as collectible in its own right.[202]

[195] Examples of enamels are as follows: BM, 28a/243, 342–47, 350–55, 358, 435–36, 674, 1894, 1903.

[196] See especially da Costa.

[197] Grew, 329. On the subject of the Cornish industry Grew cites a report "communicated by Dr. Christopher Merret, and by Me published in the [Phil.] Transactions." By 1681, though, Merret had suffered a fall from grace in the eyes of the fellows. See Mauck; Allen. For the "archiving" of waste, see Thrill, 86.

[198] Grew, 329.

[199] On glass recycling economies, see Freestone; D. Keller.

[200] In the late sixteenth-century *Kunstkammer* of the Hessian Landgraves in Kassel, for example, "a fine goblet with white threads" was shown almost immediately on the occasion of its making; to the Landgraves, the finished goblet, rather than the ash, sand, or stones that went into its production, was what was prized as material testimony to the practical knowledge of those Venetian glassworkers who had recently journeyed to work at Kassel in 1583: see Vickers. See also *The Origins of Museums*, 36–37, 72, 104–06, 110, 229. This is not to say that Sloane's own collection omitted finished wares.

[201] Vickers, 229.

[202] Vickers, 229.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press


Figure 6. Drop including a potstone impurity excavated at Broadgate, London, later seventeenth century. © Andy Chopping, Museum of London Archaeology (MOLA).

But in the context of early seventeenth-century Antwerp, where Neri had stayed with the Portuguese merchant-banker Emanuel Ximenez (1564–1632) and observed the Venetian-style Gridolphi glassworks, what attention the merchant community paid to the process of glass manufacturing did not lead to their valuing either raw materials or evidence of failed trials as commodities worth collecting outside the trade economy.[203] Rather than licking sand or crumbling stones, connoisseurs familiar with the composition of Venetian sodic glass instead preferred to exercise their *Augenmaß* (visual judgment) on

[203] Dupré, 2010, 53–78.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

finished products. They took pleasure in picking out the prized crystal from within arrays of luxury objects where its vitreousness played off both *naturalia* and *artificialia* to extravagant effect.[204]

The society's repository, and later Sloane's cabinets, facilitated similar comparative analysis of glass alongside other objects. No further artifice was attempted for visual effect, though, as the fellows were less keen to ogle at form than they were to handle materials—and perhaps even taste them—in order to deconstruct processes of manufacture. Items worthy of accession included the raw ingredients from which glass derived its properties, described above; by-products of failed furnace experiments; and artifacts of chemical alteration either due to time or subterranean conditions. In cabinet 199, Sloane exhibited "Cinders from the iron furnace in Sussex by Mr Fuller, glasse bottles are made of it at Brystoll" alongside the rarities of "A piece of concave mettall in glasse- belong'd to Dr Hook?" and "Chrystall glasse wch when heated turns of a red colour from France?"[205] In cabinet 216, he displayed "the cinder of slagg of some metal" together with both contemporary discards—such as "glasse found at the bottom of a lime kiln" and "two pieces of glass of bottom of a Pott from the glasse house"—and antique specimens, among them an iridescent bit of "colour'd glasse I suppose from lime" attributed to Hooke.[206]

Sloane's inventories nonetheless separate contemporary glass matter from antique finds by way of the labels "Miscellanies" and "Antiquities." That he appears to have mixed examples of these two groups in his cabinets demonstrates how the physical arrangement of his collection encouraged the diachronic assessment of colors and compositions that Gyles speaks of in his letters to Thoresby, cited above.[207] The varied composition of cabinet 216 (a and b) in particular embodies the virtuosi's fascination with glass's chemical deterioration, namely the iridescence known as *Electrum britannicum*.[208] Sloane brought together antique examples of this effect, originally collected by Conyers, with modern specimens displaying the same, such as that from Hooke, aforementioned; a fragment of "a glase bottle by lying in mud earth or water covered wt. the electrum or shining sulphureous vapours"; and another piece from his nephew, "a glasse bottle wch had lain in mud in Hampshire & was of the colour of the rainbow blew redish & yellow like gold the colours vivd.

[204] Dupré, 2010, 74. For Kunckel and expert visual perception, see Dupré, 2017, 184, 186.

[205] BM, 28a/1246, 266, 259.

