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Small Mites for the Treasury of Learning: The Everyday Life of the New Science in Late Seventeenth-Century London

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Small Mites for the Treasury of Learning:

The Everyday Life of the New Science in Late Seventeenth-Century London

A dissertation submitted in partial satisfaction

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in History

by

Laura Ritchie Morgan

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ABSTRACT OF THE DISSERTATION

Small Mites for the Treasury of Learning:

The Everyday Life of the New Science in Late Seventeenth-Century London

by

Laura Ritchie Morgan

Doctor of Philosophy in History

University of California, Los Angeles, 2016

Professor Margaret C. Jacob, Chair

Drawing on experimental notebooks, account books, estate inventories, and bureaucratic memoranda, this dissertation demonstrates that the investigation and manipulation of the natural world in Restoration London stretched beyond the well-known Royal Society. The Society relied on skills, labor, and unexpected expertise outside its Fellowship to shape its work, while skills valued by the Society's Fellows were found in pre-existing industries. In addition, the experimentation, observation, and collection practices essential to the new science occurred in small shops, Royal palaces, and the streets of metropolis.

Chapter Two argues that the Society's first home at Gresham College was an uncontrolled space, neither public nor private, through which many Londoners moved. While some servants, craftspeople, and experts were invited in to contribute skill or labor, the experience and knowledge outsiders unexpectedly brought into the Society, the College, or London itself also influenced the questions investigated by the Society.

Chapter Three is a detailed examination of apothecary John Conyers's years-long efforts to disprove the theory of air pressure by observing changes in atmospheric moisture. Conyers's commitment to the explanatory power of Galenic humoral theory and aspects of Aristotelian physics, while simultaneously embracing observation, experiment, and basic mechanism, demonstrate that the ideas of the new science were accepted in piecemeal amalgamation with older theories.

Chapter Four reconstructs Conyers's collections of curiosities, antiquities, and *naturalia* and argues that the formation of such small-scale collections involved people and locations across the social spectrum. In Restoration London, collecting objects of curiosity, antiquity, or natural history intersected seamlessly with existing local commercial routines and the chance discoveries unearthed in a city constantly under construction.

Chapter Five examines the importance of practical natural knowledge for the Restoration Royal Mint. The production of dependable English coinage relied on mathematical, chymical, and technological skills, but the work of the Royal Mint did not attract attention from devotees of the new science. Chymically minded Fellows of the Royal Society simultaneously spoke of embracing learning from those with manual experience, and dismissed the skills practical metalworkers had to offer, obscuring the similarities between laboratories of the virtuosi and workshops at the Mint.

The dissertation of Laura Ritchie Morgan is approved.

Mary Terrall

Lynn A. Hunt

Deborah Harkness

Margaret C. Jacob, Committee Chair

University of California, Los Angeles

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In memory of Robert M. Ritchie.

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The Wellcome Collection, and the Mercer's Company Archive. Particular thanks to LMA staff, who possessed infinite patience and good humor as they searched through many boxes of rolled inventories to find the ones I was interested in. The library staff at Charles Young Research Library at UCLA and at the Bibliotheque National de France in Paris made it easy to find any secondary source I could imagine, even far away from the British Isles.

I was fortunate to be surrounded by a love of reading, learning, and writing from birth. To every teacher who encouraged my love of reading and writing and erudition along the way, and to all the family and friends who have supported me from afar, I send my thanks. Especially important has been my mother, Carolyn, who not only imparted her love of the written word to me, but who also enjoyed reading even some less-than-coherent dissertation drafts. My sister Ruth Ann has inspired me through her own accomplishments and, in her love of travel, reminded me of the importance of looking around *outside* the archives from time to time. Karola Kirsanow's conversation, companionship, and encouragement across many years and many countries have been invaluable. Most importantly, my husband, Stuart, has supported my dissertation in every way imaginable. He's known when to free me from distractions and when to encourage me to take a break. He's endured long separations, read drafts, listened to monologues about the 17th century, made cocktails, and offered friendly reminders about the power of outlines. Above all, the constancy of his support, his belief in me, and his willingness to do whatever needed to be done so that I could finish this dissertation has helped buoy me up in times of doubt, enabling me to reach the end. I couldn't have had a better partner on this journey.

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Chapter 1

Introduction

When London apothecary John Conyers began composing a treatise on magnetism in the 1670s, he acknowledged that he was approaching a "difficult" topic on which others were far more expert. Nevertheless, he wrote that he had something new to contribute, and so dared to "offer my small mite into the Treasury of the Learning of this kind."[1] Such expressions of authorial modesty were common tropes amongst Restoration authors, including those writing on the new experimental natural philosophy, a literature with which Conyers was undoubtedly familiar. Conyers's phrase, however, also suggested that he believed he was one of many contributors to a cooperative compilation of valuable new knowledge, and that his personal observations of magnetic phenomena would add, in a small but significant way, to a growing collection of information about the workings of the natural world.

Language about the collaborative study of nature was widespread in the elite circles around the Royal Society of London, founded in 1660 to "promot[e] by the authority of experiments the sciences of natural things and of useful arts."[2] The Society's apologist Thomas Sprat employed this language in his 1667 *The History of the Royal Society*, extolling the virtues of a collective approach to studying nature. Embracing Francis Bacon's idea of a cooperative investigation of nature, Sprat claimed that the study of nature would benefit from employing many hands. By removing the study of the natural world and useful arts from the control of university-based Aristotelian philosophers, the Royal Society, argued Sprat, would make great

[1] John Conyers. British Library (hereafter BL) Sloane MS 852, 17th cent., The Natural History of the Loadstone, 30r. This draft is not dated, but the vast majority of Conyers natural philosophical work found throughout his notebooks date from the 1670s. Further discussion of Conyers can be found below in Chapters 3 and 4.

[2] Translation of First Charter, Granted to the President, Council, and Fellows of the Royal Society of London, by King Charles the Second, A.D. 1662, (https://royalsociety.org/about-us/governance/charters/, Accessed December 4, 2015).

progress by "by distributing the burden" of studying nature.[3] The varied professions of the men that formed the Fellowship would bring in a variety of perspectives and knowledge, while helping to guard against the biases of any particular interests. The Society, Sprat wrote had "shew'n to the World this great secret, That Philosophy ought not only to be attended by a select company of refin'd Spirits….They exact no extraordinary praeparations of Learning: to have sound Senses and Truth, is with them a sufficient Qualification. Here is enough business for Minds of all sizes: And so boundless is the variety of these Studies, that here is also enough delight to recompence the Labors of them all, from the most ordinary capacities, to the highest and most searching Wits."[4]

Despite these rhetorical flourishes, the organization Sprat depicted was not notable for the diversity of its membership, and the early Fellows themselves varied in their desire to interact with "Minds of all sizes" outside of a fairly restrictive social milieu.[5] Gentlemanly social norms shaped the way the Society and its Fellows determined who was considered to have "sound Senses" and access to true experience, creating a printed record of their studies that emphasized contributions by men of a certain standing, and eliding the contributions of others.[6] The emphasis in the new natural philosophy on rejecting ancient texts and basing natural knowledge on first hand experience of the world meant that access to the kinds of facts and experiences sought by the Fellows was not confined to their circles. While John Conyers, as will be discussed in

[3] Thomas Sprat, *The History of the Royal Society of London for the Improving of Natural Knowledge* (London: Printed by T. R. for J. Martyn and J. Allestry, 1667), 435.

[4] Ibid.

[5] The early membership is analyzed most extensively in Michael Cyril William Hunter, *The Royal Society and Its Fellows, 1660-1700 : The Morphology of an Early Scientific Institution*, BSHS Monographs 4 (Chalfont St. Giles, Bucks, England: British Society for the History of Science, 1982).

[6] Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England*, Science and Its Conceptual Foundations (Chicago: University of Chicago Press, 1994).

Chapters 3 and 4, was connected to the fringes of the Society, manipulating nature—either experimentally or in the pursuit of the practical arts—and collecting observations and natural specimens were activities pursued by many in Restoration London.

This dissertation begins to answer two different, but interrelated, questions: *who* was studying the natural world in London between 1660 and 1700, and *where* within the city were they doing it? As I will show, the cast of characters associated with the pursuit of natural knowledge in late 17th century London was larger than has been depicted in the literature. Simultaneously, these investigations took place in a broader array of locations than the historiography usually depicts. The people and places associated with the new experimental science were contingent and fluctuating, tied strongly—despite rhetoric of newness—to preexisting institutions and social structures, and to the uncertainty associated with adapted and non-purpose built locations.

Those in London who pursued the new science—both inside and outside the Royal Society—found their investigations shaped by their urban environment. While pre-existing organizations—guilds, commercial centers, government departments—concentrated certain skills and resources within the city, urban life in the late 17th century was not pre-designed for the easy study of nature. Carving out a new enterprise in the Restoration and beyond, Fellows, virtuosi, curious investigators, and artisans of all kinds regularly contended with the messy, chaotic, dangerous, and happenstance nature of life in a growing metropolis, often squeezing experiment, observation, and collection into spaces designed for, and sometimes simultaneously used for, other pursuits. Activities, spaces, hazards, and developments unrelated to the new science provided unplanned opportunities for unexpected experiments, observations, or inventions.

The historiography concerned with science in late seventeenth-century England is, of course, extensive. Historians of science searching for the roots of modern practice have been drawn to the study of the Royal Society of London, seeing in this institution a direct predecessor of today's centralized, institutionalized science. While modern historiography has done much to complicate the triumphalist view of the Royal Society presented in Sprat's official statement, much of the study of science in Restoration England continues to focus on the work of the largely gentlemanly Fellows.[7] The organization's survival to the present day (foreshadowing the formation of today's many scientific organizations), the wealth of archival material pertaining to the Society and individual Fellows, and the undeniable importance of work by such 17th century Fellows as Robert Boyle and Isaac Newton, make such an emphasis understandable and warranted.

In emphasizing the new organization, however, historians of science have failed to adequately appreciate the ways in which the study of nature in late 17th century London was connected with aspects of early modern urban life, and the particularities of London itself. The Royal Society as an organization, its individual Fellows, and others in London who pursued similar interests in the natural world, found their work shaped by forces outside of scientific questions. Many scholars have examined the ways in which the Society's supporters positioned themselves in response to the significant religious and political questions facing Restoration England; far less attention has been paid to the impact of smaller scale details of living and

[7] See for example, P.W. Wood, "Methodology and Apologetics: Thomas Sprat's *History of the Royal Society*," *British Journal for the History of Science* 13, no. 43 (1980); John Morgan, "Science, England's 'Interest' and Universal Monarchy: The Making of Thomas Sprat's *History of the Royal Society*," *History of Science* xlvii (2009); John Morgan, "Religious Conventions and Science in the Early Restoration: Reformation and 'Israel' in Thomas Sprat's *History of the Royal Society* (1667)," *The British Journal for the History of Science* 42, no. 3 (2009); Tina Skouen, "Science Versus Rhetoric? Sprat's *History of the Royal Society* Reconsidered," *Rhetorica: A Journal of the History of Rhetoric* 29, no. 1 (2011); William Lynch, *Solomon's Child: Method in the Early Royal Society of London* (Stanford, California: Stanford University Press, 2001), chapter 5.

working in 17th century London. How those factors affected experimental questions and procedures, the formation of collections, access to skilled and unskilled labor, and the spaces of and participants in the new science have yet to be fully studied.

Previous generations of historians have thoroughly explored the institutional and ideological origins of the Society, demonstrating the influence of both Oxford- and London-based Interregnum circles, and the complex influences and interpretations of Bacon's thought on the vision and actions of the early Society.[8] Studies focusing on the "baconianisms" of the early Royal Society explored questions of the methodologies adopted by the Society in rhetoric and in practice during its early years, highlighting both shared commitments and divergent approaches.[9]

Prior historians have also examined the religious and political orientation of the new science, particularly in debates over the ideology of the early Royal Society. In the 1660's, the upheavals and radical ideas of the previous decades were fresh in the memories of all Londoners, and the shape of the political and religious restoration was in flux. In this environment, everything could be political, including natural philosophy and experimental science, and historians have shown the ways in which advocacy of the new science was tied up with broader social, religious, and political visions by many of the early Fellows. While Sprat's *History* placed the new organization's roots in a gathering of those seeking freedom from the "passions and

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[8] Thomas Birch, *The History of the Royal Society of London for Improving of Natural Knowledge, from Its First Rise.* (London: Printed for A. Millar, 1756) (hereafter Birch, *History*, volume: page) ; Francis R. Johnson, "Gresham College: Precursor of the Royal Society," *Journal of the History of Ideas* 1, no. 4 (1940); Marie Boas Hall, *Henry Oldenburg : Shaping the Royal Society* (Oxford ; New York: Oxford University Press, 2002); Charles Richard Weld, *A History of the Royal Society with Memoirs of the Presidents : Compiled from Authentic Documents*, 2 vols. (London: J.W. Parker, 1848); A. Rupert Hall and Marie Boas Hall, "The Intellectual Origins of the Royal Society. London and Oxford," *Notes and Records of the Royal Society of London* 23, no. 2 (1968); Dorothy Stimson, *Scientists and Amateurs; a History of the Royal Society* (New York,: H. Schuman, 1948); Margery Purver, *The Royal Society: Concept and Creation* (Cambridge: M.I.T. Press, 1967); Charles Webster, "The Origins of the Royal Society," *History of Science* 6 (1967).

[9] Lynch, *Solomon's Child*; Marie Boas Hall, *Promoting Experimental Learning: Experiment and the Royal Society 1660-1727* (Cambridge England ; New York: Cambridge University Press, 1991).

madness" of the political and religious debates of the 1640s, many scholars have explored ideological roots of the Royal Society and its early Fellows, demonstrating the integral place that natural philosophy held in a broader social, economic, political, and religious vision of England's future.[10] For many Restoration elites, the study of nature in 17th century England was fundamentally linked to both epistemological questions indissoluble from the religious debates of the day, and social questions inseparable from the political uncertainties lingering after decades of civil war and unsettled government. Whether the Royal Society possessed a clear corporate purpose is more difficult to understand. While Fellows argued for their new group's orthodoxy, loyalty, and stabilizing influence, the diversity of religious and political backgrounds among the Fellows created competing visions of how the Society should pursue its work, and even what kinds of work to which the organization should dedicate itself. [11]

In addition to works focused on the Society as an institution, previous scholars have devoted considerable attention to the work of individual Fellows. Recent work on Robert Boyle (including the publishing of new critical editions of his *Correspondence* and his collected *Works*)

[10] James R. Jacob, *Robert Boyle and the English Revolution : A Study in Social and Intellectual Change*, Studies in the History of Science (New York: B. Franklin, 1977); James R. Jacob and Margaret C. Jacob, "The Anglican Origins of Modern Science: The Metaphysical Foundations of the Whig Constitution," *Isis* 71, no. 2 (1980); Margaret C. Jacob, *The Newtonians and the English Revolution, 1689-1720* (Ithaca, N. Y.: Cornell Univ. Press, 1976); B. J. Shapiro, "Latitudinarianism and Science in Seventeenth-Century England," *Past & Present*, no. 40 (1968); Christopher Hill, "Puritanism, Capitalism and the Scientific Revolution," *Past & Present,* no. 29 (1964); Christopher Hill, *Intellectual Origins of the English Revolution* (Oxford: Clarendon Press, 1965); Lotte Mulligan, "Civil War Politics, Religion and the Royal Society," *Past & Present,* no. 59 (1973); Michael Hunter, "Latitudinarianism and the 'Ideology' of the Early Royal Society: Thomas Sprat's *History of the Royal Society* (1667) Reconsidered," in *Establishing the New Science: The Experieince of the Early Royal Society* (Woodbridge, Suffolk: The Boydell Press, 1989).

[11] Michael Cyril William Hunter, *Science and Society in Restoration England* (Cambridge: Cambridge University Press, 1981); Michael Cyril William Hunter, *Establishing the New Science : The Experience of the Early Royal Society* (Woodbridge, Suffolk: Boydell Press, 1989); Michael Cyril William Hunter, *Science and the Shape of Orthodoxy : Intellectual Change in Late Seventeenth-Century Britain* (Woodbridge, Suffolk, UK ; Rochester, NY, USA: Boydell Press, 1995). Michael Cyril William Hunter and Paul B. Wood, "Towards Solomon's House: Rival Strategies for Reforming the Early Royal Society," in *Establishing the New Science : The Experience of the Early Royal Society* (Woodbridge, Suffolk: The Boydell Press, 1989). Hunter, *Royal Society and Its Fellows*; J. R. Jacob, "Restoration Ideologies and the Royal Society," *History of Science* 13 (1980).

has expanded our understanding of his complex interests and motivations, contributing to a new emphasis on understanding the alchemical interests and religious motivations of 17th century English scientists.[12] Robert Hooke, the Society's long-time Curator of Experiments, has received recent historical scrutiny, resulting in a new appreciation for his work in many areas, including his involvement in the rebuilding of London after the Great Fire.[13] Recent work on Isaac Newton's study of alchemy, chronology, and theology have added to and complicated earlier interpretations of his natural philosophy.[14] Additionally, historians of this period now benefit

[12] Jan W. Wojcik, *Robert Boyle and the Limits of Reason* (New York: Cambridge University Press, 1997); Rose-Mary Sargent, *The Diffident Naturalist: Robert Boyle and the Philosophy of Experiment*, Science and Its Conceptual Foundations (Chicago: University of Chicago Press, 1995); Michael Hunter, *Boyle: Between God and Science* (New Haven: Yale University Press, 2009); Michael Hunter, *Robert Boyle Reconsidered* (Cambridge; New York: Cambridge University Press, 1994); Michael Hunter, *Robert Boyle, 1627-91: Scrupulosity and Science* (Woodbridge England; Rochester, N.Y.: Boydell Press, 2000); Lawrence Principe, *The Aspiring Adept : Robert Boyle and His Alchemical Quest: Including Boyle's "Lost" Dialogue on the Transmutation of Metals* (Princeton, N.J.: Princeton University Press, 1998); Jacob, *Robert Boyle and the English Revolution: A Study in Social and Intellectual Change*.

[13] Michael Hunter and Simon Schaffer, eds., *Robert Hooke: New Studies* (Woodbridge [England] ; Wolfeboro, N.H., USA: Boydell Press, 1989); Jim Bennett et al., *London's Leonardo: The Life and Work of Robert Hooke* (Oxford ; New York: Oxford University Press, 2003); Lisa Jardine, *The Curious Life of Robert Hooke: The Man Who Measured London* (New York: HarperCollins, 2004); Allan Chapman, *England's Leonardo: Robert Hooke and the Seventeenth-Century Scientific Revolution* (Bristol; Philadelphia: Institute of Physics, 2005); Michael Cooper and Michael Hunter, eds., *Robert Hooke: Tercentennial Studies* (Aldershot, England ; Burlington, Vt.: Ashgate, 2006); Paul Kent and Allan Chapman, eds., *Robert Hooke and the English Renaissance* (Leominster, Herefordshire: Gracewing, 2005); M. A. R. Cooper, *A More Beautiful City: Robert Hooke and the Rebuilding of London after the Great Fire* (Stroud, Gloucestershire: Sutton, 2003); Matthew C. Hunter, *Wicked Intelligence: Visual Art and the Science of Experiment in Restoration London* (Chicago; London: The University of Chicago Press, 2013). M. A. R. Cooper, "Robert Hooke's Work as Surveyor for the City of London in the Aftermath of the Great Fire. Part One: Robert Hooke's First Surveys for the City of London," *Notes and Records of the Royal Society of London* 51, no. 2 (1997); M. A. R. Cooper, "Robert Hooke's Work as Surveyor for the City of London in the Aftermath of the Great Fire. Part Three: Settlement of Disputes and Complaints Arising from Rebuilding," *Notes and Records of the Royal Society of London* 52, no. 2 (1998); M. A. R. Cooper, "Robert Hooke's Work as Surveyor for the City of London in the Aftermath of the Great Fire. Part Two: Certification of Areas of Ground Taken Away for Streets and Other New Works," *Notes and Records of the Royal Society of London* 52, no. 1 (1998).

[14] Richard S. Westfall, *Never at Rest : A Biography of Isaac Newton* (Cambridge Eng.; New York: Cambridge University Press, 1980); Betty Jo Teeter Dobbs, *The Foundations of Newton's Alchemy: Or, "the Hunting of the Greene Lyon"* (Cambridge; New York: Cambridge University Press, 1975); Betty Jo Teeter Dobbs, *The Janus Faces of Genius: The Role of Alchemy in Newton's Thought* (Cambridge; New York: Cambridge University Press, 1991); Isaac Newton, *The Correspondence of Isaac Newton*, 7 vols. (Cambridge Eng.: Published for the Royal Society at the University Press, 1959); Stephen D. Snobelen, "Isaac Newton, Heretic: The Strategies of a Nicodemite," *British Journal for the History of Science* 32, no. 4 (1999); Stephen D. Snobelen, "'God of Gods, and Lord of Lords'": The Theology of Isaac Newton's General Scholium to the Principia," *Osiris* 16, no. Science in Theistic Contexts: Cognitive Dimensions (2001); Stephen D. Snobelen, "'A Time and Times and the Dividing of Time': Isaac Newton, the Apocalypse, and 2060 A.D.," *Canadian Journal of History* 38 (2003); James E. Force and Sarah Hutton, *Newton*

from an increasing number of scholarly editions of the correspondence of Fellows of the early Society and biographical studies of both famous and less well-known Fellows.[15]

Even as the questions asked by historians of science have changed in recent decades, reflecting the influences of approaches from anthropology and sociology, the scholarship on English science in the 17th century often continues to center on the Royal Society. Shapin and Schaffer's *Leviathan and the Air-Pump* (1985), while raising questions about the nature of scientific truth, remained focused on the Royal Society through their analysis of a dispute between Boyle and Thomas Hobbes.[16] Shapin's subsequent book, *A Social History of Truth* (1994), traced the origin of some of the fundamental characteristics of modern science to the particular socio-political environment of Restoration London, locating the trustworthiness of objective knowledge in a fundamentally gentlemanly ethos of the later 17th century, the class of most early Fellows.[17] Thus, these works influenced by the social studies of science remained rooted in the focus on the social classes and institutional structures that were investigated by

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and Newtonianism: New Studies, Archives Internationale D'histoire Des Idées = International Archives of the History of Ideas (Dordrecht ; Boston: Kluwer Academic Publishers, 2004); Jed Z. Buchwald and Mordechai Feingold, *Newton and the Origin of Civilization* (Princeton ; Oxford: Princeton University Press, 2013). See also The Newton Project at http://www.newtonproject.sussex.ac.uk/.

[15] Henry Oldenburg, *Correspondence. Edited and Translated by A. Rupert Hall & Marie Boas Hall* (Madison: University of Wisconsin Press, 1965); Robert Boyle, Michael Cyril William Hunter, and Edward Bradford Davis, *The Works of Robert Boyle*, 14 vols. (London; Brookfield, Vt.: Pickering & Chatto, 1999); Robert Boyle, *The Correspondence of Robert Boyle* (London; Burlington, Vt.: Pickering & Chatto, 2001); John Wallis, *The Correspondence of John Wallis,* ed. Christoph J. Scriba, 2 vols. (Oxford; New York, Oxford University Press, 2003-2005); John Locke, *The Correspondence of John Locke*, ed. E. S. De Beer, 8 vols. (Oxford: Clarendon Press, 1976-1989); Frances Willmoth, *Sir Jonas Moore: Practical Mathematics and Restoration Science* (Woodbridge, Suffolk, UK; Rochester, NY, USA: Boydell Press, 1993); Ted McCormick, *William Petty and the Ambitions of Political Arithmetic* (Oxford: Oxford University Press, 2009).

[16] Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life: Including a Translation of Thomas Hobbes, Dialogus Physicus De Natura Aeris by Simon Schaffer* (Princeton, N.J.: Princeton University Press, 1985).

[17] Shapin, *Social History of Truth*.

earlier scholars, even as they raised new questions for the field about the forces that shaped who counted as trustworthy observers, workers, thinkers, and writers, and in what environments.[18]

In keeping with another recent trend in the field, historians of early modern science have begun to pay greater attention to the physical manipulation of nature essential to scientific practice. Scholars now turn their attention to describing, collecting, instrument making, printing, as well as detailed examinations of experimental and observational work. Studies by historians of Continental early modern science, such as Paula Findlen, Pamela Smith, Tara Nummedal, Harold Cook, and others, have shown the importance of such activities in fields from natural history to medicine, and from chymistry to the decorative arts.[19] Scholars working on Restoration England have produced detailed analyses of how scientific materials made it into print, the skills and techniques behind the production of scientific images, the work of mathematical instrument makers, the interchange of skills between mechanical artisans and virtuosi, and the ways in which modes of gathering and organizing information drew on techniques from the mercantile, artistic, and architectural worlds.[20]

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[18] Steven Shapin, "The House of Experiment in Seventeenth-Century England," *Isis* 79, no. 3 (1988); Shapin, *Social History of Truth*; Steven Shapin, "The Invisible Technician," *American Scientists* 77, no. 6 (1989); Shapin and Schaffer, *Leviathan and the Air-Pump*; Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago, Ill.: University of Chicago Press, 1998).

[19] See, for example, Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley; London: University of California Press, 1994); Harold John Cook, *Matters of Exchange: Commerce, Medicine, and Science in the Dutch Golden Age* (New Haven, Conn.; London: Yale University Press, 2007). Pamela H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004); Pamela H. Smith and Paula Findlen, *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe* (New York ; London: Routledge, 2001); Tara Nummedal, *Alchemy and Authority in the Holy Roman Empire* (Chicago: The University of Chicago Press, 2007).

[20] R. G. W. Anderson, et al., *Making Instruments Count: Essays on Historical Scientific Instruments Presented to Gerard L'estrange Turner* (Aldershot: Variorum, 1993); James A. Bennett, "Shopping for Instruments in Paris and London," in *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe*, ed. Pamela H. Smith and Paula Findlen (New York: Routledge, 2002); J. A. Bennett, "The Mechanics' Philosophy and the Mechanical Philosophy," *History of Science* 24, no. 1 (1986); Rob Iliffe, "'In the Warehouse': Privacy, Property and Priority in the Early Royal Society," ibid. 30 (1992); Rob Iliffe, "Material Doubts: Hooke, Artisan Culture and the Exchange of Information in 1670s London," *The British Journal for the History of Science* 28, no. 3 (1995); Hunter, *Wicked Intelligence*. Other works on visual culture and the early Royal Society include Anna Marie Roos, "The Art of

Similarly, historians of science working in all periods have recently begun to challenge the idea of the universal nature of scientific knowledge and practices, through attention paid to the detailed, contingent, and site-specific conditions necessary for the production and transmission of scientific techniques and scientific knowledge.[21] For scholars at work on the history of science in early modern Europe, recent scholarship has explored the many sites of knowledge production, showing that practices such as collecting, describing, and experimenting could be found in museums, courts, merchant companies, and artisanal workshops of all sorts.[22] As Lissa Roberts and Simon Schaffer observed in the recent collection *The Mindful Hand*, "[k]nowledge was made in contexts of application, disciplines were fluid, work took place across many social sites, [and] there was pervasive reflection on the grounds of knowledge in the process of making knowledge."[23] Similarly, historians who have worked on women in science have also broadened the definition of science to include not only the activities of the laboratory, the university, and the scientific society, but also those of the kitchen, still room, and household.[24] Steven Shapin, Deborah Harkness, Jim Bennett, and others have explored the

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Science: A 'Rediscovery' of the Lister Copperplates," *Notes and Records of the Royal Society of London* 66 (2013); Sachiko Kusukawa, "The *Historia Piscium* (1686)," ibid. 54 (2000); Sachiko Kusukawa, "Picturing Knowledge in the Early Royal Society: The Examples of Richard Waller and Henry Hunt," ibid. 65 (2011); Sachiko Kusukawa, "Drawings of Fossils by Robert Hooke and Richard Waller," ibid. 67 (2013); Matthew C. Hunter, "Hooke's Figurations: A Figural Drawing Attributed to Robert Hooke," ibid. 64 (2010); Meghan C. Doherty, "Discovering the 'True Form:' Hooke's *Micrographia* and the Visual Vocabulary of Engraved Portraits," ibid. 66 (2012).

[21] David N. Livingstone, *Putting Science in Its Place: Geographies of Scientific Knowledge*, Science Culture (Chicago: University of Chicago Press, 2003). See also Part II: "Personae and Sites of Natural Knowledge" in Katharine Park and Lorraine Daston, eds., *Early Modern Science*, vol. 3, The Cambridge History of Science (Cambridge; New York: Cambridge University Press, 2006); *British Journal for the History of Science* 38, no. 1: Historical Geographies of Science (2005).

[22] Findlen, *Possessing Nature*; Cook, *Matters of Exchange*. Smith, *Body of the Artisan*; Smith and Findlen, *Merchants and Marvels*; Nummedal, *Alchemy and Authority in the Holy Roman Empire*.

[23] Lissa Roberts and Simon Schaffer, "Preface," in *The Mindful Hand : Inquiry and Invention from the Late Renaissance to Early Industrialisation*, ed. Lissa Roberts, Simon Schaffer, and Peter Dear (Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen, 2007), xix.

[24] Deborah E. Harkness, "Managing an Experimental Household: The Dees of Mortlake and the Practice of Natural Philosophy," *Isis* 88, no. 2 (1997); Alix Cooper, "Homes and Households " in *The Cambridge History of Science:*

different modes of knowledge production and transmission found within gentlemen's houses and laboratories, coffee houses, and instrument makers' shops in England.[25] Most extensively, Deborah Harkness studied the City of London in *The Jewel House* (2007), where she argued that Elizabethan London was home to vibrant communities of natural historians, medical practitioners, mathematicians, manufacturers, alchemists, and instrument makers who together created the "social foundations of England's 17th century Scientific Revolution."[26]

While continuing to recognize the importance of canonical figures and early institutions, historians of early modern science have, in recent years, begun to expand the areas studied by our field.[27] Recognizing the weakness of modern scientific disciplinary distinctions, the history of science now boasts thriving subfields in the history of alchemy and natural history, for example. Just as the disciplines (and their associated practices) have expanded, so have the cast of characters considered appropriate objects of study by historians of early modern science. The study of early modern science now encompasses not only Copernicus and Newton, but mathematical instrument makers, printers and engravers, and alchemists. As the field pays

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Volume 3: Early Modern Science, ed. Katharine Park and Lorraine Daston (Cambridge; New York: Cambridge University Press, 2006); Lynette Hunter and Sarah Hutton, *Women, Science and Medicine 1500-1700: Mothers and Sisters of the Royal Society* (Thrupp, Stroud, Gloucestershire: Sutton Pub., 1997); Londa L. Schiebinger, *The Mind Has No Sex?: Women in the Origins of Modern Science* (Cambridge, Mass.: Harvard University Press, 1989).

[25] Shapin, "The House of Experiment"; Cooper, "Homes and Households "; Harkness, "Managing an Experimental Household."; Bennett, "Shopping for Instruments in Paris and London."; Bennett, "The Mechanics' Philosophy and the Mechanical Philosophy."; E. G. R. Taylor, *The Mathematical Practitioners of Tudor & Stuart England* (Cambridge: Published for the Institute of Navigation at the University Press, 1954); Joyce Brown, *Mathematical Instrument-Makers in the Grocers' Company, 1688-1800: With Notes on Some Earlier Makers* (London: Science Museum, 1979). For coffeehouses in a slightly later period see Larry Stewart, "Other Centres of Calculation, or, Where the Royal Society Didn't Count: Commerce, Coffee-Houses and Natural Philosophy in Early Modern London," *The British Journal for the History of Science* 32, no. 2 (1999); Larry R. Stewart, *The Rise of Public Science : Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660-1750* (Cambridge England ; New York, N.Y.: Cambridge University Press, 1992); Brian Cowan, *The Social Life of Coffee: The Emergence of the British Coffeehouse* (New Haven: Yale University Press, 2005), chapters 4 and 5.

[26] Deborah E. Harkness, *The Jewel House: Elizabethan London and the Scientific Revolution* (New Haven: Yale University Press, 2007), 10.

[27] Park and Daston, "Introduction: The Age of the New."

greater attention to natural history and the techniques it used, collectors, illustrators, and anatomists have gained new importance to our understanding of who studied nature in early modern Europe.[28]

Within England, Harkness's examination of Elizabethan London revealed a world of "vernacular practitioners" who were all involved in examining the natural world.[29] Charles Webster's *The Great Instauration* illuminated the variety of people concerned with science, medicine, and natural philosophy during the Interregnum, particularly in the circles around the reformer and intelligencer Samuel Hartlib.[30] For the Restoration period, work on Robert Hooke has expanded the list of scientifically minded Englishmen. Hooke's ability to interact with mathematical instrument makers, workmen, government officials, and gentlemen of all stripes has provided historians an *entrée* into understanding the broader mathematical and scientific communities of early modern London.[31] Most recently, Matthew Hunter's *Wicked Intelligence* embraced an expansive vision of Restoration science, highlighting the connections between the worlds of the visual arts and architecture, and the "craft and craftiness materialized in experimental visual practice."[32]

While the trends discussed above have added immeasurably to our understanding of early modern English science, and early modern science in general, the literature often remains concerned with the major figures and significant changes in the ways nature was studied and

[28] See the essays in Part 2: "Personae and Sites of Natural Knowledge" in Park and Daston, *Early Modern Science*. Anita Guerrini, *The Courtiers' Anatomists: Animals and Humans in Louis XIV's Paris* (Chicago: The University of Chicago Press, 2015).

[29] Harkness, *The Jewel House*, 260.

[30] Charles Webster, *The Great Instauration: Science, Medicine and Reform, 1626-1660* (London: Duckworth, 1975).

[31] For example: Iliffe, "'In the Warehouse'"; Iliffe, "Material Doubts."

[32] Hunter, *Wicked Intelligence*, 7.

thought about in this period. Although there may not have been a "scientific revolution," the continuing focus on the Royal Society and its Fellows has created an emphasis on *newness*—on the ways in which many virtuosi sought to separate themselves from both earlier knowledge paradigms and the business-as-usual artisanal and mechanical practices around them.[33] In contrast, this dissertation is focused on illuminating the intricate, seemingly trivial, details involved in pursuing the new science and studying nature in late 17th century London, details that often were the same for those wanting to reform natural knowledge as for those unconcerned with such philosophical questions. While the early years of the Society are often seen as being full of the failures of the Fellows to realize their vision, I would argue that the aborted projects, diversity of interests, and struggle for support found throughout the Society's early minutes were functions of the difficulties of forming a new organization out of members with diverse interests, and an inevitable result of life in an early modern city.[34] Both inside and outside the Society, investigating nature was dependent on a whole host of circumstances that are often lost in our analyses of this period. In focusing on the often mundane details of the movement of people around Gresham College and the Royal Society, in the daily weather logs of a little-known apothecary, the accidental and commercial processes necessary to create a collection, and the complicated relationship between Crown goals, moneyer's skills, and licit and illicit metallurgical knowledge, this dissertation contributes to the project of understanding how nature was investigated, where these investigations took place, by whom, and for what purposes in late 17th century England. Questions of natural philosophy and Baconian utility were one part of the picture, but this study shows that other factors could play significant roles as well—chance

[33] Steven Shapin, *The Scientific Revolution* (Chicago, Ill.: University of Chicago Press, 1996); Margaret J. Osler, *Rethinking the Scientific Revolution* (Cambridge, U.K. ; New York: Cambridge University Press, 2000).

[34] Peter Dear, "Totius in Verba: Rhetoric and Authority in the Early Royal Society," *Isis* 76 (1985): 147.

encounters with a person of specific expertise, the skills learned in one's occupational training, monumental disasters, and basic economic survival could all play a part in how nature was investigated and natural materials manipulated in the post-Restoration London area. Like Harkness in *The Jewel House*, I am concerned with "minor vernacular figures" in London, but I am less concerned with the social *foundations* of any revolutionary work in this period than with the social *extent* of interest and involvement in the study and manipulation of nature associated with the new science.[35]

In keeping with a number of recent studies, I intentionally set out to explore these questions without restriction to a specific science or a specific practice. To that end, my dissertation includes discussion of some traditional early modern scientific topics such as the study of air pressure and the tension between Galenic and chemical/Paracelsian medicine, but it also touches on metallurgy, antiquities, vivisection and natural history. In keeping with the wide range of topics discussed, the following chapters introduce a wide range of characters; to the highly educated, frequently multilingual, elite who composed most of the Royal Society's Fellowship, I add figures stretching from illiterate laborers to moderately Latinate apothecaries. With the expansion of practices, sites, and people studied by our field, historians are faced with the difficulty of naming the activities of those who did not think of their actions in terms of the divisions of classical learning, who would not have thought of themselves as doing "natural philosophy" for example. As Roberts and Schaffer observed, distinctions between philosophy, science and technology are difficult to make in the early modern period, given that "[i]ngenuity, know-how and sets of skills mattered in studios and libraries, workshops and markets, courts and

[35] Harkness, *The Jewel House*, 6, 10.

mills" and that doing and thinking were intertwined in complex, historically contingent ways.[36] It is impossible to fix upon one term, such as "science" or "natural philosophy" to describe the activities of this increased spectrum of practitioners. I will employ the phrases "the new science" and "experimental philosophy" to refer to the approach of studying nature through experimentation (broadly understood) as embraced most famously by the Royal Society. "Natural philosophy" will be used where appropriate, but in general I will use more subject-specific terms to describe the investigations and manipulations discussed in this dissertation.[37]

Chapter Two of this dissertation will situate the early Royal Society in the chaotic, ever-changing world of Restoration London. While the group proposed a new approach to learning about the world and discovering useful knowledge, the Society and its members were subject to and dependent upon the materials, workers, social forms, and hazards of late 17th century urban life. The Society's first home, at Gresham College, was an uncontrolled space, neither public nor private, through which many Londoners moved, on Society business as well as on matters connected with the building's other purposes and inhabitants. While some servants, craftspeople, and experts were intentionally invited in, valued for their skill or labor necessary to a specific project, the questions which the Society investigated could also be influenced by the experience or knowledge outsiders unexpectedly brought into the Society, the College, or London itself.

Chapter Three studies the weather project of Restoration apothecary John Conyers. Conyers was tangentially associated with the Royal Society, but a detailed examination of his years-long efforts to disprove the theory of air pressure by observing changes in atmospheric

[36] Roberts and Schaffer, "Preface," xix.

[37] Andrew Cunningham and Perry Williams, "De-Centering the 'Big Picture': The Origins of Modern Science and the Modern Origins of Science," *British Journal for the History of Science* 26 (1993); Harkness, *The Jewel House*, xv-xviii; Richard R. Yeo, *Notebooks, English Virtuosi, and Early Modern Science* (Chicago: The University of Chicago Press, 2014), 5-6.

moisture shows that equipment and experimental space could be found in unexpected places. Conyers's abiding commitment to the explanatory power of Galenic humoral theory and aspects of Aristotelian physics, while simultaneously embracing observation, experiment, and aspects of mechanism, demonstrate that the ideas of the new science could be accepted in piecemeal amalgamation with old theories.

Chapter Four focuses on John Conyers's collections, using a variety of largely manuscript sources to construct a preliminary catalog of his accumulations. Taken seriously as a collector in his lifetime, Conyers's assemblages are less well known today. Reconstructing Conyers's store of curiosities and studying how smaller collections like his were formed, shows that collecting involved a wider array of people in a variety of social classes and a wider array of locations than often appears in the historiography. In London, gathering objects of curiosity, antiquity, or natural history intersected seamlessly with existing local commercial routines and the chance discoveries unearthed in a city constantly under construction. Objects of curiosity and study were found in a multitude of locations, and gathering them involved a wider swath of the Restoration social spectrum than has previously been appreciated.

Chapter Five examines the importance of practical natural knowledge for a major Restoration project, the recoinage of Charles II. Despite the abundance of skills—mathematical, chymical, and technological—needed for the successful production of a dependable English (and later British) coinage, the work of the Royal Mint did not attract much attention from devotees of the new science. Just as the Crown both encouraged new coining technology and sought to control its spread, chymically- and alchemically-minded Fellows of the Royal Society simultaneously spoke of embracing learning from those with manual experience, and dismissed

the skills practical metalworkers had to offer, obscuring the similarities between practices in laboratories and the Mint.

Together these chapters help to complicate our picture of who contributed to the study of nature in London at the end of the 17th century. While the institutionalization of the new approach to studying nature represented by the Royal Society was crucial, this dissertation demonstrates that the new science stretched out beyond the Society's confines. Never operating in a closed environment, the early Royal Society drew on skills, labor, and unexpected expertise outside its Fellowship to shape its investigations. Skills similar to those valued by the Society's Fellows could be found in industries such as coinage; the experimentation, observation, and collection essential to the new science took place in small shops, Royal palaces, and the streets of the city. The characters and the scenes of the new science were as complicated, changing, and varied as the metropolis itself.

Chapter 2

"Compounded of all sorts of men" (and a few women): The early Royal Society in Gresham College and Restoration London

Thomas Sprat's 1667 book *The History of the Royal Society of London for the Improving of Natural Knowledge,* laid out many claims in an effort to construct an effective apologetic text for the new group. Sprat was admitted as a Fellow possibly for the sole purpose of writing the *History*, a work that several early Fellows felt would bolster support and answer critics of their assembly. In one passage, Sprat asserted that by embracing a new method of studying nature, the Royal Society had "broken down the partition wall, and made a fair entrance, for all conditions of men to engage in these Studies." The experimental and experiential approach of the Society, argued Sprat, made room for men of all types—anyone with good sense and good senses could contribute to the Society's reformation of natural knowledge. This new organization, he wrote, "intends a Philosophy, for the use of Cities, and not for the retirements of Schools, to resemble the Cities themselves: which are compounded of all sorts of men, of the Gown, of the Sword, of the Shop, of the Field, of the Court, of the Sea; all mutually assisting each other."[1]

Such claims were useful rhetoric for separating the Royal Society from older strains of Aristotelian natural philosophy, based in the universities. But Sprat, whose book was intended to make a case for both the Society's methods of studying nature as philosophy and the group's potential to provide a stabilizing influence to Restoration society, was careful to avoid strong claims of the democratic availability of experiential knowledge, thus distancing the new organization from disruptive radical groups of the previous decades whose claims of religious

[1] Thomas Sprat, *The History of the Royal Society of London for the Improving of Natural Knowledge* (London: Printed by T. R. for J. Martyn and J. Allestry, 1667), 76.

knowledge being equally available to all upset the religious and social order.[2] Gentlemen were crucial in Sprat's description of the program (and his claims here are borne up by modern analysis of the membership of the early Royal Society).[3] As Sprat argued, gentlemen, being free of pecuniary worries or business involvements, were disinterested participants in the new program, and would ensure that it served no private interests, but the interest of the nation as a whole.

In practice, however, the importance of learning by doing—by "vexing nature" in experiments, manipulating and mimicking nature in the trades and useful arts, and compiling first hand experience of natural phenomena—meant that the Society relied not only on the skills and information gathered by their gentlemanly Fellows, but also on the labor, observations, and manipulations of those who were explicitly paid for their involvement in the new science. Francis Bacon's utopian vision of the ideal scientific establishment, depicted in his unfinished work *The New Atlantis* (1628), recognized this need. In Salomon's House, the successful pursuit of natural knowledge required both a variety of learned men and "a great number of servants and attendants, men and women" to assist them in their work.[4] These servants, passed over in one line in Bacon, did not need to be mentioned in Sprat's 1667 defense of the Society's program,

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[2] P.W. Wood, "Methodology and Apologetics: Thomas Sprat's *History of the Royal Society*," *British Journal for the History of Science* 13, no. 43 (1980). John Morgan, "Science, England's 'Interest' and Universal Monarchy: The Making of Thomas Sprat's *History of the Royal Society*," *History of Science* xlvii (2009); John Morgan, "Religious Conventions and Science in the Early Restoration: Reformation and 'Israel' in Thomas Sprat's *History of the Royal Society* (1667)," *The British Journal for the History of Science* 42, no. 3 (2009); Michael Hunter, "Latitudinarianism and the 'Ideology' of the Early Royal Society: Thomas Sprat's *History of the Royal Society* (1667) Reconsidered," in *Establishing the New Science: The Experieince of the Early Royal Society* (Woodbridge, Suffolk: The Boydell Press, 1989).

[3] Michael Cyril William Hunter, *The Royal Society and Its Fellows, 1660-1700 : The Morphology of an Early Scientific Institution,* Bshs Monographs 4 (Chalfont St. Giles, Bucks, England: British Society for the History of Science, 1982).

[4] Francis Bacon, *New Atlantis a Work Unfinished, Written by the Right Honourable Francis, Lord Verulam, Viscount St. Alban* (London 1658), 33.

methodology, and purpose. Servants and paid attendants and assistants of all kinds were a regular part of life for Restoration elites, even if they had no interest in natural philosophy. Some of the early Society's efforts, such as those to gather information from as many "Sea-Men, Bound for Far Voyages" as print could reach, demonstrate that parts of the Society recognized that a massive empiricist project required more than just the men on the membership lists.[5] The involvement of "servants and attendants" was often elided, however, from the written record of the new science.[6] Although interested in learning by doing, the Fellows of the Royal Society had ambivalent attitudes to those who performed manual manipulations as part of their daily work. Drawing on Baconian and Hartlibian traditions, many Fellows sought to engage with the world, seeking knowledge of practices in skilled crafts and hoping their researches would in turn spread information leading to the improvement of the productivity and magnificence of the arts. At the same time, however, some members of the Society chaffed at attempts to gather information from "mechanical capricious persons," or jealously guarded personal claims of innovation, and there were regular proposals to make the organization more like Bacon's Salomon's house—complete with building a new location outside the city where research could be pursued in a dedicated facility, removed from the distractions of the world. [7]

While Thomas Sprat's idea of a philosophy "for the use of Cities" was merely one of the many rhetorical flourishes he used to highlight the differences between the Society's program, and the work of traditional, university-based Aristotelian philosophy, the new Royal Society,

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[5] "Directions for Sea-Men, Bound for Far Voyages," *Philosophical Transactions* 1, no. 8 (1666).

[6] Steven Shapin, "Invisible Technicians," in *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994).

[7] John Evelyn to Robert Boyle in Robert Boyle et al., *The Correspondence of Robert Boyle*, 6 vols. (London ; Burlington, Vt.: Pickering & Chatto, 2001), 1: 363. Michael Cyril William Hunter and Paul B. Wood, "Towards Solomon's House: Rival Strategies for Reforming the Early Royal Society," in *Establishing the New Science: The Experience of the Early Royal Society* (Woodbridge, Suffolk: Boydell Press ; Wolfeboro, 1989).

now established in London, could hardly help being "of the City." The location in which the Society met during most of its first decades (Gresham College), its interactions with servants, and its reliance on outside sources of equipment, information, and skills ensured that the Royal Society was firmly enmeshed in the social world of Restoration London. Through examining the payments to salaried employees and servants, money spent on infrastructure, payments to outside experts, and purchases of materials, I will show that the experimental program undertaken in the first two decades of the Society's existence was reliant on the work and knowledge of many people at a variety of social levels. The Royal Society, while attempting to form something new, relied on preexisting social structures and sources of labor and skill, constantly intersecting with the muddled, chaotic world of Restoration London.