[206] BM, 28a/1432, 694, 2078; BM, 28b/86, 25, 27–29, 31, 52, 58–59, 60–61, 88, 93, 96, 143, 156, 328, 344.

[207] Sloan and Nyhan.

[208] For a summary of the contents, see Sloan and Nyhan, appendix part A. For *Electrum britannicum*, see MacGregor, 189, 197n92; Sloan and Nyhan, 19n32.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

I saw one from Oxford take up out of the Thames. . . . Tis like the electrum antiq. on glasse vessels."[209]

Like Hartlib, members of the early Royal Society remained interested in the capacity of glass to mimic the vitreous properties of other materials. Merret in his "Observations" gives much attention to the art of forgery, as did Neri,[210] and the society's minutes reference discussions on the making of counterfeit opals.[211] Sloane's catalogues for their part record numerous examples of imitative craftsmanship, mostly the use of glass to simulate the properties of naturally occurring substances.[212] The collection at one time included "Black glasse in imitation of onyx," "Glasse of sevll colours made in imitation of pretious stones & Intaglios," and several counterfeit opals, as well as "Glasse or chrystalline pebbles mixd among the diamond dust or bost to cheat people."[213] Also notable are entries of "A glasse or Past made of Chalk & clay by a Friend of Dr Hamps" and "Glasse or past in imitation of a Chrysolite of a greenish yellow colour."[214]

## CONCLUSION

On 5 November 1662, Merret presented his *materia vitraria* to the fellows in what can only be described as a multisensory performance. Some two decades later, the cache of vitreous matter again found its way into the Royal Society's minutes.[215] The physician Fredrick Slare (d.1727) had caught an error in *The art of glass* that he sought to codify in the institutional annals.[216] He argued his case with evidence gleaned from direct observation of a mineral sample recently acquired for the repository. Delivering "an account of experiments . . . made with a piece of mineral called kobalt," Slare cited Merret's published comments on the composition of zaffer only to conclude that "Dr Merret's conjecture of its being an artificial preparation is made void by this very present [the cobalt], which shews itself to be a true ore or mineral."[217] With this new entry into

[209] BM, 28b/86; BM, 28a/1647, 1687.

[210] For forgery of gems on the Continent, see Rijks; Smith et al.

[211] Birch, 2:329.

[212] Kremnitzer and Smith trouble the categories of imitation and failure in their account of unsuccessful attempts to make gemstones from colored glass.

[213] BM, 28a/774, 1576, 1774.

[214] BM, 28a/2086, 537.

[215] Birch, 4:418–19.

[216] For errors in the text that have come to light based on reconstructions of Kunckel, 1679, see Hagendijk et al., 327.

[217] Birch, 4:418–19. Frederick Slare (1646/47–1727) was at the time on the council of the Royal Society, having served a year as chymistry curator from 28 February 1683. See Principe; Hall, 1992, 23–41.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

Figure 7. Gall or sandiver, the saline scum from the surface of molten glass, excavated at Broadgate, London, later seventeenth century, with the glasshouse probably closed by the early 1690s. © Andy Chopping, Museum of London Archaeology (MOLA).

the society's collection, an object once more proved its eloquence as physical commentary, augmenting Merret's own tangible addenda to Neri's book. Slare's sample had all the refutative force of a marginal note or learned gloss, yet with its visual and haptic immediacy, it succeeded in making present properties of matter too easily lost to text.

The recent unearthing of seventeenth-century glass waste at sites across London allows modern archaeologists to continue the "codification of error" that transpired at the early Royal Society (fig. 7).[218] Through scientific analysis

[218] Pearce.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

and reconstruction, scholars might yet recover further of the *materia vitraria* that will for the moment remain conspicuous in their absence at the center of my account.[219]

[219] For the testing and attempted re-creation of a sample of frit (fused or partly fused components of a glass batch) excavated from the site of a seventeenth-century furnace at Vauxhall, see Paynter and Dungworth.

https://doi.org/10.1017/rqx.2021.331 Published online by Cambridge University Press

# BIBLIOGRAPHY


## *Archival and Manuscript Sources*

British Library (BL), London, Sloane MS 958, fols. 106$^{r-v}$, 113$^{v}$. Conyers, John. "Account of Roman urns and other antiquities found in 1675–1677 in digging the foundation of new St. Paul's with drawings"; "Observations and experiments, 1675–1690."

British Museum (BM), London, Department of Africa, Oceania and the Americas, Am, CUPBD2/SH.4. Sloane, Sir Hans. "Catalogue of Miscellanies" (some items with dates 1730–38) and "Antiquities." Cited as BM, 28a and 28b.

Royal Society (RS), London, Journal Book Original (JBO), vol. 1. "Minutes of the ordinary meetings of the Royal Society." 28 November 1660–11 November 1663.

RS, Letter Book Original (LBO), vol. 10. "Copy letter from William Musgrave, New College Oxford, to Francis Aston," n.d. [1684].

## *Printed Sources*

Allen, D. E. "Merret, Christopher (1614–1695)." *Oxford Dictionary of National Biography*. Oxford: Oxford University Press, 2004. https://doi.org/10.1093/ref:odnb/18599.

Armytage, W. H. G. "Sir Godfrey Copley, F.R.S, 1653–1709." *Notes and Records of the Royal Society* 11 (1954): 54–74.

Aston, Margaret. *Broken Idols of the English Reformation*. Cambridge: Cambridge University Press, 2016.

Bacon, Francis. *Sylva Sylvarum; or, A naturall historie*. London: J. H. for W. Lee, 1626.

"Barilla." *Bulletin of Miscellaneous Information (Royal Botanic Gardens, Kew)* 39 (1890): 56–62.

Belting, Hans. *Likeness and Presence*. Chicago: University of Chicago Press, 1994.

Beretta, Marco, ed. *When Glass Matters*. Florence: Olschki, 2004.

Beretta, Marco. "Glassmaking Goes Public: The Cultural Background to Antonio Neri's *L'Arte Vetraria* (1612)." *Technology and Culture* 58.4 (2017): 1046–70.

Birch, Thomas. *The History of the Royal Society of London*. 4 vols. London, 1756–57.

Blair, Ann. "The Rise of Note-Taking in Early Modern Europe." *Intellectual History Review* 20.3 (2010): 303–16.

Blair, Ann, and Richard Yeo, eds. *Intellectual History Review* 20.3 (2010).

Boyle, Robert. *Works*. 6 vols. Ed. Thomas Birch. London, 1772.

Brain, Colin. "'Vitrum Saturni': Lead glass in Britain." In *Glass of the Alchemists*, ed. Dedo von Kerssenbrock-Krosigk, 107–21. Corning, NY: Corning Museum of Glass, 2008.

Bray, William, ed. *The Diary of John Evelyn*. 2 vols. New York: M. Walter Dunne, 1901.

Brears, Peter C. D. "Ralph Thoresby, a Museum Visitor in Stuart England." *Journal of the History of Collections* 1.2 (1989): 213–24.

Brighton, J. T. "Henry Gyles: Virtuoso and Glasspainter of York." *York Historian* 4.4 (1984): 1–62.

Browne, Thomas. *Pseudodoxia Epidemica or, Enquiries into very many received tenents and commonly presumed truths*. London, 1646.

Browne, Thomas. *The Letters of Sir Thomas Browne*. 4 vols. Ed. Geoffrey Keynes. London: Faber and Faber, 1946.

Burnby, J. "John Conyers, London's First Archaeologist." *Transactions of the London and Middlesex Archaeological Society* 35 (1984): 63–80.

Caygill, Marjorie. "Sloane's Catalogues and the Arrangement of His Collections." In *From Books to Bezoars: Sir Hans Sloane and His Collections*, ed. Alison Walker, Arthur MacGregor, and Michael Hunter, 120–36 London: British Library, 2012.

Charleston, R. J. *English Glass and the Glass Used in England, c. 400–1940*. London: George Allen and Unwin, 1984.

Cipolla, Carlo M. "The Diffusion of Innovations in Early Modern Europe." *Comparative Studies in Society and History* 14.1 (1972): 46–52.

Clark, Colin Jeremy. "The Glass Industry in the Woodland Economy of the Weald." PhD diss., University of Sheffield, 2006.

Cole, Michael W. *Cellini and the Principles of Sculpture*. Cambridge: Cambridge University Press, 2002.

Connell, D. P., and M. J. Boyd. "Material from the 'Musaeum' of Ralph Thoresby (1658–1725) Preserved at Burton Constable Hall, East Yorkshire." *Journal of the History of Collecting* 10.1 (1998): 31–40.