Steven Shapin first raised the issue of the "invisible technician" in Restoration science several decades ago, and his analysis of the authorial suppression of the work—physical and mental—of paid assistants in formal Restoration scientific texts highlighted the important role that pre-existing social norms about who was trustworthy played in the crafting of scientific arguments and scientific literary style for Restoration natural philosophers. [8] The new science was inexorably tied to print, so Shapin's concern with the "formal documentary record" was invaluable.[9] At the same time, however, the new science was fundamentally rooted in physical spaces populated by people of all kinds. However the knowledge uncovered was presented in print, or negotiated amongst virtuosi to determine what would count as truth, much of this knowledge was rooted in actions in social spaces filled with many who would never be considered virtuosos or even virtuous. The carpenters, cleaners, and visiting demonstrators may

[8] Steven Shapin, "The Invisible Technician," *American Scientist* 77, no. 6 (1989); Shapin, "Invisible Technicians."

[9] Shapin, *Social History of Truth*, 360.

be invisible in print, but they were not literally invisible to the Fellows of the Society. The presence, labor, skills, or knowledge of these figures formed the understood—and therefore unstated—backdrop to the efforts of the new institution.

Gresham College was neither a gentleman's house nor a mechanic's shop, but both of these things, and other types of space—government offices, financial center, marketplace, almshouse, lodging for soldiers, place of education—mixed together. While some well-defined spaces could be found, in general, both spaces and people mixed together in Restoration London, although the experiences of these spaces was not the same to all groups.[10] All brought different experiences and different norms to bear in these spaces. Understanding the full social range of people that formed the unstated background of the work of the Royal Society helps shed light on the work—perhaps mundane—assumed within formal scientific narratives. I am here concerned far less with the "formal documentary record"–-the sort of scientific knowledge that was "written up and put into books"—but rather the processes necessary long before the writing up: the work of science, not necessarily the final product.[11]

In this chapter I highlight some different types of people the Royal Society interacted with. Some would count as Shapin's invisible technicians; others were less directly involved in experimental tasks.[12] My purpose is to present the Society in its' everyday social milieu. While the role played by gentlemanly norms in the formation of the new science in Restoration London was undeniably powerful, gentlemen were merely one part of Restoration English society;

[10] Amanda Flather, *Gender and Space in Early Modern England* (Woodbridge, Suffolk: The Boydell Press, 2007).

[11] Shapin, *Social History of Truth*, 360; 406. On Restoration scientific publishing see Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago, Ill.: University of Chicago Press, 1998).

[12] Shapin defined technicians as "persons in a setting dedicated to the production of scientific knowledge who are remuneratively engaged to deploy their labor or skill at an employer's behest." Shapin, *Social History of Truth*, 361.

people of all sorts lived and work side by side.[13] Their relationships were certainly not marked by equality, and I am not suggesting that all of the employees and experimental subjects discussed below were willing or even interested participants in the new science. Some were, however, and before we can begin to understand the broader perceptions and impact of the new science in Restoration London, we first have to recognize the full cast of people who populated this world. I will conclude with two case studies: the first demonstrates the variety of people and places, at both high and low social levels, involved in one investigation of the Society; the second will examine the hitherto largely ignored figure of Mr. Rockford and the effects he had on the first years of the Society. Together these cases, combined with the composite picture of the spaces and varied people around the early Royal Society, demonstrate that further attention to this kind of social history of Restoration England adds valuable layers to the history of the Royal Society.

In examining the early Royal Society's social and spatial environment, this chapter relies on both standard sources for the early history of the Society, and other, less frequently used manuscripts. The Society's meeting minutes published in Thomas Birch's 18th century *History of the Royal Society* and the information found in Henry Oldenburg's *Philosophical Transactions* are, of course, essential to any discussion of the first decades of the Society.[14] However, the

[13] See for example, Jeremy Boulton, "The Poor among the Rich: Paupers and the Parish in the West End, 1600-1724," in *Londinopolis: Essays in the Cultural and Social History of Early Modern London*, ed. Paul Griffiths and Mark S. R. Jenner. (New York: Manchester University Press, 2000).

[14] Thomas Birch, *The History of the Royal Society of London for Improving of Natural Knowledge* (London: Printed for A. Millar, 1756); Royal Society, *Philosophical Transactions, Giving Some Account of the Present Undertakings, Studies, and Labours of the Ingenious, in Many Considerable Parts of the World* (London: C. Davis, Printer to the Royal Society of London, 1665). See also Gail Ewald Scala, "An Index of Proper Names in Thomas Birch, 'The History of the Royal Society'," *Notes and Records of the Royal Society of London* 28, no. 2 (1974); I. Kaye, "Unrecorded Early Meetings of the Royal Society," ibid. 8 (1951): 81; Hunter, *Royal Society and Its Fellows*. Note that Birch's transcriptions of Council meetings (as opposed to the general membership meetings) can have significant omissions. See: The Royal Society, CLO/1, 13 May 1663-8 February 1682, Council Minutes Original. Volume 1. Transcriptions of many of these minutes are available via the online catalog for the Royal Society archives at https://royalsociety.org/collections/#archive.

starting point for the following analysis was most frequently the account books of the Royal Society from 1660-1682.[15] While earlier historians have used these accounts, the emphasis of previous studies tended to be on the half of the accounts dealing with payment of membership dues, or as an adjunct to information gathered first from the minutes of Society meetings.[16] While membership analysis has added greatly to our knowledge of the functioning of the Royal Society as an institution, information about the operation of the Society on a more day-to-day level can be gained by examining the other half of the accounts, those tracking outgoing funds. Additional information is found in the records from William Balle's stint as "Curator of Magnetics," bound into one of the account books.[17]

The account books have limitations, however. While some entries can be cross-referenced with information in the Society's minutes or other sources, many remain obscure. A number of pages are not dated, making identification and explication more difficult. In addition, skilled craftspeople and demonstrators are sometimes identified by occupation in place of name, and the accounts for the year 1674 are entirely absent. Most significant for the present examination of the details of the daily life of the Royal Society is that the fairly detailed breakdown of expenses in the early years disappears as the Society increasingly entrusted Robert Hooke and operator Richard Shortgrave with overseeing experimental costs after 1663. The bills

[15] Royal Society (hereafter RS), AB/1/1/1, 1662-1672, Account Book; RS AB/1/1/2, 1672-1682, Account Book.

[16] R. K. Bluhm, "Remarks on the Royal Society's Finances, 1660-1768," *Notes and Records of the Royal Society of London* 13 (1958); R. E. W. Maddison, "The Accompt of William Balle from 28 November 1660 to 11 September 1663," ibid.14, no. 2 (1960). Maddison treats the disbursements of the Society for these first three years in only one brief paragraph. H. W. Robinson, "The Administrative Staff of the Royal Society, 1663-1861," ibid. 4 (1946) discusses some of the non-fellow employees of the RS, but did not have access to the Account Books, which were missing from the Society archives until the 1950s. Michael Hunter has used the account books throughout his work, but has only subjected the pages recording payment of dues to intensive study. Hunter, *Royal Society and Its Fellows*.

[17] Angus Armitage, "William Ball, F.R.S. (1627-1690)," *Notes and Records of the Royal Society of London* 15 (1960); R. E. W. Maddison, "The Accompt of William Balle."

submitted for reimbursement by these men (and others) were paid without itemizing their contents within the Account Book ledgers. Only two such bills survive in the archives, from the 1670s; the content suggest the richness not recorded in the later accounts.

[1]

For making a plug of Brasse for ye wind engine and fitting it with cork &c	1-2-0
Mending the clock & [nice?] guilding the Ring	0-12-0
Joyners work about the magneticall Experiments and the Experiment of motion in the Dining[?] room	0-16-0
An ouall tub for holding water about magneticall experiments	0-7-0
Coles for the repository	0-10-0
for altering the table & fitting it to the [illegible deleted word]	0-2-0
The apparatus about the Experiment of seeing two objects at once	1-4-0
Expended about the experiments of staining marble	0-7-0
About the Experiment of making [illegible]	0-10-0
paid from bring home ye Beehive from Sir Robert Moray	0-3-0
to Mr Clay when he brought hom the Iron chest from Dr. Goddards	0-5-0
[total]:	5:18:0

[2]

Expended by Rob: Hooke upon the R: Society's Account

For making a window to the Room where the Repository was formerly kept	9-0-[0] [18]

[18] Robert Hooke. RS DM/5/20, 23 December 1681, Hooke's Bills of Expenditure by Him on the Society's Account, and an Order Dated 23 December 1681 by Sir Christopher Wren to Abraham Hill, Treasurer, to Pay Hooke £40. The date for this file reflects the date on the order to Hill. The bills themselves are undated, but probably come from the between late 1672, when the beehive was mentioned at a Society meeting, and the end of 1675. (Goddard died in 1675.) While the uncertain dating means the Royal Society may have been meeting in either Arundel House or Gresham College at the time Hooke requested reimbursement, I have interpreted the use of 'home' in both of the portage cases to refer to Gresham College. Hooke maintained residence in the College during the Arundel House period, where much of the Society's equipment and collections remained. Hooke also mentions the beehive in his diary on August 2, 1673. Robert Hooke, Henry W. Robinson, and Walter Adams, *The Diary of Robert Hooke, 1672-1680* (London: Wykeham Publications, 1968), 54.

As these detailed bills show, Hooke (and Society operators Richard Shortgrave and later Henry Hunt) oversaw numerous expenses necessary to the Society's operation, from experimental equipment and procedures, to portage fees, coal to heat the Repository, and building improvements. These bills include work performed by Hooke himself and by others, although the distinction is generally unclear. Work on the "wind engine" and the "apparatus about the experiment of seeing two objects at once" sound like tasks Hooke may have taken on himself, given his documented work on air pumps and optical instruments. But these entries could also represent money spent by Hooke on someone else's product, or a combination of expense types. From Hooke's *Diary*, we know that he bought coal from a regular supplier, although he is not named in this bill.[19] Also un-identified are the joiners who performed the work related to these two experiments. These surviving bills, however, mimic some of the details found in the earlier account books, suggesting that many types of expenditures remained the same for the Society throughout the membership, program, and institutional changes of the first few decades.

Hooke's *Diary* and the Gresham Repositories and City of London accounts concerning the operation of Gresham College provided additional information about the spaces in which the Society. Hooke's *Diary* is a well-known source for understanding experimentation in the 1670s, and has been well-used by previous scholars to understand not only Hooke, but also the Royal Society, its factions, the rebuilding of London after the Great Fire, and the skilled craftsmen Hooke regularly interacted with.[20] The most detailed account book predated the *Diary* however,

[19] Hooke regularly bought coal from suppliers named Mr. Berry and Mr. Hammond. See, for example, Hooke, *Diary*, 55, 61, 303, 318.

[20] Material left out of the print edition of the *Diary* is discussed and transcribed in Felicity Henderson, "Unpublished Material from the Memorandum Book of Robert Hooke, Guildhall Library MS 1758," *Notes and Records of the Royal Society of London* 61 (2007). Previous studies that drew on Hooke's dairy include: Rob Iliffe, "Material Doubts: Hooke, Artisan Culture and the Exchange of Information in 1670s London," *The British Journal*

and while Hooke was critical to the Society, I wished to understand its early years through a broader lens than one individual Fellow. Information on Gresham College has been used to study that institution but has not yet been employed to think about the physical space and people who occupied this location so important to the early Royal Society.[21]

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for the History of Science 28, no. 3 (1995); M. A. R. Cooper, "Robert Hooke's Work as Surveyor for the City of London in the Aftermath of the Great Fire. Part One: Robert Hooke's First Surveys for the City of London," *Notes and Records of the Royal Society of London* 51, no. 2 (1997); M. A. R. Cooper, "Robert Hooke's Work as Surveyor for the City of London in the Aftermath of the Great Fire. Part Three: Settlement of Disputes and Complaints Arising from Rebuilding," ibid. 52, no. 2 (1998); M. A. R. Cooper, "Robert Hooke's Work as Surveyor for the City of London in the Aftermath of the Great Fire. Part Two: Certification of Areas of Ground Taken Away for Streets and Other New Works," ibid. 52, no. 1 (1998); M. A. R. Cooper, *A More Beautiful City : Robert Hooke and the Rebuilding of London after the Great Fire* (Stroud, Gloucestershire: Sutton, 2003).

[21] Mercers' Archive, Gresham Repositories (hereafter GR) 2: 1626-1669, GR 3: 1669-1676, GR 4: 1676-1722. Additional information is found in the documents created by the City half of the Gresham Committee found in London Metropolitan Archives (hereafter LMA), CLA/062, 1575 - 1992, Gresham College and Royal Exchange. Ian Adamson, "The Administration of Gresham College and Its Fluctuating Fortunes as a Scientific Institution in the Seventeenth Century," *History of Education* 9, no. 1 (1980); Ian Adamson, "The Foundation and Early History of Gresham College London 1596-1704" (University of Cambridge, 1976); Ian Adamson, "The Royal Society and Gresham College, 1660-1711," *Notes and Records of the Royal Society of London* 33, no. 1 (1978); Francis Ames-Lewis, *Sir Thomas Gresham and Gresham College: Studies in the Intellectual History of London in the Sixteenth and Seventeenth Centuries* (Aldershot, Hampshire; Brookfield, Vt.: Ashgate, 1999).

Physical location: London, Gresham College and the urban setting of the Royal Society

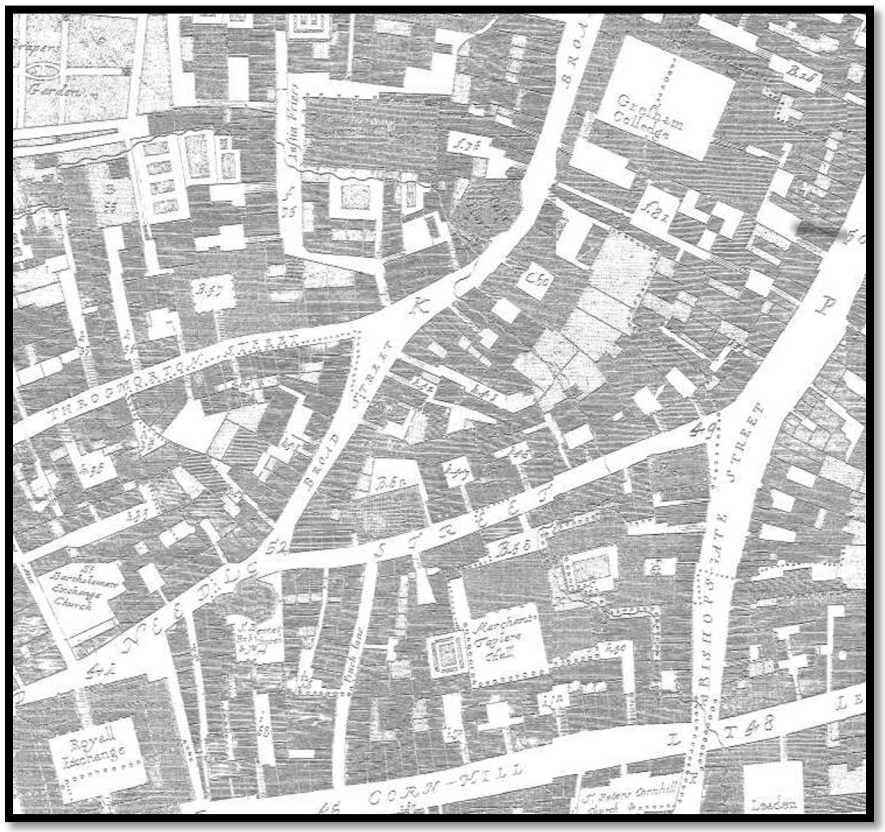

Figure 2.1- Gresham College in London, 1676.[22]

On November 28, 1660, a group of men who had been meeting informally in Gresham College, Bishopsgate, to discuss mathematics and experimental philosophy decided to form a more organized body.[23] A few locations were considered for the meetings of this new group, but it was shortly agreed to continue to convene at Gresham College.[24] Although the Society meetings were relocated to Arundel House for seven years following the Great Fire in 1666, they returned in 1673 and the College was to remain their home until they moved to a purpose-built

[22] Cropped from John Ogilby and William Morgan, "Ogilby and Morgan's Large Scale Map of the City as Rebuilt by 1676." (1676), http://www.british-history.ac.uk/no-series/london-map-ogilby-morgan/1676/map. Accessed December 1, 2015.

[23] Birch, *History*, 1:3.

[24] Ibid., 1:7.

location in Crane Court in 1711.[25] Even during their seven-year absence, the Society kept one foot in Gresham, through the continued residence of their Curator of Experiments, Robert Hooke. Through committee meetings held in his rooms, and his storage of the Society's repository and instruments, the Society never truly left Gresham, even when formal meetings were being held elsewhere.[26]

Originally the residence of Sir Thomas Gresham (*c.* 1519 – November 21, 1579), mercer, builder of the first Royal Exchange, and sometimes Lord Mayor of London, the building became an educational and charitable institution in the early 17th century. Managed by a joint committee of representatives of the City of London and the Mercer's Company, under terms laid out in Gresham's will, the College was intended to improve the educational opportunities available to Londoners, through lectures delivered by the Gresham Professors (also called Readers). These professors—one each in the areas of Divinity, Law, Geometry, Music, Physic, Astronomy, Rhetoric—were required to live in the college and deliver their lectures regularly.[27] While the degree to which these requirements were actually fulfilled varied through the years, it is clear that in the 1650s the College was a gathering place for a number of men interested in questions of mathematics and natural philosophy.[28] The Royal Society's beginning, therefore, in the rooms

[25] On the move to Crane Court see D.C. Martin, "Former Homes of the Royal Society," *Notes and Records of the Royal Society of London* 22, no. 1-2 (1967): 14-15. Ian Adamson, "The Royal Society and Gresham College, 1660-1711," ibid.33, no. 1 (1978): 10-15.

[26] Shapin emphasized the importance of Arundel House to the formation of Restoration Science, but I believe he does so at the expense of Gresham College, with which the Society remained connected. Shapin, "The House of Experiment," 381.

[27] Ames-Lewis, *Sir Thomas Gresham and Gresham College*; Adamson, "The Foundation and Early History of Gresham College London 1596-1704."; Adamson, "The Royal Society and Gresham College."; Johnson, "Gresham College: Precursor of the Royal Society."; John Ward, *The Lives of the Professors of Gresham College* (London: Printed by J. Moore for the author, 1740); Adamson, "The Administration of Gresham College."

[28] Mordechai Feingold, "Gresham College and London Practitioners: The Nature of the English Mathematical Community," in *Sir Thomas Gresham and Gresham College*, ed. Francis Ames-Lewis (Aldershot, Hampshire, UK: Ashgate, 1999). Adamson, "The Administration of Gresham College," 18-20; Bennett, "The Mechanics' Philosophy and the Mechanical Philosophy," 20-24.

of Lawrence Rooke, Gresham professor of Geometry, at the end of 1660 flowed naturally from the gatherings already taking place there.[29] The Society's continued presence at Gresham College is not so easy to understand. While the Joint Committee eventually came to prize the Society's presence in the College, formally inviting their return after the upheavals of the Great Fire had necessitated their displacement, Gresham was not a location purposely designed for the new enterprise the Society's members embraced.[30] Although the Society periodically attempted to acquire their own space, such plans failed until the early 18th century, because of lack of funds, legal obstacles, and differing ideas about the Society's purpose.[31]

Importantly, the urban location of Gresham College meant certain realities of life in an early modern city were also a fundamental part of the new institution devoted to "promoting …physic-mathematical experimental learning."[32] Attention being paid to the place of science in early modern Europe has broadened our understanding of the complex mixture of ad hoc and purpose-built locations where nature was investigated in the centuries before professionalized science. Our understanding of Restoration science, however, continues to be shaped by two dichotomies—the gentleman's home with its carefully controlled access and codes of conduct, and the mathematical instrument maker's shop where access was more open, and different codes of conduct reigned.[33] Gresham College was neither of these locations: the gentlemanly lecturers

[29] Birch, *History*, 1: 3.

[30] Ibid., 3: 93, 100-101. See also "Bill for entertaining the Royal Society at the time of their introduction into Gresham College. 1st December, 1673," LMA, Gresham College and Royal Exchange CLA/062/01/003, 1666 - 1673, Accounts: Miscellaneous Papers; GR 3, 135.

[31] Michael Cyril William Hunter, "A 'College' for the Royal Society: The Abortive Plan of 1667-8," in *Establishing the New Science: The Experience of the Early Royal Society* (Woodbridge, Suffolk: Boydell Press, 1989).

[32] Birch, *History*, 1:3.

[33] On gentlemanly places: Shapin, "The House of Experiment." On mechanics and shops see: Bennett, "Shopping for Instruments in Paris and London;" Iliffe, "'In the Warehouse'"; Iliffe, "Material Doubts."

lived in private suites of rooms, and maintained their own households, while Robert Hooke and his assistants regularly engaged in the kind of instrument production requiring mechanical activity more often found in commercial establishments throughout London.[34] In addition, the changing physical and social uses of the building meant the College served as mercantile exchange, lodging house, almshouse, and center of City government, as the need arose.

Building

Neither of the two spaces where the Royal Society met during its first decades—Gresham College or Arundel House—were built or designed for the Royal Society, or for the new science. Both were originally gentleman's houses, as Arundel House still was when the Society met there between 1666-1673.[35] Gresham College, however, was repurposed under the terms of Sir Thomas Gresham's will in the early 17th century. It became a multi-purpose space, subject to constant changes. At the basic level, the main part of the Gresham building was devoted to the College and lodgings for its Readers. Sir Thomas Gresham's foundation, however, included not just the educational establishment of the College, but money and housing for eight almsmen, whose rooms formed part of the same building complex.[36] Indeed, the almsmen's rooms were located directly beneath the West Gallery, which became the home of the Society's repository.

[34] See items described under "In the next cellar or workshop" and "In the Cellar under the Committee Roome" in Michael Hunter, "Hooke's Possessions at His Death: A Hitherto Unknown Inventory," in *Robert Hooke: New Studies*, ed. Michael Hunter and Simon Schaffer (Woodbridge, Suffolk: The Boydell Press, 1989), 293. His mechanical activities in Gresham College are also clearly documented in his *Diary*.

[35] Shapin, "The House of Experiment" 381. There is much less information available on the physical structure of Arundel House.

[36] See Figure 2.1 above. The almshouses are marked as being on the Broad Street side of the building. Gresham's will describes the eight almshouses as at the "backside" of the Gresham property. John Ward, *The Lives of the Professors of Gresham College*, 22.

The Readers had private rooms, but also communal ones, shared by all their households.[37] The entrance to the courtyard was gated, but the gate was often left open, as the lectures given by the Readers were meant to benefit the general public in London.

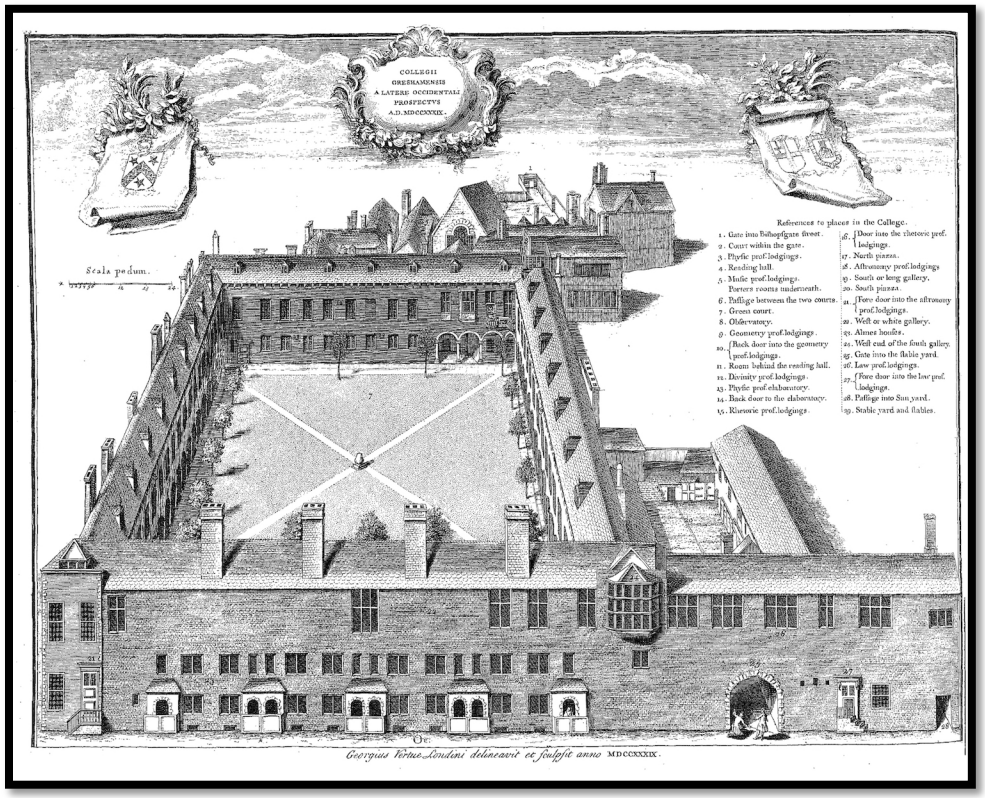

Figure 2.2: Gresham College. Engraving by George Vertue from John Ward's *Lives of the Gresham Professors*, 1740

Surviving records of the City half of the Joint Committees demonstrate that the College required regular repair.[38] In addition, over the course of the 17th century, the physical structure of the Gresham building bore witness to the inherent legal ambiguities in Gresham's will, and the tensions between the desires of the Joint Committees that oversaw the Gresham's bequest and

[37] Hooke records damage to the common kitchen after a storm in January 1673. Hooke, *Diary*, 20.

[38] See for example, the records of "Worke Done" in LMA CLA/062/01/051, 1662-4, Gresham College & Royal Exchange Journals: Summary Cash Statements.

those of the Readers.[39] The College rooms were divided, sublet, and altered to suit the needs of Readers and their lodgers, with disregard for protests from the overseeing Committee members or complaints from subsets of the Readers. For example, in 1662, a complaint lodged with the Gresham committees declared that "some parte of the house Bequeathed by Sir Thomas Gresham for [the Readers'] use is detained from them [and] have bin of late frequently applyed to uses which [cause] great Disquiet to the said Readers in their Lodgeings."[40] Scientifically minded Readers took advantage of the situation as well, as Hooke's construction projects amply attest. In 1685 he was reprimanded by the Joint Committees for the encroachment he had made into "the South West Corner of the Cloyster."[41]

After the Great Fire of 1666, the Joint Committees intentionally changed the use of the building, as a result of the emergency shortage of space for City government and merchants following the destruction of both Guildhall and the Royal Exchange. Gresham College escaped destruction, but it was immediately repurposed as the temporary home of London's City government and the trading locale for those displaced from the destroyed Royal Exchange.[42] Now, temporary structures were installed with the Joint Committee's blessing. The central courtyard was paved and stalls for the former Royal Exchange merchants erected.[43] After the rebuilt Royal Exchange began to reopen, first the new courtyard in the fall of 1669, and then the shops in March 1671, the Committees attempted to revert the space at Gresham to its original

[39] Adamson, "The Administration of Gresham College," 14-16.

[40] Mercers' Archive, GR 2, 211.

[41] Mercers' Archive, GR 4, 138.

[42] Ann Saunders, "The Second Exchange," in *The Royal Exchange*, ed. Ann Saunders (London: London Topographical Society, 1997), 123-124.

[43] Ann Saunders, "Reconstructing London: Sir Thomas Gresham and Bishopsgate," in *Sir Thomas Gresham and Gresham College*, ed. Francis Ames-Lewis (Aldershot, Hampshire ; Brookfield, Vt.: Ashgate, 1999), 11.

use, but with difficulty.[44] In March 1674, things were still not back to normal, and orders were again issued to "free the lower walks from being warehouses…."[45] Problems continued, and a few years later a subcommittee surveying the state of the College in March 1675/6 reported many violations, including that fact that "Mr. Crispe [an illegal lodger] hath made great alternation viz., hath turned the stable and hay room into a hall and kitchen with a door and steps into Broadstreet which door and steps the committee order him to shut up and take away, because they hold it not fitting that a private passage should be made into a college."[46]

Robert Hooke, Gresham Reader for Geometry from 1665, also felt free to alter the College space to suite his needs. Installing a zenith telescope in the 1660s involved cutting holes in floors and the roof.[47] Hooke did deign to get the permission (and funding) from the Joint Committees before the addition of a turret to his rooms for the better performance of certain experiments in the 1670s. Most of the work on this addition took place over the course of a month in January and February 1675, but finishing touches (including windows essential for blocking experiment-disturbing wind) took longer.[48]

Hooke's diary gives the impression of Gresham College as a constant construction site. A "work room" was being built in the "Cloysters" in August of 1672. This was not official College

[44] Saunders, "The Second Exchange," 133-134.

[45] Mercers' Archive, GR 3, 148. Adamson, "The Foundation and Early History of Gresham College London 1596-1704," 223.

[46] Mercers' Archive, GR 3, 181-183. See also Adamson, "The Foundation and Early History of Gresham College London 1596-1704," 224.

[47] Lisa Jardine, *The Curious Life of Robert Hooke: The Man Who Measured London* (New York: Harper Collins, 2004), 164-167. An illustration of the construction is in Robert Hooke, *An Attempt to Prove the Motion of the Earth* (London: Printed by T.R. for John Martyn, 1674).

[48] Hooke, *Diary*, 141-159, passim.

business, as Hooke paid the carpenter himself.[49] Less than a month later bricklayers were at work repairing a kitchen chimney, and a shed was pulled down.[50] In November Hooke had his own rooms plastered, but also did structural work in the cellar of the College, perhaps adapting newly-opened up space to his own use.[51] He also undertook tasks explicitly linked with the Royal Society, recording on December 19th that he had "mended Repository door."[52] In January, a storm "Blew down Sir A. Kings Chimny in the common kitchen" of the College.[53] And by February 4th, bricklayers had completed building a furnace in Hooke's chamber's chimney.[54] While some of the work he records was undoubtedly related to the re-conversion of the space back to the College from its uses during the rebuilding of the Exchange, the constant alteration of the place continued after the Society's return to Gresham at the end of 1673.[55]

People

In keeping with the constantly changing physical space of Gresham College, a constantly changing stream of people of various social classes could be found within the College and in its neighborhood. Recent detailed studies of London neighborhoods have shown that even areas generally thought of as exclusively wealthy contained people of all social classes.[56] The area abound Gresham College was no different. Although the College was a short distance from the

[49] Ibid., 4, 5. August, 16 and 24, 1672.

[50] Ibid., 8. September 21, 27, and 28, 1672.

[51] Ibid., 15-16. December 7, 10, 11, 12, and 13, 1672.

[52] Ibid., 17. December 19, 1672.

[53] Ibid., 23. January 8, 1673. Interestingly, King is an illegal lodger.

[54] Ibid., 26. February 4, 1673.

[55] See for example the bills contained n LMA CLA/062/01/009, 1678, 1687, Workmen, Bills for Repairs, Etc.

[56] Boulton, "The Poor among the Rich."

Merchant Taylor's Hall, home of a wealthy and influential livery company, and the Royal Exchange, center of high finance in Restoration London, Hearth Tax records for the neighborhood in 1666 list wealthy, middling, and poor households.[57] Within the precincts of the College itself, a similar diversity of people could be found, particularly if we consider the many who did not live at the College, but regularly passed in and out of the space for many reasons.

Gentry and elites

There was undoubtedly a strong gentry presence in the College. The Readers were largely university-educated men who could, at the very least, aspire to be classified as gentry, and were expected to lecture in both Latin and English on their topic.[58] The lectures, though generally poorly attended, could bring in gentlemen as well, such as the Royal Society precursor group who made a habit of attending Rooke's mathematical and Wren's astronomical lectures.[59] Representatives from the City government and the wealthy Mercer's Company inspected the College as part of their management of the property.[60] Visitors to the Readers' lodgings would, of course, also include any number of gentlemen on social or professional visits, as amply attested to in Hooke's *Diary*. Once the Royal Society formed and began meeting at the College, the noble and gentle members of the new organization along with guests attending the meetings, brought in more members of the Restoration elite.[61] When the Society sought specific

[57] "Hearth Tax: City of London 1666, St Bride Fleet Street , Peterborough Court," In *London Hearth Tax: City of London and Middlesex, 1666*. (2011), http://www.british-history.ac.uk/london-hearth-tax/london-mddx/1666/st-bride-fleet-street-peterborough-court. Accessed October 8, 2015.

[58] Adamson, "The Foundation and Early History of Gresham College London 1596-1704;" Adamson, "The Administration of Gresham College," 16-17. Gresham's will is reprinted in Ward, *Lives of the Professors*, 19-25.

[59] Birch, *History*, 1: 3.

[60] For example, Mercers' Archive, GR 4, 62, 65-66.

[61] Hunter, *Royal Society and Its Fellows*.

information from those outside their formal membership list, they often turned to other well-connected gentlemen, bringing them into the College either virtually, through extended correspondence, or physically, as when they invited well-travelled captains and diplomats to aid their inquiries.[62]

The upheavals caused by the Great Fire of 1666 resulted in a change of residents as the Joint Committees evicted the Readers and the Gresham almsmen, and divided the space between merchants, financiers, and the City officials now office-less following the destruction of Guildhall and the Royal Exchange. [63] At Michaelmas 1668, for example, the City recorded receiving over 100 separate rent payments for mercantile tenants in Gresham.[64] In addition to the rent-paying tenants, some City officials moved their offices into Gresham.[65] Although the Royal Society moved to Arundel House while the Royal Exchange was being rebuilt, Hooke continued to live at Gresham, and the College saw government officials, wealthy merchants, and Society Council members cross paths in the courtyards and buildings of the College.

In calmer times, the Gresham Readers did not hesitate to use their assigned lodgings for whatever purpose best suited them, and many rented out all (or part) of their assigned space. While these lodgers were generally of the elite, they were not formally regulated or affiliated with the College's formal purpose. The Royal Society took advantage of this practice itself, and

[62] Barely a month after the Society's formation, Daniel Colwall, who was a Fellow as well as a merchant, "introduced to the society a captain of an East-India ship, who offered to observe such inquiries, as they should propose to him." Birch, *History*, 1: 68. Henry Oldenburg was most responsible for cultivating these networks. Henry Oldenburg, A. Rupert Hall, and Marie Boas Hall, *Correspondence*, 13 vols. (Madison: University of Wisconsin Press, 1965); Hall, *Henry Oldenburg: Shaping the Royal Society*.

[63] Saunders, "Reconstructing London," 9-11. Hooke was the only exception to the eviction. In addition, the Society was allowed to continue to store equipment at the College.

[64] LMA, Gresham College and Royal Exchange CLA/062/01/041, 1667 - 1677, Account Books, Michaelmas 1668. The number of shops is not a direct mapping of lease payments as some tenants rented more than one shop, and others rented fractions of shops, and some entries list payments from more than one person as joint lease-holders. Leaseholders included both men and women.

[65] Mercers' Archive, GR 2, 225 and following.

was easily able to direct Hooke to procure lodgings at Gresham several years before his appointment as Geometry professor.[66] In addition, readers often felt unconstrained by the purported statutes, and stayed on after their ejection, and brought wives and children into the spaces meant for scholarly bachelors. For example, in 1666, the Committee discussed the case of Dr. Horton, a former divinity professor who continued to live in the College, five years after his ejection from his position at his marriage.[67] Similarly, Hooke's niece formed part of his household for many years, also an arrangement probably contrary to Gresham's vision of a quasi-university for London.[68]

Servants

Gentlemanly Readers, City officials, and Royal Society Fellows did not just associate with other gentry, however. With the Readers came their household staff, which included male and female servants. Readers with interests in the new science might employ other types of workers as well. Hooke employed a steady stream of quasi-apprentices, and Dr. Jonathan Goddard also employed experimental employees.[69]

The Royal Society also interacted with a wide range of servants. As early as December 12, 1660, they decided that there would be "two servants belonging to the society, an amanuensis, and an operator."[70] Unmentioned in the minutes, however are the lesser servants of

[66] Birch, *History*, 1: 315, 340.

[67] Mercers' Archive, GR 2, 224-225. See also, Adamson, "The Foundation and Early History of Gresham College London 1596-1704," 220.

[68] Jardine, *The Curious Life of Robert Hooke*, 252-258.

[69] Mercer's Archive, GR 2, 229. One of Goddard's servants is mentioned in the Royal Society minutes, Birch, *History*, 1:84. Payments to Goddard's servants are also recorded periodically in RS AB/1/1/1.

[70] Birch, *History*, 1:6. These positions were modified under the Society's Royal charters. The amanuensis will be discussed further below.

the Society, who began to play a role shortly thereafter. Beginning on August 26, 1661, the Account Books record regular payments to a charwoman or maid of all work. From 1661-1671, a widow named Helen Collet held this position; she was succeeded by Elizabeth (or Eliza) Boon. Both women were paid "for cleaning the Meeting-room, making Fires &c."[71] From 1669, the wage for this work was 18 shillings per quarter (or £3 12s a year). Like the amanuensis and operator, the cleaning women could also expect reimbursement or additional payment for "extraordinary" tasks taken on. While the vast majority of these bills are paid without further description, one example of such responsibilities is explicitly recorded. In the summer of 1673, Boon received an extra 10 shilling payment for "a Bill for Doggs and keeping them for Experim[ents]."[72] While this is the only specific description of extra duties undertaken by these women, the varying amounts of payments made to them over the years indicate that both took on additional tasks. The Society retained their charwoman while they met at Arundel House after the Great Fire. In the one appearance of this employee in Hooke's *Diary*, she forms part of a cleaning team for the Arundel Library. In January 1676, Hooke wrote, "To Brounker. He ordered me to returne home books to Arundell library. With Ned, Harry and woman thither. Made fire and clensed the books and Roome."[73]

The Society employed other servants as well. The porter of Gresham College, and, later, the porter of Arundel House, received regular small payments. Before the fire, the Royal Society paid the porter irregularly, 5 or 10 shillings a month for the first years of its existence, and then

[71] RS AB/1/1/1, undated entry for Elizabeth Boon "her wages for Micha[lma]s Quarter 1671." On the lives of poor women in early modern England see Sara Mendelson and Patricia Crawford, "The Makeshift Economy of Poor Women," in *Women in Early Modern England: 1550-1720* (Oxford: Clarendon Press, 1998).

[72] RS AB/1/1/2, 1672-1682, Account Book. July 12, 1673. The experiment is discussed further below.

[73] Hooke, *Diary*, 270.

settled on 10 shillings a quarter sometime before 1666.[74] Certainly that was the amount paid to the porter at Arundel house during the years of their meetings there.[75] Gresham College had its own porter, who the Society interacted with enough to warrant payment of an anniversary gift to him along with the other Royal Society servants.[76] In the late 1670s the Society employed its own porter, one Edward Roberts, the "Porter belonging to the Society," who was paid separately from the Porter of Gresham College.[77]

The Society also interacted with servants whom they did not directly employ. The Gresham College porter mentioned above is one example, and the servants of Arundel House and Hooke's household staff also played a role in the smooth running of Society meetings. Shortly after their arrival at Arundel House, the Council of the Society discussed rewarding the servants, deciding to give "a Crown…to each of the two maidservants employed on the occasion of the [visit by Margaret Cavendish to a Society meeting], and an Angel to the Housekeeper; but to the Porter an Angel each quarter."[78] Similarly, at the anniversary dinner of 1672, the Society gave £2-12-6 to the "servants at Arundel-house for their extraordinary trouble and service to the Society."[79] After the return to Gresham College, all servants, including Hooke's, were often awarded gifts on the occasion of the annual anniversary dinners. For example in 1675, "Mr. Hooke's servants", "Mr. Shortgrave's boy", and "the Doorkeeper" were rewarded.[80] Similarly at

[74] RS AB/1/1/1. After January 27, 1664 the porter was to be paid "three pounds a year for his constant attendance." Birch, *History*, 1: 375.

[75] RS AB/1/1/1. January 9, 1668.

[76] For example, a gift of 2 shillings, 6 pence on November 30, 1677. RS AB/1/1/2.

[77] RS AB/1/1/2. November 30, 1679.

[78] RS CMO/1/131, 1667, Minutes of Meeting, 3 June 1667. Note that this discussion is omitted from Birch's *History*. An angel was a gold coin, worth approximately 10 shillings.

[79] RS AB/1/1/2. November 30, 1672.

[80] Ibid. November 30, 1675.

the 1676 and 1677 dinners, Hooke's servants, "the poor woman [Eliza Boon] that makes fires" and the doorkeeper received similar gifts.[81] The Society awarded perquisites to Hooke's servants on occasions when the Society caused them extra trouble. For example, on Thursday, February 25, 1675, the Society not only met, but also dined at Gresham College.[82] Hooke's servants received 2 shillings, duly recorded in the account book on the 26th, for the extra trouble this caused.[83]

As an organization devoted (in part) to collecting specimens of natural curiosities, and investigating phenomena that could only be seen outside of Gresham College or Arundel House, the Society received a regular stream of deliveries, and interacted with other people's servants when venturing abroad. On June 14, 1661 five shillings was "Paid to the Man that brought a Loadstone," possibly the one produced in the meeting on June 19, described as weighing 2lb. 2oz.[84] A "boy that brought Mr. Graunts books" received 10s in February 1661/2, a larger amount presumably because Graunt had sent 50 copies to the Society, for distribution.[85] Similarly, "one that presented a piece of small writing" was paid 10s, "one that brought a Fish" received 5s, "one that brought the skin of the Musk-beast" also 5s, " the Messenger that brought the Elephants Tooth" also 5s, while "Dr Smiths man who brought a Present" in 1677 only received 2s6p.[86] A bill from sometime in the 1670s records the payment of 3 shillings for bringing a type of new

[81] Ibid. November 30, 1676 and November 30, 1677.

[82] Hooke, *Diary*, 149. February 25, 1675.

[83] RS AB/1/1/2. February 26, 1675. A similar occasion where the council dined at Hooke's in his absence is recorded in Hooke, Robinson, and Adams, *Diary*, 133. December 3, 1674.

[84] RS AB/1/1/1. June 14, 1661; Birch, *History*, 1: 30.

[85] RS AB/1/1/1. February 5, 1661/2. Birch, *History*, 1: 75.

[86] RS AB/1/1/1. Writing and Fish: not dated, between December 1663 and November 1667; RS AB/1/1/2. Musk-beast: February 19, 1673; Elephant's tooth: March 8, 1677; Dr. Smith's man: May 10, 1677.

beehive from Sir Robert Moray's to Gresham College, and 5 shillings to move an iron chest from Dr. Goddard's back to the College.[87]

The Society also used the servants of its Fellows to assist in the business of the Society. Sometimes these were simple non-experimental tasks, as for the anniversary meeting in 1667 the Society "Paid Mr. Howard's man for keeping the door at the Election" 5 shillings for his stint as doorman.[88] Other fellow's servants were tapped for more technical skill. Robert Hooke's work for Boyle and the Society while under Boyle's employ is well known, but other Fellow's servants provided work and skills to he Society as well.[89] In May 1661, the Society "resolved, that Sir Paul Neile be desired to continue his employment of the artificer for making glasses for perspectives."[90] In June of the same year, "The duke of Buckingham…was requested to order charcoal to be distilled by his chemist."[91] Experiments on the survival of fish in bottles in 1662 were performed at Dr. Goddard's lodgings so that Goddard could closely observe that "his servant and the [Society's] operator did not fail in their attendance upon this business."[92] The Society's brief interest in the value of potatoes for English agriculture depended on reports (and

[87] RS DM/5/20. This bill is discussed above. For the beehive see Birch, *History*, 3: 60. "Sir Robert Moray presented to the Society, for the repository, a bee-hive of a peculiar contrivance, sent out of Scotland by Sir William Thomson, made up of several pieces, to take off one; whereby bees are kept from swarming, by adding a new box for every swarm." William Thomson, "A Description of a Bee· House, Useful for Preventing the Swarming of Bees, Used in Scotland with Good Success; Whereof One, Sent by a Worthy Gentleman, Sir William Thomson, May Be Seen in Gresham Colledg," *Philosophical Transactions* 8 (1673); D.J. Bryden, "John Gedde's Bee-House and the Royal Society," *Notes and Records of the Royal Society of London* 48, no. 2 (1994).

[88] RS AB/1/1/1. November 30, 1667.

[89] Hunter, *Wicked Intelligence*; Jardine, *The Curious Life of Robert Hooke*; Jim Bennett et al., *London's Leonardo* (Oxford: Oxford University Press, 2003); Michael Hunter and Simon Schaffer, eds., *Robert Hooke: New Studies* (Woodbridge, Suffolk: The Boydell Press, 1989); Michael Cooper and Michael Hunter, eds., *Robert Hooke: Tercentennial Studies* (Burlington, VT: Ashgate, 2006); J. A. Bennett, "Robert Hooke as Mechanic and Natural Philosopher," *Notes and Records of the Royal Society of London* 35, no. 1 (1980).

[90] Birch, *History*, 1: 23.

[91] Ibid., 1: 26.

[92] Ibid., 1: 84.

samples) supplied by Boyle's gardener and "a domestic of Mr. Buckland."[93] In November 1663 the Society paid "Dr. Goddards mans Bill for Fuell," indicating that he had performed work for the Society.[94]

Skilled Craftsmen and Outside Experts

Embracing a mission of improving experimental philosophy, the Royal Society necessarily required experimental equipment. While the specific equipment desired varied widely depending on the changing interests of the Fellows, tools of some kind were always needed, an infinite number of small, unremarked upon equipment and supplies. The suppliers of these items were yet another group the Society interacted with in its early years, but skilled craftsmen entered Gresham College on mundane repair problems as well as experimental tasks.

The most detailed and coherent account of the Royal Society's equipment purchases in these early decades is found in the brief account created by William Balle, as "curator of magnetics."[95] A request from Charles II in January 1661 for the new group to study magnetism led to Balle's appointment to oversee these experiments, probably because of his pre-existing interest in such phenomena.[96] He began his charge by purchasing the most basic equipment needed for magnetic studies: "2 Needles" for 10 shillings, "2 Card-Needles" for 5 shillings, and two 'armed' magnets, one costing a pound, another 12 shillings.[97] While the suppliers of these items are not recorded, compass parts and magnets were not rare in London, as they were

[93] Ibid., 1: 216, 219.

[94] RS AB/1/1/1. November 11, 1663.

[95] Birch, *History*, 10; RS AB/1/1/1. Maddison, "The Accompt of William Balle."