Crossley, D. W. "The English Glassmaker and His Search for Materials in the 16th and 17th Centuries." In *The Prehistory and History of Glassmaking Technology* (1998), 167–79.

da Costa, Palmira Fontes. *The Singular and the Making of Knowledge at the Royal Society of London in the Eighteenth Century*. Cambridge: Cambridge Scholars Publishing, 2009.

D'Amore, Manuela. "At the Root of Learned Travel: New Science, the 'Other,' and Imperialism in the Early Philosophical Transactions." *Critical Survey* 29.2 (2017): 58–75.

Daston, Lorraine. "Taking Note(s)." *Isis* 95.3 (2004): 443–48.

Dietz, Feike, and Sven Dupré. "Youthful Minds and Hands: Learning Practical Knowledge in Early Modern Europe." *Science in Context* 32.2 (2019): 113–18.

Delbourgo, James. *Collecting the World: Hans Sloane and the Origins of the British Museum*. Cambridge, MA: Harvard University Press, 2017.

Dodds, Charles. "Christopher Merrett, F.R.C.P., First Harveian Librarian." *Proceedings of the Royal Society of Medicine* 47.2 (1954): 1053–56.

Douglas, R. W., and Susan Frank. *A History of Glassmaking*. Henley-on-Thames: G.T. Foulis & Co, 1972.

Dungworth, David, and Colin Brain. "Late 17th-Century Crystal Glass: An Analytical Investigation." *Journal of Glass Studies* 51 (2009): 111–37.

Dungworth, David, and Colin Brain. "Seventeenth and Eighteenth-Century English Lead Glass." In *Modern Methods* (2013), 1:573–82.

Dupré, Sven. "Trading Luxury Glass, Picturing Collections and Consuming Objects of Knowledge in Early Seventeenth-Century Antwerp." *Intellectual History Review* 20 (2010): 53–78.

Dupré, Sven. "Galileo and the Culture of Glass." In *Tintenfass und Teleskop: Galileo Galilei im Schnittpunkt wissenschaftlicher, literarischer und visueller Kulturen im 17. Jahrhundert*, ed. Andrea Albrecht, Giovanna Cordibella, and Volker R. Remmert, 297–319. Berlin: De Gruyter, 2014a.

Dupré, Sven. "Making Materials: The Arts of Fire." In *Art and Alchemy: Mystery of Transformation*, ed. Sven Dupré, Dedo von Kerssenbrock-Krosigk, and Beat Wismer, 84–113. Munich: Hirmer, 2014b.

Dupré, Sven. "Doing It Wrong: The Translation of Artisanal Knowledge and the Codification of Error." In *The Structures of Practical Knowledge*, ed. Matteo Valleriani, 167–88. Cham: Springer, 2017.

Dupré, Sven. "Introduction: Science and Practices of Translation." *Isis* 109.2 (2018): 302–07.

Eamon, William. *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture*. Princeton, NJ: Princeton University Press, 1994.

Foley, M. J. Y. "Christopher Merrett's *Pinax rerum naturalium britannicarum* (1666): Annotations to What Is Believed to Be the Author's Personal Copy." *Archives of Natural History* 33.2 (2006): 191–201.

Francis, Peter. "The Development of Lead Class: The European Connection." *Apollo* 151.456 (2000): 47–53.

Freestone, Ian C. "The Recycling and Reuse of Roman Glass: Analytical Approaches." *Journal of Glass Studies* 57 (2015): 29–40.

Godfrey, Eleanor Smith. *The Development of English Glassmaking, 1560–1640*. Oxford: Clarendon Press, 1975.

Grafton, Anthony. "A Sketch Map of a Lost Continent: The Republic of Letters." *Republics of Letters: A Journal for the Study of Knowledge, Politics, and the Arts* 1.1 (2009): 1–18.

Greengrass, M. "Hartlib, Samuel (c. 1600–1662)." *Oxford Dictionary of National Biography*. Oxford: Oxford University Press, 2004. https://doi.org/10.1093/ref:odnb/12500.

Grew, Nehemiah. *Musaeum Regalis Societatis*. London, 1681.

Gunther, R. T. *Early Science in Oxford*, vol. 7. Oxford: Clarendon Press, 1930.