[96] Birch, *History*, 1: 10.

[97] RS AB/1/1/1."Disbursed as Curator of Magnetics".

essential items for maritime ventures. Unlike the iconic scientific instruments of the day—such as Boyle air pump or optical instruments—much of this equipment was relatively cheap, and readily available. While Hooke (or the opticians he worked with) could spend weeks perfecting new lenses, and Boyle's air pump was famously difficult to maintain, Balle purchased many items on any given day, such as the 14 entries for February 11, 1661, including one for "38 small needles" for a mere 1 shilling a piece.[98] The ease with which he acquired these items makes it clear how readily available pre-made instruments were in London.

The account books show that Balle collected compass needles, dipping needles, armed and un-armed magnets, steel and iron, weights, scales, and pocket compasses, as well as boxes, cases, and covers for the magnets and needles he purchased. Equipment purchases involved makers of more specialist items as well. Balle required a £5 Azimuth Compass, a large instrument "essential for determining the deviation of the compass form the true North," and therefore crucial for the Society's investigations of the variation of magnetic north.[99] Several of the magnets he purchased were also ornamental objects—as in the "Loadstone armed in a brass case", "a Capped Indian Stone", a "Magnet capt with Silver", and " a magnet in leather." Balle also entered into his accounts the costs of "Capping Prince Ruperts Loadstone with Silver" and the amount "Paid for forging Capps for the Kings Terrella."[100] These luxury purchases would have involved a different set of artisans and suppliers.

Tracing the trail of later equipment purchases is more difficult, as no coherent register of equipment exists. References scattered throughout the account books, meeting minutes, and Hooke's diary, however, make it clear, that all types of investigations relied on materials or

[98] Ibid., "Disbursed as Curator of Magnetics".

[99] Gerard L'E Turner, *Scientific Instruments, 1550-1850: An Introduction* (London: Philip Watson, 1998), 34.

[100] "Disbursed as Curator of Magnetics" in RS AB/1/1/1.

equipment from suppliers in London. Some are from the relatively well-known instrument makers whose collaborations with Robert Boyle and Robert Hooke have been studied in previous literature, such as Ralph Greatorex and Christopher Cocks (also spelled Cox or Cock).[101] Christopher Cocks was the source of optical equipment such as microscopes, for example.[102] Less well-known figures populate these pages as well: A Mr. Percivall provided 120 "glasse drops," presumably the so-called "Prince Rupert's Drops," a small tear-shaped glass object which displayed perplexing tensile properties.[103] Glass equipment was purchased from unnamed artisans at one of London's glasshouses.[104] A dipping needle came from Mr. Sutton, a "perspective instrument" from Anthony Tompson, and mathematical instruments from Edward Fage.[105] Mr. Shaw, a founder, helped build the compressing engine in 1663 and a Mr. Hill constructed "a Glasse for the great Air Box" in the 1670s.[106] Other equipment came from unnamed sources: falling hammers, vipers, wicker screens, vitriol and quicksilver, beams and weights, bladders.[107]

The easy availability of the wide range of equipment and the makers of specialty items was one benefit of the Society's—and Gresham College's—location in the City of London. The

[101] Ibid. Greatorex: November 10, 14, 19, 1662; E. G. R. Taylor, *The Mathematical Practitioners of Tudor & Stuart England* (Cambridge: Published for the Institute of Navigation at the University Press, 1954), 229, 248.

[102] RS AB/1/1/1. Undated entries after August 1668.

[103] Ibid. May 22, 1661. Birch, *History*, 1: 17, 37; Laurel Brodsley, Charles Frank, and John W. Steeds, "Prince Rupert's Drops," *Notes and Records of the Royal Society of London* 41, no. 1 (1986).

[104] RS AB/1/1/1. July 9 and 23, 1661.

[105] Ibid. March 12, 1662; Dec. 23, 1663; undated entry before the end of 1672. Sutton was either Henry or William Sutton. Henry Sutton's premises were near the Exchange, and he is the more likely source. Taylor, *Mathematical Practitioners*, 220, 240. Anthony Thompson had associated with Gresham Professors and the "mathematical Club' during the Interregnum. Ibid., 220. Fage took over Thompson's shop after the latter's death. Ibid., 255.

[106] RS AB/1/1/1. December 24, 1663; August 3, 1670.

[107] Ibid. See entries for: January 2, 1661; January 16, 1661; November 6, 1661; June 19, 1661; November 30, 1661; May 13, 1662; and September 17, 1661.

suppliers and skilled workers who served as the sources for the equipment could also become part of the Society's experiments and meetings. While Fellows and the Society's operators and curators of experiment performed experimental work, outside skilled craftspeople also demonstrated experiments at Society meetings. For example, a series of experiments on the behavior of water and mercury in glass tubes, undertaken in 1663, required outside help.[108] The tubes themselves were made by specialist glaziers: in mid-1663 the Society purchased three 40-foot glass canes from a Mr. Puckle.[109] In addition, the account books show that in order to make the experiments reported in the November 18th meeting, the operator had to call in reinforcements. A carpenter, glazier, and bricklayer were all paid for their parts in "setting up and taking down the Glass-canes" at the end of November 1663.[110] The infrastructure was significant; the scaffolding and stand, presumably constructed out-of-doors in the Gresham College courtyard, required significant work and materials from the carpenter, who was paid £3-5-10 for this job—almost as much as the annual salary offered to the first operator in 1660.[111]

Bringing a range of skilled craftsmen into Gresham College was not unique to the Society's activities, however. The College building itself required regular visits from carpenters, pavers, and others to maintain the infrastructure.[112] And when Readers altered their lodgings, other workmen would be found in the College grounds as well. When Hooke built his turret in

[108] Birch, *History*, 1: 332.

[109] RS AB/1/1/1, May 27, 1663.

[110] Ibid., November, 1663.

[111] Ibid., November, 1663. Birch, *History*, 1: 6. The operator's salary was later increased.

[112] See expenses listed in LMA, Gresham College and Royal Exchange CLA/062/03/001, 1670-2, Workmen's Bills for Repairs, Decorations and Alterations at Gresham College and Bills for Curtains, Candles, Pipes, Water, Scavage, Clerks Fees, Etc; LMA Gresham College and Royal Exchange CLA/062/01/052, 1676-1704, Gresham College and Royal Exchange Account Books: Journal; LMA CLA/062/01/051; LMA CLA/062/01/009; LMA CLA/062/01/007, 1674, Bills for Repairs, Etc; LMA CLA/062/01/008, 1677, Bills for Repairs, Etc.

January and February 1675, for example, carpenters, glaziers, and laborers regularly moved in and out of the College.[113] Hooke's regular record of Gresham construction is also a regular record of the people who were part of the social space of the College.

In addition to helping construct experimental apparatus, outsiders could also be called on to demonstrate experiment or equipment from time to time. While the demonstrators' motivations for performing for the Royal Society were many (such as interesting potential patrons, hoping to establish the priority of their idea), basic pecuniary interests were also a factor. The Society paid people for these demonstrations. In December 1661, the Treasurer paid 10 shillings to "the man that shew'd Guns to the Society," a demonstration that was not recorded in the Society's minutes.[114] In January 1662 "a man introduced by the amanuensis" demonstrated the "making of marbled paper." This was undoubtedly the Mr. Angot who appears in the accounts books, receiving a payment for costs and time of £1-17-0 "for the Experiment of Marbled Paper."[115] Paying demonstrators continued in later years as well. In the mid-1670s, for example, instrument maker Henry Wynne demonstrated inclinatory needles for the Society.[116] He demonstrated a new instrument or revision of his own design, as during his first visit his device was "tried & found imperfect." Undeterred, the Society, echoing language often directed at Hooke after failed experiments "solicited [Wynne] to endeavor to make an exact one; which

[113] Hooke, *Diary*, 143, 145, 147, 148, 150.

[114] RS AB/1/1/1. December 11, 1661. Earlier in 1661 the Society had conducted experiments on the recoil of guns, but the long gap from April, the last time the experiments were recorded, to December makes linking this payment to that work uncertain. Birch, *History*, 1:8, 9, 10, 12, 16, 20, 33. Sprat, *History of the Royal Society*, 233-239. The description may also be erroneous and this could refer to someone who assisted in the previous weeks demonstration of "artificial serpents" (fireworks that burned under water). Birch, *History*, 1: 66.

[115] Birch, *History,* 1:70; *RS* AB/1/1/1. January 23, 1662.

[116] Taylor, *Mathematical Practitioners*, 242-243. Wynne had been an apprentice of Greatorex, which is perhaps how he came into contact with the Society.

he promised to do."[117] Wynne returned March 1st with an improved but still faulty model, then two weeks later presented "two other inclinatory needles, both which stood true."[118] Wynne's visits, no matter how much he enjoyed sharing his work with an audience of likeminded virtuosi, were not merely a matter of scientific research or demonstration for curiosity's sake. As the account books show, Wynne was *paid* for his demonstrations—10 shillings each for the first and third visit.[119] In addition, on his first appearance his servant (or possibly apprentice) accompanied him and received a 1-shilling perquisite.

Others

Two other groups were allowed in by statute: the Gresham almsmen and the audience for the Readers' lectures. The eight almsmen, "poore and ympotente persons" selected by the Joint Committee, lived in the eight almshouses on the Bishopsgate street side of the College, underneath the West gallery.[120] In addition, the general public was supposed to use Gresham College as an educational resource, serving as audiences for Readers' lectures. While attendance was abysmal by the end of the 17th century (due in part to decades of absentee professors), members of the public could and did access the college easily. For example, Hooke records a "rusty old fellow [walking] in the Hall from 2 till almost 3," despite the man's disinterest in the lecture Hooke was supposed to be delivering.[121] At the same time, however, the gates and porter attending the College were meant to provide some control to access to the College, albeit one

[117] Birch, *History*, 3:334.

[118] Ibid., 3:336.

[119] RS AB/1/1/1. Feb 15, 1677; March 15, 1677.

[120] Ward, Lives of the Professors, 22.

[121] Hooke, *Diary*, 323. October 25, 1677.

that failed. As Dr. William Petty complained in 1652, the College's porter neglected his duties and allowed "dangers about the Colledge...by people that lurke there in about evening times."[122] While some of the intrusions and dangers faced by the College and its occupants were the result of the unsettled climate of the Interregnum, political stability did not end the College's difficulties. In 1682, for example, the Committee made note of " the Mischeife there done by a…Multitude of Boyes & ffellowes with footballs & stones wilfully throwne" and ordered the new porter "to keepe the Doores of the Colledge Shutt, except at the reading times of the respective Lectures there."[123] While the Society's Repository was nominally open to visitors, Hooke's diary suggests that, visitors were rare, and usually guests of Fellows. For example, in August 1673, Hooke reported "Mr. Hill, Mr. Horneck, Lord Brounker, Sir J. Worden, Sir Th: Clutterbuck, in Repository."[124] Similarly, he recorded showing a Mr. and Mrs. Goldsmith around while Colwall directed other guests in the summer of 1674.[125] Occasionally unknowns ventured in, as in January 1677/8 when two unnamed "gentlemen [came] for lecture [and] to see repository."[126]

In addition to the usual people who could be found in the College, extraordinary circumstances could drastically reshape the social space of the College. While the College housed soldiers during the Interregnum, they briefly appeared back in the college in the summer of 1675, as a few entries in Hooke's diary make clear. On the 13th of August, he recorded "Mayor Puts Company here." The next days record him speaking to the Lord Mayor and

[122] Mercers' Archive, GR 2, 131.

[123] Mercers' Archive, GR 4, 87.

[124] Hooke, *Diary*, 54.

[125] Ibid., 108.

[126] Ibid., 342.

recording "shut souldiers out of the Hall." Their stay was short, if contentious, and on the 19th Hooke could note with satisfaction that the "Soldiers left the Colledge."[127]

After the Great Fire, the kinds and numbers of people who had reason to visit Gresham College changed as well. Following the arrival of Royal Exchange merchants and Guildhall officials, the building adopted a newly chaotic nature—now with a courtyard of commercial transactions, halls full of city functionaries, and constant meetings concerning emergency and regular City business. Hundreds of new people came regularly into the College space, interacting with the shops and City officials found within. While the Council of the Society meeting in Hooke's rooms during these years, the officers of the City government, merchants displaced from the Exchange, and some of the lease-holders for the shops were of London's upper classes, City business and the work of the shops and merchants would have necessitated suppliers, customers, and workers of all types to regularly enter the College. Traces of some of the inhabitants are visible in the struggles the Committees experienced in returning the College to normal after the rebuilt Exchange opened. In November of 1673, the Committee declared once again that there was need to "regulate the abuses of Gresham College as well as removing families now residing there and unfit meetings which are kept there to the disadvantage of the college."[128] In March 1674 things were still not back to normal, despite the opening of the new Royal Exchange, and orders were again issued "that families inhabiting the college were to be removed."[129]

[127] Ibid., 174-175. August 13, 15, 16 and 19, 1676.

[128] Mercers' Archive, GR 3, 133; Adamson, "The Foundation and Early History of Gresham College London 1596-1704," 223.

[129] Mercers' Archive, GR 3, 148. Adamson, "The Foundation and Early History of Gresham College London 1596-1704," 223.

These records show that both the physical and social space of Gresham College was not stable. Residents and their visitors had to deal with regular disruptions of construction and repair. Accompanying the changing nature of the building itself was the constantly changing stream of people at Gresham. From illegal lodgers in absentee readers' rooms to construction crews and members of the City of London and the Mercer's Company, Gresham College was a busy, disrupted space for the Royal Society to meet. While the Society only met periodically (at best weekly, although some committee meetings were also held in the College), and could perhaps avoid the worst of the noise, disruption, and people, they could not escape the messy reality of living in Gresham College. Gresham's lectures may have failed to consistently attract a wide audience of Londoners, but the College itself remained intertwined with the busy, noisy world of Restoration London and its population.

Two case studies

While the day-to-day life of the Society necessitated interacting with a wide range of people, many of the more extensive projects the Society pursued during their early years also depended on interactions with the broader social world of London. In some cases the Society intentionally sought out information from outsiders; in others their projects arose from more unplanned interactions. Being open to chance and willing to be "guided…according to what any foreiner[sic], or English Artificer, being present, has suggested" meant embracing a less-than-controlled experimental program, that spanned many spaces and encompassed many people outside of the circle of Fellows meeting at Gresham College.[130]

[130] Sprat, *History of the Royal Society*, 115.

(1) Testing the "Blood-Staunching Liquor"

The Society's brief involvement in the testing of a new styptic substance in the summer of 1673 demonstrates ways in which the new science spanned a multitude of spaces and included participants outside of the gentlemanly realm. In 1673, the French physician Jean-Baptiste Denis (also spelled Denys) wrote a letter to Oldenburg describing a new substance that quickly stopped the flow of blood from even serious surgical cuts or amputations.[131] Shortly thereafter, Denis was in London and his substance was tested at meetings of the Royal Society and in front of Charles II.[132] Following tests on human surgical subjects, the new liquid was declared a success, formulated in the King's own laboratory, and sent to the Navy for use aboard ship.[133] Denis returned to Paris sometime before the end of the year, and the blood-staunching liquor disappears from the historical record.[134]

At first glance, the accounts of the testing done in London reflect the involvement of English elites in the medical, political, and military community, unsurprising given such a politically and potentially militarily important substance. Just as Louis XIV had supported the initial tests of the new substance in Paris, Charles II showed personal interest when the material

[131] M. Denys, "Extract of a Letter, Written to the Publisher by M. Denys from Paris, May 1. 1673; Giving Notice of an Admirable Liquor, Instantly Stopping the Blood of Arteries Prickt or Cut, without Any Suppuration, or without Leaving Any Scar or Cicatrice," *Philosophical Transactions* 8 (1673).

[132] Monsieur Denis, "Experimens of a Present and Safe Way of Staunching by a Liquor the Blood of Arteries as Well as Veins; Made Both in London and Paris," ibid.

[133] "An Account of the Experiments Promised at the End of the Next Precedent Transactions, Concerning the Wonderful Effects of the Blood-Staunching Liquor Upon a Man and a Woman in St. Thomas's Hospital in South-Wark London," ibid.; "A Letter to the Publisher Written by One of the Principal Chirurgions of His Majesties Fleet, Concerning the Further Success of the Blood-Stanching Liquor, Formerly Taken Notice Of," *Philosophical Transactions* 8 (1673).

[134] See Denys's November letter to Oldenburg published in the *Philosophical Transactions*. Monsieur Denys, "An Extract of a Letter," ibid.

arrived in England.[135] The medical professionals involved were similarly highly ranked in their professions. Denis was a physician to Louis XIV; the surgeon Richard Wiseman was serjeant surgeon to Charles II. Dr. Walter Needham was, in addition to being a FRS, an honorary fellow of the Royal College of Physicians and a physician at the London Charterhouse.[136] After successful testing, Charles ordered the substance sent to his fleet, where surgeons serving under noted naval officers the Earl of Ossory, Sir Edward Spragg, and Sir John Berry embraced its use.[137]

Similarly, the Society's involvement in this project came through the usual channels. The Society's first notices came from a letter sent to Henry Oldenburg from Jean-Baptiste Denis, a physician to Louis XIV, reporting on the amazing substance that was then being tested in Paris.[138] While the Society had performed and reported on blood transfusion trials in the 1660s, and indeed sparred with the same Denis over priority claims, their involvement in the styptic trials only occurred because of Denis' arrival, with the substance, in London.[139] His presence

[135] M. Denys, "Extract of a Letter, Written to the Publisher by M. Denys from Paris, May 1. 1673; Giving Notice of an Admirable Liquor, Instantly Stopping the Blood of Arteries Prickt or Cut, without Any Suppuration, or without Leaving Any Scar or Cicatrice," ibid.

[136]John Kirkup, "Wiseman, Richard (Bap. 1620?, D. 1676)," In *Oxford Dictionary of National Biography*. (Oxford University Press, 2004; online edn, Jan 2008), http://www.oxforddnb.com/view/article/29792. Accessed Oct 8, 2015; D'A. Power and rev. Patrick Wallis, "Needham, Walter (Bap. 1632, D. 1691)," In *Oxford Dictionary of National Biography,*. (Oxford University Press, 2004; online edn, May 2006), http://www.oxforddnb.com/view/article/19849 Accessed Oct. 8, 2015.

[137] "Further Success."

[138] M. Denys, "Extract of a Letter, Written to the Publisher by M. Denys from Paris, May 1. 1673; Giving Notice of an Admirable Liquor, Instantly Stopping the Blood of Arteries Prickt or Cut, without Any Suppuration, or without Leaving Any Scar or Cicatrice," ibid.

[139] A. Rupert Hall and Marie Boas Hall, "The First Human Blood Transfusion: Priority Disputes," *Medical History* 24 (1980).

was a testament to the international connections foster by Oldenburg and to the French-English military alliance against the Dutch.[140]

Studying the accounts of this new substance more closely, however, reveals that the English tests reached beyond the international Republic of Letters and circles of courtly political influence, involving local people and resources in London.[141] Animal experiments in general necessarily involved a work force that extended beyond the gentry. The meeting minutes largely treat animal specimens as any other type of equipment. When the need arises the relevant person—most often the operator—is ordered to procure the necessary animal(s) for the next meeting.[142] How those animals were procured is absent from the records, but at least by the time his *Diary* opens, Hooke records no such menial activities as dog-catching or chicken-wrangling, by himself or other Society employees. Some birds were undoubtedly purchased from food markets, and stray dogs and cats were abundant in any early modern city. In Paris, the Académie des Sciences designated an employee, Claude-Antione Couplet, whose job included procuring animals for experiments and dissection, although he undoubtedly purchased animals from other,

[140] The Society's involvement in these tests was undoubtedly partly political. Although the question of staunching blood without tying or burning veins and arteries was of interest to physicians and surgeons in general, this particular substance's arrival in London in the hands of Jean-Baptiste Denis, physician to Louis XIV was subject to more than mere professional curiosity. As Denis wrote to Oldenburg, in a letter describing the earlier tests in France, "You may judge, how useful this Essence is like to prove in Armies, where most men dye for want of a good remedy to stop the blood." (Denys, "Admirable Liquor," 6039.) In 1673, France and England were allied against the Dutch in the Third Anglo-Dutch war. J. R. Jones, *The Anglo-Dutch Wars of the Seventeenth Century* (London; New York: Longman, 1996), 179-216. Denis and physicians of the Royal Society had sparred in the 1660s over questions of priority in the matter of blood transfusion, and it seems likely that the public alliance of Denis and the Royal Society, and Oldenburg's publicity of it in the pages of the *Philosophical Transactions*, reflect the Society's courtly and military connections, and desire to support the military action and alliance between their counties. In addition, in 1667, during the Second Anglo-Dutch war, Oldenburg was briefly imprisoned on suspicion of espionage. The accounts of these experiments in the *Philosophical Transactions*, which he produced, may also represent his awareness of the benefits of advertising his connections with foreign allies.

[141] The substance was also tested in Italy. Domenico Bertoloni Meli, *Mechanism, Experiment, Disease: Marcello Malpighi and Seventeenth-Century Anatomy* (Baltimore: Johns Hopkins University Press, 2011), 184-185.

[142] See, for example: Birch, *History*, 1: 220, 237, 286. Mr. Croune, a Fellow and the Society's register until the issuing of the first charter, was also directed to procure animals. Ibid., 1:31, 33. A more general exception to this approach was when unusual specimens—monstrosities, oddities, or specimens preserved by a new method—are featured at meetings. In these cases the source of the specimen is usually given.

unnamed sources, as did the operator and Fellows in London.[143] In addition, references to previously-experimented upon animals being presented for observation in subsequent weeks make it clear that *someone* regularly took on the task of tending to a menagerie of small animals. Once again this task was sometimes assigned to the operator.[144] However, an entry in the account books related the blood staunching experiment reveals that tasks were not necessarily completed by the person to whom they were assigned. After the first test before the Society, on June 11, the dog was "committed to the care of Mr. Hooke to see whether the wound would keep staunch."[145] The Society's cleaning woman, Eliza Boon, had a hand in these matters from time to time, and was involved in the blood staunching tests. The Society paid her extra upon presentation of a "a Bill for Doggs and keeping them for Experim[ents]" in July 1673, just one month after these experiments.[146] In addition, Hooke's Diary, while recording the demonstrations in front of the Society omits mention of any fact concerning the fate of the dog post-surgery and makes no reference to Boon or her task.[147] Boon, and other servants, were essential for the overlooked but essential task of cleaning the detritus of this and the Society's other animal experiments.

Performing the tests of this substance also required additional hands. While the descriptions of the initial test trials assign Wiseman and Needham active roles in cutting and bandaging in some instances, other descriptions are unclear as to who performed these actions.[148]

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[143] Guerrini, *The Courtiers' Anatomists*, 117.

[144] See, for example, Birch, *History*, 1:214. "The kitten not dying whilst the society was together, the operator was appointed to observe what should become of it."

[145] Ibid., 3: 92.

[146] RS AB/1/1/2, July 12, 1673.

[147] Hooke, *Diary*, 46-47. This example should make us cautious about uncritically assigning experimental tasks directly to Hooke.

[148] Denis, "Experimens of a Present and Safe Way of Staunching by a Liquor the Blood of Arteries as Well as Veins; Made Both in London and Paris," 6052-6053.

For both the dog experiments at the Royal Society and the calf experiments in front of the King, crucial to the effectiveness of the liquor was keeping the animal still for a period of time, and certainly no single surgeon could have held down a calf. In the first demonstration in front of the King, one calf had an artery cut open, the other part of his leg amputated. The account is not explicit about who performed the arterial dissection, but it is clear about who was involved in the amputation: a butcher, who remains unnamed, and who would have undoubtedly required assistants to hold down the animal, or at least to help him securely tie it down before beginning.[149]

The human trials of the substance also involved more than just the elite physicians and surgeons the King had at his command. Mr. Wiseman performed tests on some of his surgical patients. While unnamed, they were undoubtedly well-to-do, as benefited his position in the medical community.[150] In contrast, when the two amputations testing this material were performed in early July at St. Thomas hospital, the regular staff at St. Thomas' performed the operation on two unnamed lower-class patients: a woman suffering from the King's Evil and a seaman wounded by the Dutch.[151] Finally, naval surgeons treating unnamed victims of battles against the Dutch used the substance.[152]

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[149] Ibid., 6053-6054.

[150] Wiseman held a royal appointment, and one of his patents is described as being transported in a coach. Ibid., 6052.

[151] "An Account of the Experiments Promised at the End of the Next Precedent Transactions, Concerning the Wonderful Effects of the Blood-Staunching Liquor Upon a Man and a Woman in St. Thomas's Hospital in South-Wark London," ibid.: 6078-6079. We do have to wonder how accurate this account was, however, as the physicians reported the incredible fact that immediately after her amputation, the first patient "look'd very cheerful, and was free from pain…" an astonishing report even given the immoderate quantities of alcohol the patient may have been plied with before the operation. The patients were certainly selected for their political symbolism—the seaman injured in the war the Crown was fighting, and the woman suffering from the disease whose miraculous cure was part of the pageantry of divine-right kingship.

[152] "Further Success."

In Restoration England, as in early modern Europe in general, there was no clear boundary between medical and biological studies and spectacle. Even before the blood-staunching trials in 1673, experimental spaces involving animals were not tightly controlled, and necessarily involved the participation of others outside the Fellowship. In extreme cases, spectators could create problems as when Dr. Edmund King tried his animal-to-human blood transfusion techniques in 1667.[153] The "great crowd of spectators….would not admit of that exactness" with which the experiment was intended to be performed, and the Society's physicians were asked to repeat their work.[154] Hospital amputations were part of the sights to see in London, meaning that the audience for the tests at St. Thomas's likely had an audience beyond the recorded medical professionals.[155]

The experiments on the dogs, performed for the Society took place at Arundel House, a more private location than the Gresham College setting the Society was to return to at the end of the year. Nevertheless, Charles Howard had rooms to offer to the Society after the Fire, and later his brother Henry, willingly accommodated the Society with additional space for anatomical work (in addition to the library where Society meetings were more regularly held).[156] In addition, the public renown of the library and statuary collection, gathered by the earlier Earl of Arundel, and the regular payment of tips and perquisites to Arundel House servants during the Society's

[153] Edmund King, "An Account of the Experiment of Transfusion, Practised Upon a Man in London," ibid. 2 (1667).

[154] Birch, *History*, 2:225; Anita Guerrini, "The Ethics of Animal Experimentation in Seventeenth-Century England," *Journal of the History of Ideas* 50, no. 3 (1999): 404; quoting Oldenburg to Boyle, November 25, 1667 in Oldenburg, Hall, and Hall, *Correspondence*, 3: 611-612.

[155] Both Pepys and Evelyn record observing amputations. John Evelyn, *Diary*, ed. E. S. de Beer (Oxford: Clarendon Press, 1955), 3: 610; Samuel Pepys, *The Diary of Samuel Pepys. Volume 4: 1663*, ed. Robert Latham and William Matthews (Berkeley: University of California Press, 1971), 340.

[156] Birch, *History*, 2: 114, 138, 300.

years there should make us hesitate before declaring the space purely private.[157] Similarly, while the demonstrations before Charles II took place in the elegant setting of Inigo Jones's Banqueting House, the spectacular nature of vivisection experiments means we should imagine courtiers (and their servants) witnessing the tests as well.[158] At the second set of tests made before the King, the styptic performed so well it excited the "admiration of all the Spectators."[159] Once the King ordered the styptic to be manufactured in his laboratory, the cast of characters expanded to include Christian Harrell, head of the King's laboratory in 1673, as well as operators or laborers under his direction.[160]

While the speed with which this substance disappeared from the public record suggests that reports of its great efficacy were stretched, perhaps because of its political import, it is clear that testing the styptic passed out of traditional spaces of the new science and medicine and simultaneously crossed paths with a varied subset of the London population.[161]

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[157] Shapin, "The House of Experiment," 381. David Howarth, *Lord Arundel and His Circle* (New Haven: Yale University Press, 1985).

[158] Denis, "Experimens of a Present and Safe Way of Staunching by a Liquor the Blood of Arteries as Well as Veins; Made Both in London and Paris," 6054. The language used makes it clear the experiments were inside the building, rather than in the adjoining courtyard. The calves "by his Majesties command were brought *into* the Banqueting house" (emphasis added) and after the first animal's bleeding had stopped it "walked about the house."

[159] "An Account of the Experiments Promised at the End of the Next Precedent Transactions, Concerning the Wonderful Effects of the Blood-Staunching Liquor Upon a Man and a Woman in St. Thomas's Hospital in South-Wark London," ibid.

[160] Ibid., 6079. "The Medical Establishment: Chemist 1660-1837," In *Office-Holders in Modern Britain*, ed R O Bucholz. (London: University of London, 2006), http://www.british-history.ac.uk/office-holders/vol11/pp173-177. Accessed October 8, 2015.

[161] Italian tests also reported its inefficacy. Bertoloni Meli, *Mechanism, Experiment, Disease: Marcello Malpighi and Seventeenth-Century Anatomy*, 184-185.

(2) Diving and Mr. Rockford:

While the spaces and people involved in the blood-staunching liquor trails are relatively easy to follow, it is harder to determine what direct impact many of these people had on the testing program. In the case of the Society's initial foray into diving experiments in 1661-2, the influence of a hitherto largely ignored employee of the Society is clear. Although the Society clearly had interests that intersected with diving experiments, the actual impetus was the knowledge and skills of the amanuensis, a paid employee of the Society. Although the amanuensis was originally desired to be "some discrete person, skilled in shorthand writing," the minutes of the early meetings make clear that the unnamed man was also knowledgeable about various things of interest to the Fellows of the Society.[162] He was often called upon to perform tasks indistinguishable from those assigned to the operator, a person who was supposed to assist the curators (who were envisioned as Fellows) in experiments.[163] For example, the amanuensis provided glass equipment, some of which he purchased and some he was "ordered to make."[164] He was also tasked with subjecting antimony to calcination (heating it until converted into a friable substance) when the Society tested claims published by M. Le Febvre about the process.[165] The amanuensis also connected people with relevant skills to the Society, as when he introduced an expert in making marbled paper at one meeting, and a man with a new idea about melting lead ore with coal rather than charcoal at another.[166]

[162] Birch, *History*, 1: 4. See also discussion of payment for extra writing work on pages 6-7.

[163] Ibid., 1: 6-7.

[164] Ibid., 1: 17, 21.

[165] Ibid., 1: 19, 20.

[166] Ibid., 1: 70, 119, 120.

While unnamed in the meeting minutes, other evidence suggests that this position was filled for a time by the otherwise unknown Mr. Rockford, who built a diving engine for the Society in its first years. Rockford may have been French or of French extraction, given the description of varnish was provided to the Society (in French), by a man with the same name. Additionally, the amanuensis was tasked with translating several of Huygens' early letters to the Society for the Fellows insufficiently familiar with French.[167] Not only did the amanuensis "provid[e] a diving engine," he was himself the diver when it was tested in July 1661, staying submerged for 28 minutes.[168] A year after this initial foray into the world of diving, the amanuensis was "ordered to write an account of the particularities of his diving under water in Sweden."[169] An account of diving in Sweden survives in the Royal Society archives and is entitled "Details of a relation of M. Rochford's walking underwater at Gottenberg in Sweden," further cementing the link between the two figures.[170] In addition, an entry in the Society's account book for January 23, 1662 records "Paid Mr. Rockfords bill and ¼ Sallery." While outside workers as well as Fellows and Society employees could present bills for payment, only two people received remuneration labeled "salary" this early in the Society's existence—the operator and the amanuensis. Richard Shortgrave already held the operator's position.[171]

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[167] Ibid., 1: 102, 106. Mr. Rochefort, RS Cl.P. 2/26, nd, Vermis De La Chine. Rockford is the spelling used in the Society's Account Books, which comprise the majority of occurrences of his name. It is also spelled Rochefort and Rochford in other Society records. Hunter refers to this man as "Roquefort," (for example Hunter, *Science and Society in Restoration England*, 95). I have not seen a contemporary source that uses that spelling, but it would fit with a possible French ancestry.

[168] Birch, *History*, 1: 35.

[169] Ibid., 1: 102.

[170] M Rochford, RS Cl.P/6/28, nd, Details of a Relation of M Rochford's Walking Underwater at Gottenberg in Sweden.

[171] Robinson, "The Administrative Staff of the Royal Society, 1663-1861." RS AB/1/1/1.The amanuensis is first paid a sum denoted a "salary" on August 29, 1661. Thereafter, the amanuensis, Rockford, who I argue is the same person, Richard Shortgrave (also referred to as the operator), and later Michael Wicks (the clerk after 1663), Hooke

The Society tapped into Rockford's experience not only through soliciting the written account, but also by hiring him to build them their own diving bell. As with most of the Society's early projects, multiple motivations drove this investigation. Robert Boyle collected divers' accounts to understand the nature of air and air pressure.[172] Information about the natural history of the ocean, and the topography and zoology of the watery world below the surface was also of interest.[173] Unlike the Society's interest in diving in 1663/4, which was explicitly linked to the important project of building a breakwater and port at newly-acquired English Tangier, the initial foray into diving was not clearly linked to any one cause and seems to be the result of the fortunate embrace of M. Rockford's expertise.[174] In addition, a satirical poem written by a Fellow during the Society's early years suggest a certain unfamiliarity with the *fait accompli* of the diving bell, saying that success in this area would be "a Miracle."[175]

In fact, diving was not a new practice in early modern Europe, and outside of the Royal Society, practicing salvage divers could be found in maritime cities throughout Europe. They were usually employed to recover valuable commodities from foundered vessels. Primarily this

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and Oldenburg are paid salaries. Regular payments to the cleaning woman and porter are sometimes denominated "wages" but never salaries. Most payments to individuals are based on now lost "bills" or "notes."

[172] Anecdotes about divers and diving from unidentified sources are liberally scattered throughout Boyle's works. See: Robert Boyle, Michael Cyril William Hunter, and Edward Bradford Davis, *The Works of Robert Boyle*, 14 vols. (London ; Brookfield, Vt.: Pickering & Chatto, 1999). *Spring of the Air*, vol. 1: 292; *Defence Against Linus*, vol. 3: 80; *Experiments touching cold*, vol. 4: 373-4; *Of the Temperature of the Submarine Regions As to Heat and Cold*, vol. 6: 345, 347-9, 351-2; *Tracts (1670): Bottom of the Sea*, vol. 6: 360-36; *Usefulness* II, vol. 6: 482; *Tracts (1672) Hydrostatical Discourse*, vol. 7: 171, 176, 181-2; *Tracts (1672): Heavy Solids and Fluids*, vol. 7: 220-221, 225; Tracts (1673): *Saltness of the Sea*, vol 7: 395-396.

[173] Birch, *History*, 1: 29-30. The Society's concern with understanding the saltiness of the sea in different locations (and with wanting to compare English (fresh) water with water from other parts of the world) derived in part from their desire to replace Aristotelian models with ones based on direct observation. The broad Aristotelian tradition (although based on Pliny more than Aristotle) embraced an explanation for why the sea was salty that included a contention that this saltiness should vary by location. Margaret Deacon, *Scientists and the Sea, 1650-1900; a Study of Marine Science* (New York: Academic Press, 1971), 7-8.

[174] Birch, *History*, 1: 330, 370, 384-385.

[175] Dorothy Stimson, "'Ballad of Gresham Colledge'," *Isis* 18, no. 1 (1932): 113; F. Sherwood Taylor, "An Early Satirical Poem on the Royal Society," *Notes and Records of the Royal Society of London* 5, no. 1 (1947).

meant bringing to the surface the valuable weapons sunk with military ships; naval ships were increasingly weighed down with cannon, which were expensive to produce. Even if the weapon itself was no longer battle-ready, the value of the scrap metal was high enough to make expensive and risky salvage operations a viable enterprise.[176] Durable, and therefore recoverable, valuables could also include coins (especially from Spanish shipwrecks), and anchors.[177] For example, In 1629, the Lords Commissioners of the Admiralty authorized Jacob Johnson "to employ his art and industry by diving in the harbours and creeks in the Isle of Wright, the Lizard of Cornwall, Castlehaven on the Coast of Ireland, and elsewhere for the recovery of ordnance, money bullion, anchors, cables, and other commodities."[178] Periodic petitions throughout the reign of Charles I indicate that while Johnson thought he had a monopoly on the position, local authorities and ship owners periodically impeded or challenged Johnson's work.[179] Since these challengers were recovering ordnance, money, and other goods without Johnson's expertise, it is clear that others earlier in the 17th century British Isles had the skills and equipment necessary to undertake salvage dives. This knowledge persisted throughout the century. At the Restoration, James Maule petitioned for a patent from Charles II for "his sole power for 31 years to fish up and recover all sunken ships, guns, &c., for the use of the Crown" based on "a new invention of

[176] Mårten Triewald et al., *The Art of Living under Water* (London: Historical Diving Society, 2004); Robert F. Marx, *Into the Deep: The History of Man's Underwater Exploration* (New York: Van Nostrand Reinhold, 1978); Deacon, *Scientists and the Sea, 1650-1900; a Study of Marine Science*; Philippe Diolé, *Under-Water Exploration, a History*, trans. H. M. Burton (London: Elek, 1954).

[177] Moray tells a story, for example, from the French ambassador about a diver in Dieppe who brought up 40,000 guilders from a wreck. Birch, *History*, 1: 396.

[178] *Calendar of State Papers Domestic: Volume 144: Charles I, 1628-29*, ed John Bruce. (London: Her Majesty's Stationery Office, 1859), http://www.british-history.ac.uk/cal-state-papers/domestic/chas1/1628-9/pp562-579. Accessed July 8, 2015.

[179] *Calendar of State Papers Domestic: Volume 167: Charles I, 1629-31*, ed John Bruce. (London: Her Majesty's Stationery Office, 1860), http://www.british-history.ac.uk/cal-state-papers/domestic/chas1/1629-31/pp262-273. Accessed July 8, 2015.

working at 20 or 30 fathoms, in which he was employed by the late King of Sweden."[180] William and Mary were similarly petitioned by divers, and in the 1690s, London newspapers carried notices of tests of new diving equipment and advertisements by an inventor seeking backers.[181]

Despite this, the Society felt it was worthwhile to sponsor Rockford's equipment, perhaps in connection with the Society's interest in practical and useful projects or for any inquiries the Society had regarding air and water pressure.[182] Even if they were not intimately concerned with improving salvage operations, a philosophical interest in the submarine world was a desideratum for the new natural philosophy according to both Francis Bacon and John Wilkins.[183] Judging by the costs involved, it was clearly an important project for the Society. Before they parted with Rockford, the Society had paid him nearly £70. While the wording of the last entry ("Paid Mr. Rockford all his Demands") suggests that they had hoped to get the engine for a lower price, this total dwarfs most of the Society's other expenditures in these years.[184]

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[180] *Calendar of State Papers Domestic: Volume 19: Charles II, 1660-1*, ed Mary Anne Everett Green. (London: Her Majesty's Stationery Office, 1860), http://www.british-history.ac.uk/cal-state-papers/domestic/chas2/1660-1/pp317-331. Accessed July 8, 2015.

[181] October 28, 1691, "Proceedings upon the petition of John Tyzack, and Nicholas Finchley." in *Calendar of State Papers Domestic: William and Mary, 1690-1*, ed William John Hardy. (London: Her Majesty's Stationery Office, 1898), http://www.british-history.ac.uk/cal-state-papers/domestic/will-mary/1690-1/pp534-557. Accessed July 8, 2015. "Yesterday a Skilful Person in the Art of Diving..." *Post Boy (1695)*, September 17 - September 20 1698; "Advertisements: The Parties Concerned in Mr. John William's Diving Engine…," *Flying Post or The Post Master*, July 2 - July 5 1698.

[182] Hunter, *Science and Society in Restoration England*, 94-95.

[183] Francis Bacon, Lisa Jardine, and Michael Silverthorne, *The New Organon*, Cambridge Texts in the History of Philosophy (Cambridge England ; New York: Cambridge University Press, 2000), 209. John Wilkins, *Mathematical Magick, or, the Wonders That May Be Performed by Mechanichal Geometry: In Two Books, Concerning Mechanical Powers [and] Motions : Being One of the Most Easie, Pleasant, Useful, (and yet Most Neglected) Part of Mathematicks* (London: Printed for Edw. Gellibrand, 1680), 178-190.

[184] Some of these "demands" from the last payment of £37-8-0 could also have been for payment owed for amanuensis work, not just for the diving bell. Earlier, over £20 was paid out for expenses explicitly associated with the diving bell.

While illustrations of innovative suits and designs appeared in natural philosophical books, the equipment used by practical salvage operators and on the Society's behalf took the form of a diving bell.

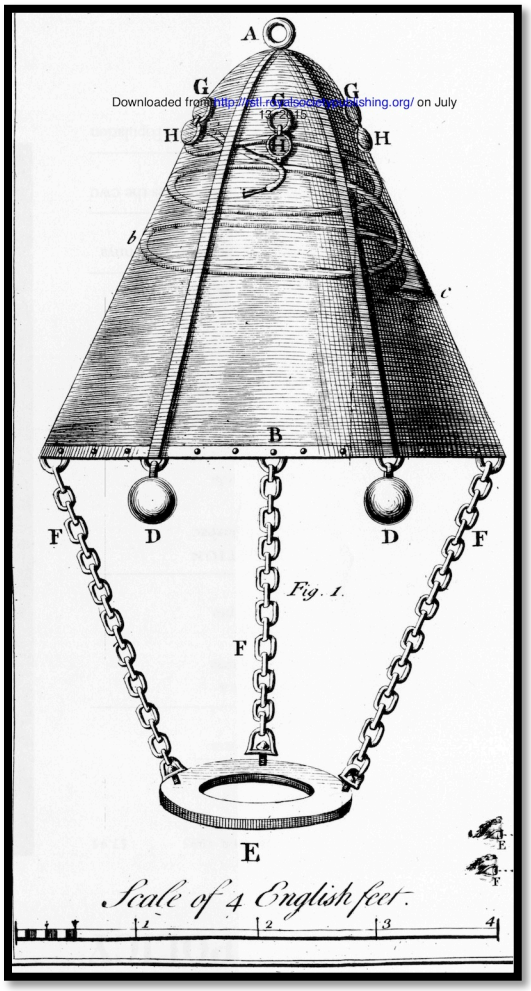

Figure 2.3: The common shape of a diving bell as illustrated in an 18th century article in the *Philosophical Transactions* on improvements to diving equipment.[185]

Mentioned in works as early as Aristotle, these bell-shaped metal or wooden structures could come in many sizes, and all took advantage of basic hydrostatic principles to create a

[185] Martin Triewald, "A Letter to the Reverend John Theoph. Desaguiliers, L. L. D. F. R. S. From Mr. Martin Triewald, F. R. S. Captain of Mechanics, and Military Architect to His Swedish Majesty, Concerning an Improvement of the Diving Bell," *Philosophical Transactions* 39 (1735).

repository of air for the underwater diver.[186] The bell, filled with air at sea level, was slowly and evenly lowered down to the desired depth. While the pressure of the seawater compressed the air in the interior of the bell, at the depths at which it was employed, the air pressure and water pressure reached an equilibrium with a reservoir of breathable air remaining in the top of the bell. The actual form of the instrument built by Rockford for the Society is unknown, but some of his earlier ideas are documented in his account of diving in Sweden.

While his experiences originated in salvage operations ("in the getting up of some bras[sic] guns, sunk upon the coast of Sweden, in the ship Sophia belonging to the King of Denmark"), Rockford's account is not focused on the business of salvage.[187] Rockford instead devotes considerable space to details of the equipment he used during these trials, a focus that makes sense given the Society's support for his inventiveness in the form of sponsoring the construction of a diving bell. Rockford's account depicts himself as an inventive virtuoso, attempting several designs of suits and bells during the attempts on salvaging from the *Sofia*. He also details his observations about his physical sensations while diving, from difficulties with condensation from his breath dampening a leather suit to the notes he made about the rise and fall of seawater as the bell was lowered and raised. Furthermore, Rockford details his own device for recording this data reliably:

> We often let down the bell before any one went ni[sic] it, to know how high the water ascended, and the best invention I found, was two peeces of soft wax, like tapers, one stuck agst the brim of the bell, and the other severll[sic] inches higher, and a peece of wellgumm'd white paper, cut as long as that distance, and stuck to the waxe that no part of the paper touch the bell, but was above an inch off; for

[186] Marx, *Into the Deep*, 31.

[187] RS Cl.P/6/28. Rochford's Walking Underwater, f. 50r-51v. This would be the shipwreck of the *Stora Sofia*, a Danish ship that sank off the coast of Sweden in 1645. As a flagship of the Danish navy, the *Sofia* was heavily armed and, therefore, a good target for salvage operations. Hans Albrecht von Treileben raised at least 17 cannon from the wreck in the 1660s. Thomas Bergstrand, "The Danish 17th-Century Man-of-War *Stora Sofia*: Documentation and *in Situ* Preservation," *The International Journal of Nautical Archeology* 39, no. 1 (2010): 57.

> otherwise it would filter up, and leave…an uncertainty, but so, the water would marke the paper so streight, as any line can be drawne, and in this manner we tryed the immersion of the bell at ever fathom, and found that past 6 fathom there was then a visible difference of the rise of water ever fathom after.[188]

In addition to demonstrating his interest and aptitude in diving and hydrostatics, Rockford also used his account to record his broader interests in the natural world, describing 'sea-bottom fruits' he brought to the surface after one dive.[189] These natural curiosities were

> as big as Carye Mellons, but in such shape, as the spots of Colors throwne on the gumme water to make marbled paper: and when I thought, I should have need of both my hands to take up one, I found, that I tooke three of them in one hand, of which I brouk one by squeezing it too hard, and the other two I brought up, which being broke by the much handling of the Admirers of them, kept their color till they were dry, then faded; the matter within was [illegible] matter, and cleer and very slippery.[190]

He further supported his claim to be of the social and educational quality of the Fellows by ending his report with an amusing tale of an ignorant "Country fellow" whose drunken excesses the night before and ignorance of proper precautions cause him to "swoon" after going down in the diving bell, "so much that his fellows thought him dead." Rockford's quick thinking revived the man, who ashamedly returned to the diving bell to bring up more "sea bottom fruits," the only item of value recovered during this operation.[191]

Overall, Rockford's account reads as an attempt to place himself amongst the Fellows of the Society. Although he was paid for specific clerical tasks, the minutes make it clear Rockford possessed connections to instrument makers and inventors around London. Many of his

[188] RS Cl.P/6/28. Rochford's Walking Underwater, f.51v.

[189] Ibid., f. 50v. Rockford says he had lately "related...something [about the fruits] to the Society" but I have been unable to find a record of his account.

[190] Ibid.

[191] Ibid., f. 51r, v.

assignments were indistinguishable from those delegated to the operator, whose job was presumably envisioned to be more concerned with experimental practice and equipment.[192] The "virtuositic" nature of Rockford's account is especially clear when compared with the other diving account in the Society's records. The second account was collecting in 1664 and takes the form of a second-hand report given to Sir Robert Moray, not a first-hand account. This second account was from a Mr. Maule, presumably James Maule, a working salvage-master who, at the Restoration, had petitioned Charles II for a patent for "the sole power for 31 years to fish up and recover all sunken ships, guns, &c., for the use of the Crown" based on a "new invention of working at 20 or 30 fathoms, in which he was employed by the late King of Sweden."[193] Maule's report straightforwardly describes the shape of the diving bell, the length of time a diver could usually stay down in one, and the effect of heat and what we would now call carbon dioxide poisoning. His report is salvage-focused. Where Rockford's account does not tell us if any material was successfully salvaged from the *Sophia* by his team, Maule describes the tools he uses for his operations and their purposes (cutting holes in decks and removing ballast, for example).[194] While Maule did describe the crushing pressure of water at great depths, this is not a disinterested observation about the natural world, but explicitly tied to his hopes that the Royal

[192] Birch, *History*, 1:7. The operator's job or desired qualifications is not described in the minutes. Certainly by 1663, when Richard Shortgrave held the position, it was largely about supporting the experimental program of the Society.

[193] Ibid., 1: 400-401. The manuscript of this report is in RS Cl.P/6/15, nd, Notes Concerning Dyving [Diving] and Working under Water from Mr Mawle. *Calendar of State Papers Domestic: Volume 19: Charles II, 1660-1*; *Calendar of State Papers Domestic: Volume 29: Charles II, 1660-1*, ed Mary Anne Everett Green. (London: Her Majesty's Stationery Office, 1860), http://www.british-history.ac.uk/cal-state-papers/domestic/chas2/1660-1/pp482-500. Accessed October 27, 2015.

[194] Birch, *History*, 1: 399.

Society could develop a method to use barrels or other floatation devices to raise a sunken ship.[195] Rockford's interests are never expressed in such explicitly practical terms.

Rockford's direct influence on the Royal Society ended in 1663, receiving his last payment in January.[196] With Rockford gone, the Society decided to sell his engine. John Evelyn, who lived near the Naval docks at Deptford and was well positioned to have contact with those who dove professionally, was ordered to "take care, that [it] be sold to the best advantage of the Society."[197] After several months, however, Evelyn was only able to get "five pounds thirteen shillings, for the sale of the Diving-Engine."[198] Was Rockford's invention a scam, a dud, or were local divers happy with their tried-and-true equipment?

When the matter of breathing underwater next arose at the Society, they merely served as a middle-man, negotiating terms for Ralph Greatorix to build a diving engine for testing for use in Tangier, but the Society itself did not invest any money in the invention.[199] When it performed its own experiments, the Society relied on unnamed divers to test ideas that arose from within their ranks.[200] While unnamed "seamen at Deptford" were used in Rockford's experiments, account entries from between 1664 and 1667 show only unnamed participants being paid for diving experiments.[201] After Rockford's departure, both John Evelyn and Samuel Pepys were

[195] Ibid., 1: 392, 400-401. "[Moray] observed, that this diver [Maule] desired to be directed, how to convey a good number of barrels under water at a great depth, for the raising of sunk ships."

[196] RS AB/1/1/1. Entry is dated January 1662, but is entered out of order. From context it seems to refer to a date that would normally have been written January 1662/3.

[197] The Royal Society, CMO/1/12, 1663, Minutes of Meeting, July 20, 1663. Note that this information is missing from Birch's *History*.

[198] The Royal Society, CMO/1/25, 1663, Minutes of Meeting, 26 October 1663. Note that this information is missing from Birch's *History*.

[199] Birch, *History*, 1: 370.

[200] RS AB/1/1/1.

[201] Ibid., July 18, 1661 and undated entries between 1664-1667.

commissioned at different times to find divers for the Society's experiments.[202] The Society may have acquired a reputation of interest in diving, as in March 1664, Shortgrave reported that "there was a man presenting his service to dive," even though it was too early in the year for this activity.[203] None of these recruits were named, nor is there any evidence that any ideas they had were investigated. The Society's experience with Rockford had not been all for naught, however, as his written account of his experiences in Sweden was deemed reliable enough to be consulted during a later resurgence of interest in diving.[204]

Conclusion

In combination with the changing cast of characters intersecting the Society's work through the vicissitudes of life in Gresham College, and those hired by the Society for tasks skilled and unskilled, it is clear that the Society's first decades were not solely shaped by a purely gentlemanly or scholarly remove from the world, but a constant engagement with it. The social norms of the largely gentlemanly Fellows undoubtedly shaped their work—and perhaps more importantly—their public presentation of the new enterprise they sought to create. Historians have long recognized that this public presentation effaced the presence and work of others. This chapter has shown, however, that it is possible to recover some of these historical actors. Without accepting the equally inflated claims of supreme utility and universal reach of the new science in Restoration London, this chapter has shown that the early Royal Society and its Fellows were situated in a society, that, while stratified, did not have impermeable walls built between those in different social, economic, or educational classes.

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[202] Evelyn: Birch, *History*, 1: 392. Pepys: ibid., 2: 24, 55.

[203] Ibid., 1: 396.

[204] Ibid., 1: 385.

The way that the Society's initial foray into diving technology was so closely tied to the particular skills and experiences of Mr. Rockford demonstrates the significant role that those outside the restricted Fellowship list could play in shaping the direction of the Society's pursuit of the new science. Whether Rockford's attempt to present himself as a virtuoso failed, there was a falling out over the expense of his diving bell, or other matters entirely took him from London, he disappears from the records after 1663. With his international travel, language and drafting skills, and connections with artificers and inventors around London, Rockford was clearly not at the bottom of the social hierarchy. But neither was his status assured. His interest and experiences in the skills and theoretical questions essential to the new science are reconstructible because of his connection with the Royal Society, but suggest the presence of wider interests and investigations that could be found in the middling sort of London.

Chapter 3

"Whether there be a Pressure in the Atmospheres or noe:" John Conyers's weather records and the apothecarial "profession"

"[If] God spare my life & abilitity you shall find in consequent pages each day for[ward] these observations...not observed by anny man in England or beyond the sea that I know of "

John Conyers, BL Sloane 937, f. 135

On December 17, 1673, John Conyers, a London apothecary living just outside the City walls, on Fleet Street, headed a blank page in his notebook with the title, "Memorandum." He began to describe the preparation of some new instruments that he intended to use to monitor changes in the humidity of the atmosphere. When he had finished his note, Conyers had three new tools for his task: a piece of sponge hung in the air on a silk string, exposed to all influences; a small glass globe with two small openings, containing a piece of the same sponge; and, finally, a larger glass globe, with two openings (which Conyers often called "ears"), somewhat larger than on the first globe, also holding a piece of sponge.[1] Having described his procedure, Conyers continued his notes with an account of how these items were used: "I took a strict account of [the sponges'] weight together with the glasses…Found the [half a dram] sponge without the glass hanging on the string had gained three grains the next morning. And at the same time [the] small-eared glass globe had gained two grains weight and the large-eared glass globe also had gained two grains." After seeing how the weights of these instruments changed over the course of the week, Conyers noted that during this time, "this large-eared Globe glass or egg kept to one weight while the other varied with the weather," only changing when an accident broke one of the long "ears" off the larger globe. Only after this damage did the weight increase on this

[1] John Conyers. BL Sloane MS 919, Meteorological Journals, 1673-1674*,* 27 r,v. Conyers, and others, occasionally spelled his last name "Coniers."

instrument. Perplexed, Conyers noted that the difference in weight gain amongst the sponges was "very considerable and odd. "[2] Undeterred by these puzzling results, however, he continued to record similar observations—noting down the state of the weather, the weight of some instruments, and height of liquids in others—until the second half of 1680. These data "not observed by any [other] man in England or beyond the sea" were all undertaken in service of a grand project: "for the benefit of mankind [and] for the discovery of the truth: whether there be a Pressure in the Atmosphere or no."[3]

The study of air pressure in Restoration England is generally associated with Robert Boyle and the Royal Society, not with an impecunious apothecary, who is better known to modern scholars, if at all, for his reputation as an antiquarian.[4] Never solely an antiquary,

[2] Conyers's spelling, punctuation, and grammar are often erratic, partly due to the work-in-progress nature of these notebooks. In addition, he frequently employs symbolic abbreviations to refer to his different instruments. Therefore, quotations from his manuscripts used in the body of this text will be silently modernized for readability, and symbols replaced with the name of the instrument to which they refer. Exact transcriptions, minus symbols and with standard abbreviations expanded, will be located in the footnotes for reference. Ibid., 27v, 28r. "I taking a strict accompt of their weight ^together^ with the glasses at night pretty late found the ^[half dram]^ sponge without the glass hanging in the string had gained three graines the next morneing & at the same tyme [illegible] small eared glass globe had gained 2 graines weight & the large eard glass globe allso had gaind two graines the next night following but one I found the naked sponge had gained 2 grames more & the small eared globe had lost one graine twenty foure hours after the same ^small^ globe eard glass gained that graine again & another: now all this while the naked sponge ^in the string^ kepps at one ^ viz^{t} 2 grames^ weight ^ added [illegible]^ & so dureing twenty four ^houres^ more & so did the large eared globe not haueing anny thing added to the weight since the first night which I wondered ^at^ untill by a small stress of accident broke ofe one of the eares at the small part pretty late at night then weighing the Globe with one eare ^that night^ I found it had gained the next morneing which is verry considerable & odd I say gained ^ in weight^ two grains the naked sponge ^in the string^ & the short eard glass globe hauing gained nothing at all that night this being at least a weekes spase in all that this large eard Globe glass or egg kept to one weight whilest the other varied with the weather this not altering untell the fashion of the glass altered"

[3] John Conyers. BL Sloane MS 937, Meteorological Journals, 1674, 135v. "not observed by anny man in England or beyond the sea that I know of I pray God they may be usefull for the benefitt of mankind for the discovery of the truth whether there be a Pressure in the Atmospheres or noe"

[4] Although historians have long known of Conyers's notebooks (they are in the Sloane papers at the British Library), they have not yet been thoroughly analyzed. He is regularly mentioned in passing in works about antiquarians of the period (see Chapter 4). Juanita Burnby has given Conyers the most detailed treatment, but she most frequently focuses on his collecting activity. J. Burnby, "A Study of the English Apothecary from 1660 to 1760," *Medical History*, no. Supplement No. 3 (1983). J. Burnby, "John Conyers, London's First Archaeologist," *Transactions of the London & Middlesex Archeological Society* 35 (1984); J. Burnby, "John Conyers - Apothecary and Archaeologist (C. 1633-1694)," *Pharmaceutical historian* 34 (2004).

however, Conyers's extensive manuscripts show that he, like many of the more well-known natural philosophers who formed the early Royal Society, was interested in a wide variety of topics.[5] From a foundational interest in fluids and heat, Conyers's investigations, notes, and ideas for treatises covered topics such as magnetism, movement of sap in plants, causes of seasonal change in the weather and winds, chymistry, craft secrets such as dying and etching, and creation of practical instruments, such as pumps, speaking tubes (i.e. megaphones), hygroscopes, and novel thermometers. Most of the materials in these manuscripts are weather records, although Conyers's study of the weather is highly idiosyncratic. Rather than being primarily concerned with recording observations with the goal of deciphering broad rules to predict and bring order to human experience of meteorological phenomena, Conyers's obsessive recording of the readings from his own cornucopia of instruments is focused on *disproving* Robert Boyle's theory of the weight of the air. Through charting the way a wide variety of materials and instruments altered their weight in response to changing weather and humidity, Conyers believed that the idea of "the pressure of the atmosphere… now strongly maintained by all the world," could be "rebuked."[6]

Unlike the objections to Boyle's work by others, such as those of Thomas Hobbes studied in Schaffer and Shapin's *Leviathan and the Air Pump*, Conyers wanted to demonstrate Boyle's

[5] John Conyers, BL Sloane 61, 17th cent., Copy of Rev. F. Fletcher's Narrative of the First Part of Sir F. Drake's Second Voyage in 1577 Round the World; BL Sloane MS 816, Meteorological Journals, 1676-1680; BL Sloane MS 839, Meteorological Journals, 1675-1676; Bl Sloane MS 852; BL Sloane MS 916, Meteorological Journals, 1674-1675; BL Sloane MS 919; BL Sloane MS 937; BL Sloane MS 958, Papers of John Conyers, Etc; BL Sloane MS 2031, Loose Medical Papers of Mr. Conyers, Etc; BL Sloane 2251, after 1669, Draft Letter. In chronological order, the weather notebooks are as follows: Sloane 919 (Dec. 27 1673 to March 17, 1674), Sloane 937 (March 17, 1674—July 1674), Sloane 916 (July 18, 1674-11 Feb 1675), Sloane 839 (Feb. 12, 1675 to Feb. 11, 1676), Sloane 816 (Feb. 12, 1676–17 Aug 1680)

[6] BL Sloane MS 958, 110r. "Now conserning the pressure of the attmospher which is now strongly maintained by all the world seems to be thus rebuked"

errors not by arguing that Boyle's approach to discovering truth in nature was wrong, but by accumulating different experimental data. Conyers embraced the experimental approach to studying nature, even if he thought the concept of air pressure was fundamentally wrong. Conyers's detailed records of the weights of his weather instruments were begun as a direct response to work done by Robert Boyle, although not Boyle's work with the air pump. Rather, the multi-year project documented in these notebooks began after Conyers became aware of – either through reading an early copy, seeing the account in the *Philosophical Transactions*, or through conversations with his Royal Society Fellow acquaintances—of the 1673 Boyle publication, now generally referred to as *Saltness of the Sea*.[7] A collection of short essays on loosely-related topics composed in the 1660s and early 1670s, *Saltness of the Sea* included several short pieces on an instrument Boyle named the "statical hygroscope."[8] This fancy name cloaked a simple tool: a piece of sponge placed on a balance or hung in the air, whose weight changes could provide a method of assessing the degree of moisture or dryness of the air.[9]

Although clearly a direct reaction to the publication of *Saltness of the Sea*—a copy was presented to the Royal Society on November 13, 1673, and Conyers's entry describing the construction of his first sponge devices is dated a month later on December 17, 1673—Conyers did not merely parrot Boyle's procedure.[10] He added to the experimental set up (Boyle never speaks of glass globes and in fact explicitly sought to create a "easie" and portable instrument)

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[7] Robert Boyle, "Tracts Consisting of Observations About the Saltness of the Sea [Etc.] by the Honourable Robert Boyle (1673)," in *The Works of Robert Boyle*, ed. Michael Hunter and Edward B. Davis (London: Pickering & Chatto, 1999).

[8] Michael Hunter and Edward B. Davis, "Introduction to *Saltness of the Sea*," ibid., xxxiii-xxxvii.

[9] The essays on the statical hygroscope are found in Robert Boyle, "Tracts Consisting of Observations About the Saltness of the Sea [Etc.] by the Honourable Robert Boyle (1673)," ibid., 427-451. The instrument is described in on pages 429-432.

[10] Michael Hunter and Edward B. Davis, "Introduction to *Saltness of the Sea*," ibid., xxxvi.

and expanded it, weighing an assortment of devices and materials by the end of his records in 1680. Conyers's adoption of this particular project as his own was clearly influenced by his professional training as an apothecary. This was a project that drew on a skill he used daily—precise measurements using a balance scale—and the weather was fundamentally tied up with early modern ideas about human health. Questions of moisture and dryness, heat and cold, while fundamental to studying the weather, were also essential to the Galenic theory that underpinned English medical practice in the late 17th century. Throughout these notebooks, Conyers records indications of his persistent belief in the Galenic framework as well as some aspects of Aristotelian meteorology and the influence of traditional macrocosmic-microcosmic links.

In the following discussion, I want to consider Conyers as an experimenter, and examine how affording him this status (despite the "incorrect" and anti-Boylean ideas about air pressure that drove much of his work), allows us to re-capture the seriousness with which he regarded the experimental endeavor, and expand our ideas about the location, tools, and methods of science in Restoration London. While Conyers was not part of the same institutional setting as his more famous contemporaries, his manuscripts show that experimentation took place not only in the laboratories of the well funded, but also in more *ad hoc* locations. Similarly, a scientific instrument could look very different than the air pumps and microscopes typically studied in this period. For Conyers, the answers to questions about nature could be found in his own shop or home, or perhaps a short way down the street. Unlike the Royal Society, which collected accounts of phenomena through correspondence networks throughout the British Isles, Europe, and the world, Conyers's approach to studying the natural world was largely local. He was rarely interested in weather outside of his immediate surroundings, and his instruments were ones that fit easily into his shop, in an attic "closet," or attached to an exterior wall. Yet Conyers's

extensive recording of phenomena meant to play a part in one of the most important scientific discussions of the day—the question of air pressure—shows that he believed his local phenomena were a valid way of ascertaining truths about nature. In addition, a close study of Conyers's techniques shows an approach to studying nature based in the skills tied to his profession, notably the careful weighing of materials. While one certainly did not have to be an apothecary to weigh things (Boyle's air pump work often involved weight), Conyers's study of nature through this approach opens the door to an examination of how craft skills could be, and were, used to study nature, outside of the classically educated gentlemen meeting at the Royal Society. John Conyers's manuscripts provide evidence of the sometimes-piecemeal acceptance of the new ideas, demonstrating that even intimates of the boldest partisans for experimentation and mechanism found intellectual satisfaction by mingling old ideas with the new.

John Conyers, Pharmocopolist[11]

John Conyers was born around 1633 and bound as apprentice to the Worshipful Society of Apothecaries in 1649. While his parents had married in London, and clearly maintained ties to the City, when Conyers began his apprenticeship, they had returned to Leicestershire.[12] The family's roots are obscure, but his parents were of sufficient means to apprentice at least three of their children to London Livery Companies: John, as well as his (probably younger) brothers Edward (Leathersellers' Company, freedom in 1667) and Emanuel (Grocers' Company, freedom

[11] Conyers writes his name in this, or similar, form in several of his notebooks. See, for example, the authorship line in the draft magnetism treatise in BL Sloane MS 852, 28r.

[12] Juanita Burnby, "Conyers, John (c.1633–1694)," In *Oxford Dictionary of National Biography*. (Oxford: Oxford University Press, 2004; 28 Aug 2013), http://www.oxforddnb.com/view/article/56834.

in 1664).[13] The connection to Leicestershire must have remained strong, however, as Edward Conyers, having made money from a position as keeper of the stores in the Tower of London, bought an estate in that county in 1679.[14]

Conyers was made free of the Apothecary's Company in 1658, and practiced as an apothecary until the last few years of his life.[15] He spent most, if not all, of his professional life in the area of Fleet Street. At the time of the Great Fire in 1666, he lived and worked on Fleet Street near Peterborough Court, but was displaced by the disaster.[16] He returned to the same neighborhood, residing at the sign of the White Lyon, also on Fleet Street, and later moved into the nearby Shoe Lane.[17] He married Mary Glisson, niece of physician and Fellow of the Royal Society Francis Glisson, in 1666. They had ten children, but only two daughters lived past childhood.[18] When his wife's uncle died in 1677, Conyers was £80 pounds in debt to Dr. Glisson.[19] Despite his later reputation as a collector and antiquary, Conyers apparently died poor, and his accumulation of notable objects was due mostly to his own industry (an anecdote from

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[13] Burnby, "John Conyers - Apothecary and Archaeologist (C. 1633-1694)," 16.

[14] Burnby, "John Conyers, London's First Archaeologist," 71. Burnby supplies a possible family tree on page 72 of this article, but information about the generations before John Conyers's is taken from the clearly error-filled family tree created by John Conyers's brother Edward, in attempt to establish his *bona fides* with the Herald's Office after purchasing an estate. John Nichols, *The History and Antiquties of the County of Leicester*, vol. 2: Part 2 (London 1798), 456.

[15] Burnby, "Conyers, John (C.1633–1694)."

[16] Hearth Tax: City of London 1666, St Bride Fleet Street , Peterborough Court," in *London Hearth Tax: City of London and Middlesex, 1666*. (2011), http://www.british-history.ac.uk/london-hearth-tax/london-mddx/1666/st-bride-fleet-street-peterborough-court. Accessed October 8, 2015; BL Sloane MS 2251, 86v; LMA P69/BRI/B/041/MS14819, 1649 - 1666, List of Householders of Parts of the Parishes of St. Bride, 79r.

[17] Burnby, "John Conyers, London's First Archaeologist," 71.

[18] Burnby, "Conyers, John (C.1633–1694)."; Guido Giglioni, "Glisson, Francis (1599?–1677)," in *Oxford Dictionary of National Biography* (online edn, May 2006), http://www.oxforddnb.com/view/article/10819. Accessed Feb. 15, 2012.

[19] Perogative Court of Canterbury. The National Archives (herafter TNA) PROB 11/355/319, 1677, Will of Francis Glisson, Doctor in Physic of Saint Bride, City of London.

the 18th century speaks of him digging in empty fields), and in expressing interest in items that were otherwise destined for the trash heap.[20]

Conyers's money problems suggest that he could not have afforded the Royal Society membership dues, even if he had wished to join. However, he was certainly not disconnected from the investigations pursued there, despite his lack of membership. In addition to the family connection to Dr. Glisson, Conyers knew Robert Hooke, Christopher Wren, Jonathan Goddard, John Flamsteed, the Society's operator Richard Shortgrave, as well as renowned instrument maker Thomas Tompion.[21] Henry Oldenburg published accounts of three of Conyers's inventions in issues of the *Philosophical Transactions*, and it is clear from the content of Conyers's notebooks that he was interested in the new philosophy.[22]

Training

Between August 1649 and February 1659, John Conyers was trained as an apothecary through apprenticeship. While detailed records of individual apprenticeships do not exist, the regulations laid out in the Apothecary's Company tell what the prospective apothecary should have learned during their training. Even before beginning an apprenticeship, the prospective apothecary possessed two things that set him clearly above most of the population of London (or

[20] Conyers's collections will be further discussed in the next chapter.

[21] Goddard: BL Sloane MS 958, 118v. Flamsteed: ibid., 121r; Tompion: ibid., 124v. Christopher Wren: ibid., 105r. Richard Shortgrave: BL Sloane MS 937, 15v. Robert Hooke: Robert Hooke, Henry W. Robinson, and Walter Adams, *The Diary of Robert Hooke, 1672-1680* (London: Wykeham Publications, 1968), 104, 451, 455.

[22] John Coniers, "A Description of Mr. John Coniers, Apothecary and Citizen, His Hygroscope, in Two Several Contrivances; Together with Some Observations Made Thereon: Communicated in a Letter to the Publisher, Octob. 23. 1676," *Philosophical Transactions* 11 (1676); John Conyers, "A Letter of Mr. John Conyers, Citizen of London; the Author of the Hygroscope Described in Numb. 129; in Which Letter Is Contained a Draught and Description of a Very Useful and Cheap Pump, Contrived by the Said Mr. Conyers; a Trial of Which Was Also Made at the Repairing of the New Canal of Fleet-River in London, and Elsewhere," ibid.12 (1677-1678); John Conyers, "Extract of a Letter from Mr. John Conyers, of His Improvement of Sir Samuel Moreland's Speaking Trumpet,Etc.," *Philosophical Transactions* 12 (1677-1678).

England) at the time—some degree of Latin literacy (a requirement for entering into an apprenticeship), and a family or guardian with sufficient spare financial resources to invest in the young man's training.[23]

During his apprenticeship, Conyers learned a variety of practical skills based largely on the handling and preparation of plant-based medicines: how to identify the raw ingredients in fresh or prepared form, how to preserve and prepare herbs, seeds, roots, and flowers through processes that included drying and distillation. Essential to the correct and careful preparation of early modern medicines was skill with the basic balance. Raw ingredients were sold by weight (sometimes volume for liquid preparations, or on a per-item basis for large materials), and physician's receipts specified amounts by ounces, drachm, scruple, or grain.

By the time John Conyers was being trained, herbal medicines were not the only component of the pharmacopeia of the London medical community. Chemical medicine was making inroads in the English medical community.[24] Preparing one's own chemical medicines, however, often required additional skills, tools, hazards, and investments. Niçaise Le Févre's textbook of chemistry, published in English in the early 1660s, spelled out a dizzying variety of furnaces required for the true chemical "Artist" who would need different equipment for each type of operation he wished to perform.[25] Mindful of the difficulties inherent in the production of many of the new chemical medicines, the Apothecaries' Company took the opportunity to add a laboratory to their Hall in 1672, from which prepared chemical medicines could be purchased.[26]

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[23] Penelope Hunting, *A History of the Society of Apothecaries* (London: The Society of Apothecaries, 1998), 45.

[24] Allen G. Debus, *The English Paracelsians* (New York: Franklin Watts, 1965).

[25] Nicaise Le Fèvre, *A Compendious Body of Chymistry*, trans. P.D.C. Esq. (London: printed for Tho. Davies and Theo. Sadler, 1662), 89-96.

[26] Anna Simmons, "Medicines, Monopolies and Mortars: The Chemical Laboratory and Pharmaceutical Trade at the Society of Apothecaries in the Eighteenth Century," *Ambix* 53, no. 3 (2006): 225.

The Laboratory was also intended to serve a pedagogical purpose, and two of the Laboratory's early operators or their assistants were associated with Robert Boyle—Peter Stahl, and Ambrose Godfrey Hanckwitz.[27] While Conyers' notebooks do not directly record interacting with these two men, he did record experiments with phosphorus, taking place not long after Hanckwitz introduced the material to England.[28]

Although it is impossible to reconstruct the specific medical background that Conyers had acquired before he began his weather experiments in the 1670s, his training and profession as an apothecary make it clear that he was thoroughly familiar with the Galenic theoretical framework that continued to underlie much of Restoration medicine, even with the growth of chymical medicines and mechanistic thought. As Allan Debus has argued, the influence of Paracelsus on English medicine was marked by a widespread adoption of certain chemical remedies, while at the same time an avoidance of adoption of Paracelsian (or, later, Helmontian) theory, except for the most partisan.[29] While the tensions between those advocating chymical physick and more traditional practitioners periodically erupted throughout the seventeenth century, for medical practitioners of all kinds it was possible to proceed with a theory based in Galenic humoral theory, and a toolkit that included both humoral and chemical medicines. During his apprenticeship, an apothecary such as Conyers was immersed in medical botany, learning identification and gathering skills during the mandatory Company-sponsored "herbarizings," and learning the skills necessary for preserving and employing each plant part in

[27] Hunting, *A History of the Society of Apothecaries*, 157, 160-161; Simmons, "Medicines, Monopolies and Mortars," 226, 229; R. E. W. Maddison, "Studies in the Life of Robert Boyle, F.R.S. Part V. Boyle's Operator: Ambrose Godfrey Hanckwitz, F.R.S," *Notes and Records of the Royal Society of London* 11 (1955).

[28] BL Sloane MS 958, 139r. On phosphorous at the Royal Society, see Jan Golinski, "A Noble Spectacle: Phosphorous and the Public Cultures of Science in the Early Royal Society," *Isis* 80, no. 1 (1989).

[29] Debus, *The English Paracelsians*, 177.

the variety of medicinal forms (pills, oils, waters, etc.) during the years spent under his master's tutelage.[30] While the London pharmacopeia contained some chemical medicines, the majority were plant-based. Apothecaries were not necessarily well versed in the new chemical medicine, or in the techniques it drew on, but increasingly had the opportunity to learn if interested.

The apothecary in Restoration medicine

As an apothecary, Conyers was a member of an important group of medical practitioners in seventeenth-century London, particularly for those who could not afford to pay physicians' fees. Although apothecaries were technically under the supervision of the College of Physicians, the two groups vied for authority over medicine in London throughout the seventeenth century.[31] A few years before Conyers's weather project began, the tensions between these two groups, as part of a broader contest for authority between traditional and new approaches to medical knowledge and practice that had its roots in concerns about the Royal Society's emphasis on experimentation over ancient texts, erupted in a pamphlet war. Several of the early members of the Royal Society, who were also physicians, participated in this battle of words, and they were unsparingly critical of apothecaries and of their intellectual attainments.[32]

Previous scholars studied the driving forces behind the pamphlet wars, pointing out the roots of the controversy in the Royal College of Physician's declining regulatory power, the competition from irregular practitioners who embraced the new chemical medicine, tensions

[30] Hunting, *A History of the Society of Apothecaries*, 45-47.

[31] Harold John Cook, *The Decline of the Old Medical Regime in Stuart London* (Ithaca: Cornell University Press, 1986). Hunting, *A History of the Society of Apothecaries*.

[32] Cook, *Decline of the Old Medical Regime*, 167-182. Aaron Mauck, "'By Merit Raised to That Bad Eminence': Christopher Merrett, Artisanal Knowledge, and Professional Reform in Restoration London," *Medical History* 56 (2012).

between the purpose and methods of the Royal Society and the traditional knowledge on which medicine relied, and the ways in which all of these tensions were exacerbated by the political upheavals of the proceeding decades.[33] While the flurry of publications was never solely about the role of the apothecary in Restoration medicine, this group as a whole was much maligned.

Three physicians who were also members of the Royal Society contributed to this battle—Daniel Coxe, Christopher Merret, and Jonathan Goddard.[34] Aaron Mauck has recently examined Merret's publications on medical reform and has argued that Merret, despite the inflammatory words of his contributions to the pamphlet war, envisioned a reformed medicine that drew on both the traditional philosophical training of the Universities ***and*** lessons drawn from artisanal practices—namely the hands-on, tacit, and experimental trades that studied matters medical, and not so medical. (Merret believed that physicians should train with apothecaries and surgeons as part of their education, but should also undertake a version of the Grand Tour, studying antiquities, art, natural history, and architecture throughout the Continent.[35]) While Merret undoubtedly believed important things about medicine—and nature in general—could be learned from tradesmen, he was also unapologetic about the importance of the proper philosophical background. In arguing that physicians should make their own medicines, Merret wanted to remove the expertise of drug manufacture from the apothecaries,

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[33] Cook, *Decline of the Old Medical Regime*, Chapters 4 and 5; Mauck, "'By Merit Raised to That Bad Eminence'."

[34] Christopher Merret, *A Short View of the Frauds, and Abuses Committed by Apothecaries as Well in Relation to Patients, as Physicians, and of the Only Remedy Thereof by Physicians Making Their Own Medicines* (London: Printed for James Allestry, 1669); Thomas Coxe and Daniel Coxe, *A Discourse Wherein the Interest of the Patient in Reference to Physick and Physicians Is Soberly Debated, Many Abuses of the Apothecaries in the Preparing Their Medicines Are Detected, and Their Unfitness for Practice Discovered: Together with the Reasons and Advantages of Physicians Preparing Their Own Medicine* (London: Printed by C.R., 1669); Jonathan Goddard, *A Discourse Setting Forth the Unhappy Condition of the Practice of Physick in London and Offering Some Means to Put It into a Better, for the Interest of Patients, No Less, or Rather Much More, Then of Physicians* (London: Printed by John Martyn and James Allestry, 1670).

[35] Mauck, "'By Merit Raised to That Bad Eminence'," 42-45.

believing that it could be done more safely, if placed in the hands of a properly educated (gentlemanly) physician. The apothecary, Merret wrote dismissively, was "but a Tradesman, and manual Operator."[36] They lacked the education necessary to practice medicine, being ignorant of "Arts and Languages" and even "all Philosophy." Without this background, it was impossible for apothecaries to recognize diseases, or their causes, leaving them unable to choose "fit remedies." In Merret's depiction, the apothecary's ignorance had no limits, lacking any knowledge of anatomy or the basics of surgery, unable to offer advice on diets for curing disease or preserving health. Even in their particular realm, the compounding of medicines, apothecaries were merely "practising their way rather by rote then by rule." Indeed, Merret scornfully concluded "with better reason may a Brick-layer or Carpenter pretend to be a Mathematical, or a Common Fidler to be a Musick Reader in the Universities, or Gresham-College, since both these have the practical part of those Sciences, which Apothecaries have not in Physic, in the least measure."[37]

For Merret, the solution was simple. Only if physicians themselves, who had received the appropriate education, turned to the manufacture of their own prescriptions, could medicine, indeed knowledge in general, improve. A physician who turns to pharmacy:

> will much inlarge *Materia Medica,* Chymistry and Pharmacy, and discover the grounds of them, and wherein the efficacy of remedies lyes, and thereby lay open a whole Ocean for new discoveries, and by the by observe many useful products and Phaenomena of Nature, to the great improvement of his Art, and sound Natural Philosophy, which are not taken notice of by *Apothecaries,* and their Servants; for all which they have neither will nor skill.[38]

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[36] Christopher Merret, *A Short View of the Frauds, and Abuses Committed by Apothecaries, as Well in Relation to Patients, as Physicians, and of the Only Remedy Thereof by Physicians Making Their Own Medicines* 2nd ed. (London: Printed for James Allestry, 1670), 26. The first edition was published in 1669.

[37] Ibid., 61.

[38] Ibid., 43-44.

The apothecary, Merret claimed, spent his whole life engaged in commerce and those acts that would most easily forward his mercenary intentions; his devotion to commerce and charlantanry was "never diverted by studies." If he attempted to present himself as learned, his imposture was easily detected when he dared to engage the truly educated found in "Coffee-Houses, and in other mixt Companies." [39] Amongst the educated, the pretended learning of apothecaries was "met with and baffled," forcing them "to depart thence with shame and discredit enough."[40] The contents of their shops with "painted Pots and Glasses, with false Titles on them, more win the vulgar then a Physicians Library of far greater value."[41]

Merret's diatribe spoke clearly to the tension found within the community of gentlemanly virtuosos. Although physicians did not embrace the rhetoric of the strain of Baconianism that argued for the study of the knowledge found in the skilled trades, Merret's denunciation of apothecaries carried overtones of the tension found within the founders of the Royal Society. Thomas Sprat's *History of the Royal Society* claimed the new organization, following the Baconian precepts that called for the collection of knowledge about all sorts of skilled trades, included men who pursued trades, but he also lauded the fact that the majority of members were men of means, and argued that these men were the best qualified to engage in the new science because they were free from prejudices and influences that men who depended on commerce and trade must necessarily be.[42] Many members of the early Royal Society are known to have had interactions with other apothecaries, and the predecessor group that met in Oxford during the

[39] Ibid., 59-60.

[40] Ibid., 60.

[41] Ibid., 60-61.

[42] Thomas Sprat, *The History of the Royal Society of London for the Improving of Natural Knowledge* (London: Printed by T. R. for J. Martyn and J. Allestry, 1667), 65-70.

Interregnum met at apothecaries' houses and took instruction from them.[43] While they were willing to learn from apothecaries' tradecraft and chymical knowledge, the Royal Society as an institution only had a few apothecarial members during the first decades of it's existence.[44] Whether Conyers was never proposed as a fellow because of a general reluctance to admit tradesmen, or because he lacked the financial resources to pay the membership fee, is unknown. But the language in these pamphlets—as complicated as the motivation behind them was—showed that the curious apothecary might face a battle to be taken seriously as an intellectual.

Merret (and his fellow pamphlet writers) occasionally conceded that they were referring to *most* but not all apothecaries. The records do not show if Merret or Goddard knew Conyers at the time of the pamphlet war, but they *did* know him later in the 1670s and in the 1680s, during which period Conyers was also quite at home with the intellectual conversation found in Restoration coffeehouses, as the diary of Robert Hooke attests.[45] More importantly, Conyers' manuscripts show an apothecary who was not interested in infringing on physicians' practice, who was skilled in chymistry, and who indulged his curiosity about the world past and present through experimentation, invention, collection and learning from interpersonal networks. While Conyers was plagued with money concerns throughout his life, his experimental programs were

[43] W. H. G. Armytage, "The Royal Society and the Apothecaries 1660-1722," *Notes and Records of the Royal Society of London* 11 (1954): 22.

[44] The most illustrious was Nicaise Le Févre, a French apothecary who had been a royal apothecary in France before moving to serve Charles II after the Restoration. Le Févre had instructed English exiles in Paris during the Interregnum, and in the English court served as both professor of chemistry to the king, and apothecary-in-ordinary to the royal household. N. G. Coley, "Le Févre, Nicaise (C.1610–1669)," In *Oxford Dictionary of National Biography*. (Oxford University Press, 2004), http://www.oxforddnb.com/view/article/16342. Accessed Nov. 2 2015. Regardless of his technical occupational identity with Conyers, it is clear that the two men moved in very different social circles. John Houghton, a decade younger than Conyers, and from a more comparable social level, was made an FRS in 1680. Houghton possessed additional financial or social resources since he spent some time at Cambridge before his apprenticeship, had sufficient access to capital to supplement his apothecary's shop with exotic specialties such as coffee and chocolate, and was able to publish a book before he began to move in the circles of the Royal Society. Anita McConnell, "Houghton, John (1645–1705),"Ibid., http://www.oxforddnb.com/view/article/13868. Accessed Nov. 2, 2015.

[45] Hooke, *Diary*, 223.

never explicitly tied to potential monetary gain, indeed the largest part of his work, on heat and cold and humidity, was only driven by a desire to discover the truth about air pressure.

A draft letter written sometime after 1669 shows that Conyers was aware of the inflammatory pamphlets, and provides a glimpse of how he viewed the importance of his own occupation, and of the educational standards an apothecary should reach. The undated letter was addressed to one of Conyers's family members residing outside of London and involved a complicated monetary dispute between two branches of the family. Part of the disagreement revolved around Conyers's cousin's rejection of the bill Conyers submitted for costs incurred while he (Conyers) treated the cousin's son for smallpox in his London home. "Possibly you have been…of Dr. Merret's counsel, who lately wrote against our profession as useless," Conyers wrote, and accused his kinsman of basing his complaints on Merret's claims, not on an actual evaluation of the bill presented to him.[46] (Merret had included a paragraph in his *Short View of Frauds and Abuses* explicitly dealing with cases of smallpox or measles, decrying the "multiplication of Medicines" that apothecaries promulgated in these cases.)[47]

In defending himself, Conyers's draft demonstrates how he thought of his own profession and skill in that profession. The ill man came to London in a failed apprenticeship or partnership arrangement with Conyers, which ended, not due to the unexpected illness, but because his kinsman's son was deficient in both textual and practical medical knowledge. "I suppose he hath neither read over Galen, nor Hippocrates," wrote Conyers scornfully. Neither was the man well acquainted with more recent works, Conyers observed, as "for later authors, I think I have more

[46] BL Sloane MS 2251, 87v. "posably you hand been of late of Dr Merretts counsell, who lately wrote against our profession as useless".

[47] Merret, *A Short View of the Frauds, and Abuses Committed by Apothecaries*, 16-17.

by me than he [knew]…all that I ever heard him speak of was but of his observations in anatomy, which were but tautology to me." Conyers conceded that the son had read some moderns, but his knowledge was parroted from their works. "[I]f you strip him of Harvey, Glisson, Willis, and Lower, I believe you will leave him naked of his anatomy also," Conyers fumed.[48]

In decrying the ill-fated apprentice's knowledge, Conyers claims his own expertise in book learning, implying he had read Galen and Hippocrates, as well as the unspecified more "later authors" that he had at hand. His practical, anatomical knowledge is also superior to the unnamed relative; to Conyers, the kinsman's anatomical knowledge was merely based on having read a few books, implying Conyers valued real experience, perhaps gained through attending anatomies held at the Company of Barber surgeons or other locations in London.[49] In contrast to this training, "I don't understand [the] whereabouts [of] the theory of your son's physical learning...except at random," Conyers wrote.[50]

Importantly for the dispute at hand, without expert knowledge, neither the cousin nor his son were fit to judge the appropriateness of Conyers's bill. Without the right education, how could they claim to know "the quantities nor qualities of the ingredients and compositions" prescribed, "nor the necessity" of those prescriptions?[51] In arguing for his payment, Conyers strikingly compared his right to payment with that of two of the *gentlemanly professions* of early

[48] BL Sloane MS 2251, 87r. "I suppose he hath neither read over Gallen, nor Hipocrates,& for later authors, I thinke have more by me then he that , all that ever I heard him speake of was but of his observation in anottomye, which was but Tautollogye to me, & possibley imp[erinent?] & if you strip him of Harvye, Glisson, Willis, & Lwer, I beleeve you will leave him naked of his anatomy allso."

[49] Hunting, *A History of the Society of Apothecaries*, 45-47.

[50] BL Sloane MS 2251, 87v. "I don't understand whereabouts the theorye of your sons phisicall learning...except at random"

[51] Ibid. "allso I cannot take you for a competent judge of the Bill…not knowing the quantatyes nor quallityes of the Ingredients & cmpositions nor the necessitye"

modern England—doctors and lawyers: "a doctor is to be satisfied though the patient die; and a lawyer though he cause mistrial; how much more should the apothecary [in charge of] so dangerous and worst sort of...disease" receive his fee."[52] In the social hierarchy of Restoration London, an apothecary was a tradesman, not a gentleman, but Conyers here argued for the importance of his occupation, an importance that placed it higher on the social ladder than tradition dictated. While apothecaries' knowledge was rooted partly in practical tactile knowledge, Conyers argued that its roots lay more fundamentally in the work of Galen and Hippocrates—the authors whose works were also the basis of the elite medical practice of Restoration London.

The weather project

Unlike the purely mercenary apothecary depicted in the pamphlet wars of the 1660s, John Conyers found time to investigate natural phenomena that would not lead to direct professional gain. Throughout his notebooks, Conyers recorded notes, described experiments, and began drafting treatises on such subjects as magnetism, phosphorus, heat and cold, pumps, and the discovery of Roman artifacts in London. Conyers also records some chemical experimentation, including experimentation with phosphorus.[53] It is his weather project that forms the largest part of the material, however.

While the format of his records changes slightly over the years, most of the entries are in a similar form, with a short description of the weather at the time of observation, followed by a

[52] Ibid. "a Doctor is to be satisfied though the patient dye; & a lawyer though he casue [illegible]; how much more should the Apothecary[who had charge] of so dangerous & worst sort of the disease"

[53] BL Sloane MS 958, 139r. The Royal Society also investigated phosphorus, although publications in the *Philosophical Transactions* did not feature the new substance until the 18th century. See, for example: Francis Hauksbee, "Experiments on the Production and Propagation of Light from Phosphorus in Vacuo, Made before the Royal Society, by Mr. Fra. Hauskbee," *Philosophical Transactions* 24 (1704). Golinski, "A Noble Spectacle."

list of his instruments (usually abbreviated with symbols) and their current weight. Below the measurements, or in the margin beside them, Conyers added other notes, generally ones pointing out any trends he noticed in his measurements. With an increasing number of instruments, and, one suspects, with a decreasing patience for the tediousness of his chosen task, Conyers's records became more abbreviated, evolving first into a standardized chart, which eliminated the descriptive and note-taking portions of earlier entries, and then, in the last years, into a running list of dates with the most important weights recorded in long, unbroken horizontal lines winding their way down the page.[54]

John Conyers was not the only person interested in the new science to turn his attention to the weather. Meteorological phenomena proved particularly intractable to attempts to reduce them to rules, and collecting weather data with an eye to predicting and understanding weather was a project that both pre- and post-dated the Restoration period.[55] Questions related to both air pressure and the weather more generally were a regular feature of discussions pursued at the early Royal Society and in the activities and interests of its Fellows. The study of air pressure is the more well-known, as discussed in many studies of the work of Robert Boyle.[56] While barometric and meteorological reports never dominated the early issues of the *Philosophical*

[54] The most striking changes are evident in the last notebook: BL Sloane MS 816.

[55] W. E. Knowles Middleton, *The History of the Barometer* (Baltimore,: Johns Hopkins Press, 1964); Craig Martin, *Renaissance Meterology: Pomponazzi to Descartes* (Baltimore: Johns Hopkins University Press, 2011); W. E. Knowles Middleton, "A Footnote to the History of the Barometer," *Notes and Records of the Royal Society of London* 20 (1965); Jan Golinski, *British Weather and the Climate of Enlightenment* (Chicago: The University of Chicago Press, 2007); Vladimir Jankovic, *Reading the Skies: A Cultural History of English Weather, 1650-1820* (Chicago: University of Chicago Press, 2000). Golinski's study focuses on weather diaries, but Conyers's records are not strikingly similar to any of those Golinski considers.

[56] Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump* (Princeton, N.J.: Princeton University Press, 1989).

Transactions, both areas put in periodic appearances, often as reports on Boyle's work.[57] For Boyle, "nothing [was] so neerly indicative of the change of weather as this Ballance"[58] [mercury barometer], and he called for others throughout England to make use of weather instruments and careful observation so that "by comparing Notes, the Extent of the Atmospherical Changes, in point of Weight, might be the better estimated."[59] He encouraged potential observers to "take notice not only of the day, but as near they can, of the Houre wherein the Mercurial Cylinder is observ'd....It will require also, that the Observers give notice of the Scituation[sic] of the place...[because] the Observations will much disagree, even when the Atmospher is in the same state, as to Weight, if one of the Instruments stand in a considerably higher part of the Country than the other."[60]

While Conyers's project was begun in response to a different Boyle publication of 1673, his approach to weather records was similar in some ways to the procedure Boyle laid out in the barometer essays. Conyers was careful to record measurements of all his instruments (including the mercury barometer) at least twice a day, and generally noted the time of his morning and evening observations. Unlike Boyle, however, Conyers did not place absolute faith in the mercurial barometer. Boyle endorsed the barometer after comparing it to observations of a "store of Hygroscopes of divers kinds...the sweatings of Marble, and as many other famed Prognostics, as I can hear off" and reported that "the open Weather-glass is known to signifie nothing at

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[57] For example, Robert Boyle, "Some Observations and Directions About the Barometer, Communicated by the Same Hand, to the Author of This Tract," *Philosophical Transactions* Vol. 1 (1665-1666); Robert Boyle, "Observations Continued Upon the Barometer, or Rather Ballance of the Air " *Philosophical Transactions* 1 (1665-1666); Robert Boyle, "Of a New Kind of Baroscope, Which May Be Called Statical," *Philosophical Transactions* 1, no. 14 (1666).

[58] Boyle, "Observations Continued Upon the Barometer," 164.

[59] Boyle, "Directions About the Barometer," 182.

[60] Ibid. On the barometer in general, see Middleton, *The History of the Barometer*.

certainty, having a double obedience to two Masters, sometimes to the Weight of the Air, sometimes to Heat, as the service is commanded." Conyers, however, was either unaware of, or doubted, this condemnation; he collected a "store of Hygroscopes of divers kinds," and his belief in their ability to give him useful information outlasted Boyle's.[61]

Experimental Equipment

Although inspired by a Boyle publication describing a specific instrument, Conyers developed an instrumental repertoire far beyond what Boyle described in *Saltness of the* Sea, and in doing so he drew on the materials at hand in his apothecary's shop. While the number and type of instruments changed over the years, the clearest account of his equipment, given in a list probably dating from 1675, is indicative of his tools. [62] On two folio pages, Conyers recorded a complete list of the instruments he used at the time, including the symbols he used to refer to the instruments in his daily records.[63] From his beginnings with the three sponge pieces in December of 1673, Conyers had added steadily to his assemblage, counting at least 16 instruments at this point.[64] Many were variations on the instrument whose creation was described in the opening paragraphs of this chapter—glass containers consisting of a globe plus a single or double opening in different shapes, with a piece of sponge inserted into the globe. The most compact globe is described as "about the bigness of a small hen egg"; the others are "the same bigness", although it is not clear if this description refers to the instruments' total size, or merely the size of

[61] Boyle, "Observations Continued Upon the Barometer," 164.