Hagendijk, Thijs, Márcia Vilarigues, and Sven Dupré. "Materials, Furnaces, and Texts: How to Write about Making Glass Colours in the Seventeenth Century." *Ambix* 67.4 (2020): 323–45.

Hall, Marie Boas. "Oldenburg, the *Philosophical Transactions*, and Technology." In *The Use of Science in the Age of Newton*, ed. John Burke, 21–47. Berkeley: University of California Press, 1983.

Hall, Marie Boas. "Frederick Slare, F.R.S (1648–1727)." *Notes and Records of the Royal Society* 46.1 (1992): 23–41.

Hammer, K., D. Pignone, S. Cifarelli, and P. Perrino. "Barilla (Salsola soda, Chenopodiaceae)." *Economic Botany* 44.3 (1990): 410–12.

Hanson, Craig Ashley. *The English Virtuoso*. Chicago: University of Chicago Press, 2009.

Harkness, Deborah. *The Jewel House: Elizabethan London and the Scientific Revolution*. New Haven, CT: Yale University Press, 2007.

Harley, R. D. *Artists' Pigments c. 1600–1835*. London: Butterworth Scientific, 1982.

Hartlib, Samuel. *Ephemerides*. The Hartlib Papers CD, 2nd ed. Sheffield: HROnline, 2002. https://www.dhi.ac.uk/hartlib/.

Hartshorne, Albert. *Old English Glasses*. London: Edward Arnold, 1897.

Hendriksen, Marieke M. A. "Necessary, Not Sufficient: The Circulation of Knowledge about Stained Glass in the Northern Netherlands, 1650–1821." *Nuncius* 31.2 (2016): 332–60.

Hevelius, Johannes, and Henry Oldenburg. "Promiscuous inquiries formerly recommended to Monsieur Heuelius, particularly about cold; together with his own, and his correspondents answer to some of them." *Philosophical Transactions* 19 (1666): 344–46.

Honour, Hugh. "York Virtuosi." *Apollo* 65.386 (1957): 143–45.

Houghton, Walter E., Jr. "The History of Trades: Its Relation to Seventeenth Century Thought as Seen in Bacon, Petty, Evelyn, and Boyle." *Journal of the History of Ideas* 2.1 (1941): 33–60.

Howell, James. *Epistolae Ho-Elianae: The Familiar Letters of James Howell*, vol. 1. Ed. Joseph Jacobs. Boston, MA: Houghton, Mifflin and Co., 1907.

Hunter, Michael. *Science and Society in Restoration England*. Cambridge: Cambridge University Press, 1981.

Hunter, Michael. "The Cabinet Institutionalised." In *The Origins of Museums* (1985), 159–68.

Hunter, Michael. *Establishing the New Science*. Woodbridge: Boydell Press, 1989.

Iliffe, Rob. "Material Doubts: Hooke, Artisan Culture, and the Exchange of Information in 1670s London." *British Journal for the History of Science* 28.3 (1995): 285–318.

Jackson, Caroline M., H. E. M. Cool, and Emma C. W. Wager. "The Manufacture of Glass in Roman York." *Journal of Glass Studies* 40 (1998): 55–61.

Janssens, K. S. Cagno, I. De Raedt, and P. Degryse. "Transfer of Glass Manufacturing Technology in the Sixteenth and Seventeenth Centuries from Southern to Northern Europe." In *Modern Methods* (2013), 1:539–62.

Johns, Adrian. *Nature of the Book: Print and Knowledge in the Making*. Chicago: University of Chicago Press, 1998.

Jones, Peter Murray. "A Preliminary Check-List of Sir Hans Sloane's Catalogues." *British Library Journal* 14.1 (1988): 38–51.

Kavey, Alison. *Books of Secrets: Natural Philosophy in England, 1550–1600*. Urbana: University of Illinois Press, 2007.

Keller, Daniel. "Social and Economic Aspects of Glass Recycling." In *TRAC 2004: Proceedings of the Fourteenth Annual Theoretical Roman Archaeology Conference*, ed. J. Bruhn, B. Croxford and D. Grigoropoulos, 65–78. Oxford: Oxbow Books, 2005.

Keller, Vera. "Storied Objects, Scientific Objects, and Renaissance Experiment: The Case of Malleable Glass." *Renaissance Quarterly* 70.2 (2017): 594–632.