[62] BL Sloane MS 839, 62r.

[63] Ibid.

[64] The arrangement of the page and the cramped writing makes it difficult to discern if one section refers to a single instrument or two different items. Conyers added more instruments later; the tables from the end of the project in 1680 contain symbolic entries for 27 different items. BL Sloane MS 816, 216r.

the globe contained within each. The collection featured globes with “ears” (round or oval appendages attached on opposite sides of the globe, each open to the outside air), either a pair of ears or a single ear; a globe with two conical appendages; its mate with one conical appendage; and another set comprising one globe with two tubes open to the outside world and another with one tube. All of the globes were made of "white glass blown by a lamp."[65] In addition to his collection of glass globes, Conyers's instruments included: a "quicksilver baroscope;" "a common weather glass [filled] with green water and [with an] open bolt-head set in it;" a piece of sponge left out in the open air (no container); his double thermometer of "two small bolt-heads sealed only in the outmost;" several of small glass bulbs with stems placed into a container of water; his panel of deal hygroscope; another glass instrument containing "spirit of wine" in a "small stemmed bolt-head"; a modification of a common weather glass containing "Oil of Almonds colored Red...instead of [being colored with] green water;" and a triple thermometer referred to as the "3 stems."[66] This last item, Conyers described further as being made of "three bolt-heads, one foot [in] length, one within another, each one less than the other and supported

[65] BL Sloane MS 839, 62r. "all of these of white glass blowne by a lamp."

[66] Ibid., 62r. "a comon weather glass with green water & open bolthead sett in it"; "2 small boltheads sealed onely in the outmost";"spirit of wine" in a "small stemd bolthead"; modification of a common weather glass containing "Oyle of Almonds colourd Redd...instead of greenwater." The term “bolt-head” is used by Conyers (as it was in Royal Society circles) to refer to any number of globular glass flasks with long tube necks. The flask portion could be small—as in a modern thermometer bulb—or much larger, depending on what the experimenter desired. They were originally used in distillation. "Bolt-Head | Bolt's-Head, N. ," In *OED Online*. (Oxford University Press, September 2015), http://www.oed.com/view/Entry/21154. Accessed November 05, 2015. An account of the deal hygroscope was published in the *Philosophical Transactions*: Coniers, "A Description of Mr. John Coniers, Apothecary and Citizen, His Hygroscope, in Two Several Contrivances; Together with Some Observations Made Thereon: Communicated in a Letter to the Publisher, Octob. 23. 1676." A description of a suspiciously similar device had been published as part of a report from the Dublin a few months before: "An Extract of a Letter Etc. From Dublin May the 10th, 1676," ibid.: 651-652.

with a rest of whalebone to keep them from touching one another at the top." These bolt-heads were marked with a scale "divided into 1/2 inches."[67]

In addition to these itemized instruments, Conyers's work depended on another, unnamed tool—a sensitive balance. Boyle, in the publication that inspired Conyers's project, believed that his arrangement's reliance on a good balance was a point in favor of its utility to atmospheric studies. "Now when one is resolved to employ a Spunge, there will not need to be much added about the turning it into a *Hygroscope*," Boyle wrote, adding that one merely required "a good balance" and the appropriate counterbalancing weights in common quantities such as drams, grains, and fractions of grains.[68] The instrument could even be modified depending on the equipment at hand, as the original "weight of the Spunge may be greater or less according to the bigness and goodness of the balance, and the accurateness you desire in the discoveries it is to make you."[69] The "weights imployed to determine [the changes] are easily procurable," Boyle wrote, making it easy for observers in many locations to share standardized results.[70] Whether or not a balance of sufficient accuracy and precision was as easily obtainable as the weights Boyle referred to, any practicing apothecary would have multiple examples on hand, as a fundamental tool of the trade.

Several of Conyers's pieces of equipment were standard and available for purchase in the consumer markets of London. The common weatherglass had been for sale in London since the 1630s and was formed from a glass bulb with a tube neck. The usual weatherglass contained

[67] BL Sloane MS 839, 62r. "by 3 stems understand 3 boltheads ^one foote length^ one within another each one less then the other & supported with a rest of whalebone to keep them from the touching one another at the Topp"; "this...divided into ½ inches." This instrument is also described elsewhere in the notebooks, for example BL Sloane MS 958, 123v.

[68] Boyle, *Saltness of the Sea*, 431-432.

[69] Ibid., 431.

[70] Ibid., 433.

water and air; change in the level of the water "was taken to signify the state of the atmosphere in general."[71] Conyers's notes show that he modified this design by filling weatherglasses with other liquids (for example, oil of almonds and "green water"—water dyed green by adding verdigris). Conyers also possessed a mercury barometer ("quicksilver baroscope"), but it was not given primary importance amongst his instruments; the mercury's level was merely one of a number data of points he hoped would make clear the relationship between heat, cold, moisture, and dryness, which he believed drove the weather and all phenomena that the Royal Society wished to attribute to the air's pressure.

In creating his many instruments, Conyers drew on another category of goods important to the apothecarial trade: glassware. The fact that Conyers's instrument collection was formed primarily of glassware is not surprising given the importance of the same for his profession. Vital for preparation of medicines, the apothecary was surrounded by glassware of various sizes and shapes even if he was not undertaking a project like Conyers's. Inventories from the London Orphans' Court from the second half of the 17th century demonstrate the ubiquity of glassware among apothecarial possessions. Apothecaries of both large and small means possessed sometimes surprisingly large quantities of glassware in a variety of sizes. While some inventories lumped containers into barely descriptive entries covering all the material in the shop, others itemized glass and earthenware pots and other containers separately. One William Harvey, who died about the time Conyers began his project, possessed with his partner-in-trade, widow Anne Graves, "28 square gallon glasses, 13 round gallon glasses, 53 pottle bottles round & square 8 doz[en] of round & square quarts, with 16 pints & 10 oyl potts & 10 stone bottles; 82 shopp potts of severall sorts, 4 stall boxes…4 gallon glasses ,with several small potts and glasses" as

[71] Golinski, *British Weather and the Climate of Enlightenment*, 112.

well as "3 grosse and 4 doz[en] of small glasses."[72] The value of all of these items together came to £8-09-0. Even an undifferentiated "parcell of Glasses potts & boxes" could form a substantial percentage of an apothecary's estate, in one case being valued at £13.[73] Individual pieces of glassware were often relatively inexpensive (especially when compared with iconic instruments of the period, such as microscopes and air pumps), a necessity for a man in Conyers's financial position. In the late 1660s, for example, pint containers ran sixpence each, with an additional 1 shilling for a matching headpiece. A pint retort would cost five pence, while the "bolt heads" used by Conyers to create his double and triple thermometers were similarly priced: a quart bolt head cost 9 pence, while the smaller pint size was sixpence.[74] Other crucial chemical equipment such as funnels (2s6p the dozen), subliming pots (1s each), and Glauber's retort (2s6p), generally cost from around sixpence to a few shillings, with cheaper items being sold in lots of one dozen.[75]

In addition to using ready-made glassware, it is clear from the notebooks that Conyers was at least slightly familiar with the production of glass. In several places, he draws comparisons to heating techniques used in glasshouses.[76] In addition, his discussion of the Roman artifacts found in the excavation of St. Paul's cathedral and in the rebuilding of the Fleet

[72] LMA, Court of Orphans, City of London CLA/002/02/01/0840, 1662-1677, Hardy, William, Citizen and Apothecary. Graves was presumably the widow of an apothecary. Livery Company rules allowed widows to carry on their deceased husband's trades. A pottle was a unit of measurement equal to a half-gallon. "Pottle, N.1," In *OED Online*. (Oxford University Press, September 2015), http://www.oed.com/view/Entry/148937. Accessed November 03, 2015.

[73] LMA, Court of Orphans, City of London CLA/002/02/01/1111, 1662-1677, Tomlinson, Richard, Citizen and Apothecary.

[74] BL Sloane MS 3776, 17th cent., Commonplace Book, f. 51r.

[75] Ibid., f. 50b.

[76] For example, BL Sloane MS 919, 97v.

Ditch, show familiarity with the process of producing both fired earthenware pottery and glass.[77] Burney hypothesized that, as “an avid experimenter,” Conyers "probably learnt to handle glass himself in order to make his equipment" although there is no direct evidence for this.[78] While Boyle relied on others for the production of his specialist glassware, other experimentalists may have learned to make their own glassware.[79]

Experimental Spaces

Rather than let his multiplying instruments take over his shop, Conyers created a special container to hold them, a sort of cage he called the “Phoenix nest,” with a wire bottom and holes in the wooden sides “to let in air freely.”[80] Depending on the instrument and what he was studying at the moment, however, certain devices could be moved around shop and home as needed. In addition to his apothecary's shop, Conyers also possessed another workspace in the house, in which he recorded mounting one new instrument: "Being thus prepared I carried it up three pair of stairs and hung it in my closet, on the sunny side my house (though a good distance from the window)."[81] Another instrument, a "a Hydroscope made of cat gut" lent to him in 1679 "by Mr. Bansby of Clement Inn" he decided to located "in the lower Room” above the cellar.[82] In another instance, Conyers described a pair of instruments "standing...over my shop door on

[77] See, for example, BL Sloane MS 958, 106 r and v. Discussed in Burnby, "John Conyers, London's First Archaeologist," 66-68, with reproduction of Conyers's drawing of Roman kilns on 67.

[78] Burnby, "John Conyers, London's First Archaeologist," 68.

[79] Brodsley, Frank, and Steeds, "Prince Rupert's Drops," 9.

[80] BL Sloane MS 958, 114v."hanging in the ayre which I call the Phonix nest that is wired at bottom & holes in the sides of wood to lett in Ayre freely."

[81] Ibid., 129v-130r. "Being thus prepared I caried it up 3 paire of staires & hung it in my closset one the sunny side my house though a good distant from the window."

[82] Ibid., 131r. Another instrument, a "a Hydrooscope made of catt gutt" lent to him in 1679 "by Mr Bansby[???] of Clemn Inn" he decided to located it "in the lower Roome except the Sellar ."

the sunny side [of the building], the way in [from] Fleet Street…in a glass window."[83] While the next day, Conyers recorded that the "[common weather glass] with green water [was] 40 foote & better to the north side my house" while the "[weather glass filled] with oyle of Almonds" was further away and "not near my show windows opening into the Street."[84]

In his daily weather records, Conyers made notes of which days the shop was closed, indicating that many of his instruments were located within the commercial part of his household, and showing he was attentive to changes in readings that might result from the experimental room being closed and/or unheated on a given day.[85] On March 18, 1675, he noted in his evening observations that "the temperature varies" "now [that] the shop is shut," and "odd" readings the next day were perhaps due to "the shop shutting…which might make the oil in the [weather glass filled with oil of almonds] warmer and so sink lower."[86] A few months later he recorded similar changes in the environmental conditions as he went about his daily routine. As he began his entry for the morning of May 23, 1675, Conyers recorded that "the shop is shut and the warm air comes in the back (north) door." Shortly thereafter he observed that "upon opening the door" the liquid level in one of his instruments quickly fell.[87] When Conyers attempted to replicate another Boylean experiment, this time involving observing the movement of glass bubbles placed in a larger container of water, he recorded that he hung the instrument "in the

[83] Ibid., 121v. "standing...over my shopp dore on the sunny side the way in fleet Street here in a glass window.

[84] Ibid., 117r. "[common weather glass] with green water 40 foote & better to the north side my house distant from [weather glass filled] with oyle of Almonds not being neer my show windows opening into the Street"

[85] See, for example, BL Sloane MS 839, 25r.; ibid., 28v."

[86] Ibid., 20v. "the temper[ature] varries" "now the shopp is shut." BL Sloane MS 958, 117r. "caused from it may be the shopp shutting in which might make the oyle in the [weather glass filled with oil of almonds] warmer & so sinke lower."

[87] BL Sloane MS 839, 53r."the shopp is shut & the warme ayre comes in at the back ^north^ dore"; "Upon opening the doore this easily fell lower"

sun...in a window on the sunny side [of] the house one story high, that is, ten foot high in Fleet Street in my shop window there."[88] Other instruments' readings caused him to conclude that "it seems the south side of the house, next [to] Fleet Street, in my shop...was then the warmer and so made the oil [in the instrument hung there] the lowest."[89] A few days later, still attempting to understand the effect of the local conditions on his measurements, Conyers wondered if "maybe there is something in keeping my shop shut, it being Sunday, which might alter the temper of the glass as to the rarefication."[90]

Hot/Cold, Wet/Dry: Conyers's Theoretical Galenism

Despite his disagreement with Boyle, Conyers's weather project, with its massive compilation of data and instrumentation designed to observe the behavior of nature in artificial settings, clearly draws on the Baconian traditions embraced by the Royal Society. The material found in these notebooks reflects an attempt to compile the vast stores of data that the compilation of a true Baconian natural history of the air would require, a project proposed, but never carried out, by early Royal Society Fellows.[91] A careful reading of Conyers's notes makes clear, however, that while he embraced these new practices, he had not whole-heartedly embraced the theoretical frameworks of mechanism. Both his focus on weather, and the way in

[88] BL Sloane MS 919, 9r. "in the son...in a window one the sonny side the house one story hight that is ten foot high in fleet street in my shop window there."

[89] BL Sloane MS 958, 116v. "It seems the south side of the house next fleet street in my shopp that was then the warmer & so made the oyle [in the instrument hung there] the lowest."

[90] Ibid., 118r. "may be there is something in keepeing my shopp shutt it being Sunday which might alter the temper of the glass as to the rarification."

[91] Boyle, "Directions About the Barometer," 181-182; Birch, *History*, 1: 301-302, 311. A few individuals kept weather records for shorter periods of time. For example, Robert Plot, "Observations of the Wind, Weather, and Height of the Mercury Inthe Barometer, through out the Year 1684," *Philosophical Transactions* 15 (1685); John Locke, "A Register of the Weather for the Year 1692, Kept at Oates in Essex," ibid.24 (1704-5).

which he studied the phenomena make it clear that Conyers still thought of much of the world from a Galenic, and by extension Aristotelian, framework. His Galenism/Aristotelianism was not absolute, but when it came to weather, much of Conyers's approach was rooted in the frameworks in which he had been trained as an apothecary.

Conyers interest in the weather may have stemmed in part from Boyle's work on air pressure, but it also reflects his training in Galenic medicine. For Conyers, the air, and its corresponding attributes of heat and cold, moisture and dryness, was an irreducible phenomenon, one that was tied up in the production of weather and in his understanding of the interaction between the earth's globe and the air above it. Humoral theory conceived of human health in terms of balances of the four humors—blood, phlegm, black bile, and yellow bile. Particularly important for our discussion here, is that each humor was associated with temperature and wetness; each humor possessed either a hot or cold property, and either a wet or dry property. Maintaining or restoring the humoral balance in the body was not just a matter of balancing the four humors, but also of understanding the properties of those humors, and the properties of each item in the pharmacopeia, and using the respective hot/cold, wet/dry properties of the latter, to create the correspondingly necessary properties in the body. Weather was known to affect the balance of humors, and therefore the health; indeed, the air was one of the six 'non-naturals' that were fundamental to the understanding of how the outside world affected the body.[92] Understanding the weather, including the humidity level, therefore, was basic to the theoretical framework Conyers drew on in his apothecarial practice.

[92] Louise Hill Curth, "The Medical Content of English Almanacs, 1640-1700," *Journal of the History of Medicine and Allied Sciences* 60 (2005): 266. Andrew Wear, *Knowledge and Practice in English Medicine, 1550-1680* (Cambridge: Cambridge University Press, 2000), 156.

Conyers was not the first Galenist to study the world through the kind of instrumentation more usually associated with the partisans of the new science. Earlier in the century, a colleague of Galileo's, Sanctorius Sanctorius, had experimented with the use of thermometers and hygroscopes to place the degrees of heat/wetness fundamental to Galenic medicine on a more objective footing.[93] In England, although operating from a very different theoretical framework than Conyers, Robert Fludd called for the use of thermometers in the aspects of Galenic medicine he was willing to retain, as well as seeing a use for the new instruments in providing proof for his particular mystical system of macrocosmic-microcosmic interactions, demonstrating that the tools so often associated with the rise of mechanistic thought could be employed to support or refute a variety of natural philosophical systems.[94] In addition, as Craig Martin has recently argued, the study of meteorology in the Aristotelian theoretical framework was far more experiential (and experimental) than the stereotype of Aristotelian philosophers promulgated by the partisans of the new science.[95] Conyers fits into the pattern Martin lays out, a little-known practitioner adopting the same amalgam of ideas and methodology to pursue his studies, like the more famous writers Martin examines.

For Conyers, degrees of heat and humidity explained much about the world; there was every reason to believe that it explained the movement of liquids in the weatherglass and barometer. Although the originality of Conyers's "deale wood hygroscope" device (two pieces of deal separated by a small crack, whose changing width would serve as an indicator of the moisture absorbed by the wood, and therefore a measurement of the humidity in the air) is

[93] Wear, *Knowledge and Practice in English Medicine, 1550-1680*, 39, footnote 72.

[94] Allen G. Debus, "Key to Two World: Robert Fludd's Weather-Glass," in *Chemistry, Alchemy and the New Philosophy, 1550-1700* (London: Variorum, 1987).

[95] Martin, *Renaissance Meterology*, 1-2.

questionable, the way in which Conyers describes his device reveals his commitment to Galenic principles.[96] In the version sent to Henry Oldenburg (though not appearing in the *Philosophical Transactions* version or in Conyers's own copy), Conyers spoke of "somers heat & drynes & Motion" and "winters Moysture Cold & quiet" reflecting the pairing of Galenic properties and Aristotelian elements that associated Summer with Fire, Hot, Dry and the Winter with water and its Galenic properties of wet and cold.[97] In the version published in the *Philosophical* Transactions, Oldenburg added emphasis to Conyers's suggestion 'that Deal-wood, as it hath a fit texture & body for *moisture* & *drought*, *heat* & *cold* [emphasis in the original] and such like qualities to be discovered thereby, so it doth much like the same thing with what is also performed by the whole body of the outward mass of this globe of Earth."[98] Oldenburg himself recognized the role the four Galenic properties played in Conyers' project.

Conyers was not unversed in mechanism; indeed, he partly employed a mechanistic explanation in his draft magnetism treatise, referring to globular and triangular particles, fitting together in dovetail joins.[99] Elsewhere, as he attempted to understand the different behaviors of his instruments, he proposed that the movement of moisture into and out the containers followed lines of motion determined by the geometric shapes.[100] Nevertheless, his embrace of the new theories was less than complete, and he invoked the occasional Aristotelian physical idea, as when he observed that "fire made in the upper region burns not so clear as in the lower

[96] "An Extract of a Letter Etc. From Dublin May the 10th, 1676," 651-652 and illustration.

[97] Oldenburg, Hall, and Hall, *Correspondence*, vol. 13: 112; Wear, *Knowledge and Practice in English Medicine, 1550-1680*, 38.

[98] Coniers, "A Description of Mr. John Coniers, Apothecary and Citizen, His Hygroscope, in Two Several Contrivances; Together with Some Observations Made Thereon: Communicated in a Letter to the Publisher, Octob. 23. 1676," 718.

[99] BL Sloane MS 852, 28-39b, throughout, especially 30v.

[100] BL Sloane MS 916, 9v.

region...on earth, because here on earth there's more darkness & the higher the region the more light."[101]

Although Conyers was still strongly connected to the older theories, a comparison of Conyers' ideas about the environment with Boyle's is revealing. As Barbara Beigun Kaplan has argued, Boyle developed a corpuscularian understanding of the commonly held belief that the relationship between the environment and the human body was important to understanding health and disease.[102] For Boyle, "collection of data on weather and climate" was an essential part of using the new science to improve the human condition through enhanced medical knowledge.[103] Conyers is far less explicit than Boyle in spelling out any specific medical agenda for his work, but he periodically recorded medical information along with the changing weights of his instruments. His own health is almost never mentioned, but during some periods he recorded weekly deaths in London, often indicating the breakdown by disease (plague or spotted fever, for example).[104] Conyers also details the climatic conditions that attended Francis Glisson's death in 1677, recording that the doctor was "wasted to skin and bone" by a "tedious looseness or diarrhea & at last a cough & asthma" the asthma being a regular problem for Glisson in very frosty air.[105]

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[101] BL Sloane MS 937, 174v. "fier made in the upper region burnes not so cleere as in the lower region...one[sic for 'on'] earth becasue heere one earth theres more darknes & the higher the region the more light."[101]

[102] Barbara Beigun Kaplan, *"Divulging of Useful Truths in Physick": The Medical Agenda of Robert Boyle* (Baltimore: Johns Hopkins University Press, 1993), 98-99. On Boyle's complicated relationship with both the Galenic and empirical approaches to medicine, see Michael Hunter, "Boyle Versus the Galenists: A Suppressed Critique of Seventeenth-Century Medical Practice and Its Significance," *Medical History* 41, no. 3 (1997).

[103] Kaplan, *"Divulging of Useful Truths in Physick"*, 99.

[104] See, for example: BL Sloane MS 816, 71r, 72r. BL Sloane MS 839, 23v, 27r.

[105] BL Sloane MS 816, 217r. "being wasted to skin & bone with a tedious loosness or diarhea & at last a cougth & asthma"

While Conyers did not accept the idea of the weight of the air, his ideas about weather, and the causes behind the changes in instrumental readings were not far removed from the theories embraced by Boyle and other Fellows of the Royal Society. As Golinski has discussed, the relationship between barometric readings, air pressure, and weather was not clear in the late 17th century. The causes of variation or stability in mercury levels in weather barometers were still debated by the Royal Society through the 1680s. In the middle of that decade, Martin Lister "doubt[ed] that the variation primarily reflected a change in air pressure [and] speculated that it revealed instead the peculiar way mercury contracted and expanded as the temperature changed."[106] Similarly, John Wallis supported a theory proposed by a Scottish scholar that "variation in [barometer readings] was primarily due to the concentration of effluvia dissolved in [the air], along with the effects of heat & cold."[107]

Boyle himself embraced similar ideas of effluvial influences on the weather (and the related barometer readings) in his early *Philosophical Transactions* articles on the barometer. Acknowledging that "...it be more difficult than onewould[sic] think, to settle any general rule about the rising and falling of the Quick-silver," he attempted to explain a recent pairing of high mercury levels and dry weather by wondering "whether these obstinate Droughts, may not by cleaving of the ground too deep, and making it also in some places more porous and as it were, spungy, give a more copious Vent than is usual, to subterraneal steams, which adscending into the Air, increase the gravity of it."[108] Oldenburg's postscript to Boyle's article added that subsequent observations had supported this theory that "the cause of the height of the Quick-silver in Droughts [is] the elevation of steams from Crust or Superficial parts of the Earth, which

[106] Golinski, *British Weather and the Climate of Enlightenment*, 116-117.

[107] Ibid.

[108] Boyle, "Directions About the Barometer," 184-185.

by little and little may add to the Weight of the Atmosphere."[109] In wet weather the mercury readings would show a *lighter* atmosphere, as the added effluvia would be "carried down from time to time by the falling Rain."[110]

Boyle's ideas of effluvia were mechanistic, operating through corpuscles of various sizes and shapes.[111] While "Aristotle had recognized two kinds of exhalations, terrestrial (called 'fumes'), which were hot and dry, and aqueous (called 'vapors'), which were hot and moist. Boyle felt that this categorization was overly simplistic," believing that what was commonly called "air" was composed of a mixture of many things. Boyle held that "[t]hese various emitted effluvia were carried through the air and eventually insinuated themselves into other bodies whose pores were of an appropriate size and shape to receive them."[112]

Conyers was uncertain whether the earth was "spongy or organically hollow," but he was certain that the globe could "draw...air to it" as well as expel "the heat of the sun as of the fermenting heats in the earth."[113] In trying to decipher the meanings of his different instrumental readings, Conyers spoke of the "fumes of the earth" and wondered about the "organs" by which the "earths globe may gather moisture."[114] The apparent different temperature of rain at different times of the year was due to the nature of the material expelled from the earth in each season. In

[109] Ibid., 185.

[110] Ibid.

[111] Kaplan, *"Divulging of Useful Truths in Physick,"* 100.

[112] Ibid., 105-106.

[113] BL Sloane MS 916, 3v. "For the cause of winds its propper to say that the earth & the shape of it whether spongy or ^organically^ hollow & the heats thereof by ffermentation the pressure that is made in the bowells thereof by a cold & thinn ayre first drawing ayre to it & then afterwards by heat exspanded as well the heat of the sunn as of the fermenting heats in the earth"

[114] BL Sloane MS 839, 4r,v. "ffumes of the earth" "now its probable the earths globe may gather moysture as much by the helpe of few organs within as many which are more liable to obsruct the motion of tydes"

summer, "rain is cold…because it stop the hot reeks [as] it rises out of the earth." In winter, "rain is warm…because it stops the cold reeks."[115] Conyers also proposed that the weather was affected by a constant movement of the hot and cold matter from different parts of the globe, and this "continual motion from some other warmer parts of the world that partakes of more of heat of the sun" provided an explanation for hot springs that maintained their temperature regardless of season.[116] Conyers began to outline a treatise in which he would expand upon this view of the world by starting a list of "Memorandums that prove the Earths shrinking and swelling...in like Manner as the wooden Panel of Deal."[117]

Boyle was not specifically concerned with the effluvia in his essay on the sponge hygroscope, but did select this material in part because "by its readiness to soak in Water, seem'd likely to imbibe the Aqueous particles that it may meet with dispers'd in the Air, and which, by its great porousness throughout, has much more of *Superficies* in reference to its bulk, than any [other] Body...that came into my thoughts."[118] Conyers followed Boyle in using the sponge as the basis of his instruments, but he found the sponge particularly appropriate because they mimicked the porous structure of the earth. For Conyers, the way that the atmosphere interacted with the earth could be successfully modeled through the creation of miniature earths—his series of globe-based glass instruments, each bearing a piece of porous (earthlike) sponge inside. In his outline for an argument to "prove the Earths shrinking & swelling" the behaviors of "all the

[115] BL Sloane MS 916, 13r."as in sommer raines is colde is becasue it stopps the hott reikes it rise out of the earth & that raine is warme in winter because it stops the Cold reekes." Reek is here used in the sense of a vapor resembling smoke or steam. The OED lists it as a rare and regional usage, and is possibly a sign of Conyers's Leicestershire roots. "Reek, N.1," In *OED Online*. (Oxford University Press, September 2015), http://www.oed.com/view/Entry/160630. Accessed November 03, 2015.

[116] BL Sloane MS 916, 13r-14v. Hot springs, 13v. "continuall motion from some other warmer parts of the world that partkes of more of heat of the sunn"

[117] BL Sloane MS 958, 112r.

[118] Boyle, *Saltness of the Sea*, 430.

sponge glasses & naked sponge" was listed just after the behavior of the deal panel as evidence supporting his idea.[119] The behavior of the deal was similarly important given that it too was a porous (and therefore earth-like) body, a material that possessed "harmonizing & sympathizing texture" that responded to moisture, dryness, heat, cold. This behavior, Conyers argued, "also is performed by the whole body...of this terrestrial globe."[120]

In addition to the porosity of his materials, Conyers emphasized that many of his instruments are of "an orbicular, oval form, as it is thought the world and sun is" and argued that many of his results could be explained through properties of this shape, rather than the existence of air pressure. [121] From his results, Conyers concluded, "it appears that these glasses are actuated more or less as they are informed by virtue of their inward concavity or outward convexity."[122]

> The globular polar glass with the sponge in it shows more plainly the improbability of the pressure of the atmosphere because in cold [it] weighs lighter and in heat heavier…[This] all proceeds from the shape of the glass being convex and concave…[The containers] act upon bodies according to heat as burning glasses unite the rays of light and so produce a degree of heat which actuates the glass either with heat to draw in [moisture] or cold to abate moisture…as I have elsewhere in this book found out, discoursed, and made appear by many days observation of the globular glasses with ears and sponges acting contrary to the thermometer and barometer as to weight of moisture.[123]

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[119] BL Sloane MS 958, 112r.

[120] Ibid., 142r. "harmonizing & sympahtizing texture"; "allso is performed by the whole body of outward mass of this terestriall Globe."

[121] BL Sloane MS 919, 6v. "an orbicular ovall forme as it is thought the world ^ & son^ is"

[122] Ibid., 7r. "it appears that these[?] glasses are actuated more or less as they are ineforne by vertue of their in ward concavity or outward convexity"

[123] Ibid., 7v. "The globular polar glass with the sponge in it showes more plainly the improbablity of the pressure of the atmosphere because in cold that weighes liter & in heat heavier & all proceedes from the shape of the glass being convex & concave so actus upon bodies according to heat as burning glasses uniteing the rayes of light & so preduces a degree of heat which actuate the ^glass^ either with heat to draw in or cold to abate moisture in the sensible weight as I have elsewehre in this booke found out dixcoursed & made appeare by many dayes observation of the globular glasses with eares & sponges thes acting contrary to the Thermometer & Barometer as to weight of moisture"

The idea that the shape of the container affected the instruments also explained other things he had observed. The slower motion of quicksilver in smaller tubes, when compared with their larger cousins, was “because there is less heat in a small burning glass then a great one."[124] Similarly, the fluid in thermometers moved differently than that in barometers since water and quicksilver reacted differently to heat, and differently to heat directed by different shaped “burning glasses.”[125] Similarly, while musing on an attempt to recreate another Boyle experiment (glass drops floating in a container of water), Conyers tried to understand the movements of the drops by comparing them with more universal motions. To Conyers, it made sense that the predominant movements of these glass drops should be "as the sun’s course…from east to the west."[126] The motion of heat & cold in any object was "more powerful" the closer it was to "a globular shape." Though water and quicksilver, the components of the standard weather glass & barometer, both wanted to assume globular forms (i.e. drops), constraint in "long tubes" disturbed the natural interaction of heat & cold with these materials. Given these physical properties, Conyers thought, it was no wonder the results from his newly invented instruments differed from results given by thermometer & baroscope.[127]

Although Conyers's detailed weather observations ended in 1680, he continued to be interested in questions of moisture and its dispersion at least until a few years before his death. In reporting observations about the drying of clothes on a pebble-covered table (dated October 20, 1690, a few years before his death in 1694), Conyers drew parallels between what he saw on

[124] Ibid. "And the reason of the small tubes makeing a slower motion of quicksilver than the larger Tube is becasue theire is less heat in a small burneing glass then a great one”

[125] Ibid., 8r.

[126] Ibid., 6v. "as the sunns course...vizt: from east to the west."

[127] Ibid., 8r.

his table and the larger scale of weather phenomena, observing that the ways in which the fabric dried more quickly in the "interstices or hollow places between the pebbles" provided "this answer to the globular motion of moisture on the Earth's surface as to heat and cold while it is in Exhalation."[128] The exacting observations of his weather project were a decade behind him, but his basic understanding of how moisture moved between Earth and atmosphere remained steadfastly rooted in the same ideas about the primacy of degrees of temperature and moisture.

Conclusion

Conyers embodied several aspects of the new science—pursuing the hallmark Baconian tasks of experimentation and collection of experiential knowledge of nature. At the same time, however, Conyers's work was influenced by his profession as an apothecary, which reflects itself in the nature of the experiments he chose to pursue, the equipment he used to pursue them, as well as the theoretical frameworks he used to attempt to understand his results. With a strong background in the theory and practice of Galenic medicine, Conyers was an experimentalist but only a partial mechanist. His focus on humidity and temperature, as well as his inability to accept Boyle's ideas about air pressure, reflect Conyers's continued acceptance of Galenic theory (and its Aristotelian roots), even while adopting chymical medicines, experimental practices and some mechanical explanations for natural phenomena. Examining Conyers's work, therefore, provides another example of the non-linear way in which the changes associated with the "scientific revolution" took place, demonstrating that even for those in regular contact with the vanguard of the new science, new ideas were adopted piecemeal, forming an amalgam with the long-standing explanatory powers credited to the old theories.

[128] BL Sloane MS 958, 140r."interstices or hallow places between the Pebbles"; "this answer to the globular motion of moysture one the Earths surface as to heat & cold whilest it is in Exhalation"

Chapter 4

"A vast number of Curiosities:" Collecting in London c.1660-1700

On November 21, 1691, the *Athenian Gazette* recorded that "Mr. John Conyers, Apothecary in Shooe-lane [had] lately made a Proposal to the publick, of exposing his Collection of Rarities to such as shall be curious to see them." The *Gazette* praised this step, lauding Conyers' accumulation as one that would be useful to "any Person of Curiosity," since it contained "a vast number of Curiosities" of all types. According to the notice, Conyers had collected exotic natural productions—from all categories of animal, vegetable and mineral—as well as "Antiquities very valuable" from "Egyptian, Jewish, Grecian, Roman, Brittish[sic], Saxon, [and] Danish" cultures. He also held a great number of texts sure to interest the learned virtuoso including "Philosophical Manuscripts," "Ancient Manuscript Rolls," historic law books of all the kingdoms of the British Isles, and manuscripts in many languages, including "Chinese, Saxon…[and] Muscovite." In case this impressive list did not convince the reader, the *Gazette* added that Conyers also held "Outlandith[sic] Garments, Weapons, his Pictures, Prints, and a vast many other things."[1]

The *Gazette*'s description of Conyers' collection reads like an ideal gentlemanly virtuoso's cabinet, but Conyers's collections have only warranted brief mention in studies of early modern collecting. While many scholars have studied collecting and collections in early modern Europe,

[1] "Quest. 4: Mr. John Conyers, Apothecary in Shooe-Lane, Having Lately Made a Proposal to the Publick, of Exposing His Collection of Rarities to Such as Shall Be Curious to See Them; I Desire Your Opinion Concerning the Proposal, Whether It May Be of Use to the Publick.," *Athenian Gazette*, no. 16 (1691): 2. On the history, content, and context of the *Athenian Gazette*, also known as the *Athenian Mercury*, see Gilbert D. McEwen, *The Oracle of the Coffee House: John Dunton's Athenian Mercury* (San Marino, California: The Huntington Library, 1972); Helen Berry, *Gender, Society and Print Culture in Late-Stuart England: The Cultural World of the Athenian Mercury* (Burlington, VT: Ashgate, 2003).

the focus of these studies has tended to be the acquisitions of wealthy patrons. The collections of powerful European leaders, such as those of Rudolph II and Peter the Great, have been studied from both the art historical and history of science perspectives. Historians have also studied the accumulations of scholars, gentlemen, and aristocrats that were of particular note in their own time, particularly collections that left a strong presence in print (through catalogs or travel guides) or in the correspondence networks of European intellectuals.[2] In England, the most studied collections of this period are those of the John Tradescants, Elias Ashmole, and, in the early 18th century, Sir Hans Sloane. As with their Continental counterparts mentioned above, historical study of these English examples have benefited from being very well documented, both in print and manuscript. In addition, both the Tradescant-Ashmole collection and Sloane's collection were unusually long-lived. While most early modern collections were dispersed upon a collector's death, the Tradescant collection metamorphosed into the collection of Elias Ashmole, and formed the basis of the present day Ashmolean Museum in Oxford, while Sloane famously provided the founding collection of the British Museum.[3]

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[2] Notable works in the study of collecting/collections include: Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley; London: University of California Press, 1994); O. R. Impey and Arthur MacGregor, eds., *The Origins of Museums: The Cabinet of Curiosities in Sixteenth- and Seventeenth-Century Europe* (Oxford: Clarendon, 1985); Krzysztof Pomian, *Collectors and Curiosities: Paris and Venice, 1500-1800* (Cambridge: Polity, 1990); Marco Beretta, ed. *From Private to Public : Natural Collections and Museums* (Sagamore Beach, MA: Science History Publications/USA, 2005); Arthur MacGregor, *Curiosity and Enlightenment: Collectors and Collections from the Sixteenth to the Nineteenth Century* (New Haven, Ct.: Yale University Press, 2007).

[3] On the Tradescant/Ashmolean collection see: Prudence Leith-Ross, *The John Tradescants: Gardeners to the Rose and Lily Queen* (London: P. Owen, 1984); Arthur MacGregor and Ashmolean Museum, *Tradescant's Rarities: Essays on the Foundation of the Ashmolean Museum, 1683, with a Catalogue of the Surviving Early Collections* (Oxford; New York: Clarendon Press; Oxford University Press, 1983). Michael Cyril William Hunter et al., *Elias Ashmole, 1617-1692, the Founder of the Ashmolean Museum and His World: A Tercentenary Exhibition 27 April to 31 July 1983* (Oxford: Ashmolean Museum, 1983). Marjorie Swann, *Curiosities and Texts: The Culture of Collecting in Early Modern England*, Material Texts (Philadelphia: University of Pennsylvania Press, 2001), chapter 1. On Sloane: Michael Hunter, Alison Walker, and Arthur MacGregor, eds., *From Books to Bezoars: Sir Hans Sloane and His Collections* (London: British Library, 2012); Arthur MacGregor, ed. *Sir Hans Sloane: Collector, Scientist, Antiquary, Founding Father of the British Museum* (London: British Museum Press, 1994).

In this chapter I will focus on a more typically transient and poorly documented collection, an almost invisible assemblage created in the late 17th century by Restoration apothecary John Conyers.[4] A younger contemporary of Elias Ashmole, Conyers was known as a collector during his lifetime, as references from his contemporaries and early eighteenth century antiquaries who followed him attest.[5] He has received little focus from modern scholarship, however, aside from regularly warranting a passing mention in relevant studies.[6] While Juanitia Burnby published several short articles on John Conyers, drawing attention to his work as an "archeologist," an anachronistic term for his investigations, Conyers's collections are mostly absent from the history of collecting.[7]

By focusing on Conyers's assemblage—using the one brief printed notice in the *Athenian Mercury*, the records left in his own notebooks, as well as through the manuscript and print records of his contemporaries—I will show that the collecting of antiquities, *naturalia*, and curiosities was not merely an activity of the Restoration elite. Far more than the Tradescants or

[4] On an invisible collection of a French apothecary, see E. C. Spary, "Pierre Pomet's Parisian Cabinet: Revisiting the Invisible and the Visible in Early Modern Collections," in *From Private to Public: Natural Collections and Museums*, ed. Marco Beretta (Sagamore Beach, MA: Science History Publications, 2005).

[5] For example, John Aubrey and John Fowles, *Monumenta Britannica: Or, a Miscellany of British Antiquities*, 1st subscription ed., 2 vols. (Sherborne Eng.: Dorset Pub. Co., 1980), Volume I, part 1, p. 98. John Bagford, BL Lansdowne MS 808, Collections of John Bagford, f. 77r-78r; William Camden, *Camden's Britannia, Newly Translated into English: With Large Additions and Improvements. Publish'd by Edmund Gibson* (London: Printed by F. Collins, for A. Swalle etc., 1695), 334.

[6] Joseph M. Levine, *Dr. Woodward's Shield : History, Science, and Satire in Augustan England* (Berkeley: University of California Press, 1977), 141-142, 151; Michael Hunter, *John Aubrey and the Realm of Learnng* (London: Duckworth, 1975), 200. MacGregor, *Sir Hans Sloane*, 186-189. MacGregor, *Curiosity and Enlightenment:* 183; 195-196; Jill Cook, "The Elephants in the Collection: Sloane and the History of the Earth," in *From Books to Bezoars: Sir Hans Sloane and His Collections*, ed. Alison Walker, Arthur MacGregor, and Michael Hunter (London: British Library, 2012), 160-162.

[7] J. Burnby, "John Conyers, London's First Archaeologist," *Transactions of the London & Middlesex Archeological Society* 35 (1984); J. Burnby, "John Conyers - Apothecary and Archaeologist (C. 1633-1694)," *Pharmaceutical Historian* 34 (2004). While the term "archeology," in the sense of ancient history or the study of antiquities had appeared by the 17th century, the term 'archeologist' was not used until the 19th century. (See "archaeology, n." and "archaeologist, n." OED Online. December 2013. Oxford University Press. http://www.oed.com/view/Entry/10283 (accessed January 09, 2014).

Ashmole, Conyers represents the "middling sort" in England in a time of transition.[8] John Conyers held a respectable place in the social hierarchy; having served his apprenticeship and achieved his freedom of the Worshipful Company of Apothecaries, he was a citizen of London in an age when most had no right to take part in local government. He struggled financially, however, and died impoverished.[9] (A more successful brother was able to make further movement up the social ladder through the purchase of a country estate and attempts to create marital ties with the established gentry.)[10] Through a partial reconstruction of Conyers's collections and an examination of the sources and fates of these objects, I will show that in Restoration London, the act of collecting, and using those objects to study the natural world, extended further into society than has been considered. Pursuing the trails of this relatively obscure collection through Conyers's own manuscripts and through the surviving account books of the more elite collector William Courten, reveals that while objects of curiosity were certainly found in the homes of the wealthy and elite, the more public venues of street and shop were also vital to collecting.

The re-created catalog of Conyers's collection (Appendix 1) allows us to more fully understand why his assortment of items was considered noteworthy by his contemporaries, and offers us insight into how the collecting impulse was pursued lower down on the social scale, amongst men who were interesting in a virtuosic range of topics, but restricted by limitations in time, money, and influence from amassing a collection of international scope. The specific ways

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[8] Swann, *Curiosities and Texts*, 27-54.

[9] TNA PROB 11/355/319; BL Sloane MS 2031, f. 41. John Woodward, *An Account of Some Roman Urns, and Other Antiquities, Lately Digg'd up near Bishops-Gate. With Brief Reflections Upon the Antient and Present State of London. In a Letter to Sir Christopher Wren, Kt. Surveyor-General of Her Majesty's Works* (London: E. Curll, 1713), 6.

[10] Edward Conyers's life is briefly described in Burnby, "A Study of the English Apothecary from 1660 to 1760," 101.

in which Conyers built his collections, as shown through his notebooks and extrapolated from Courten's accounts—through his occupation, through local finds, and through small-scale purchases of locally available objects—suggest mundane mechanisms of collecting that have been underappreciated in the historiography thus far, further illustrating the blurry lines between the "economic and the epistemological" for early modern collectors.[11] These mechanisms, in turn, took place in a wider range of places, accessible to a wider swath of the population of early modern London—including women—than the privately held gentlemanly cabinets that are the usual object of historical study. Conyers's and Courten's manuscripts show us a world where historical and natural historical collectors occupied—sometimes quite literally—the streets and public spaces of London, engaging in observations, exchanges, and commercial transactions with all kinds of Londoners.

Collecting in Early Modern Europe: Purposes

Collections, and the act of acquiring them, served many purposes in early modern Europe. From the early princely or noble *Kunstkammern* or *Wunderkammern* in European courts, cabinets of curiosities provided visual and material presentation of a leader's wealth, connections, erudition, and power.[12] Even if most such assemblages were seen only by a select few, rumors of the magnificence of a collection could spread and add to a leader's political

[11] Spary, "Pierre Pomet's Parisian Cabinet," 63.

[12] See for example, Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150-1750* (New York: Zone Books, 1998), 101-108. Anthony Anemone, "The Monsters of Peter the Great: The Culture of the St. Petersburg Kunstkamera in the Eighteenth Century," *The Slavic and East European Journal* 44, no. 4 (2000): 596.

power.[13] Amongst the learned, naturalists, philosophers, and physicians created similar collections that could have "encyclopedic ambitions, intended as a miniature version of the universe, containing specimens of every category of things and helping to render visible the totality of the universe."[14] Nature in all her forms—monstrous, marvelous, or mundane—was a text that the early modern natural philosopher aspired to read. The accumulation of intriguing goods was driven by the hope that "possession of nature eventually would precipitate an understanding of her contents."[15] Collectors often chose "the strangest things from [nature and art], those which were not seen ordinarily and which, for this very reason, seemed better representatives of the creative powers at work in the universe."[16] Early modern natural philosophers grappled with the challenge of discovering laws of nature that explained the production of the commonplace and the rare. Collecting broadly of both the everyday and the exotic, so as to better grasp the entirety of nature and the many ways in which humankind shaped it, led Francis Bacon, among others, to advocate collecting as an important tool for the study of the world.[17]

Like the rulers who hoped to augment their political positions through their collections, natural philosophers and virtuosi who collected could also gain status from the activity, and from the presence of particularly notable items in their possession. Possessing a "rare, outlandish piece…immediately conferred status on a collection and spread its fame…" fame that could be

[13] Thomas DaCosta Kaufmann, *The Mastery of Nature: Aspects of Art, Science, and Humanism in the Renaissance* (Princeton, N.J.: Princeton University Press, 1993), 178-179.

[14] Krzysztof Pomian, *Collectors and Curiosities: Paris and Venice 1500-1800* (Cambridge, U.K.; Cambridge, Mass., USA: Polity Press ; Basil Blackwell, 1990), 69.

[15] Paula Findlen, *Possessing Nature,* 56.

[16] Pomian, *Collectors and Curiosities*, 75.

[17] Daston and Park, *Wonders and the Order of Nature*, 221-222; Swann, *Curiosities and Texts*, 59-62.

spread by word of mouth, or, in the right circumstances, through publication with a description, catalogue, or pamphlet discussing the collection.[18] Even without a defining specimen, collecting was seen as an activity marking a gentleman. Collectors accumulated goods and placed them on display both for practical purposes and to place themselves within certain social realms. Someone who had the time to seek out materials for a cabinet, money or influence to procure rare specimens, and the time, learning, and space to arrange and display such goods was demonstrating the possession of those useful gentlemanly skills of time, means, and erudition.[19]

For late 17th century English intelligentsia, collecting was a multi-purpose activity. Strains of earlier *wunderkammern* remained, even in the most learned grouping, as objects considered wonders or marvelous still appeared in serious assemblages.[20] The growing international trade with all parts of the world necessitated the creation of new ways of understanding and communicating about the world, and collecting became allied to this commercial purpose as well.[21] Following Bacon's directives on how to learn about the natural world, collections were seen as important tools for amassing knowledge about the world—both the usual and the unusual. In fact, extensively collecting all types of materials from all over the globe—so as to better understand the full range of nature's normal activities—was essential to pursuing a thorough Baconian program of knowledge improvement. Just as the good natural

[18] Giuseppe Olmi, "Science - Honour - Metaphor: Italian Caminets of the Sixteenth and Seventeenth Centuries," in *The Origins of Museums: The Cabinet of Curiosities in Sixteenth and Seventeenth-Century Europe*, ed. O. R. Impey and Arthur MacGregor (Oxford [Oxfordshire]; New York: Clarendon Press ; Oxford University Press, 1987), 8. For an example of this see the case of Aldrovandi in Findlen, *Possessing Nature*, 17-24.

[19] Swann, *Curiosities and Texts*, 21, 27.

[20] Hunter, "Between Cabinet of Curiosities and Research Collection."; Walter E. Houghton, Jr., "The English Virtuoso in the Seventeenth Century: Part 1," *Journal of the History of Ideas* 3, no. 1 (1942); Walter E. Houghton, Jr., "The English Virtuoso in the Seventeenth Century: Part II," *Journal of the History of Ideas* 3, no. 2 (1942); Craig Ashley Hanson, *The English Virtuoso: Art, Medicine, and Antiquarianism in the Age of Empiricism* (Chicago: The University of Chicago Press, 2009).

[21] See for example: Smith and Findlen, *Merchants and Marvels*; Cook, *Matters of Exchange*.

philosopher should gather facts (histories) before forming theories, so too should the good natural historian, antiquarian, physician, or philosopher gather facts in the shape of material objects to compile a complete understanding of the world: anatomical specimens showed the range of possibilities in human anatomy; curiously formed stones helped explicate (and complicate) the understanding of the boundaries between minerals and living productions; examples of exemplary workmanship demonstrated the heights to which human ingenuity could reach; statues and coins could be collected for their artistic or technical merit, or as important pieces of historical data.

John Conyers never laid out an explicit reason behind creating his collections, unlike his clear statement of motivation for the weather experiments that occupied his attention in the 1670s.[22] It seems likely that his collecting was driven by a combination of factors. As discussed in the previous chapter, Conyers was proud of his position as an apothecary and believed that apothecaries had an important roll to play in the intellectual world of Restoration London. In this light, his collecting can be seen—like his experimental program—as both a reflection of his own sense of place in the intellectual hierarchy, and as an attempt at self-fashioning to increase his social status. He would contribute to the sum of human knowledge by giving time and attention to developing a collection; simultaneously, having a good collection would provide additional support to his claims of intellectual worth. I would also like to point out that amassing a variety of materials would in some ways be a natural activity for an early modern apothecary. Just as experimentation via careful weighing grew out of Conyers's occupational skills, so too might collections of antiquities, *naturalia*, man-made objects, and more grow out of the apothecary's regular task of keeping and organizing a well-stocked shop.

[22] See Chapter 3 above.

In addition, with respect to Conyers's interests in London's Roman past, there was a long tradition of Londoners of the "middling sort" (citizens and freemen who may or may not have had significant involvement in the governance of the city, or significant wealth) pursuing "civic historical scholarship," a tradition that dates from the 15th century.[23] In the late 17th century there was a surge of chorographic writing, often containing natural history and antiquarian material, which was connected to local gentry who wished to establish the antiquity and importance of particular families or areas to the history of England.[24] While this movement is most frequently associated with emphasis on local histories created by English country gentry, for Conyers, the urban setting of London *was* his local, and the history of the City important to his own position as a freeman of that City.[25]

Cataloging Conyers's Collection

Most of the historical work on collecting in early modern Europe, and in England has, unsurprisingly, focused on assemblages for which printed catalogs or extensive manuscript records concerning the accumulation of objects survive. Collections, no matter how renowned during their creator's life, tended to disappear quickly after their owner's death, disbursed by inheritors lacking interest in maintaining the accumulated objects, or desiring the cash value of

[23] Ian W Archer, "John Stow, Citizen and Historian," in *John Stow (1525-1605) and the Making of the English Past: Studies in Early Modern Culture and the History of the Book*, ed. Ian Anders Gadd and Alexandra Gillespie (London: British Library, 2004), 16.

[24] Swann, *Curiosities and Texts*, 97-148.

[25] Stan A.E. Mendyk, *'Speculum Britanniae': Regional Study, Antiquarianism, and Science in Britain to 1700* (Toronto: University of Toronto Press, 1989). Conyers's brother, Edward, who procured a lucrative position at the Tower of London that allowed him to buy a country estate, embraced the self-fashioning possible through the genealogical part of local history. He concocted a spurious family tree for the benefit of the Herald's office, and then attempted to use marriage to link his family to established land-owning gentry. The inopportune deaths of his wives, one surviving daughter, and ultimately himself, foiled Edward Conyers's attempts to found his own gentle dynasty. Burnby, "John Conyers, London's First Archaeologist," 71; for the family tree see John Nichols, *The History and Antiquties of the County of Leicester*, vol. 2: Part 2 (London 1798), 456.

the goods. Catalogues also provide insight into how a collector thought about the objects around them.[26] For a collection's contents to be memorialized in print however, one had to have monetary resources, social connections, or patronage support.[27] Conyers clearly lacked these resources as John Woodward regretted in 1713, lamenting that while Conyers was "very indefatigable in his Inquiries," he "had not Encouragement to set forth some relation of them. But he having only the Returns of his Profession to depend upon, and there being at that time so very few that were forward to contribute any Thing to the Support of such Studies, however curious and useful, Posterity has been depriv'd of the Benefit of his."[28] While brief accounts of three of his inventions were published in the *Philosophical Transactions*, Conyers never developed a larger work based on his years of weather observations and sponge weighing.[29] Similarly, the magnetism treatise he began, clearly intending it for publication, (his proposed titled described the following treatise as being "illustrated with cuts and proper figures," terminology that would have only applied to a printed volume with wood cuts and not the pen and ink sketches of his draft) ended after 24 folio pages, and was not developed further.[30] The 1691 advertisement in the *Athenian Gazette* is the closest to a published catalogue we have of Conyers's accumulations, and this undoubtedly reflects the hidden character of most collections

[26] Findlen, *Possessing Nature*, 36-44; Swann, *Curiosities and Texts*, 9-15.

[27] On print culture in Restoration London see Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago, Ill.: University of Chicago Press, 1998).

[28] Woodward, *An Account of Some Roman Urns*, 6.

[29] John Coniers, "A Description of Mr. John Coniers, Apothecary and Citizen, His Hygroscope, in Two Several Contrivances; Together with Some Observations Made Thereon: Communicated in a Letter to the Publisher, Octob. 23. 1676," *Philosophical Transactions* 11 (1676); John Conyers, "A Letter of Mr. John Conyers, Citizen of London; the Author of the Hygroscope Described in Numb. 129; in Which Letter Is Contained a Draught and Description of a Very Useful and Cheap Pump, Contrived by the Said Mr. Conyers; a Trial of Which Was Also Made at the Repairing of the New Canal of Fleet-River in London, and Elsewhere," ibid.12 (1677-1678); John Conyers, "Extract of a Letter from Mr. John Conyers, of His Improvement of Sir Samuel Moreland's Speaking Trumpet,Etc.," *Philosophical Transactions* 12 (1677-1678).

[30] See John Conyers. British Library, Sloane MS 852, 17th cent., The Natural History of the Loadstone.

of the period. While a complete manuscript record of his assemblage also does not survive, it is possible to begin a reconstruction. The preliminary catalog of Conyers's collection (found in Appendix 1) shows that, while the *Gazette* announcement may have exaggerated the extent of Conyers's displays, it is clear he gathered a wide range of objects and held items valued by his contemporaries.

The catalogue recreated in Appendix 1 is derived from several sources, independent of the *Gazette*. Within Conyers's notebooks at the British Library, there are several sections where he devotes significant time to discussing items he has found in London, either in an antiquarian context, or in a natural philosophical context. Further information derives from the records of another collector, William Courten, who recorded purchasing parts of Conyers's collection in 1693. Finally, some of Conyers's contemporaries made note of a few items they thought were of particular importance. References to the manuscript sources are included in the table below. It is likely that information about additional items could be found if all of the pages of Conyers's surviving notebooks were read for passing references to items he held.[31]

There is ambiguity in the preliminary catalog as it was not always possible to determine which of Conyers's own descriptions refer to the same individual object, or to different, but similar, specimens. In addition, he often wrote of having imprecise quantities, such as "hatful's" of coins.[32] Nevertheless, this preliminary catalog of Conyers' collections demonstrates the essential truth of the *Athenian Gazette* article—throughout his life, Conyers amassed objects that

[31] There may also be scattered additional information in the surviving catalogs made by Sir Hans Sloane. Sloane acquired some of Conyers's materials in later years, and there are at least a few explicit attributions of materials to Conyers in one of Sloane's antiquarian catalogs. See quotations from this catalog in Arthur MacGregor, "Prehistoric and Roman-British Antiquities," in *Sir Hans Sloane: Collector, Scientist, Antiquary, Founding Father of the British Museum*, ed. Arthur MacGregor (London: British Museum Press for the Trustees of the British Museum, 1994), 187-191.

[32] John Conyers. British Library, Sloane MS 937, Meteorological Journals, 1674*,* f. 179r.

reflect the wide range of late 17th century interests. As Appendix 1 shows, Conyers's accumulation included pictures, *naturalia*, natural philosophical instruments, manuscripts, and antiquities (including a substantial number of coins). Certainly, Conyers's collections compare favorably with that of John Bargrave, a canon of Canterbury, whose manuscript catalog of his goods was not published until the 19th century.[33] Bargrave's collection was almost entirely formed during his travels in Europe (particularly Italy) during the Interregnum, and thus possessed the patina of exoticism and erudition that Continental travel imparted.[34] Bargrave was a small-scale collector, and his catalog, includes just over 71 entries (excluding his coins). His assemblage included ancient and modern brasses, stones chipped from ancient ruins, minerals, fossils, shells, a dried and stuffed chameleon, optical instruments, and porcupine quillwork from the Americas.

Conyers had not traveled on the Continent, but his collections were just as far-reaching. Comments and references by his contemporaries tended to focus on his antiquarian interests, and certainly Conyers held many goods from London's past—particularly Roman Britain. His assorted coins included ones bearing the images of Roman emperors, others with Anglo-Saxon lettering, and much more recent creations, such as heavily worn coins he thought might have originated during Henry VIII's reign. Pots and potsherds from Roman times—identifiable by the inscriptions on some fragments—also had a place in his collection. The pieces most famous amongst his contemporaries—fragments of what he called an elephant tusk and the hand axe found with it—were thought by Conyers and his colleagues to date from Roman encounters with

[33] John Bargrave and James Craigie Robertson, *Pope Alexander the Seventh and the College of Cardinals*, Camden Society Publications, No. XCII (Westminster: Printed for the Camden Society, 1867), 113-140. See also Stephen Bann, *Under the Sign: John Bargrave as Collector, Traveler, and Witness* (Ann Arbor: The University of Michigan Press, 1994).

[34] Bargrave and Robertson, *Pope Alexander the Seventh and the College of Cardinals*, x-xii; 115-116.

British tribes (elephants must have become a standard part of Roman army transport after Hadrian's famous Alp crossing, the thinking went).[35] A shield thought by some to be of Roman origin, had a moment in the intellectual spotlight after Conyers' death when it passed to John Woodward.[36]

Conyers' was not merely an antiquarian, however, no matter how many Roman coins he collected. Remnants of more recent history were found in manuscript rolls (Aubrey explicitly identified one from the time of Henry VI, held by Conyers) and in a hand-copied version of part of Hakluyt's *Principle Navigations*.[37] He accumulated art as well. Despite having suffered losses in the Great Fire of 1666, for example, by 1672 Conyers had a small group of pictures, which demonstrated the full range of 17th century tastes, from landscapes, to portraits of historical figures, to Biblical scenes, and a few bawdier subjects. In addition, he collected broadly in the natural world, including boundary-crossing items, such as fossil remains, as well as mineralogical samples, insects trapped in amber and carved Roman "talismans" on stones whose quality was just as important as the carving they held. Animal specimens appeared in fossilized bones and also in animal parts fundamental to the early modern pharmacopeia. The plant world was present in samples of curiously shaped fruit-stones and gnarled branches, in addition to the plants and plant parts lining the walls of his apothecary's shop.

[35] These two items are now known to be approximately 350,000 years old and were the result of an encounter between a type of elephant living in Ice Age Briton, and the Paleolithic hunters of the day. The hand axe is now held by the British Museum, one of only two items of Conyers's collection whose present-day whereabouts are certain. British Museum., *Pointed Flint Handaxe*, (http://www.britishmuseum.org/explore/highlights/highlight_objects/pe_prb/p/pointed_flint_handaxe.aspx, November 5, 2015).

[36] Levine, *Dr. Woodward's Shield*.

[37] Aubrey and Fowles, *Monumenta Britannica*, Part I, p. 98; John Conyers. British Library, Sloane 61, 17th cent., Copy of Rev. F. Fletcher's Narrative of the First Part of Sir F. Drake's Second Voyage in 1577 Round the World.

Conyers also had an extensive, if idiosyncratic, collection of scientific instruments. He had several good examples of loadstones and other magnets in a variety of shapes.[38] In addition, as discussed in the previous chapter, Conyers created many weather instruments during the 1670s. This assemblage included standard items, such as barometers and weatherglasses, as well as his own contraptions. In addition to these items, he also had equipment on hand—such as balances, measures, and distillation equipment—for preparing medicines and experimenting with new substances like phosphorus. This equipment created another collection, as the information he compiled during his weather experiments was carefully recorded, forming an assortment of data to take its place alongside the accumulation of material objects.

Acquisition and dispersal-How did John Conyers acquire such a varied collection?

In general, the historiography of early modern collecting has emphasized status-related acquisition and exchange of goods in all categories. From the earliest *Wunderkammer,* the ability to acquire the unusual, the rare, and the costly carried social caché. Gift giving and exchanges between patrons and clients, intellectual comrades creating a virtual community through correspondence and travel, and the commissioning of acquisition of samples could all play a part in the creation of groups of wonders, *naturalia*, *materia medica*, antiquities, or the encyclopedic assemblages of a virtuoso.[39] More recent historiography has begun to emphasize the role played by the growing global movement of goods.[40] While Conyers may have acquired some of his items through personal connections or exchanges with his like-minded contemporaries or

[38] BL Lansdowne MS 808, f. 74r; BL Sloane MS 852, ff. 28-39 b.

[39] Swann, *Curiosities and Texts*, 16-54; Findlen, *Possessing Nature*, especially 346-392.

[40] Smith and Findlen, *Merchants and Marvels*; Daniela Bleichmar and Peter C. Mancall, eds., *Collecting across Cultures: Material Exchanges in the Early Modern Atlantic World* (Philadelphia: University of Pennsylvania Press, 2011).

travelers passing through London, the manuscript evidence highlights a number of other important mechanisms for the creation of collections. Specifically, I will consider the roles of (a) Conyers's occupation as an apothecary (b) accidental local discoveries, and (c) small-scale local commercial transactions in the formation of his collection.

(a) Apothecarial collections

Long before John Conyers proposed "exposing his collection of Rarities" to the world, he had been in the business of creating and maintaining a semi-public stock of goods (albeit not all rarities) in his shop.[41] The largely plant-based medicine of the 17th century meant that a well-stocked apothecary's shop was a veritable treasure trove of botanical and zoological specimens, and the growth of the new chemical medicine meant an increasing presence of mineral and chemical preparations as well.[42] These specimens required equipment for preparation, storage, and, sometimes, display, equipment that may also have lived on the shop shelves. Determining the exact contents of Conyers's apothecary's shop is impossible, but records from other 17th century apothecaries help create a picture of what a customer entering Conyers' shop was likely to see.[43]

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[41] "Quest. 4: Mr. John Conyers, Apothecary in Shooe-Lane, Having Lately Made a Proposal to the Publick, of Exposing His Collection of Rarities to Such as Shall Be Curious to See Them; I Desire Your Opinion Concerning the Proposal, Whether It May Be of Use to the Publick.."

[42] Penelope Hunting, *A History of the Society of Apothecaries* (London: The Society of Apothecaries, 1998), 155; Anna Simmons, "Medicines, Monopolies and Mortars: The Chemical Laboratory and Pharmaceutical Trade at the Society of Apothecaries in the Eighteenth Century," *Ambix* 53, no. 3 (2006): 222-227.

[43] Information about the contents of Restoration apothecaries' shops can be found in the estate inventories created by the Court of Orphans in the City of London, now held at London Metropolitan Archives. (A description of the collection can be found at:

http://www.aim25.ac.uk/cgi-bin/vcdf/detail?coll_id=11437&inst_id=118&nv1=search&nv2=)

As an administrative body designed to ensure the protection of the inheritance of underage children of deceased freemen of the City of London, the Court created inventories in order to calculate the worth of the deceased freeman. By the second half of the seventeenth century, being free of a certain Livery Company no longer necessarily

Not all apothecaries made their own medicines, but evidence from Conyers's notebooks showed that he did concoct at least some of the remedies he sold.[44] Prescriptions gathered under the title "loose medical papers of Mr. Conyers" provide further evidence that he compounded prescriptions rather than merely selling pre-made medicines.[45] The wide variety of botanical materials needed showed up not only in the lists in the London *Pharmacopeia*, but also in the ingredients of these sample prescriptions. One prescription alone called for juniper leaves, horseradish root, burdock root, cardamom, china root, rosemary, golden wood, saxifrage, and winter chervil.[46] These items were called for in other receipts, along with other common early modern ingredients such as myrrh, veronica (speedwell), Melissa (lemon balm), nasturtium, cinnamon, syrup of cloves, gilly flowers, syrup of roses, and turpentine.[47]

Inventories of contemporary apothecaries' estates support this picture of a diverse group of botanical ingredients stocking their shop shelves. The men inventorying the estate of Robert Amy, who died in 1674, for example, listed a characteristic assortment of items found "In the

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reflected a freeman's actual occupation. Several inventories showed apothecaries who continued to maintain a shop, but who derived most of their net worth from practices such as moneylending. For example, the estate of Richard Godsalve, who died in 1671, derived most of its worth from his loans to a long list of clients, including hundreds of pounds to the Duke of Richmond, an illegitimate son of Charles II. (LMA CLA/002/02/01/0752, 1671, Godsalve, Richard. Citizen and Apothecary.) Enough inventories of shops exist, however, that valuable information can be obtained from this source. For the use of Orphans' Court inventories to re-construct contents of apothecary's shops, see Patrick Wallis, "Consumption, Retailing, and Medicine in Early-Modern London," *Economic History Review* 61, no. 1 (2008).

[44] See, for example, John Conyers. British Library, Sloane MS 958, Papers of John Conyers, Etc., f. 133r-135r; John Conyers. British Library, Sloane MS 919, Meteorological Journals, 1673-1674, 120r.

[45] BL Sloane MS 2031, ff. 1-35, 38, 42, 44, 45-51. The catalogue follows the inscription of f. 1v and attributes all of these materials to Conyers. A careful reading of these folios, however, suggests that not all of these materials were originally his. For examples, f. 16r is a copy of a prescription for the "Right Hon[ourable] Earl of Romney." This title was not created until 1694, the year of Conyers's death. The overall information about medical ingredients at the time remains the same, regardless of which particular pieces of paper originated with Conyers.

[46] Ibid., 4r.

[47] Ibid., 6r, 10r, 11r, 11v, 15r.

Shopp," from simple and compound waters through pills, conserves, and "chymicall oyles."[48] The inventory of John Betriffe, who died between 1662 and 1677, records similar categories of materials, listing "Distilled waters, Syrropps and Juyces," "Conserves & pills," "Implaisers and unguents," "Electuaryes," "Medicinall rootes herbs and seeds" and the catchall "Oyles powders, and Druggs of diverse sorts."[49] The estate of Arthur Hollingsworth was recorded in the same way in October of 1674, where "Simple Waters," "Compound waters," "syrropes of several sorts," "conserves", "Electuaryes" "Pills," "oyntments," "chymicall oyles," "comon oyles," "Plyasters," "seeds," and "Druggs" filled his shelves.[50]

Within these broad categories, a bewildering array of goods could be found, as some of the more detailed inventories make clear. The goods of Henry Atkinson's estate were divided into the familiar broad categories such as drugs, pills, powders and plasters. Underneath those divisions, however, the compilers of this inventory were more specific. Atkinson was of modest means, with an estate valued just under £51. Not counting the specific entries for the containers that were essential for the apothecary's trade, Atkinson's inventory still lists over forty specific items.[51] The inventory of William Hardy's estate listed over fifty items; some individual entries hid further materials through catchall descriptions such as "severall stones salts & other drugs weighing in all 40 pounds and ½."[52] The long list of the goods in another apothecary's shop from this period suggests that he stocked "a small quantity" of most of the items listed in the London

[48] LMA CLA/002/02/01/1104, 18 Mar 1674, Amy, Robert, Citizen and Apothecary.

[49] LMA CLA/002/02/01/0749, 1662 - 1677, Betriffe, John, Citizen and Apothecary. An electuary was a medicinal paste.

[50] LMA CLA/002/02/01/1073, 1662 - 1677, Hollingsworth, Arthur, Citizen and Apothecary.

[51] LMA CLA/002/02/01/1050, 1662 - 1677, Atkinson, Henry, Citizen and Apothecary.

[52] LMA CLA/002/02/01/0840.

Pharmacopeia.[53] The running ledger of an earlier 17th century London shop records a similarly extensive inventory of many simples and preparations.[54]

In addition to the extensive collection of botanicals necessary to run an apothecary's shop, a few chymical recipes (including two whose semi-poetic language and creation of red mixtures preceding the production of a white stone suggest origins in more alchemical sources) in the Conyers papers show that John Conyers was at least acquainted with the newer mineral schools of medical thought.[55] The London *Pharmacopeia* gave instructions for simple chemical medicines as well, reflecting the fact that the two schools of thought existed side by side in later 17th century London. Conyers's notebooks also bear witness to his experimentation with phosphorus and his acceptance of the possible importance of salts and sulfur to explanatory frameworks involving the weather and the behavior of the earth.[56] Conyers also invented an artificial spa water, a draft ad for which describes it as "An Essence Made of the mineral which giveth the virtue to Tunbridg Waters" for persons who could not travel to the source themselves.[57]

Unless the establishment possessed a back room for the purpose, visitors to Conyers's shop would also have seen the equipment needed to prepare medicines and their ingredients. The inventory of Benjamin Bannister, who died in early 1665, recorded an estate with multiple rooms

[53] LMA CLA 002/02/01/0786, 1662 - 1677, Atkinson, William, Citizen and Apothecary.

[54] Wellcome Library, MS.7646, 1635-1637, Apothecary's Stock Book, Early 17th Century.

[55] Chymical recipes: BL Sloane MS 2031, 13r, 14r. Alchemical influences: ibid., 19r, 26r. There is also a page with information about a pill described in Richard Matthew's *The Unlearned Alchemist his Antidote* (1660). George Starkey claimed that he was the true inventor of this remedy. See ibid., 2r; William R. Newman and Lawrence Principe, *Alchemy Tried in the Fire : Starkey, Boyle, and the Fate of Helmontian Chymistry* (Chicago: University of Chicago Press, 2002), 153-154.

[56] Phosphorous experiment: BL Sloane MS 958, 139r. Sulfur and salt are mentioned occasionally throughout the notebooks. For example: BL Sloane MS 919, 94v, 107v-109r, 118r; BL Sloane MS 937, 166v, 167r; BL Sloane MS 916, 13v, 14r.

[57] BL Sloane MS 958, f. 2r.

that were filled with a typical assortment of equipment: "4 brass morters & iron pestles…7 paire of Small Scales, 1 large beame & Scale,…21 pounds of leaden weights, 4 chaires & stooles, & 14 pounds of brass weights,…4 Stone morters, & 1 counter with Shelves, 2 ioynt stooles, & 1 iron stove,…1 iron morter & two copper Limbecks with their wormes & tubs, 1 pewter still, & Lumber."[58] Even apothecaries with less spacious facilities still required a lot of equipment, as the inventory of the goods of one Owen Crane (d. 1670) shows. At the time of his death, he had "potts, glasses & boxes & frame of the shop" and "morters & pestles stills kettles weights & scales spatulas & ladels" valued at about half of the worth of all the "medicines & drugs" in his shop.[59] Similarly, a John Stratford, who died in 1673, had largely become a moneylender, but still maintained a shop, of which the "Druggs & Medicines of severall sorts" were worth £56-10-4, while the "Morters stills potts glasses boxes counters shelves other utensils & material belonging to the shop" were valued at £25-15-4.[60] Equipment could be an even greater percentage of an apothecary's worth, as the inventory of Hammet Rigby shows. When he died in 1671, his equipment including "4 pairs of brasse scales & weights" pewter pots, mortars and pestles, stills and an astonishing 351 "potts glasses barrells & stone bottles" was worth £16, while all the "Druggs & Medicines" in the shop were listed at £16-19s.[61]

As Bannaster's inventory shows, scales and stills, mortars and storage containers—all were essential to an apothecary. Prescriptions were mixed by weight and ingredients sold by weight, so scales were invaluable—apothecaries usually had more than one set. As we saw in the

[58] LMA CLA/002/02/01/0321, 1662 - 1677, Bannister, Benjamin, Citizen and Apothecary.

[59] LMA CLA/002/02/01/0636, 1670, Owen Crane, Citizen and Apothecary. "medicines & drugs" at £ 78-16-0, equipment at £ 36-4-12

[60] LMA CLA/002/02/01/0883, 1662-1677, Stratford, John, Citizen and Apothecary.

[61] LMA CLA/002/02/01/0865, 1671, Rigby, Hammet, Citizen and Apothecary.

previous chapter, weighing was a fundamental activity for an apothecary, and one that Conyers deployed to pursue experimental questions as well, both in his daily weather records and in one-time experiments such as that involving the changing weight of sand.[62] Stills could be for domestic or commercial production (or both), but were essential if an apothecary intended to manufacture his own medicaments. The standard pharmacopeia of the day relied heavily on distillation of plant materials, but this practice was also pursued by the Fellows of the Royal Society and across the Channel in France. Indeed, in its early years, the *Académie des Sciences* pursued many distillation experiments, through alchemically minded quests to "arrive at the pure essence of things."[63]

Dealing with such a mass of goods necessitated attention to organization and categorization. Organizing, storing, and displaying this panoply of materials was essential to the apothecarial profession. The inventories show the use of a variety of containers to order the array of ingredients needed. Apothecary jars were one of many devices employed to organize medicinal material in the shop.[64] Although invective against apothecaries often accused the profession of using the jars to deceive, glasses, boxes, counters, and "nests of drawers" were also essential tools for the organization and display of the apothecary shop's goods.[65] The men compiling these inventories (who were often, but not always apothecaries), frequently subdivided the goods found in an apothecary's shop into basic categories—drugs, emplasters,

[62] For the sand experiments see BL Sloane MS 958, f. 129v-130v.

[63] Margaret C. Jacob, *Strangers Nowhere in the World : The Rise of Cosmopolitanism in Early Modern Europe* (Philadelphia: University of Pennsylvania Press, 2006), 58.

[64] See Wallis, "Consumption, Retailing, and Medicine in Early-Modern London," 33-35; 37-38.

[65] LMA CLA/002/02/01/0749, 61, 76; Christopher Merret, *A Short View of the Frauds, and Abuses Committed by Apothecaries, as Well in Relation to Patients, as Physicians, and of the Only Remedy Thereof by Physicians Making Their Own Medicines* 2nd ed. (London: Printed for James Allestry, 1670).

troches and the like, a categorization followed by the index to Nicholas Culpeper's 1653 translation of the London *Pharmacopeia*, for example.[66]

The problem of storage of medicines and their components becomes clear when we consider the containers itemized in some Orphans' Court inventories. For example, at the time of his death in 1674, apothecary Robert Amy owed money to an assortment of tradesmen and private individuals, including £16 to one Mr. Parrott, "Glassman."[67] Henry Atkinson, who died in 1675, operated on a smaller scale than did Amy, but his inventory included 17 two-gallon glasses, 8 1-gallon glasses, 20 pottle (half-gallon) glasses, 6 quart glasses, 7 pint glasses, and "a greate stall pott and two quart oyle pots."[68] John Betreiffe's shop held "2 nests of drawers 95 gally potts….64 glasse quarte bottles" amongst other "things appertaining to the shop."[69] William Hardy's business, held in partnership with another apothecary, possessed "28 square gallon glasses 13 round gallon glasses 52 pottle bottles round & square 8 dozen of round & square quarts with 16 pints & 10 oyl potts & 10 stone bottles…82 shopp potts of severall sorts 4 stall boxes …4 gallon glasses with severall small potts & glasses" in addition to several gross of small glasses, nests of boxes and "7 Ligherne potts."[70] Henry Atkinson's shop held "17 two gallon glasses, 8 Gallon glasses, 20 pottle glasses, 6 quart glasses & 7 pint glasses, a greate stall pott & two quart oyle pots."[71] The inventory of Hammet Rigby listed "one Case of drawers shelves &

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[66] Royal College of Physicians of London and Nicholas Culpeper, *Pharmacopoeia Londinensis, or, the London Dispensatory* (London: Printed for Peter Cole, at the sign of the Printing- Press in Cornhil neer the Royal Exchange, 1653).

[67] LMA CLA/002/02/01/1104.

[68] LMA CLA/002/02/01/1050. A pottle was a unit of volume for liquids, approximately half a gallon. "pottle, n.1". *OED Online*. September 2015. Oxford University Press. http://www.oed.com/view/Entry/148937?rskey=cXNwiM&result=1 (accessed November 06, 2015).

[69] LMA CLA/002/02/01/0749.

[70] LMA CLA/002/02/01/0840.

[71] LMA CLA/002/02/01/1050.

painted boxes" in addition to "pewter potts for Electuaries," "4 pewter potts—containing 2 quarts," and several hundred "potts, glasses, barrels, and stone bottles."[72] John Conyers's occupation as an apothecary trained him in gathering and organizing a wide assortment of goods, skills that were invaluable for both his trade and his pursuit of broader antiquarian and natural historical collections.

(b) Local discoveries

In addition to gathering materials through his profession, Conyers joined many of his more-famous contemporaries in pursuing an interest in history, in particular in London's Roman past. Unlike well-connected, well-funded, or well-traveled collectors that are more frequently objects of historical study, Conyers's antiquities were not acquired during travel on the Continent, through the work of paid agents working on his behalf, or as the result of the careful cultivation of an extensive network of correspondents. Based on the notes left in his notebooks, and from references made by other collectors, Conyers's material—at least of antiquities—was largely built through regular attention to very local sources of Roman antiquities in the rough—particularly the building sites of St. Paul's Cathedral and the less glamorous worksite at the Fleet Ditch.

An interest in antiquities, especially those from London's past, was easy to pursue in Restoration London. In the aftermath of the Great Fire of 1666, vast swaths of the City required rebuilding, and construction activity not infrequently unearthed artifacts from previous inhabitants of the London area. Conyers was not alone in having an interest in these local antiquities. John Aubrey gathered accounts of Roman remains found in London as part of his

[72] LMA CLA/002/02/01/0865.

work *Monumenta Britannica*, making notes from several sources, including Christopher Wren and Robert Hooke.[73] Wren's observations about things uncovered during the rebuilding work in London are also found in the papers published by his son in *Parentialia* in 1750.[74] Hooke and Wren were both intimately involved in the rebuilding of London—Wren as the King's surveyor, and Hooke as one of the City's surveyors—so their attention to what was uncovered in the rubble is unsurprising, even if we do not normally think of these two men as antiquaries.[75] The notes in *Parentialia* make it clear that Wren, at least, engaged in a little collecting of antiquities as he worked. He retained at least one Roman urn (this one from Spitalfields, and not the St. Paul's site), "which he presented to the Royal Society, and [was] preserved in their Museum."[76] One did not have to be an architect, surveyor, or dedicated antiquary to be interested in the history being uncovered, however. Pepys, for example, recorded stopping by the wreckage of St. Paul's to view the body of "Robt. Braybrooke, Bishop of London, that died 1404. He fell down in his tomb out of the great church…this late Fire, and is here seen his Skeleton with the flesh on; but all tough and dry like spongy dry leather."[77] This was a sight to be visited by the royal (Pepys

[73] Aubrey and Fowles, *Monumenta Britannica*. References to London antiquities can be found in this edition in Part 2, pages 382, 388, 412, 422, 498, 500-511, 516.

[74] See, for example, Christopher Wren, *Parentalia: Or, Memoris of the Family of the Wrens; Viz. Of Mathew, Bishop of Ely Christopher, Dean of Windsor & Co. But Cheifly of Sir Christopher Wren* (London: printed for T. Osborn etc., 1750), 264-267; 285-286; 302-263.

[75] Hooke's role in the rebuilding of London is most thoroughly covered in M. A. R. Cooper, *A More Beautiful City: Robert Hooke and the Rebuilding of London after the Great Fire* (Stroud, Gloucestershire: Sutton, 2003); M. A. R. Cooper, "Robert Hooke's Work as Surveyor for the City of London in the Aftermath of the Great Fire. Part One: Robert Hooke's First Surveys for the City of London," *Notes and Records of the Royal Society of London* 51, no. 2 (1997); M. A. R. Cooper, "Robert Hooke's Work as Surveyor for the City of London in the Aftermath of the Great Fire. Part Three: Settlement of Disputes and Complaints Arising from Rebuilding," *Notes and Records of the Royal Society of London* 52, no. 2 (1998); M. A. R. Cooper, "Robert Hooke's Work as Surveyor for the City of London in the Aftermath of the Great Fire. Part Two: Certification of Areas of Ground Taken Away for Streets and Other New Works," *Notes and Records of the Royal Society of London* 52, no. 1 (1998).

[76] Wren, *Parentalia,* 267.

[77] Samuel Pepys, *The Diary of Samuel Pepys. Volume 7: 1666*, ed. Robert Latham and William Matthews., 11 vols., vol. 7 (Berkeley: University of California Press, 1970), 367. Henry Oldenburg reported on this phenomenon to the Royal Society on November 7, 1666. Birch, *History*, 2: 121.

records the Duke of York had just left when he arrived), but also by a less refined crowd. The body was "now exposed to be handled and derided by some, though admired for its duration by others. Many flocking to see it."[78]

While Conyers was not involved in the actual construction and re-construction of London after the Fire, he was well placed to make casual observations and pursue his interests by a more dedicated attendance to construction sites. As shown in the map below, from the 1660s until his death in 1694, Conyers lived and worked in the area between Fleet Street and Holbourn, at first on Fleet Street, and then on Shoe lane. He suffered from the Great Fire, having been burned out of his home, but returned to the same neighborhood afterwards.[79] He was well placed to follow the progress of the new St. Paul's, a short walk away up Ludgate Hill. Less glamorous, but also nearby, was the Fleet River (also called the Fleet Ditch) and the Fleet's outfall into the Thames. This waterway was subject to its own frequent construction, from work on bridges to attempts to widen or clear the notoriously noxious waterway. A special attempt was made to return the river to its former glory during the rebuilding of London after the Fire, and it was dredged, faced, and wharfed, in an attempt to restore the river to navigability as high as Holbourn and to cleanliness for the benefit of all.[80]

[78] Pepys, *The Diary of Samuel Pepys*. Volume 7: 1666, 368.

[79] John Conyers. British Library, Sloane 2251, after 1669, Draft Letter, 86v.

[80] T. F. Reddaway, *The Rebuilding of London after the Great Fire* (London: Jonathan Cape, 1940), 200-221; Cooper, "Certification of Areas of Ground Taken Away for Streets and Other New Works".

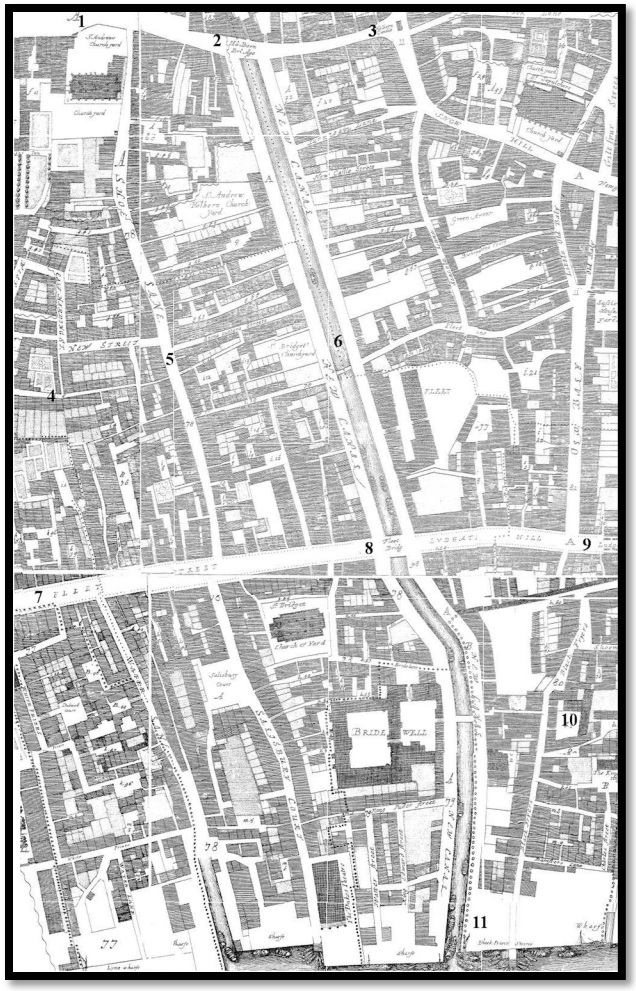

Figure 4.1: John Conyers's London.[81]
Some locations mentioned in Conyers's notebooks are marked as follows: 1-St. Andrew's Churchyard; 2-Holborn Bridge; 3-Holborn Conduit; 4-Peterborough Court. Conyers lived near here in 1666; 5-Shoe Lane. Conyers began living here sometime after 1666; 6-Fleet Ditch/River/Canal; 7-Fleet Street; 8-Fleet Bridge; 9-Ludgate Hill. St. Paul's is just off the map to the right; 10-Apothecary's Hall; 11-Outfall of the Fleet into the Thames.

The long history of human habitation in the London area was well known to educated men in the 17th century. Latin histories, including accounts of Roman invasions, were a mainstay of the grammar school curriculum.[82] In addition, two well-known English histories from the late 16th century—John Stow's *Survey of London* (1598) and William Camden's *Britainia* (1586)—

[81] Base map: Ogilby and Morgan, "Ogilby and Morgan's Large Scale Map of the City as Rebuilt by 1676."

[82] Freyja Cox Jensen, *Reading the Roman Republic in Early Modern England* (Leiden ; Boston: Brill, 2012), 25-30.

included tales of London's Roman past.[83] St. Paul's Cathedral was popularly thought to sit on the site of an ancient Roman temple to Diana, an origin that was repeated in several books published just before the Restoration.[84] Certainly by the time excavations were underway for the building of Christopher Wren's Cathedral, John Conyers was aware that the site was one worth attending to. He made a regular habit of investigating what the ongoing work was uncovering; for example, on January 25, 1677, Conyers recorded that, casually "coming by the new building of the cathedral of St. Paul's London, I stopped in to view the proceedings."[85] His notebooks show no interest in the architectural, mathematical, or administrative challenges the monumental project presented, but only in what the construction revealed about the history of London and Britain.[86] Observing the excavations, Conyers recorded the changing characteristics of the earth, linking these changes with different events in the history of St. Paul's. For Conyers, the natural historical study of the ground was intrinsically linked with the human history that had been lived in that location. Describing the changes he observed in the excavation pits at St. Paul's, he observed that in one location "about 12 foot deep there was a layer of white matter which might

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[83] Graham Parry, *The Trophies of Time: English Antiquarians of the Seventeenth Century* (Oxford: Oxford University Press, 1995).

[84] James Howell, *Londinopolis, an Historicall Discourse or Perlustration of the City of [H]London, the Imperial Chamber, and Chief Emporium of Great Britain Whereunto Is Added Another of the City of Westminster, with the Courts of Justice, Antiquities, and New Buildings Thereunto Belonging* (London: Printed by J. Streater for Henry Twiford, George Sawbridge, Th and John Place,, 1657), 2-4; William Dugdale, *The History of St. Pauls Cathedral in London from Its Foundation Untill These Times Extracted out of Originall Charters, Records, Leiger Books, and Other Manuscripts : Beautified with Sundry Prospects of the Church, Figures of Tombes and Monuments* (London: Printed by Tho. Warren, 1658), 3-4. On the political context for Dugdale's chorographic and antiquarian writing, see Swann, *Curiosities and Texts*, chapter 3, esp. 118-121.

[85] BL Sloane MS 958, f. 127r. "Jan: 25 1676/7 coming by the ^new^ building of the cathedrale of st Pauls London I stopped in to view the Prodeedings"

[86] On these aspects see Anthony Gerbino, et al., *Compass and Rule: Architecture as Mathematical Practice in England, 1500-1750* (New Haven, Conn.: Yale University Press, 2009); Lisa Jardine, *On a Grander Scale: The Outstanding Life of Sir Christopher Wren* (New York, NY: HarperCollins, 2002); Lisa Jardine, *The Curious Life of Robert Hooke: The Man Who Measured London* (New York: Harper Collins, 2004); Matthew C. Hunter, *Wicked Intelligence: Visual Art and the Science of Experiment in Restoration London* (Chicago; London: The University of Chicago Press, 2013), especially chapter 6.

be chalk [or] stone [from] when the church was built by William the Conqueror I [and] Lanfranc, bishop of London." Further down, "there appeared here & there flint pavement, which was the pavement of yards. For Lanfranc is said to [have] purchased houses of Citizens…to add [land] to the churchyard of St Paul." Below these remains of earlier iterations of the Cathedral, "the ground ceased to be black earth and came to be more of the yellow sand color," Conyers noted. These layers also held his interest, as Conyers detailed the remnants of London's earlier inhabitants uncovered as the workers dug. One layer, for example, contained "red earthen potsherds…as red…as sealing wax." Some fragments had inscriptions in Latin, which led him to conclude that these were remains of "the old Romans use in Brittannia."[87]

In another note, Conyers recorded the cornucopia of other objects that were found "in gravel pits 26, 27, and near 30 foot deep opposite and near St. Paul's school in London under the graves of Normans and Saxons and Danes." This site held "ivory work, and great pins made of bone, and bodkins of the same [material], great numbers of each," which were buried with "bore's teeth …oyster shells…Roman coins …[green-blue] ornamental beads like enamel…the fibulae they used to fastened their garments and earthenware with inscriptions and glass."[88] Not

[87] BL Sloane MS 958, f. 105r. "about 12 foot deep there was a layer of white matter which might bee chalke & hereings[?] of stone when the chiech was built by Wm: the Conqor I [illeg] Lanfrank bishop of London now a little below this seme of white shalke (that lay all along paralel the east end of St Paull) there appeared here & there flint pave[me]nt which was the pavement of yards for Langrank if said to purchase houses of Citizens then to add to the chiryard of St Paul which chirch was then layed in a larger foundation then then[sic] ever before now below the ^[illeg]^ flint payements as the ground ceased to be blackearth & came to be more of the yellow sand Collour there was foudn a foot of Redd earthen Pottsheards the Pott as redd & rimm as sealing wx & upon som of the Pott or cupp bottoms inscriptions som upon cupps to drink athers upon dishes like saflet dishes but cuningly ^divised & ^ wrought the inscriptions on som de Primani: apor[?] de Parici: other [illeg] others victor: other Janns[?] & Recinio [illeg] all which appeares to bee of the old Romans use in Brittania" Lanfranc was a Norman monk who served as Archbishop of Canterbury under William I (William the Conqueror). The Bishop of London at that time was Maurice, and it was he who was involved in rebuilding St. Paul's, after a fire destroyed the Anglo-Saxon church in 1087. See H. E. J. Cowdrey, 'Lanfranc (*c.*1010–1089)', *Oxford Dictionary of National Biography*, Oxford University Press, 2004 [http://www.oxforddnb.com/view/article/16004, accessed 10 Jan 2014] and Falko Neininger, 'Maurice (*d.* 1107)', *Oxford Dictionary of National Biography*, Oxford University Press, 2004 [http://www.oxforddnb.com/view/article/18381, accessed 10 Jan 2014]

[88] BL Sloane MS 958, 113v. "in gravel pitts 26 27 & neer 30 foot deep oposite & neer S Pauls school in London under the graves of Normans & Saxons & [danes?]." This site turned up "Ivoryworke & great Pinns made of Bone

all uncovered antiquities were so small. While potsherds and coins could easily be carried back to Fleet Street or Shoe Lane, remnants of a Roman kiln uncovered near St. Paul's required a careful drawing to be made, as Conyers captured this artifact with pen and ink, to ensure its place in his collection.[89]

While St. Paul's was a particularly rich source of antiquities, Conyers also made observations and accumulated artifacts from other locations in his neighborhood, such as work done on the Fleet Ditch (also called a River or Conduit) and the Holbourn Conduit. As John Aubrey observed in a draft of one section of *Monumenta Britannica*, "Mr. Conyers (Apothecary) at the White Lion in Fleetstreet hath preserved a world of antique curiosities found in digging of the ruins of London, principally Fleet Ditch e.g. many urns, lachrymatories [tear bottles] Priapus's [garden statues to the god Priapus] &c."[90] Conyers himself recorded that work on the Fleet unearthed not only previous iterations of bridges and wharfing, but also daggers, arrow shafts, spurs, keys, pins, scissors, copper and brass Roman coins, and items made of silver and glass.[91] Similarly, excavations for a new wall in the place where "the stone of the Parish bounds with St Andrews cross upon it [is] fixed one story [up] on the side of a house either at or next the sign of the dog" uncovered "coins...in black gravel" that "were bright like gold & yet worn & fretted away with long continuance in that frotting water."[92] Giving less detailed locations,

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& bodkins of the same great numbers of eatch" buried with "Boresteeth & allso oyster shells & other shells & Roman coines & ornamentall beads of green blew like enamel & the fibbulae they used to fasted their garments & earthenware with inscriptions & glass"

[89] ibid., f. 106v. This page is reproduced in Burnby, "John Conyers, London's First Archaeologist," 67.

[90] Aubrey and Fowles, *Monumenta Britannica*, 511.

[91] BL Sloane MS 958, 113v.

[92] BL Sloane MS 937, f. 178v."Just where the stone of the Parish bounds with St Andrews cross upon it fixed onestory one the side of a house either at or next the signe of the dogg these coynes lay in black gravel yet they were bright like gould & yet worne & fretted away with long continuance in that frotting water."