Kenyon, G. H. *The Glass Industry of the Weald*. Leicester: Leicester University Press, 1967.

Knowles, John A. "The History of Copper Ruby Glass." *Transactions of the Newcomen Society* 6.1 (1925): 66–74.

Koinm, Albert. "Christopher Merret's Use of Experiment." *Notes and Records of the Royal Society* 54.1 (2000): 23–32.

Kremnitzer, Kathryn, and Pamela H. Smith. "Imitation Rubies and Failure in Ms. Fr. 640." In *Secrets of Craft and Nature in Renaissance France: A Digital Critical Edition and English Translation of BnF Ms. Fr. 640*, ed. Pamela H. Smith, Naomi Rosenkranz, Tianna Helena Uchacz, et al., https://www.doi.org/10.7916/7qxw-2832. New York: The Making and Knowing Project, 2020. http://edition640.makingandknowing.org.

Kunckel, Johann von Löwenstern. *Ars Vitraria Experimentalis*. Frankfurt, 1679.

Lancaster, W. T., ed. *Letters Addressed to Ralph Thoresby F.R.S.: Printed from the Originals in the Possession of the Yorkshire Archaeological Society*. Leeds: Thoresby Society, 1921.

Leong, Elaine. "Read. Do. Observe. Take Note!" *Centaurus* 60.1–2 (2018): 87–103.

Loibl, Werner. "Johann Rudolph Glauber und die 'gläsernen' Folgen." *Journal of Glass Studies* 49 (2007): 81–101.

MacGregor, Arthur, ed. *Sir Hans Sloane: Collector, Scientist, Antiquary, Founding Father of the British Museum*. London: British Museum Press, 1994.

Maclean, Ian. *Episodes in the Life of the Early Modern Learned Book*. Leiden: Brill, 2021.

MacLeod, Christine. "Accident or Design? George Ravenscroft's Patent and the Invention of Lead-Crystal Glass." *Technology and Culture* 28.4 (1987): 776–803.

MacLeod, Christine. *Inventing the Industrial Revolution: The English Patent System, 1660–1800*. Cambridge: Cambridge University Press, 1988.

Mactaggart, Peter, and Ann Mactaggart. "Refiners' Verditers." *Studies in Conservation* 25.1 (1980): 37–45.

Mádl, Martin. "Joachim Becher and the Beginnings of Baroque Glassmaking in Central Europe." In *Glass of the Alchemists*, ed. Dedo von Kerssenbrock-Krosigk, 96–105. Corning, NY: Corning Museum of Glass, 2008.

Marples, Alice. "Creating and Keeping a National Treasure: The Changing Uses of Hans Sloane's Collection in the Eighteenth Century." In *Collecting the Past: British Collectors and Their Collections from the 18th to the 20th Centuries*, ed. Toby Burrows and Cynthia Johnston, 8–24. London: Routledge, 2018.

Marples, Alice. "Scientific Administration in the Early Eighteenth Century: Reinterpreting the Royal Society's Repository." *Historical Research* 92.255 (2019): 185–204.

Marples, Alice, and Victoria Pickering. "Exploring Cultures of Collecting in the Early Modern World." *Archives of Natural History* 43.1 (2016): 1–20.

Mauck, Aaron. "'By Merit Raised to That Bad Eminence': Christopher Merrett, Artisanal Knowledge, and Professional Reform in Restoration London." *Medical History* 56.1 (2012): 26–47.

McCray, W. Patrick. *Glassmaking in Renaissance Venice*. Farnham: Ashgate, 1999.

Mentasti, Rosa Barovier, ed. *L'arte vetraria, 1612*. Milan: Edizioni il Polifilo, 1980.

Merret, Christopher. *Pinax Rerum Naturalium Britannicarum*. London, 1666.

Merrit [Merret], Christopher. "The Art of Refining, Communicated by Dr. Christopher Merrit." *Philosophical Transactions* 12 (1677): 1046–52.

*Modern Methods for Analysing Archaeological and Historical Glass*. Ed. Koen Janssens. 2 vols. Chichester: Wiley, 2013.

Moody, Brian. "The Life of George Ravenscroft: An Addendum." *Glass Technology* 30.5 (1989): 191–92.