Conyers also reported that "here and there in other Parts of the ditch...there was taken up Roman coins"[93] as well as "other brass instruments."[94]

We know that Conyers did more than observe these finds *in situ*, as his records of other caches indicate. A memorandum (undated but possibly from 1674) about artifacts uncovered during work on the Fleet recorded not only observation, but also active collection: "Just about the clay [level] lay Roman coins, some of which, pretty faire, *I have by me*" noted Conyers (emphasis added). He continued, noting that, "near these Roman coins at the same depth *I took up*...tiles and potshards and bricks which I suppose might be made at the same time by the Romans."[95] A site "off the highway after you [cross] over Holbourn Bridge as you gaze up to the conduit" turned up old Roman coins, including "a copper piece as big as half crown with Nero's head (the Emperor) and on the reverse a plain triumphant arch." Examples of these finds, Conyers recorded, "a great number *I have by me*."[96] In notes considering the survival of iron in water, Conyers listed "old antique spurs and large spur rowels and daggers, keys, knives, scissors, arrow shafts, files, punches, nails which *I have by me*" which he had "*taken up* out of the cleansing [of] the ditch at Fleet Bridge."[97] This same memoranda continued, adding that he had "old Roman coins of brass, copper, and coarse gold….*I keep* good large numbers of each

[93] Ibid.

[94] Ibid., f. 179r.

[95] Ibid., f. 175v, 176r."below this sand Just about the clay lay Roman Coines som of which pretty faire I have by me....neare these Roman coines at the same depth I tooke up...Tyles & postharde & bricks wch I suppose might be made at the same tyme by the Romans."

[96] Ibid., f. 178r."Of the high way after you be over holbourn bridg as you gaz up to the conndit" turned up old Roman coins, including "a Copper peise as bigg as halfe crowne with neroes head the Emperour & one the Reverse a plaine Triumphant arch."

[97] Ibid., f. 180v. "that Iron keeps longer in the sand and watery moisture of fleet ditch then it would have done in the open ayre appeares by old antique spurrs & large spurr rowles & daggers keyes knives scissors arrow shafts files punches nayles which I have by me taken up out of the clensing the ditch at fleet bridge"

laying by me."[98] Of coins discovered in the ditch on another day, Conyers recorded "I have, I think, a hat full."[99] Sometimes interesting materials were lost due to his absence, as when workers on another nearby water project at Holborn discovered a "glass vial [containing] clear water in it…mingled with soil by stirring & [having] no cork." While the glass was safe in his possession, he regretfully recorded that the Hobourn laborers had "throw[n] it[the liquid] away & so I could not give accompt of the Liquor."[100]

Conyers also acquired other types of materials that were uncovered around London. Most famously (to his contemporaries) were the bones and teeth of an elephant unearthed in gravel pits not far from the current site of King's Cross Station.[101] From this site Conyers acquired several pieces of the "elephant's" skeleton, which he described as an "Elephant's tooth about two yards long…. the greatest part [I have] in my keeping as a great rarity." Found at the same time was the animal's "spade bone [shoulder blade] as big as if of a whale," which Conyers also added to his collection.[102] These gravel pits also revealed another important addition to Conyers's assemblage, "a British weapon made of flint, dexterously shaped by their extraordinary art"

[98] Ibid., f. 181r. "The like of which I have of old Roman Coynes of Brass Copper & course gould…which I keep good large numbers of each laying by me

[99] Ibid., f. 179r. "these coynes one or other I have I thinke a Hatt full"

[100] Ibid., f. 177r,v."in this Coffin was a glass viol one this fashion [picture] & brass like hinges these lay amonst the bords the glass had cleere water in it which being mingled with soyle by stirring & no corke the labourers[177v] throw it away & so I could not give accompt of the Liquor but the glass I have by me neare"

[101] BL Lansdowne MS 808, f. 77v, 78r. Another (nearly identical) copy of this account is found in John Bagford, BL Harley MS 5953, Collections Relating to London, f. 112r-114v. Jill Cook has identified the find spot as "on the east side of the modern junction between King's Cross Road and Farringdon Road." Cook, "The Elephants in the Collection: Sloane and the History of the Earth," 160.

[102] BL Sloane MS 919, f. 11v. "an Ellephant tooth dugg out of a sand Pitt aboute nine or tenn foote deep which I thinke to have layne buried in that plase a small ^hill^ next one the left hand the fleet ditch neere pindr of wakfield in the feilds [illeg word] threescor yards of the Highway which comes form grayes Inn which I do suppose to have layne there buried ever since Claudius Cesar his tyme there have been within three yards the spade bone as bigg as if of a whale dugg up allso which Ellephants tooth about two yards long I have the greatest part in my keeping as a great raritye"

which artifact could "be seen at [his] house in Shoe-lane."[103] The finds at the gravel pit were only one source of elephant bones for Conyers; John Bagford recorded that in 1679 Conyers "tooke up part of an other tooth and bone of the Elephant as he supposeth slaine in the Battel between the Romans and the Brittainns 10 or 12 foot deep near the Drying hous on the other side of the River."[104]

Finds from these excavations were subjects not only for archeological collections. Observing the decay or survival of materials in the dirt, mud, and water of London, Conyers gathered details from these excavations as part of his studies of the properties of materials and the role of air and water in the working of the world (see previous chapter). The preservation of metals in the mud and water of the Fleet Ditch led him to conclude "that iron keeps longer in the sand and watery moisture of Fleet ditch then it would have done in the open air." The iron pieces he recovered from the site were covered "with a hard stony bluish crust with sand sticking in it, which [served as] a guard or crust to preserve it longer then it would…naturally in the air."[105] Some of the coins he kept had had a similar crust, and if the crust was removed "underneath would be the exact shape still remaining fresh, the outer coat [having] guarded them from ruin."[106]

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[103] BL Lansdowne MS 808, f. 77v. This weapon is the Paleolithic hand-ax, which is one of the few items from Conyers's collections whose current whereabouts are known. It is held by the British Museum. See "Pointed Flint handaxe," http://www.britishmuseum.org/explore/highlights/highlight_objects/pe_prb/p/pointed_flint_handaxe.aspx accessed January 8, 2014. Cook, "The Elephants in the Collection: Sloane and the History of the Earth," 160-162.

[104] BL Lansdowne MS 808, f. 78r.

[105] BL Sloane MS 937, f. 180v. "that Iron keeps longer in the sand and watery moisture of fleet ditch then it would have done in the open ayre";"with a hard stony blewish crust with sand sticking in it which is a guard or crust to proserve it longer then it would else[?] naturally in the Ayre."

[106] Ibid., f. 181r. "underneath would bee the exact shape still remaining fresh the out coat being taken ofe which guarded them[?] freom ruine."

Conyers did not view his collection materials as strictly adhering to one category or another. This is shown by how he discussed antiquarian finds in the same paragraphs as ones in which he considered his favorite natural philosophical themes of rarefication and condensation. The clearest demonstration of the way in which Conyers did not maintain strict boundaries between his interests is found in one of the instruments he created several years into his weather/air pressure experimentation. In late 1676 he began to add more materials to the accumulation of things he weighed daily. In addition to different types of wood and stone, Conyers added a new cylindrical symbol to his accounts, a symbol he explained several days later as an "Iron and tinned vessel" holding a "silk bag filled with Roman earth." This "Roman earth" was a sample of the dirt, from nine feet underground, which had covered the elephant's tusk he had uncovered in 1673 (a tusk he associated with the Roman invasion of Britain). This earth he had kept in the "top of the house in a box there drying" until it was repurposed as another tool for understanding changes in atmospheric humidity.[107]

Small-scale local transactions: Buying and Selling Curiosities

Conyers's materials, like those of his contemporaries, were not accumulated only through chance unearthing at local construction sites. For the collector in 17th century London, commercial transactions also played an important role. Collections could, of course, be bought in their entirety, and could carry a stiff price tag. The Royal Society began their Repository by purchasing the collection of Robert Hughes/Forges for £100.[108] In the early 18th century Sir Hans Sloane paid £4000 for James Petiver's enormous natural history stockpile and Sloane's goods

[107] BL Sloane MS 816, f. 141r-142r. This model of hygroscope is also referenced in Bl Sloane Ms 958, f. 112r.

[108] Hunter, "Between Cabinet of Curiosities and Research Collection," 127-136.

were offered to the nation by his estate for the discount price of £20,000 (they were thought to be worth at least four times as much).[109] Wealthy collectors could hire agents or commission people to find goods for them, a practice that took place in the fine arts, as well as natural history and antiquities.[110] One of these agents, William Courten, who also amassed an impressive collection of his own, kept account books of his purchases, thus enabling us to better understand the sources of individual items.

Evidence only exists to demonstrate that Conyers purchased one of his items—the gold shield later associated with Dr. John Woodward, which an 18th century antiquarian noted had been "bought by Mr. Conyers of a Smith in Rosemary Lane, who bought all the Waste Things in the Tower at the New-Fitting up of the Armoury at the latter end of the reign of K. Charles 2d."[111] If we include his natural philosophical equipment as part of his collection, he would have purchased some of the standard weather instruments in his assemblage. The common weatherglass, for example, had been for sale in London since the 1630s and was formed from a glass bulb with a tube neck; change in the level of the water "was taken to signify the state of the atmosphere in general."[112] While Conyers constructed many of his other instruments himself, he undoubtedly purchased the constituent glass tubes and globes from a glassmaker. In the 1660s, a

[109] Swann, *Curiosities and Texts*, 196-198.

[110] David Howarth, *Lord Arundel and His Circle* (New Haven: Yale University Press, 1985).

[111] Conyers's brother, Edward, was Keeper of the Stores at the Tower of London in this period, so Conyers might have been able to acquire the shield more directly when the items were disposed of. Edward Conyers was also associated with collections, albeit not his own, as his position at the Board of Ordnance originally included the chance to show the King's collections of rich (ornamental) weapons to visitors for a price. See Levine, *Dr. Woodward's Shield*, 327-328, n.321. Sir George Wharton, BL Additional MS 38158, 30 Jun 1679-30 Jun 1680, The Accompt of Sr George Wharton Bartt. Treasurer and Paymaster of the Office of His Mats Ordnance Aswell of All Moneys by Him Received out of His Mats, Excheqr or Otherwise as of All Moneys by Him Paid for His Mats Service in the Said Office, f. 164v.

[112] Jan Golinski, *British Weather and the Climate of Enlightenment* (Chicago: The University of Chicago Press, 2007), 112.

quart bolt head, for example, of a kind he may have used to construct his double and treble thermometers, cost 9 pence.[113]

In addition to the purchases involved in acquiring scientific equipment, Conyers most likely purchased other items as well. The ability to purchase objects worth collecting on the continent was, of course, known to gentlemanly travelers abroad. John Bargrave, whose collection is unusual in its almost complete survival in Canterbury, recorded purchasing specific items while on his travels during the Interregnum.[114] Bargrave purchased fossils, anatomical models, optical instruments, and antiquities, for example. More well known in the history of science is the case of John Evelyn's anatomical tables, preparations displaying the veins and arteries of the human body, purchased in Italy and later donated to the Royal Society.[115]

Less well studied, however, is the vibrant market in collectables that could be found in London itself. Evidence from the accounts kept by William Courten (1642-1702), collector and broker of collectables, shows the ways in which the acquisition of coins, *naturalia*, curiosities, and antiquities was tied into the local commercial landscape of 17th century London. While Courten moved in the elite circles Conyers did not, his interaction with Conyers's collection and how he acquired other objects for himself and his clients demonstrates the importance of local transactions with people on a wide variety of social levels. Courten maintained his own collection, but also was a broker for others, buying, selling, gifting, and exchanging natural goods, coins, and curiosities with many late-17th century collectors.[116] Several of Courten's

[113] Anonymous. British Library, Sloane MS 3776, 17th cent., Commonplace Book*,* ff. 50 b-52 b.

[114] Bargrave and Robertson, *Pope Alexander the Seventh and the College of Cardinals*, 113-140.

[115] Nehemiah Grew, *Musaeum Regalis Societatis* (London: Printed by W. Rawlins, 1681), 4.

[116] B. D. Jackson, 'Courten, William (1642–1702)', rev. A. J. Turner, *Oxford Dictionary of National Biography*, Oxford University Press, 2004; online edn, Oct 2006 [http://www.oxforddnb.com/view/article/6447, accessed 6 Feb 2014]. Courten went by the alias "William Charleton" for part of his life, possibly to avoid legal problems stemming

detailed account books survive, from a brief period in the mid 1660s, and then in regular detail from 1689-1693, and some shorter periods thereafter.[117]

Unsurprisingly, Courten's accounts record transactions with well-known figures from this period: Adrian Beverland, Dr. Leonard Plunkett, Samuel Doody, John Bagford, Dr. Hans Sloane, Dr. Martin Lister, and a "Mr. Petifar" (who is presumably James Petiver), all appear in these accounts.[118] In addition to these well-known figures, however, Courten's records show us that many others were essential to acquiring materials of note. And Courten's *was* a collection of note: in 1690, John Evelyn thought that his "Curiosities both of Art & nature [and] his full & rare collection of Medals…is doubtlesse one of the most perfect assemblys of rarities that can be any where seene."[119] Acquiring this "most perfect assembly" required not only international connections in Europe and in European colonies—who could provide you with antiquities, plant specimens, and anthropological bric-a-brac—but also a network much closer to home.

For example, Courten's early records, from 1667, record (in a typical mixture of English and Italian) that he purchased some items at "Leaden Hall Strata," a thoroughfare on the eastern side of the City of London. In the shops there, Courten recorded purchasing two books (one entitled *Metamorphosis Naturalis*, another on fish).[120] In addition to booksellers, however,

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from his father's estate. He should not be confused with the medical doctor and Fellow of the Royal Society, Walter Charleton, to whom he was not related.

[117] William Courten, BL Sloane MS 3961, 17th cent, Papers Relating to Medals, Engravings, Etc; William Courten, BL Sloane MS 3988, 17th cent., Papers Relating to His Collections. Carol Gibson-Wood, "Classification and Value in a Seventeenth-Century Museum: William Courten's Collection," *Journal of the History of Collections* 9, no. 1 (1997). Courten's records are in a mixture of English, Italian and Latin, reflecting his cosmopolitan upbringing and exile on the Continent due to his father's debts. In addition, Courten recorded some of his accounts in a partial code, the key to which is found in Hans Sloane, BL Sloane MS 4019, f. 79.

[118] William Courten. Ibid.MS 3961, 17th cent, Papers Relating to Medals, Engravings, Etc.

[119] Evelyn, *Diary*, Vol. 5: 13-14 (March 11, 1690).

[120] BL Sloane MS 3988, f. 5r.

Leadenhall Street was also the location of a Mr. Archer, from whom Courten purchased some new natural items, including a shell and a starfish.[121]

In the notebook that contains entries from 1688 onwards, Courten was more assiduous about recording the sources of his purchases, allowing us to get a glimpse of where natural rarities and other collectables were available in late 17th century London. Courten, unsurprisingly, regularly purchased medals and coins from an assortment of goldsmiths, a practice that Evelyn recommended to Pepys when the latter expressed an interest in beginning a collection of this type. Even purchases from goldsmiths could be acquisitions driven by chance, as Evelyn wrote, "[coins and medals] are likliest met with all, amongst the Goldsmiths, and casualy, as one walkes in the Streetes on foot, and passes by their stalls."[122] Courten recorded purchases from "the little goldsmith in Cheapside,"[123] "Of Mr Wilson the goldsmith in Fleet street,"[124] "Of Mr Spencser the goldsmith"[125] "Mr Ironmonger g[old]smith at charing crosse,"[126] "a g[old]smith in the strand Mr. Galliard's fri[e]nd"[127] and a whole series of goldsmiths he only recorded by the location of their shops: Fleet Street, Russell Street, Henrietta Street, and Holbourn.[128]

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[121] Ibid. "1 stella marina comp del Sig^re^ Archer."

[122] Evelyn to Pepys, 26 August 1689. In Guy de la Bédoyère, ed. *Particular Friends: The Correspondence of Pepys and Evelyn* (Woodbridge, Suffolk: The Boydell Press, 1997), 193

[123] BL Sloane MS 3961, f. 48r.

[124] Ibid., f. 56r.

[125] Ibid.

[126] Ibid., f. 59r.

[127] Ibid.

[128] Ibid, 59r.

Other sources for Courten's acquisitions are less expected. Other skilled craftsmen were the sources of other goods, as a cutler sold him some semi-precious stones, and a spectacle maker two Roman medals.[129] Several locations that were inns or coffeehouses appear in Courten's records. For example, "The White Hart in Cheapside" appears as a source of purchases of large quantities of shells.[130] Also in Cheapside was one Mr. Harison, who provided Courten with a few items on several occasions; it is not clear if this was the same Harison described as being "at the Hen & chickens."[131] Other purchases took place in locations that sound like taverns, inns, or coffeehouses, such as the medals and coins purchased "Of Mr. Eales at the flying horse in Kings street Westminster" and "Of young Mr. Hore at the bottle in Fleet street."[132] A parcel "of things from Jamaica" came from "Captain Bennet's son who lies in Broad Street near old Gravel Lane,"[133] while "a widdow at St. Katherines" (an area near the dockyards) was the source of another group of exotica from over the seas.[134] A Mr. Coopman, a lieutenant from Ceylon, sold Courten exotic animal specimens.[135] "A waterman" sold Courten things that were found in the Thames.[136] "A stranger" sold him a shell,[137] and "a person Mr. Jackson (one of Courten's regular sources of shells) sent to me" sold him some medals.[138]

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[129] Cutler: ibid. Spectacle maker: ibid., f. 56v.

[130] Ibid., f. 34r, 37v.

[131] Ibid., f. 56r & 59r; 'Hen & chickens' on f. 48v.

[132] Ibid., f. 59v.

[133] Ibid., 36r.

[134] Ibid., f. 39v.

[135] Ibid., f. 40r.

[136] Ibid., f. 49r.

[137] Ibid., f. 56r.

[138] Ibid., f. 59r.

Most of the items Courten purchased had relatively low individual prices. In his transactions with John Conyers' wife in April 1693, he purchased over 50 items over several days for a total of about £10, a useful sum for the Conyers, but small when compared to the bargain price of £100 the Royal Society paid for its initial collection.[139] Many items cost him only 1 shilling each. Courten occasionally recorded the price at which he sold a given item, often showing a significant markup. For example, Courten acquired a "spleen stone" and "spleen stone pipple" (pebble) at no cost from Mrs. Conyers, and then sold them both to a Mr. Marlow for 2s and 10s respectively.[140] Marlow also bought a "Large piece serpentine stone" for 5 shillings, more than double the purchase price of 2 shillings.[141] Similarly, Courten sold a "spleen stone hatchet" for at least 6 shillings, after acquiring it for a mere 2 shillings.[142]

Courten's notes also highlight the important role played by women in the world of late 17th century collecting. At least 14 women appear in Courten's two notebooks under consideration here. Some are known through their more famous husbands—Mrs. Conyers sold items belonging to her husband, and Courten also purchased goods from Hester Tradescant, and "Madame Ashmoile[sic]."[143] In addition to Mrs. Conyers, several other women make multiple appearances in the accounts. In contrast to her entries, those for a Mrs. Alley, Mrs. Goldsmith, Mrs. Harvey, and Mrs. Bonfield appear several times over the course of a few years, indicating an ongoing trading relationship, rather than a one-time sale of desperation. Mrs. Bonfield, for

[139] On the purchase of Forges' collection for the Royal Society, see Hunter, "Between Cabinet of Curiosities and Research Collection."

[140] BL Sloane MS 3961, f. 53r, v. Thanks to Carolyn England Ritchie for untangling the meaning of "pipple."

[141] Ibid., f. 53v.

[142] Ibid.

[143] BL Sloane MS 3988, 12v; BL MS Sloane 3961, 48r; R. T. Gunther, *Early Science in Oxford*, vol. 3 (Oxford 1925), 288-289.

example, mostly provided shells to Courten, but also was a source for other natural rarities including pieces of "a sort of owle from Russia."[144] In 1689, for example, Courten purchased from her a large number of shells (snails, crabs, cockles, scallops) as well as "1 bottle with a fish in it of the Thames" a "Brasse meddall of Faustina," "Common nutmeg with its maze," two Coronation Meddalls of K[ing] Wm & Q[ueen] Mary," "1 Birth piece of K Charles the 2d" (the commemorative coin struck by the Royal Mint when Charles was born), and an exotic flying lizard from Java, which fetched a princely sum of £2-3-0. (The more plebian Thames fish cost only one shilling.)[145] A Mrs. Goldsmith also sold shells.[146]

As with some of Courten's purchases from male sources, we have locations for some of the women from whom he purchased goods. Early in the first account book, he records purchasing one "echinas verde" (a green sea-urchin) from a Mrs. May in Poplar, an area now part of East London.[147] Of his regular sources, Mrs. Alley was located "in upper Shadwell near the Morocco head,"[148] and Mrs. Harvey could be found in Chiswell Street.[149]

[144] BL Sloane MS 3961, f. 28v.

[145] BL Sloane MS 3961, 31v, 32r. The lizard is listed as "1 Lacertus volans ex Java."

[146] Ibid., 26v.

[147] BL Sloane MS 3988, f. 11r.

[148] BL Sloane MS 3961, f. 27r.

[149] Ibid., 37r.

Figure 4.2: William Courten's London.[150]
Some of the locations recorded in his notebooks: 1-Billingsgate Dock; 2-Cannon Street; 3-Waitling Street; 4-St. Katherine's Docks; 5-Henreitta Street; 6-The Minories; 7-Fleet Street; 8-The Strand; 9-King Street, Westminster; 10-Chiswell Street; 11-Cheapside; 12-Bedfordbury; 13-Royal Exchange; 14-Holburn; 15-Charring Cross; 16-Russell Street; 17-Drury Lane; 18-Shoe Lane; 19-Upper Shadwell

As is clear from the map, Courten's purchases took place all over the City of London and the West End, dipped into Westminster, and spread East past the City walls. Just as virtuosi gathered materials from a diversity of categories, so did they seek out objects from all parts of the city. Like Conyers's fixity, Courten's mobility was an accident of his status—gentlemen often traveled widely throughout the city, having both social access to (most) neighborhoods and financial resources to avail themselves of land-or water-based transport. (The peregrinations recorded in Pepys's diary most famously attest to this mobility for a slightly earlier period.) While Courten's access to all these sources and dealers may be unusual, his travels make it clear that there was not one defined district for curiosities. The sprinkling of collectables throughout the city meant that even those with less means or needs to travel could find items of curiosity in the neighborhoods they already frequented.

Ample evidence exists for the public display of curious, monstrous, and unusual items in late 17th century England. For a price one could see a cabinet of curiosities, the crown jewels, or

[150] Base map: "Morgan's Map of the Whole of London in 1682 ". (1682), http://www.british-history.ac.uk/no-series/london-map-morgan/1682/map. Accessed December 7, 2015.

the king's menagerie.[151] Exotic animals were shown at coffeehouse auctions, and performed in the Bartholomew and Southwark Fairs.[152] Books were auctioned off in coffeehouses and taverns. Souvenirs from all corners of the world were brought back to London by common seamen. The shifting banks of the Thames and constant construction unearthed fragments left by earlier inhabitants—and these remains were sometimes displayed on the new buildings.[153] Similarly, Courten's accounts demonstrate that curiosities could be purchased anywhere and individual items might only cost a few shillings. While these were still not within the reach of the vast majority of London's population, they were within the reach of far more than those who could afford to travel to Europe or buy a collection wholesale.

Conclusion

While we know that John Conyers attended at least one meeting of the Royal Society, spent time in the workshop of instrument maker Thomas Tompion, and occasionally visited the coffeehouses frequented by Robert Hooke, his notebooks reveal other important, but unstudied, locations. The places used by Conyers were not shaped by the social rules controlling

[151] Richard D. Altick, *The Shows of London* (Cambridge, Mass.: Belknap Press, 1978).; Samuel Pepys, *The Diary of Samuel Pepys.*, ed. Robert Latham and William Matthews., 11 vols. (Berkeley: University of California Press, 1970), 1:15; 13: 76; 14:118; 119:172. W. Schellinks, Maurice Exwood, and H. L. Lehmann, *The Journal of William Schellinks' Travels in England, 1661-1663*, Camden Fifth Series, (London: Offices of the Royal Historical Society, University College London, 1993), 45-51, 53, 62-63, 76, 177. Gunther, *Early Science in Oxford*, 3: 282-286; Robert Hubert, *A Catalogue of Many Natural Rarities ... Collected by Robert Hubert, Aliàs Forges, Gent. ... And Dayly to Be Seen at the Place Called the Musick House at the Miter, near the West End of St. Pauls Church.* (London: Printed by Tho. Ratcliffe, 1664); John Tradescant, *Musaeum Tradescantianum: Or, a Collection of Rarities. Preserved at South-Lambeth Neer London by John Tradescant.* (London: Printed by John Grismond, 1656).

[152] Evelyn, *Diary*, 3: 389-391; Pepys, *The Diary of Samuel Pepys. Volume 4: 1663*, 4:298; Hooke, Robinson, and Adams, *Diary*, 309.

[153] John Bagford, "A Letter to the Publisher, Written by the Ingenious Mr. John Bagford," in *Joannis Lelandi Antiquarii De Rebus Britannicis Collectanea*, ed. Thomas Hearne (Oxford: e theatro Sheldoniano, 1715), lxii-lxiii.

gentlemanly households, or by the complicated norms of credit, secrecy, and exchange of the workshop of a master craftsman.[154]

While at first glance Conyers's notebooks give a picture of a deceptively solitary practice—other people are mentioned only rarely, generally as sources of anecdotal information—considering the spaces involved forces us to realize the people left out of these texts. His instruments hung in his shop, a much more "public" space than the rooms of Gresham College, or the laboratory of Robert Boyle, since this space opened directly onto the street *and* into the house. The (possibly) more private domestic space further within the building was home to Conyers's wife, children, servants, and lodgers.[155] Like those patronizing mathematical instrument makers' shops, Conyers's customers could see his instruments; unlike those seeking out Tompion and others, Conyers's customers were not entering his store to buy or learn about these instruments. They were coming to buy medicine. Conyers's "phoenix nest" hung on the wall for all to see, meaning that anyone who entered—whether their purpose was to see Conyers's collections, discuss the latest philosophical controversy, or simply purchase medicine—could serve as a witness to his activities, and to the data he was recording. Additionally, since some of his instruments hung *in his shop window*, the public did not even need to enter the building in order to witness the experimental activities taking place there.

Similarly, anyone in London could stroll up Ludgate Hill and observe the work at St. Paul's; countless people lived in the neighborhoods adjoining the Fleet Ditch, and had an interest

[154] Rob Iliffe, "Material Doubts: Hooke, Artisan Culture and the Exchange of Information in 1670s London," *The British Journal for the History of Science* 28, no. 3 (1995); Larry Stewart, "Other Centres of Calculation, or, Where the Royal Society Didn't Count: Commerce, Coffee-Houses and Natural Philosophy in Early Modern London," ibid.32, no. 2 (1999); Markman Ellis, *The Coffee House: A Cultural History* (London: Weidenfeld & Nicholson, 2004), 150-165. Steven Shapin, "The House of Experiment in Seventeenth-Century England," *Isis* 79, no. 3 (1988).

[155] On the "bipermeability" of shops see, for example, Laura Gowing, "'The Freedome of the Streets': Women and Social Space, 1560-1640," in *Londinopolis: Essays in the Cultural and Social History of Early Modern London*, ed. Paul Griffiths and Mark S. R. Jenner. (Manchester: Manchester University Press, 2000), 135-136.

in its cleaning and repair (an olfactory if not philosophical interest). John Bagford's account of antiquities in London suggests that it was common to encounter Roman remains in all parts of the city.[156] The relatively unrestricted nature of these sites presents us with the possibility that many people could have observed the same geological and historical details that Conyers noted. Both the public nature of the collection sites and the way Conyers used his shop space to hold instruments and experiments also raise intriguing questions about ***who*** undertook activities associated with the new science. These two locations—the shop/home and the street—were controlled by different—generally looser—social rules of access than the more frequently studied locations of early modern science. To consider just one possible line of inquiry, analysis of gendered geographies of early modern London have suggested that at many social levels, women moved through more of the metropolis than men of the same class did, although their experiences of those spaces were different.[157] Certainly, women were generally in charge of household shopping, and of domestic medical care, meaning that the accidental witnesses to Conyers's shop-mounted meteorological array may have been largely female. This is strikingly different than the steadfastly masculine nature of many other sites of early modern science. The spaces brought to our attention by John Conyers's manuscripts, therefore, open avenues for further investigation for those trying to understand the social and gendered nature of natural knowledge in the early modern period.

Looking beyond the published catalogs and extensive correspondence networks of collectors traditionally studied with respect to late 17th century natural history and antiquarianism

[156] Bagford, "A Letter to the Publisher, Written by the Ingenious Mr. John Bagford."

[157] Pepys, *The Diary of Samuel Pepys. Volume 7: 1666*, 367. See also Robert B. Shoemaker, "Gendered Spaces: Patterns of Mobility and Perceptions of London's Geography, 1660-1750," in *Imagining Early Modern London: Perceptions and Portrayals of the City from Stow to Strype, 1598-1720*, ed. J.F. Merritt (New York: Cambridge University Press, 2001).

shows that collecting was an activity pursued at many social levels. As the Appendix shows, Conyers's collection, though never formalized by a contemporary catalogue, possessed many of the key elements of better-known repositories. One did not have to have an extensive relationship with the emerging Republic of Letters in order to study history and natural history through material goods. In addition, this chapter has shown that collecting could be a deeply commercial activity. Elite collectors commissioned the acquisition of samples from far-flung regions, or hired agents to search out goods on the Continent. A careful reading of Courten's accounts has shown that collectors, and their agents, could, and did, find many specimens of the natural world and human history in the shops of London. Anyone could have an item of interest—from a goldsmith to a stranger, from an apothecary to a waterman. Courten's accounts also make clear that women played a vital role in this commercial world. Selling *naturalia* and antiquities was no different than selling anything else in early modern London, where women commonly participated in the business of the household. While some of the women in Courten's records are clearly wives or sisters of well-known naturalists of the period, the history of the others cannot be so easily determined, making it impossible for us to know if they were associated with (male) figures now forgotten, or if they operated these businesses in a more independent fashion. Despite the *lacunae* in the historical record, the reconstruction of the contents and life of John Conyers's assemblage, and the examination of the transactions of William Courten, make clear that collecting in 17th century London was an activity that took place at more levels of society than has been appreciated.

Chapter 5

"For the Coyning of the Monie:" Skills and Practices in the Restoration Royal Mint

Influenced by Francis Bacon's ideas about the potential utility of experiential investigation of nature and humanity's manipulation of nature, members of the early Royal Society planned to study a number of practical trades. As Thomas Sprat described it in *The History of the Royal Society*, the group had "propounded the composing a Catalogue of all Trades, Works, and Manufactures, wherein men are emploi'd[sic], in order to the collecting each of their Histories." If all went well, the Society would record "all the Physical Receipts, or secrets, the Instruments, Tools, and Engines, the Manual operations or sleights, the cheats, and ill practices, the goodness, baseness, and different value of Materials, and whatever else belongs to the operations of all trades."[1]

The study of "all Trades, Works, and Manufactures" was a large order, and historians have written much about the failures of this early History of Trades program.[2] In this chapter, I will closely examine one particular "manufacture" which, while initially of interest to the Royal Society, quickly disappeared from their investigations: minting coins. Despite connections with the Royal Mint, and the common interests and skills found among the skilled workers producing England's currency, these devotees of the new science and its utilitarian aspects never attempted to become involved in coinage. In examining the production of English coins after the

[1] Thomas Sprat, *The History of the Royal Society of London for the Improving of Natural Knowledge* (London: Printed by T. R. for J. Martyn and J. Allestry, 1667), 190.

[2] Kathleen H. Ochs, "The Royal Society of London's History of Trades Programme: An Early Episode in Applied Science," *Notes and Records of the Royal Society of London* 39, no. 2 (1985). Michael Cyril William Hunter, *Science and Society in Restoration England* (Cambridge Cambridgeshire; New York: Cambridge University Press, 1981), chapter 4; Michael Cyril William Hunter, *Establishing the New Science: The Experience of the Early Royal Society* (Woodbridge, Suffolk: Boydell Press, 1989), chapter 3.

Restoration of Charles II, I will show that the Mint was a pre-existing state institution that relied upon skilled workers who were numerate, metallurgically proficient, and mechanically inclined. While the Crown's support for these skills meant the Royal Mint was something of a Baconian Solomon's House, competing matters of personal position, state power, and secrecy complicate any attempt to depict the Tower Mint as an idyllic bastion of technological innovations and repository of artisanal skills. After discussing the range of skilled artisans needed for the successful production of English coin, I will then consider the apparent lack of interaction between the skilled workers of the Mint and the alchemically-minded devotees of the new science. This disconnect demonstrates that by 1660, English alchemy had separated from one long-held alchemical goal—the production of silver and ultimately gold. Interested in the natural philosophical, medical, and theological knowledge they could gain from pursuing transmutation and other alchemical processes, English alchemical practitioners of the late 17th century no longer considered alchemy as a practical method of large scale bullion production.

The production of coins is not an activity that has traditionally received much attention from historians of science and technology. The basics of coin production are quite ancient, and the procedures of melting, assaying, and hammering did not change much before the 17th century. The introduction of mechanical milling in Europe and England in the 17th century has also not attracted the attention of historians of technology, although the application of the steam engine to British coin production a century later was recently studied by George Selgin.[3] Connections existed between the new science and the Restoration Royal Mint, however. Founder and Fellow of the Royal Society Henry Slingsby was involved with the mechanization of the

[3] George A. Selgin, *Good Money: Birmingham Button Makers, the Royal Mint, and the Beginnings of Modern Coinage, 1775-1821*, Independent Studies in Political Economy (Oakland, Calif.; Ann Arbor: Independent Institute ; University of Michigan Press, 2008).

Mint at the Restoration, and later became the Master-worker, or head, of the Royal Mint.[4] More famously, Isaac Newton served as Warden and then Master of the Mint after his departure from Cambridge in 1696. Newton biographers have studied Newton's tenure at the Mint, generally with a focus on his exhaustive pursuit of coiners and clippers while Warden, and his general sensitivity to strengthening his position vis à vis other officers at the Mint and the Tower while Warden and Master.[5] Newton's intense focus on the minutia of the regular operation and bureaucratic distribution of power at the Mint echoes his similarly intense focus working on other projects—universal gravitation or theological chronology, for example. In contrast to his alchemical and theological studies, modern scholars have not yet paid significant attention to Newton's time at the Mint, nor has the impact of his alchemical, theological, mathematical, or other work on his time at the Mint been studied.

Other historians have studied the Mint itself, most recently in C.E. Challis's edited collection *A New History of the Royal Mint* (1992). The studies there provide a wealth of detail, but focus mainly on the administrative history of the institution.[6] John Craig's older study of the Mint provided more technical detail of the processes involved, but does not place these in the context of any intellectual debates of the day.[7] Studies of economic policy of the late 17th century often touch on the Mint, particularly with regard to the recoinage of 1696, but there has been

[4] C. E. Challis, "Slingsby, Henry (1619/20–1690)," In *Oxford Dictionary of National Biography*. (Oxford University Press, 2004; online edn, Jan 2008), http://www.oxforddnb.com/view/article/58155. Accessed Oct. 24 2014. Note that he is occasionally confused with his more famous relative, Sir Henry Slingsby, a royalist army officer and conspirator, who was executed in 1658. David Scott, "Slingsby, Sir Henry, First Baronet (1602–1658)," ibid., http://www.oxforddnb.com/view/article/25727. Accessed Nov. 11, 2015.

[5] John Craig, *Newton at the Mint* (Cambridge: Cambridge University Press, 1946); Thomas Levenson, *Newton and the Counterfeiters: The Unknown Detective Career of the World's Greatest Scientist* (Boston: Houghton Mifflin Harcourt, 2009). John Craig, *The Mint: A History of the London Mint from A.D. 287 to 1948* (Cambridge: Cambride University Press, 1953), 198-222; Westfall, *Never at Rest*, chapter 12.

[6] C.E. Challis, ed. *A New History of the Royal Mint* (Cambridge: Cambridge University Press, 1992).

[7] Craig, *The Mint: A History of the London Mint from A.D. 287 to 1948*.

little work done analyzing the skills and technologies behind the production of English coin of this period.[8]

Despite this absence in the modern literature, coins were important to many in 17th century England. Among the elite, coins were essential objects for collectors interested in art, ancient history, or even Roman architecture.[9] With the relative abundance of Roman coins in London, even men of modest means could take up their study, as the earlier examination of John Conyers showed. Modern coins could be gathered as markers of recent historical events, or retained as exemplars of the heights to which human arts had reached. The admirer of coins, ancient or modern, however, needed to be alert, and studying degrees of "filing, sharpenesse, and due extancy, Politure, vernish and other markes, criticaly necessary to be skill'd in, to prevent the being [cheated and] impos'd on by Copies [and counterfeits] for Originals and Antique."[10] Thus, the learned collector needed some knowledge of the production of coins in order to be a discerning student and connoisseur.

Initially, Fellows of the Royal Society expressed an interest in coining, among other manufactures they hoped to improve through study. One of the original Fellows, Henry Slingsby, was, in 1660, a deputy to Mint Master-Worker Sir Ralph Freeman, and later held the Master-Worker position on his own.[11] The officers of the Mint had at least a token association with the

[8] Ming-Hsun Li, *The Great Recoinage of 1696 to 1699* (London: Weidenfeld and Nicolson, 1963).

[9] Guy de la Bédoyère, ed. *Particular Friends: The Correspondence of Pepys and Evelyn* (Woodbridge, Suffolk: The Boydell Press, 1997), 191.

[10] Ibid., 192.

[11] Challis, "Slingsby, Henry (1619/20–1690)." Thomas Birch, *The History of the Royal Society of London for Improving of Natural Knowledge* (London: Printed for A. Millar, 1756), 1: 3, 4.

Royal Society for decades: another Fellow, Sir Thomas Neale, succeeded Slingsby, and Neale was, in turn, succeeded by Isaac Newton.[12]

While the explicit interest in Mint activities rarely appears in the records of the early Royal Society, the group was interested in questions closely tied to production of coins. Thomas Sprat enumerated the Society's many metallic interests in his *History*, proclaiming that the Society intended to help "the multiplying, and beautifiying of Mechanick Arts [such as] Graving, Statuary, Limning, Coining, and all the works of Smiths, in Iron, or Steel, or Silver."[13] These interests were evident in early meetings. For example, on January 23, 1661, Henry Slingsby was asked "to communicate his remarks upon the business of the mint" to a meeting of the Society, although it is not clear if he complied with this request.[14] At the same time, other Fellows performed experiments "on the weight of bodies increased in the fire," which involved heating cupels containing lead, copper, and combinations of the two in an assay furnace. These trials were performed using furnaces at the Tower of London, perhaps at the assaying furnaces used to test the purity of coin alloys.[15] Shortly thereafter, at the Society meeting of February 25, 1661, the Fellows resolved that the Society build its own furnace and acquire "an accurate beam" necessary for performing such trials-by-fire in the future.[16] In addition to this corporate interest, several of the founding Fellows had significant interests in chymistry, including chrysopoetic

[12] C. E. Challis, "Neale, Thomas (1641–1699)," In *Oxford Dictionary of National Biography*. (Oxford University Press, 2004; online edn, Jan 2008), http://www.oxforddnb.com/view/article/19829. Accessed November 30, 2015.

[13] Sprat, *History of the Royal Society*, 149.

[14] Birch, *History*, 1: 13, 16.

[15] Ibid., 1: 16, 17. Sprat, *History of the Royal Society*, 228-229.

[16] Birch, *History*, 1: 17.

alchemy.[17] As will be discussed below, the metallurgical skills needed for searching for philosophical gold or refining silver and gold at the Mint were the same, and depended upon furnaces built to produce the right kind of heated environment. As Newton described it, assaying required a furnace built of

> copper plates luted half an inch thick within. It is about 18 inches square 10 inches high to the grate (which is of iron barrs) & about 15 inches above the grate. The muffle stands upon the grate & thee coppels are set in with a pair of tongues upon the floor of the grate through a round hole in the side of the Furnace which is afterwards filled with live charcoal.[18]

At the Restoration, activities at the Mint became a matter of special interest even to those who were not interested in chymistry per se. Slingsby was in the process of overseeing the introduction of new production methods. Following several previous failed attempts at mechanizing coin production over the previous century, Charles II had hired Frenchman Pierre Blondeau to introduce new machines into the Tower Mint. While English coins had been manually struck with hammers, Blondeau's process stamped coins with a mechanical stamp press. In addition, he claimed his new edge-marking machine was fundamental to saving English

[17] Most famously Robert Boyle and Isaac Newton, but they were not alone in possessing chyimical and chysopoetic interests.

[18] Isaac Newton, *The Correspondence of Isaac Newton*, 7 vols. (Cambridge Eng.: Published for the Royal Society at the University Press, 1959), 4: 255; Isaac Newton. The National Archives, MINT 19/1, late 17th century - 1726, Holograph Drafts, Memoranda Etc. Of Sir Isaac Newton as Warden and Master of the Mint, Volume 1, 10-11.

coins from clippers and counterfeiters.[19] The new methods and the new coins were objects of interest and curiosity, as Pepys recorded in his diary.[20]

Political importance of the coinage

By Charles II's return in 1660, every English person lucky enough to handle the currency of the realm paid special attention to it, keeping an eye out, just as Evelyn advised the gentlemanly collector, for cheats and copies. Coinage in England was in a deplorable state; due in large part to the higher bullion prices on the Continent, English coins were in short supply, as they were illegally hoarded, melted and exported for more lucrative sale abroad. The coins that did change hands in London were likely to be counterfeited or clipped in some way.[21] The state of the coinage was thus a political issue. Among claims that taxes, failure of the state to adequately protect fishing convoys, and inefficient use of agricultural land were to blame for England's precarious economic and international standing of the mid-seventeenth century, some pointed to the state of England's coinage as a primary culprit behind the national woes. Debasement through counterfeiting and clipping was seen as damaging England's foreign trade, placing merchants at an economic disadvantage when trading with their European neighbors, and

[19] Peter Blondeau, *A Most Humble Mem[O]Randum from Peter Blondeau, Concerning the Offers Made to Him by This Commonwealth, for the Coyning of the Monie, by a New Invention, Not yet Practised in Any State of the World, the Which Will Prevent Counterfeiting, Casting, Washing, and Clipping of the Same: Which Coyn Shall Be Marked on Both the Flat Sides, and About the Thickness or the Edge; of a Like Bigness and Largness, as the Ordinarie Coyn Is: And Will Cost No More Than the Ordinarie Unequal Coyn, Which Is Used Now* (London 1653); *Calendar of State Papers Domestic: Charles II, 1661-2*, ed. Mary Anne Everett Green (London 1861), 375.

[20] Samuel Pepys, *The Diary of Samuel Pepys. Volume 4: 1663*, ed. Robert Latham and William Matthews (Berkeley: University of California Press, 1971), 143-147.

[21] Clipping coins involves removing a piece of metal from the edge of a coin. The clipped edge would then be polished smooth to make any perceptible damage to the coin appear to be old—either an older depredation or an irregularity from the production of the coin.

preventing nations on the continent from assigning England her proper weighty role in world affairs.[22]

The perceived worthiness of England's coin was more than economically important, however. For the returning monarch, ensuring the value of the coin of the realm and controlling what images it carried were essential parts to re-establishing the Crown's strength. As Kevin Sharpe argued, coins and cheap (base metal) commemorative badges could serve an important public relations role, since they were the medium through which most subjects encountered pictorial representations of the English ruler.[23] Charles II's predecessors—both monarchical and republican—recognized the important role coins could play in promoting a certain image of the kingdom and its ruler. Following Charles I's execution, the Commonwealth government rapidly deployed the coinage of England as a tool to embody its authority. In July 1649, Parliament issued "An Act touching the moneys & coyns of England," which stated, "the Ordering of Moneys and Coyns, and setting the same at such valuations and prizes as shall be thought convenient & necessary" was a right "belonging to the Soveraign and Supreme Authority of this Commonwealth."[24] Having this authority, Parliament had "Resolved to change and alter the former Stamps, Arms, Pictures, with the Motto's, Words, Stiles and Iuscriptions[sic] in and about the same." The Act spelled out the specifics of the new coins, including not only their values and weights, but also the decorations to be stamped upon them. No longer would a monarchical

[22] For example, see the letter to Sir Robert Stone, May 26, 1652 "Volume 24: May 1652," In *Calendar of State Papers Domestic: Interregnum, 1651-2*, ed Mary Anne Everett Green. (London: Her Majesty's Stationery Office, 1877), http://www.british-history.ac.uk/cal-state-papers/domestic/interregnum/1651-2/pp231-272. Accessed November 9, 2015. Carl Wennerlind, *Casualties of Credit: The English Financial Revolution, 1620-1720* (Cambridge, MA: Harvard University Press, 2011), 123.

[23] Kevin Sharpe, *Image Wars: Promoting Kings and Commonwealths in England, 1603-1660* (New Haven: Yale University Press, 2010), 361-363, 442.

[24] England and Wales, "An Act Touching the Moneys & Coyns of England," (London: printed for Edward Husband, printer to the Parliament of England, 1649).

figure and royal coat of arms adorn English coinage, but instead most denominations were to be "stamped on the one side with the Cross, and a Palm and Lawrel, with these words, The Commonwealth of ENGLAND; and on the other side with the Cross and Harp, with these words, God with us."[25] Thus, the images associated with the old regime were removed, the mottos were to be in English, not Latin, and the coins explicitly called out the godly nature of the Commonwealth, in part to counteract the message of divine kingship portrayed on earlier English coins.[26]

While the Parliament and Commonwealth governments issued new coins with their own messages, no Interregnum government demonetized or recalled the pre-existing currency. The 1649 *Act*, for example, merely declared that the new issue was to pass like "others heretofore used" as current money for all transactions.[27] Despite the efforts to use English coinage to indicate the arrival of the new regime, the majority of coin circulating in England during the Interregnum was older, monarchical coin from the reigns of Charles I, James I, and Elizabeth. This was the case when Charles II returned to England in 1660, and his directives about the currency show he was aware of the symbolic import the mixture of coins in his subjects' hands could have.

Just as Parliament and then Cromwell issued their own coins after new patterns to (ideally) replace images of a divinely ordained king that circulated on the older monarchical money, Charles wanted to eliminate the images of Parliamentary rule found on the so-called

[25] Ibid.

[26] Sharpe, *Image Wars*, 442-443.

[27] England and Wales, "An Act Touching the Moneys & Coyns of England." An earlier act (September 1647) demonetized clipped money, but explicitly stated that money naturally worn down during use would remain current. See "September 1647: An Ordinance That from Henceforth No Clipt Moneys, Filed or Diminished, Shall Be Payable or Received in Payment Withim This Kingdom," In *Acts and Ordinances of the Interregnum, 1642-1660*, ed C H Firth and R S Rait. (London: His Majesty's Stationery Office, 1911), http://www.british-history.ac.uk/no-series/acts-ordinances-interregnum/pp1008-1009. Accessed July 3, 2013.

harp-and-cross money minted during the Interregnum. In preparing for a new issue of coin, Charles asserted his own authority by exercising one of the fundamental rights of early modern heads of state—creating coins.[28] Unlike the Parliament and Cromwell, Charles did not content himself with merely ordering the issue of new coins bearing his image. He went a step further and demonetized and recalled the harp-and-cross money issued during the Interregnum.