Neri, Antonio. *L'arte vetraria*. Florence: Stamperia de'Giunti, 1612.

Neri, Antonio. *De Arte Vitraria Libri Septem*. Trans. Andreas Frisius. Amsterdam, 1668.

Neri, Antonio, and Christopher Merret. *The art of glass, wherein are shown the wayes to make and colour glass, pastes, enamels, lakes, and other curiosities*. Trans. Christopher Merret. London: A. W. for Octavian Pulleyn, 1662.

Neven, Sylvie. "Transmission of Alchemical and Artistic Knowledge in German Mediaeval and Premodern Recipe Books." In *Laboratories of Art: Alchemy and Art: Technology from Antiquity to the 18th Century*, ed. Sven Dupré, 23–51. Cham: Springer, 2017.

Newton, R. G., J. T. Brighton, and J. R. Taylor. "An Interpretation of Peckitt's Eighteenth Century Treatise on Making Glasses and the Stains for Them." *Glass Technology* 30.1 (1989): 33–38.

Noble, Michael. "The 'Invencon' of Lead Crystal—Or Was It Flint Glass?" *Journal of Glass Studies* 58 (2016): 185–95.

Ochs, Kathleen H. "The Failed Revolution in Applied Science: Studies of Industry by Members of the Royal Society of London, 1660–1688." PhD diss., University of Toronto, 1981.

Ochs, Kathleen H. "The Royal Society of London's History of Trades Programme: An Early Episode in Applied Science." *Notes and Records of the Royal Society* 39.2 (1985): 129–58.

Oldenburg, Henry. *The Correspondence of Henry Oldenburg*. 13 vols. Ed. and trans. A. Rupert Hall and Marie Boas Hall. London: Taylor & Francis, 1965–86.

*The Origins of Museums: The Cabinet of Curiosities in Sixteenth and Seventeenth Century Europe*. Ed. Oliver Impey and Arthur MacGregor. Oxford: Oxford University Press, 1985.

Paynter, Sarah, and David Dungworth. "Recognising Frit: Experiments Reproducing Post-Medieval Plant Ash Glass." In *Proceedings of the 37th International Symposium on Archaeometry*, ed. Isabella Turbanti-Memmi, 133–38. Berlin: Springer-Verlag, 2011.

Pearce, Jacqui. "Glass Waste from Broadgate, London." *Glass News* 71 (January 2017): 12–14.

Powell, Harry James. *Glass-Making in England*. Cambridge: Cambridge University Press, 1923.

*The Prehistory and History of Glassmaking Technology*. Ed. Patrick McCray. Westerville, OH: American Ceramic Society, 1998.

Principe, Lawrence M. "Slare, Frederick (1646/7–1727)." *Oxford Dictionary of National Biography*. Oxford: Oxford University Press, 2004. https://doi.org/10.1093/ref:odnb/25715.

Rijks, Marlise. "Gems and Counterfeited Gems in Early Modern Antwerp: From Workshops to Collections." In *Gems in the Early Modern World: Materials, Knowledge and Global Trade, 1450–1800*, ed. Michael Bycroft and Sven Dupré, 309–42. Cham: Palgrave Macmillan, 2019.

Schaffer, Simon. "Glass Works." In *The Uses of Experiment*, ed. David Gooding, Trevor Pinch, and Simon Schaffer, 67–104. Cambridge: Cambridge University Press, 1989.

Sloan, Kim. *A Noble Art: Amateur Artists and Drawing Masters (c.1600–1800)*. London: British Museum Press, 2000.

Sloan, Kim, and Julianna Nyhan. "Enlightenment Architectures: The Reconstruction of Sir Hans Sloane's Cabinets of 'Miscellanies.'" *Journal of the History of Collections* 33.2 (2021): 199–218.

Smedley, J. W., C. M. Jackson, and C. A. Booth. "Back to the Roots: The Raw Materials, Glass Recipes, and Glassmaking Practices of Theophilus." In *The Prehistory and History of Glassmaking Technology* (1998), 145–65.

Smith, Pamela H. *The Business of Alchemy: Science and Culture in the Holy Roman Empire*. Princeton, NJ: Princeton University Press, 1994.

Smith, Pamela H. *The Body of the Artisan: Art and Experience in the Scientific Revolution*. Chicago: University of Chicago Press, 2004.

Smith, Pamela H. "Why Write a Book? From Lived Experience to the Written Word in Early Modern Europe." *Bulletin of the German Historical Institute* 47.2 (2010): 25–50.

Smith, Pamela H., and Paula Findlen, eds. *Merchants and Marvels: Commerce, Science and Art in Early Modern Europe*. New York: Routledge, 2001.

Smith, Pamela H., Naomi Rosenkranz, Tianna Helena Uchacz, et al., eds. *Secrets of Craft and Nature in Renaissance France: A Digital Critical Edition and English Translation of BnF Ms. Fr. 640*. New York: The Making and Knowing Project, 2020. http://edition640.makingandknowing.org.

Stacpoole, Alberic, ed. *The Noble City of York*. York: Cerialis Press, 1972.

Stein, Günther. "Johann Kunckels 'Ars Vitraria' als Synthese internationalen Glaswissens im 17 Jahrhundert." *Glastechnische Berichte* 25 (1952): 411–16.

Swann, Marjorie. *Curiosities and Texts: The Culture of Collecting in Early Modern England*. Philadelphia: University of Pennsylvania Press, 2001.

Thomas, Jennifer. "Compiling 'God's great book [of] universal nature.'" *Journal of the History of Collections* 23.1 (2011): 1–13.

Thoresby, Ralph. *Musaeum Thoresbyanum*. London, 1712.

Thrill, Brian. *Waste*. London: Bloomsbury, 2017.

Thrush, Andrew. "Mansell, Sir Robert (1570/71–1652)." *Oxford Dictionary of National Biography*. https://doi.org/10.1093/ref:odnb/17992.

Turnbull, G. H. "Samuel Hartlib's Influence on the Early History of the Royal Society." *Notes and Records of the Royal Society* 10.2 (1953): 101–30.

Turnbull, Jill. *The Scottish Glass Industry, 1610–1750*. Devon: Short Run Press, 2001.

Turner, Gerard L'E. "The Government and the English Optical Glass Industry, 1650–1850." *Annals of Science* 57.4 (2000): 399–414.

Turner, W. E. S. "A Notable British Seventeenth-Century Contribution to the Literature of Glassmaking." *Glass Technology* 3.6 (1962): 201–13.

Turner, W. E. S. "The Tercentenary of Neri-Merrett's *The Art of Glass*." In *Advances in Glass Technology, Part 2*, ed. Frederick R. Matson and Guy E. Rindone, 181–201. New York: Plenum Press, 1963.

Tyler, Kieron, and Hugh Willmott. *John Baker's Late 17th-Century Glasshouse at Vauxhall*. London: Museum of London, 2005.

Van Elk, Martine. "Female Glass Engravers in the Early Modern Dutch Republic." *Renaissance Quarterly* 73.1 (2020): 165–211.

Velde, B. "Glass Compositions over Several Millennia in the Western World." In *Modern Methods* (2013), 1:67–78.

Verità, Marco. "Venetian Soda Glass." In *Modern Methods* (2013), 1:515–36.

Vickers, Michael. "Greek and Roman Antiquities in the Seventeenth Century." In *The Origins of Museums* (1985), 223–31.

Victoria and Albert Museum. *Circle of Glass Collectors, Commemorative Exhibition, 1937–62*. London: V&A, 1962. Exhibition catalogue.

Walker, Alison, Arthur MacGregor, and Michael Hunter, eds. *From Books to Bezoars: Sir Hans Sloane and His Collections*. London: British Library, 2012.

Webster, Charles. *The Great Instauration: Science, Medicine and Reform, 1626–1660*. London: Duckworth, 1975.

Wilkinson, R. S. "The Hartlib Papers and Seventeenth-Century Chemistry Part II." *Ambix* 17.2 (1970): 85–110.

Willmott, Hugh. *Early Post-Medieval Vessel Glass in England, c. 1500–1670*. York: Council for British Archaeology, 2002.
Willmott, Hugh. *A History of English Glassmaking, AD 43–1800*. Stroud: Tempus, 2005.
Young, John T. *Faith, Medical Alchemy and Natural Philosophy*. Farnham: Ashgate, 1998.
Zecchin, Luigi. "Il libro di Prete Neri." *Vetro e Silicati* 7.42 (1963): 17–20.