Just as he dated his regnal years from the regicide and not from his actual assumption of the throne of England, and as he explicitly called for the use of the older, traditional forms and ceremonies during his coronation ceremony, Charles's early proclamations for the coinage reflected his desire to cement his power, and the power of monarchy, in the eyes of the English people.[29] If all had gone as planned, within a few years of his return to England, all coin passing through his subjects' hands would be a reminder of central place of the monarch. Charles' coin, and therefore his image and place in the lineage of monarchs, would take its place besides those of his predecessors. As far as daily commercial activity was concerned, Parliamentary control and the Cromwellian Protectorate would be erased from history.

In his first step towards enacting this plan, in September 1661, Charles II issued his first proclamation announcing the demonetization of the coinage of the Interregnum. In "calling in all Moneys of Gold and Silver Conyned, or Stamped with the Cross and Harp and the Circumscription The Commonwealth of England," Charles gave several reasons, both emphasizing the illegitimacy of those who had ruled in his absence.[30] First, he explicitly acknowledged that the harp-and-cross money owed its existence solely to "the late Usurpers." While he had (graciously) allowed it "to pass in all Receipts and payments as other lawful and

[28] Sharpe, *Image Wars*, 510.

[29] Anna Keay, *The Magnificent Monarch: Charles II and the Ceremonies of Power* (London: Continuum, 2008), 4.

[30] TNA MINT 1/1, 1587 Oct.-1730 July, Record Books, Volume 1, 136.

current Moneys...Since Our Return," such a policy could not continue. "[W]e cannot but take notice that these Coyns were Stamped not only without but against Our Authority and were intended by the late Usurpers as a high Contempt of Us Our Crown and Dignity" Charles observed, and while his concern for his people and the impact any "too Sudden an Alteration in the Common Traffick and Intercourse between Our Subjects" might cause, these symbols of parliamentarian contempt would no longer pass as current money after November.[31] The recall of the harp-and-cross money was not merely the suppression of an affront to royal power, Charles continued, but was also a measure to safeguard his subjects. For, just as they had been issued by an illegitimate power, the Interregnum coins were by their very nature prone to another form of illegitimacy, as Charles claimed, "Experience [showed] that this Our Indulgence hath proved the Unhappy Occaion of Very great Mischeif to Our People in general whilst evil disposed persons have taken a liberty to Counterfeit wash Clip and ffile as many of this Coyn as they thought fit." As long as the harp and cross coins were in circulation, Charles claimed, his subjects went in "the dayly hazard of receiving false and Adulterate Moneys."[32]

While harp-and-cross coins were certainly subject to the same ills as the monarchical coin issued under Charles II's predecessors, his claim that the Parliamentarian coin was *more likely* to be counterfeit or underweight was undoubtedly an exaggeration meant to reinforce the illegitimacy of these coins and, by extension, the governments that had issued them. In recalling the coins, Charles did not recall early Parliamentarian coins, struck using dyes left at the Mint at the Tower when Charles I abandoned London.[33] Those coins still bore Charles I's image and

[31] Ibid., 137.

[32] Ibid.

[33] The recall is specifically limited to "all such pieces of Gold and Silver as have been Coyned since the Year One Thousand Six hundred fforty Eight, with the Stamps, Motto's and Inscriptions" of the Commonwealth. Ibid. The coins in question are itemized and described ibid., 136. Interestingly, this proclamation does not specifically

mottos.[34] Similarly, he did not, in this proclamation or in any other, make an attempt to call in even older coinage—that issued under Charles I, James I, and even by Queen Elizabeth. Despite the King's claims to the contrary, Interregnum coin was no more likely to be debased or counterfeit than these older issues—as the continued deplorable state of English currency after Charles II's limited recall demonstrated. Commonwealth and Protectorate had been illegitimate rule; therefore their coins could not continue to pass as current money. The coins from his monarchical predecessors, however, had an intrinsic worth separate from their soundness; each one emphasized the power of the monarch, and by association with the new coins soon to be issued, Charles's rightful place in the line of rulers.

In the event, Charles's desire to use the currency for symbolic purposes was temporarily foiled by the practicalities. The demonetization had to be delayed slightly, as the newly re-established Royal Mint could not produce coin quickly enough to replace all of the harp-and-cross money in circulation.[35] Moreover, his decision to link himself to his predecessors through currency meant the continued circulation of counterfeit and debased coin (and the continuation of practices of clipping and counterfeit coining) long after the new technology meant to safeguard England's money came into effect. The emphasis placed on the symbolic weight of the new coinage led to a fundamental flaw in Charles's plans. Instead of restoring and protecting the value of English currency through new manufacturing methods, or even widely promulgating his

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demonetize the limited run of coins baring Cromwell's image that were issued in 1657-8. See Sharpe, *Image Wars*, 508-510.

[34] Sharpe, *Image Wars*, 363.

[35] England, Sovereign Wales, and King of England Charles II, *By the King. A Proclamation, That the Moneys Lately Called in, May Nevertheless Be Currant in All Payments, to, or for the Use of His Majesty, until the First Day of May Next* (London : printed by Roger Norton, one of the printers to the King's most excellent Majesty, 1661., 1661); England, Sovereign Wales, and King of England Charles II, *By the King. A Proclamation for Restraining the Payment of the Moneys Lately Called in, to His Majesties Use, Any Longer Then until the First of March Next* (London : Printed by John Bill and Christopher Barker, printers to the King's most excellent Majesty, 1661 [i.e. 1662], 1662). Challis, *A New History of the Royal Mint*, 338.

image as king, the selective recall of coins current at Charles's Restoration in 1660 doomed the purpose of the issue to failure. Only coins issued during the Commonwealth were de-monetized, leaving the symbolically potent, but worn, clipped and easily immitated coins from the reigns of earlier monarchs to pass as legal tender. Charles may have succeeded in eliminating one mark of the Commonwealth's existence, and ensured that England's coins only bore evidence of monarchical rule, but the new coins did nothing to solve the problem of devaluation. People hoarded the new, true weight coins (often for melting down and exporting or selling as bullion) and used the old, degraded coinage. Coins bearing Charles' image as king did not circulate, and, since old coins were in circulation, counterfeiters could continue to fake old coins, and clipping could continue apace. Despite the introduction of the new technology, therefore, English currency continued to degrade, until the "Great Recoinage" under William and Mary combined new coins with the recall of older examples.[36]

Skills for Making Coins I: Metallurgy and Mathematics

Even before the introduction of new machinery at the Mint, certain skills were essential to the production of coins. While pre-Restoration money was struck by brute force hammering, earlier steps in the coining process required many metallurgical skills, skills that remained important after mechanization. English currency was legally defined by its weight and purity, as spelled out in the indentures between the Master-Workers and the Crown. While the precise definitions of fineness (or purity) and the allowable variation in that fineness (officially called the "remedy") changed through time, the indenture of Sir Ralph Freeman and Henry Slingsby in 1662 illustrates the kinds of limits placed on English coin production. For gold coins, every

[36] On the Great Recoinage of 1696 see: Challis, *A New History of the Royal Mint*, 379-397; Li, *The Great Recoinage of 1696 to 1699*; Craig, *Newton at the Mint*.

pound of money should contain in value "fourty four pounds & ten shillings & shall be in fineness at the Tryall…two & twenty Carrotts of fine Gold…& two Carrotts of Allay"[37] Similarly, every pound weight of silver coins should contain "three pounds & two shillings sterling, & shall be in fineness at the Tryall of the same Eleaven Ounces & two penny weight of fine Silver & eighteen penny weight of Allay."[38] Recognizing that some variation in production was bound to occur, even with the greatest attention to the Crown's interests, the indenture declared that "when the said mony of Gold shall be found at the Assay before the deliverance too strong or too feeble…the Sixth part of a Carrott in the pound weight of Gold & no more…[that] Sixth part … shall be called Remedy for the Master that then that mony shall be delivered for good."[39] However if the defect exceeded the sixth part of a karat, "then cease the deliverance & that money to be challenged & adjudged ^less^ then good & be new molten & recoyned at the Cost of the said Master."[40]

Within this legal framework, the successful functioning of the Royal Mint depended on the work of skilled assayers, who assessed purity during the intake of bullion into the Mint and as part of the refining and alloying process to produce the metal plates from which coins would be cut. It was also part of the periodic Trial of the Pyx, the process by which sample coins were checked by the representatives of the Goldsmiths' Company in front of representatives of the King to ensure that the Mint Master was producing gold and silver coins that met the legal standards.

[37] BL Additional MS 31053, 1624-1677, Accounts, Reports, and Papers Relating to the Mint, f. 20v.

[38] Ibid., f. 21v.

[39] Ibid., f. 21r.

[40] Ibid.

Assaying in turn relied upon precise scales and weights. As Newton described it late in the century, the importance of careful measurement meant the assay master had delicate scales. They "turn with the 128th part of a grain, that is with the 2560th part of the weight…which answers to less than the 10th part of a penny weight," Newton recorded. "They are fenced about with glass windows to keep them from the motion of the air & have in them little thin brass platters to take away the weights by without handling the scales."[41]

The processes of melting, assaying, and allaying performed by Mint workers was described by Samuel Pepys after his visit to the Mint in 1663. Pepys was unfamiliar with the metallurgical/chemical processes involved, but was interested enough to carefully record the steps in great detail in his diary. For gold, Pepys wrote that Mint workers began by "taking an equall weight of that and of Silver… this they wrap up in thin leade," placing the combination into "little earthen cupps made of Stuffe like tobacco pipes," which was then placed into the furnace.[42] If silver were being tested, it alone was placed in the cupel with lead. In either case, the heating of the cupel caused the base metal impurities to oxidize, and be absorbed into the cupel. Aqua fortis was then used to dissolve the silver, leaving the gold behind. Pepys found this step particularly mystifying, writing that the aqua fortis "separates them [gold and silver] by spitting out the silver into such small parts that you cannot tell what it becomes; but turns into the very water and leaves the gold at the bottom clear of itself," a process he found to be a "great mystery." Precise weighing of the samples before and after the assaying process was essential, as weight determined the purity of the sample, and how it needed to be modified to achieve the legally defined standard of purity for English gold or silver coins. As Pepys explained, the

[41] Newton, *Correspondence*, 4: 255; TNA Mint 19/1, 10-11.

[42] Pepys, *The Diary of Samuel Pepys. Volume 4: 1663*, 144. Pepys was in error here, as cupels were made of bone ash, not clay.

difference in weight enabled the Mint workers to "know what proportion of worse gold or silver to put to such a quantity of the Bullion to bring it to the exact standard [if too fine, or to know that it] requires such a proportion of fine mettall to be put to the Bullion to bring it to standard [if worse than standard].[43]

While Pepys was recording the techniques used at the Tower Mint, the basic metallurgical processes described in this passage reflect those standard throughout Europe in the early modern period for assaying in many settings. Mining operations, alchemical pursuits, and iatrochemical or Parascelsian investigations could all require similar skills and equipment.[44] For those concerned with the transmutational possibilities of chrysopoea, for example, an indisputably crucial skill was a familiarity with the basic methods of assaying in order to determine that a given substance was or was not gold. In Boyle's unpublished "Dialogue on Transmutation," (written in the 1660s and 1670s) his characters describe a number of transmutations or putative transmutations to an audience mixed with chymical supporters and skeptics, in which tests of the substances involved were essential.[45] While there was debate about whether philosophical gold was distinguishable from natural gold, attentive virtuosi would, at the

[43] Ibid., 144-146.

[44] On the diverse purposes and locations of early modern chemical practices see: R. Werner Soukup, "Crucibles, Cupels, Curcurbits: Recent Results of Research on Paracelsian Alchemy in Austria around 1600," in *Chymists and Chymistry: Studies in the History of Alchemy and Early Modern Chemistry*, ed. Lawrence M. Principe (Sagamore Beach, MA: Science History Publications, 2007), 166-167; Marcos Martinón-Torres, "The Tools of the Chymist: Archaeological and Scientific Analyses of Early Modern Laboratories," in *Chymists and Chymistry: Studies in the History of Alchemy and Early Modern Chemistry*, ed. Lawrence M. Principe (Sagamore Beach, MA: Science History Publications, 2007); Tara Nummedal, *Alchemy and Authority in the Holy Roman Empire* (Chicago: The University of Chicago Press, 2007), chapter 5.

[45] Published in appendix 1 of Lawrence Principe, *The Aspiring Adept: Robert Boyle and His Alchemical Quest: Including Boyle's "Lost" Dialogue on the Transmutation of Metals* (Princeton, N.J.: Princeton University Press, 1998), 223-295. Principe dates this material to two periods, one in the second half of the 1670s, and one to the early 1680s. The sections I quote from are all from the earlier material.

very least, test putative objects of transmutation to ensure that they were *some* type of gold.[46] In one example, before melting together their ingredients, Boyle's characters described carefully weighing mysterious powders and the natural gold with which they would be mixed. The resulting product was carefully weighed on the same scale, and amazement at the increase in weight duly noted.[47] Then the product was tested to see if it could be "fixt." It was combined with lead in the same cupellation process Pepys had witnessed at the Mint, in which base metals were oxidized, leaving gold behind. The resulting product was a mystery to Boyle's character: "a dark colour'd Heterogeneous Substance, to which I cannot give a name, because neither I, nor my Experienc'd Assitant could reduce it to anything near any Body we know."[48]

Boyle's characters tested the so-called "anti-elixir" in a similar fashion. Careful weighing preceded testing the mysterious powder, and the gold used in the trial had been "cupell'd with a sufficient quantity of lead and quarted, as they speak, with refin'd Silver, and purg'd Aqua fortis, to be sure of the goodness of the Gold."[49] As with the earlier powder, the gold and mystery substance were combined carefully in a new crucible, then removed from the fire, cooled and weighed. Since the appearances of the resulting metal were not promising—it looked like a "lump of Metal of a dirty colour, and as it were overcast with a thin coat"—further tests were pursued to compare this substance with a known sample of gold.[50] It was tested on a "good Touchstone," tapped with hammers to test brittleness and ductility, and then cupeled again to see what would result. Boyle's characters did not forget the specific gravity test, as one speaker

[46] Ibid., 241. Principe says this based on account of Helvetius about the additional properties of philosophical gold. Ibid., 94.

[47] Ibid., 258-259.

[48] Ibid., 259.

[49] Ibid., 283.

[50] Ibid., 284.

described it: "having provided my self of all the requisites to make Hydrostatical Tryals, (to which perhaps I am not altogether a stranger) I carefully weighted in the water the ill-lookt Mass, (before it was divided for the coupelling of the above mentioned dram) and found, to the great confirmation of my former wonder and conjectures, that in stead of weighing about nineteen times as much as a bulk of water equal to it, its proportion to that liquor was but that of fifteen….so that its specifick gravity was less by about 3 1/3; than if it had been pure Gold it would have been."[51] The theoretical explanation for what had happened was uncertain, but the laboratory results clearly told that what had been gold was no longer.

Boyle's descriptions of the laboratory practices of the careful adept echo those performed in more mundane metallurgical settings. At the Royal Mint, where the purity of gold and silver was regularly a matter of test, adjustment, and quality control, melters, refiners, and assay masters performed the same tasks. As Pepys witnessed it in 1663, Mint assayers testing silver for fineness wrapped the silver pieces in lead "then put…them into little earthen cupps made of Stuffe like tobacco pipes and put them into a burning hot Furnace; where after a while the whole body is melted and at last the lead in both is sunk into the body of the cup, which carries away all the copper or dross with it."[52] Although Pepys was clearly a newcomer to questions of metallurgic practice, descriptions of basic assaying techniques were widespread in early modern print culture. Most famously, Agricola had discussed this in Book 7 of his *De re metallica*.[53]

[51] Ibid., 286.

[52] Pepys, *The Diary of Samuel Pepys. Volume 4: 1663*, 144-146.

[53] Georg Agricola, *De Re Metallica.*, trans. Herbert Clark Hoover and Lou Henry Hoover (New York: Dover Publications, 1950), 247-265.

Newton is known to have had a copy of Agricola's book, and he attempted to quote from him at one point in writing about Mint assaying procedures [54]

Despite the parallels between alchemical practice and the operation of the Mint, Newton was often dismissive of those who performed the physical processes of minting. In Newton's memoranda working through the establishment of the Mint and the relationship of the different positions to one another, he clearly identifies many of the Mint employees as servants of the Master. Certainly, the "Workers & Moneyers …are no standing Officers," wrote Newton, "nor have salaries but as workmen receive wages after a certain rate in ye pound weight for all the gold and silver they work & coyn."[55] Even the other officers of the Mint could come in for harsh criticism from Newton. Although the Assay master *did* have a salary, Newton described "refining & assaying [as] manual trades."[56] The Assay master's job was merely to "act…only as a manual Artificer" and his job did not require independent judgment, but was solely fulfilled in ensuring that the "officers of the Mint" (Newton here means those above the Assay master: the Master, Warden, and Comptroller) were "satisfied of his acting with Skill and Candour."[57] In a memorandum on the Trial of the Pyx, Newton enumerated the many ways of erring during an assay, implying that results derived by these mere artificers were prone to fault.[58]

In other instances Newton did recognize the importance of the skills of those practicing the occupations the Mint relied on. The best way to avoid errors at the Trial of the Pyx, he wrote, was to have a Jury made of "workmen very well skilled & exercised in assaying refining &

[54] Newton, *Correspondence*, 4: 258. n. 6 and 7.

[55] TNA Mint 19/1, 6v.

[56] Ibid., 99r.

[57] Ibid., 90r.

[58] Ibid., 243v.

allaying of gold & silver."[59] Similarly, during the recoinage of Scottish currency following the 1707 Act of Union, Newton acknowledged that persistent differences between English and Scottish Mint practices could only be rectified by someone with the requisite experience. As he wrote to David Gregory, who was overseeing the Edinburgh Mint, detailed information about melting procedures in London would only go so far, as

> "its not practicable for any man to undertake the meltings with your Pit coal until he has had some experience in working with it, & finds out by that experience how the fire may be governed[?] so as not to over heat the metal. For no man can undertake to do a thing before he knows how to do it, nor know how to do a thing of this nature without experience."[60]

In addition, part of the success of Charles Brattel's application for the position of Assay master in 1712 was due to his carefully performed assays (which "agreed perfectly with one another except one which differ'd from the rest only about the Twelfth part of Grain"[61]). Brattel also "handle[d] things with more dexterity and dispatch" than his competitor for the post.[62]

Even when recognizing the importance of these practical skills, however, Newton viewed the more gentlemanly officers of the Mint as the best judges of assayers' skills. The Assay master "acts only as a manual Artificer," Newton wrote, whose job was to give "satisfaction of the officers of both parties" involved the weighing of bullion.[63] Above all else, it was the officers of the Mint who were to be "satisfied of his acting with Skill and Candour" and were therefore, "as the proper Judge of their [assay masters'] Qualifications in point of Skill."[64]

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[59] Ibid., 243r.

[60] Ibid., 201r.

[61] Ibid., 90r.

[62] Ibid.

[63] Ibid.

[64] Ibid.

Mathematics

In addition to needing adeptness at certain manual skills and metallurgical processes, assay masters also needed mathematics. Mathematical literacy and ability to accurately calculate proportions of allay needed to produce legally fine silver and gold from bullion and plate of varying degrees of purity was essential.[65] The publications of one 17th century Mint employee demonstrate the significance of mathematics and of the related activity of precise mensuration. John Reynolds, who worked in the Mint assay house from 1607 until his death in 1666, published several short tracts throughout his life containing reference tables and mathematical instructions for those involved in assaying and alloying.[66] Most notably, his tract of 1651, *A Brief and Easie way by Tables to Cast up Silver to the Standerd of XI. Ounces ij. Penny-weight. And Gold To the Standerd of XXII. Carrots. With Questions wrought by the Golden-Rule. Also by Decimall Tables*, included not only the tables (meant to spare the reader the tedium of calculation), but also instructions on how to work out the amount of allay needed in any situation. Reynolds included pages of word problems and example calculations that both demonstrated his own mastery of the mathematical skills involved and suggested that he thought his audience might be seeking to acquire similar skills.

Reynolds's skills and precision were recognized outside of the narrow world of assaying, as a passage from John Wybard's 1650 text on mensuration makes clear. Wybard (fl. 1630-1674) was a medical doctor who was also interested in practical mathematics. He designed surveying

[65] On mathematics and coinage, see J. Williams, "Mathematics and the Alloying of Coinage 1202-1700: Part 1," *Annals of Science* 52 (1995); J. Williams, "Mathematics and the Alloying of Coinage 1202-1700: Part 2," *Annals of Science* 52 (1995). Part 2 specifically treats the English situation.

[66] C.E. Challis, "Mint Officials and Moneyers of the Stuart Period," *British Numismatic Journal* 59 (1989): 172. E. G. R. Taylor, *The Mathematical Practitioners of Tudor & Stuart England* (Cambridge: Published for the Institute of Navigation at the University Press, 1954), 194. See also letter from Sir Robert Moray to Henry Slingsby, April 5, 1666 in Misc. British Library, Additional MS 81611, 1660-before 1690, Graham and Slingsby Papers Vol. Xiii. Letters to Henry Slingsby.

instruments, studied the moon, and investigated weights and measures.[67] In his book *Tactometria. Seu, Tetagmenometria. Or, The geometry of regulars practically proposed* (1650), a work on solid geometry and its practical applications in mensuration and gauging, Wybard was openly appreciative of what could be learned from the skilled but non-university-educated artisans he sought help from. In one section, Wybard wished to know the weight of cast iron spheres, but was hesitant to accept the "common Tenant" about the weight of spherical pieces of iron. After finding the printed authorities (unspecified gunnery textbooks) to contain unacceptable variation in the number reported, Wybard sought out someone with the skills to determine a value through a "certain and exact experiment."[68] The man he turned to, John Reynolds, was described as being "noted for his industry and ingenuity in the Mathematiques" an assessment Wybard heartily agreed with.[69] While the idea for the weighing of a cannon ball was Wybard's, the author noted that Reynolds had recently performed a similar task as part of his (Reynolds's) ongoing study of the relative weights of metals.[70]

Early members of the Royal Society also recognized Reynolds's skill, as in February 1661 some members of the Royal Society performed some experiments at the Tower of London using the expertise of Reynolds.[71] The account of these experiments was printed in Sprat and survives in the Royal Society's classified papers. While the printed account in Sprat (and Birch's reference to it) assigns authorship of the account to Brouncker, the table of contents of the

[67] Taylor, *Mathematical Practitioners*, 212-213.

[68] John Wybard, *Tactometria. Seu, Tetagmenometria. Or, the Geometry of Regulars Practically Proposed* (London: printed by Robert Leybourn, for Nathaniel Brooks, at the Angel in Cornhill, 1650), 215-216.

[69] Ibid., 216.

[70] Ibid.

[71] Birch, *History*, 1: 16.

volume containing the manuscript lists the author as one "Mr. Reynolds."[72] Reynolds shows up in the Society's minutes again in 1670, after his death, when Mr. Smethwick presented a paper on some "Experiments to show the weight of some metals, stones and liquids by Mr Reynolds in the Tower of London." [73] It is not clear why the paper was presented at this time, but Wybard spoke of Reynolds's series of experiments underway in his 1650 book.

Mathematical skill continued to be important to the Mint after Reynolds's time, as shown by a manuscript in the Mint papers dating from around 1700. Entitled, "The most Practicall method of resolving the most usefall Arithmeticall Questions which relate to the Standarding of Gold or Silver of any degree of courseness or finess explained and demonstrated," this manuscript explains how to calculate the amount of pure silver or gold needed to bring a given ingot up to the English monetary standard.[74] While incorporating material similar to that explained in Reynolds's 1651 text, MINT 9/2 is written in a more formal style, adopting the use of propositions and corollaries found in gentlemanly texts on more advanced mathematical subjects. This document codified one aspect of the melter's and refiner's job into formal mathematical form, and suggests the anonymous author believed others wished to know how the process worked, or that the text could educate others to in essential knowledge for the effective operation of the Royal Mint.

[72] RS Cl.P/6/1, 1660, Experiment to Show the Weight of Bodies Increased by Heat.

[73] Birch, *History*, 2: 442. See also RS Cl.P/6/26, 1670, Experiments to Show the Weight of Some Metals, Stones and Liquids by Mr Reynolds in the Tower of London, f. 45r, v. Reynolds died in 1666. Challis, "Mint Officials and Moneyers of the Stuart Period," 172. The earlier reference to Reynolds' experiments is found in Wybard, *Tactometria. Seu, Tetagmenometria. Or, the Geometry of Regulars Practically Proposed*, 326.

[74] TNA MINT 9/2, 1700, The Most Practical Method of Resolving the Most Useful Arithmetical Questions Which Relate to the Standardising of Gold or Silver of Any Degree of Courseness or Finess Explained and Demonstrated.

Skills for Making Coins II: 'industrial' supplies from outside the Mint

The successful production of coinage also depended upon tools provided by skilled workers who contracted with the Mint. Blacksmiths were particularly important, as ironwork was essential to the process. From the "Beame and Scales" and "weights of [several] sizes" provided by Edward Silvester and William Smith in 1677 - 1678[75] to melting pots and furnace repairs,[76] high quality smith-work was essential to the production of English coins. Potters provided covers for the cupels, and bricklayers performed work on furnaces.[77] In addition, the melter could expect payment for any *aqua fortis*, copper, or "water silver" he used in the process of turning bullion into mint standard alloy.[78]

The importance of these suppliers is evident in some materials from the time of Henry Slingsby's ignominious departure from the Mint in the 1680s.[79] As part of his attempts to shift blame for the glaring shortfalls in Mint accounts, Slingsby drafted complaints against several blacksmiths claiming that their demands for further payment were unjustified. Part of his claim included accusations of defective workmanship. While the accuracy of Slingsby's claims are

[75] "Edward Silvester & Wm Smith ^smiths^ their bill of work by them done and Iron delivered [to the Mint] from 20 Dec. 1677 to 20 Dec. 1678." In TNA MINT 6/36, 1677 Dec.-1684 Apr., Bills and Acquittances. This bill was not paid until the 1690s, and probably represents one of Henry Slingsby's creditors from the end of his period of control at the Mint.

[76] "Edward Silvester Smith Bill for 20 Dec. 1677-20 Dec. 1678." In ibid. This bill was not paid until the 1690s, and probably represents one of Henry Slingsby's creditors from the end of his period of control at the Mint.

[77] See for example, TNA MINT 6/37, 1686 July-1687 Sept., Bills and Acquittances. 1687 Aug 20 William Parry Potter "Mufflers" for 1686-7; TNA MINT 6/38, 1687 Sept.-1688 Sept., Bills and Acquittances. Sept 30, 1688 Robert Fitch Bricklayer and Plasterer for work done in various places, including "At the silver furnace" "At the nealing furnace" and "At the Gold furnace".

[78] See, for example, TNA Mint 6/37.September 30, 1687; TNA Mint 6/38. September 30, 1688.

[79] On Slingsby's suspension, see Office Great Britain. Public Record and William Arthur Shaw, *Calendar of Treasury Books, 1679-1680* (London, 1904-), 580, 641. Great Britain. Public Record Office et al., *Calendar of State Papers, Domestic Series, 1679-1680* (London : Longman & Co., 1860-), 531-610; Office Great Britain. Public Record and William Arthur Shaw, *Calendar of Treasury Books, 1680-1685* (London, 1904-), 22, 693; Challis, *A New History of the Royal Mint*, 354.

dubious, the criticism does tell us something about the importance of high quality blacksmith's work to Mint production.[80] The intense heat necessary to melt the bullion was hard on the iron pots; pots "furnished…for the use & service of his Majesty's Mint" were supposed to be guaranteed to survive 12 meltings. "[I]f any such melting pott did [or?] should run or p[rove?] defective at any tyme or tymes before [12 meltings] the same was not to be paid for but the loss thereof did & ought to fall upon…such Smith as furnished" the defective pot.[81] Similarly, the quality of iron and steel used to produce the puncheons and dyes affected the ability to produce finely engraved coins. The additional forces (above what would be experienced in hammering) produced in Blondeau's screw press made quality even more important.[82] The Roettier brothers, appointed as engravers to the Royal Mint in 1662, were chosen not only for their artistic ability, but also for their ability to create strong dyes from their designs.[83] During his visit to the new Mint machinery in 1663, Pepys was told that "a payre of Dyes will last the marking of £10000 before it be worn out, they and all other their tools being made of hardened steel, and the Duchman[sic] who makes them is an admirable artist."[84] The work in preparing these dyes featured prominently in letters written to Slingsby in 1663. As the Mint Comptroller James

[80] "Draft bill of complaint by Henry Slingsby against Nicholas Bradley and Thomas Hodgskins, blacksmiths." In BL Additional MS 81612, 1662-1679, Graham and Slingsby Papers. Vol. XIV. Mint Papers. Slingsby's decision to attack these smiths was probably ill-advised. Hodgskins, or his family, was skilled, well connected, or both. He assumed the position of Mint smith in 1644 and "remained in office until the Restoration." Challis, *A New History of the Royal Mint*, 289. Demonstrating the political skill or technical adeptness necessary to maintain a position after the changes of the Restoration, a man by the same name then held the Mint smith's position until his death on December 25, 1673.Ibid., 352, n.306. A master smith named Thomas Hodgskins also worked for the Ordnance Board in the early 1660s. TNA WO 48/3, 1660-1664, Treasurer's Ledgers. Part 3, 44v. The family continued after 1673 as a smith also named Thomas Hodgskins helped rebuild some of London's churches after the Great Fire. LMA CLC/313/J/020/MS25491, 1678 - 1694, Rough Summary Account Book of Payments Made to Craftsmen Employed on the Rebuilding of the City Chruches after the Great Fire, 16, 28.

[81] "Draft bill of complaint" in BL Additional MS 81612.

[82] This also was an important consideration during the introduction of steam powered coining engines. See Selgin, *Good Money*, 281-285.

[83] Challis, *A New History of the Royal Mint*, 348-350.

[84] Pepys, *The Diary of Samuel Pepys. Volume 4: 1663*, 147.

Hoare, Sr. reported in one dispatch, "M. Roettier hath hardened his two puncheons…And both came out of the fyer perfectly good….His small punshyons & letters for the Gold and Silver will all be completely finished by Saturday night…[I]n the meantime his Bro: will prepare some dyes with those pynshyons already made."[85] Later letters record some temporary setbacks on account of "defecte of the steele."[86] This problem was quickly surmounted, however, as October 3 saw the completion of successful trial runs and everything performing well.[87]

Skills for making Coins III: Blondeau's machines and controlling coining technology

While the metallurgical and mathematical basis of coining remained the same throughout the century, the physical striking of English coin changed dramatically after the Restoration, due to the mechanization of the coinage process. Continental powers had adopted similar machines for their coinage earlier in the century, and England itself had made earlier attempts to adopt the new technologies, most recently during the Interregnum, when both Parliamentarian and Cromwellian (Protectorate) governments had toyed with the idea of hiring Frenchman Pierre Blondeau to introduce his special machines to the Mint in London. The reasons behind Blondeau's failure to secure a position at the Mint in the 1650s are unclear—both the political machinations of the Moneyers and the acute monetary shortages experienced by the Commonwealth government have been blamed.[88] In the event, money, political will, and

[85] Hoare to Slingsby Sept. 17, 1663 in BL Additional MS 81613, 1663-1668, Graham and Slingsby Papers. Vol. XV. Mint Papers.

[86] Hoare to Slingsby Sept. 24, 1663 in ibid.

[87] Hoare to Slingsby October 3, 1663 in ibid.

[88] Challis cites the Commonwealth's money problems as the root cause of the failure of the English Mint to mechanize in the 1650s. Blondeau's processes required an outlay of around £1000 for machinery. See Challis, *A New History of the Royal Mint*, 330. He rejects A.J. Nathanson's claim that the Moneyers influence was to blame. For that argument, see Alan J. Nathanson, *Thomas Simon: His Life and Work, 1618-1665* (London: Seaby, 1975).

corporate interests all combined at the Restoration to speedily bring the new technology and its inventor to London.

In his attempts to secure the backing of the Commonwealth government in the 1650s, and in his contract for his employment at the Mint under Charles II, Blondeau claimed mastery of not just rare, but unique, knowledge in his new milling machinery and process for engraving the small edge of coins.[89] Such knowledge was valuable to any government of England, republican or monarchical, if one believed Blondeau's claims that his specialist knowledge was the sure way of saving English currency, and, by extension, the entire English economy, from the depredations caused by counterfeiters and coin clippers.

The new technology Blondeau brought to London was a screw press for striking coins and his particular invention, an edging device for marking the edges of coins that would make any attempt at clipping plainly visible. After blanching (treating the gold or silver chemically to ensure uniform coloration), the edges were marked with Blondeau's secret process. Then the coins were milled: "that is, put on the marks on both sides at once, with great exactness and speed—and then the money is perfect" effused Pepys.[90] These two machines were meant to put an end to counterfeit and clipped coins. The screw press struck the dies with much greater force than manual hammering. This left a deeper impression on the coin faces, impressions that, in theory, would be hard to replicate without similarly large and noisy machinery (unlike hand-hammered coins that could be struck with far more common tools). The high quality of the

[89] It is not clear how unique Blondeau's machinery was, either in England or Europe. The edge-marking machine was certainly new in England, but his coin press may not have been. Attempts at mechanizing coin production had been made in England before, the last one was Nicholas Briot under Charles I. Briot brought equipment from France, of which he was not the unique inventor. Like Blondeau, Briot used a screw-press to strike some of his coins. Briot was never part of the regular Mint establishment, however, whereas Blondeau's tools were always considered for replacing the usual Mint practice of hammering coins. Challis, *A New History of the Royal Mint*, 300-302; Victor Gadoury, *Monnaies Royales Françaises Louis XIII À Louis XVI, 1610-1792 Cuivre, Billon, Argent, Or* (Monte-Carlo: V. Gadoury, 1986), 30.

[90] Pepys, *The Diary of Samuel Pepys. Volume 4: 1663*, 146-147.

engraving and the deep impressions were also supposed to provide a safeguard against "washing," as any diminishment of the sharpness of images or mottos would be obvious at a glance.

To keep the currency safe, it was essential not merely to introduce the new methods, but also to control who had access to these machines and the knowledge of how they worked. Blondeau's agreement with the Crown contained the standard concessions securing his sole right to his invention and equipment and its use in England for 21 years.[91] He also received a lump sum £1000 payment (meant to pay for the cost of the machines), denizenship, and the title of "Engineer of the Mint." This title came with a salary of £100 and all the rights and privileges afforded the other Mint officers, officers who at this time were from the gentry or minor nobility. As with all Mint employees at this time, Blondeau also received payment based on the number of coins produced by the Mint on his machines.[92]

Blondeau's contract depended on both secrecy and openness. The many privileges he was granted depended on the Crown's continued control of his technology. If it became known outside of the Mint, Blondeau's financial rewards would be canceled.[93] In an effort to stop leaks from other sources, all Mint Officers would henceforth be required to swear an oath upon taking office, promising not to "reveale or discover the said new Inventions…unto any persons or persons whatsoever directly or indirectly in part or in whole."[94] Mint Officers continued to take

[91] BL Additional MS 18759, 1652-1769, Collection of Papers Relating to the Mint, 54r; Deborah E. Harkness, *The Jewel House: Elizabethan London and the Scientific Revolution* (New Haven: Yale University Press, 2007), 150-160; Christine MacLeod, *Inventing the Industrial Revolution: The English Patent System, 1660-1800* (Cambridge: Cambridge University Press, 1988).

[92] BL Additional MS 18759, 46r.

[93] Ibid., 57v, 58r.

[94] Ibid., 72r.

this oath into the 18th century, long after it had become apparent that these technologies alone would not cure England's currency woes.[95]

At the same time, however, Blondeau's contract specified that he was required to share his expert knowledge in certain ways. He was ordered to "direct & instruct the moniers in coyning the Gold & Silver monyes by way of the Mill & Presse & in using of all such his new Invented tooles Silver moneys & Engines as shall be imployed in their taskes & undertakeing."[96] In addition, Blondeau agreed to "to discover his secrets in rounding the peeces before they are sized and in marking the Edges of the Moneys with letters and grainings unto his Majesty if he shall please to doe him the honor of being a wittness unto his Art and Inventions, unto the Master Warden Master and Worker and Comptroller of the Mint and to such other persons only of trust and confidence as the said Peter Blondeau shall from time to time find necessary to employ in assisting him to round the peeces and to marke the Edges of the moneys according to the quantities weekly coined."[97] Just as the control of the technology securing the coinage was not always certain, the transmission of the essential knowledge was not always certain. As Slingsby's assistant le Blanc reported in a letter in 1666, "Monsieur Blondeau and his family are well [but] he is becoming old and is no longer as attentive as he was before [.] There is no one who works at his house except his apprentice who is not yet so skillful a man concerning what needs to be done for the mill."[98] Despite these hiccups, sufficient knowledge was eventually

[95] For Newton taking the oath see TNA MINT 19/1, 62.

[96] BL Additional MS 18759, 44r.

[97] BL Additional MS 34358, 1336-1727, Papers and Correspondence Relating to the Mint and Coinage of England and Ireland, 15v.

[98] Le Blanc to Slingsby April 12, 1666 in BL Additional MS 81613, 1663-1668, Graham and Slingsby Papers. Vol. XV. Mint Papers. "Mons. Blondau et sa famille es portent bien, il devient agé et n'est plus si vigilant quil estoit iy devant, il na personne qui trauaille chez luy que son apprentis lequel nest pas encore assez habil homme pour faire ce qui est necessaire pour le moulin."

passed on, as the Mint continued to employ the same type of machines after Blondeau's death in 1672. Thomas D'Oyley was granted the reversion on Blondeau's patent in 1675, as a reward for help in a counterfeiting case, but did not have any technical skills; the Moneyers oversaw the actual coinage and the operation of the machines.[99]

Control of the physical implements involved in coin production was a regular worry for Mint officials in the late 17th century. At the Restoration, along with implementing the new method of coining, care was taken to issue proclamations to control the engravings necessary for coining. On January 24, 1662, the Privy Council ordered "that No Graver or Gravers whatsoever shall henceforth Grave or work any Originall Master puncheons, Matrices, Stampes and Dyes, or any Irons for Coyning either by the way of the Press or Hammer in any place but in his Majestys Mint in the Tower of London."[100] At the same time, the former engraver Thomas Simmons was "required Speedily to bring in and deliver to the Officers of his Majesty's Mint all Such Counterpuncheons, Charges, Letters and Dyes, and all other Tools and Engines for Coyning by way of the Press or Hammer as he hath in his Custody."[101] In 1662, a convicted coiner, one Richard Oliver, claimed that he had bought his "stamps for coining shillings and half crowns, from Mr. Hill, under graver of the Mint."[102]

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[99] Challis, *A New History of the Royal Mint*, 362; TNA MINT 1/7, 1664-1750, Royal Mint: Record Books: Volume 7, 33.

[100] TNA MINT 1/1, 141.

[101] Ibid.

[102] Charles II - volume 64: December 1662, In *Calendar of State Papers Domestic: Charles II, 1661-2*, ed Mary Anne Everett Green. (London: Her Majesty's Stationery Office, 1861), http://www.british-history.ac.uk/cal-state-papers/domestic/chas2/1661-2/pp578-592. Accessed November 16, 2015. Nothing more is known about Mr. Hill, as this entry in the *CSPD* is the only record of him listed in Challis's compellation of Mint employees.

It was not only former Mint employees who could be of concern, however. On March 27, 1663, Charles II issued an order commanding all of his "Loving Subjects that they presume not to make keep or Use any of the Presses…or any other Tools or Engines employed in the New Way of Conyning…Such Presses, Rowlers and other Tooles and Engines…in whose Custody Soever found (out of his Majestys Mint) be…seized and Secured by the Officers of the Said Mint."[103] Furthermore, "the Warden of the Mint or Some other of his Majestys Justices of the peace to make diligent Search in all such suspitious places (of which he or they shall receive particular notice and Information) for all Sorts of Puncheons, Stamps, and Dyes…and all other Coyning Irons that may be Used in the Counterfeiting of any of the New currant Moneys of this Kingdom or of any other Coyns that had course under the late Usurped powers, whether made by the Mill and press or by the Hammer." The order specifically called out the dangers "that may arise by permitting of Presses, Roulers, Cutters, Instruments to make the Edges of the Moneys with Letters or Graynings and other Tools and Instruments necessary and Used for Coyning to be in the possession of private persons though Under the pretence of making Farthings, Counters, or the like." Anyone in possession of such instruments was ordered to turn them into the Mint to be destroyed.[104]

This order bore little fruit, however, and in the 1670s, when there was movement towards producing official copper farthings in the Mint, the call for the destruction of "all Stamps, Engines, Presses…and other Instruments Appertaining to the Coyning of ffarthings and Half pence" was renewed.[105] Several towns, counties, and groups of shopkeepers and tradesmen petitioned for pardons for having produced farthings on their own, suggesting that such

[103] TNA MINT 1/1, 148.

[104] Ibid., 149.

[105] Ibid., 154.

instruments were widespread even outside of counterfeiting circles.[106] Although most (if not all) were undoubtedly struck by hand, the crown's inclusion of "Presses" in the declaration shows its fear that part of Blondeau's new technology had spread. This was not an idle fear, and one farthing-making outfit (George Chitty and Partner) had their "two presses or Engines for Stamping ffarthings" confiscated by Mint officials. The machines were later returned to the men, but only after "being first broken, defaced, and made Unapt" for the continued production of coins.[107] Certainly, a century later, machines were being employed to strike unofficial farthings and tokens throughout Britain.[108]

Since the old coins continued to circulate, clipping continued to be a problem, and the value of English currency continued to diminish. Milling did provide some deterrent for clippers, as recorded in the Old Bailey case of April 11, 1678 where, in attempting to acquire money to clip, one group specifically refused "Mill-money," offered to them in change.[109] Given that most milled money was promptly melted and exported to the continent for sale as bullion, it is unlikely would-be clippers had much trouble avoiding the supposedly un-clippable milled money.

Records of the Old Bailey from the 1670s and 1680s continue to show that clipping was by far the more common crime, but counterfeiters did continue to create false coin. While some defendants were counterfeiting old coins—including a pair convicted in 1679 who were

[106] For the petitions see, ibid., 154, Norwich; 158, Ipswich; 159, Counties of Cambridge and Huntingdon; 157, "Shopkeepers and others in Surry and Southwark", "Shopkeepwers and others in Westminster & county of Middlesex"; 159, "Diverse tradesmen of London;" 166, several named individuals.

[107] Ibid., 170.

[108] Selgin, *Good Money*, 268-277. Selgin finds it likely that all pre-Boulton commercial coinage was struck manually, rather than using water- or horse-powered mills.

[109] Tim Hitchcock et al., *The Old Bailey Proceedings Online, 1674-1913*, (www.oldbaileyonline.org. Version 7.1, August 13, 2014). April 11, 1678 (t16780411-5).

specifically identified as having "an Art to make a Nine-pence or Groat just new made, look as if it had been coined these hundred years"—those who attempted to replicate the new milled coinage were also to be found in the courtroom. [110] Small-scale offenders were molding counterfeit coins to mimic the appearance of milled coinage, as in the case of Ralph Cook, convicted 21 April 1680, for "unlawfully Coin[ing] several new Mill'd half-crowns, to the number of seven, which were proued to be made out of Pewter Plate." The equipment found in his possession upon search listed no noisy, capital-intensive presses, but instead "a casting Mould, a Flask, and several engraving Tools."[111]

Suggestions of larger-scale operations with mint-like presses are found in the court records as well. For example, an unnamed couple was charged 12 December 1677, and the search revealed "several sorts of Metals, divers pieces of stolen Plate, a Coyning-Press, and some other Tools."[112] Similarly, the aptly named Daniel D'Coiner and Catherine D'Coiner were brought before the court at the end of December 1684 for clipping and coining, including the production of "false Guinneys, half Guinneys, Mill'd Half-Crowns, and Crowns" and his lodgings were found to contain "almost all manner of Coining Instruments"[113]

A surviving list of confiscated items dated from 10 September 1686 gives some idea of the range of equipment employed by “Clippers & Coyners.” The items confiscated ranged from small, fairly ordinary items such as files and melting pots, through a “Mill Engine for drawing & coyning of money.” The list makes it clear that Blondeau’s technology had not stopped counterfeiters, as the entries include “iron molds engraved for casting mill’d Crowns,” “Two pair

[110] Ibid. February 26, 1679 (t16790226-16).

[111] Ibid. April 21 1680, Ralph Cook (t16800421-11).

[112] Ibid. December 12, 1677 (t16771212-7).

[113] Ibid. December 10, 1684. Daniel D'Coiner, Catherine D'Coiner (t16841210-42).

of Dyes for coyning mill'd halfe crownes" and "Two small iron cases with Letters for marking the edges of mill'd half Crownes".

At the end of the century, two petitions presented to the Treasury concerning confiscated instruments suggest that many metalworking occupations used tools that could be construed as too similar to the machines used in the Mint. A Mr. Bovey petitioned to have his invention "an useful Engine for [making metal buttons] being a small Hand Engine going with a single Screw never before or since used in England by any other" released. Despite an earlier vindication of his tools, the Mint had called in this equipment, possibly due to the machinations of one Daniel Critchlow who was trying to hurt Bovey's business.[114] At the same time a man who manufactured "hooks and chains for watches" submitted a similar petition, also claiming he was also the victim of the devious Mr. Critchlow.[115] Newton and his fellow Mint Officers were not persuaded by these petitions, reporting to the Treasury that they thought allowing these machines to be returned to their owners would set a dangerous precedent. The Officers believed that "their Presses may be used in Coynage" despite the petitioners' claims to the contrary (and the apparent clearing of both machines at an earlier date). The officers conceded that while "one or two Presses might perhaps be safely licensed" this would merely encourage more petitions, "and after the precidents of licensing these presses, it may be more difficult to refuse the rest: and it may be of ill consequence to licence too many."[116] In some queries drafted around the same time, Newton pondered the extent to which similar machinery could be safely used outside of the Mint in legitimate industry:

[114] TNA MINT 19/1, 454r.

[115] Ibid., 456r.

[116] Ibid., 458r.

> Several persons have been taken up with Presses sufficient to coin money & plead in excuse that they use them ^only^ in their trades of making metal-buttons bowes for watch keyes, middles for Dial-plates of watches & pillars for watches
>
> Quare 1. Is this a sufficient excuse to free them from being prosecuted for high treason.
>
> Quare 2. May not the presses be demolished by order of one or more Justices of the Pease[sic] without a Prosecution.
>
> Quare 3. May not one or two Artificers be authorised to have Presses for doing this sort of work for Watch-makers & Button-makers & others, without leaving every man at liberty to have coining Presses who can pretend that he uses them in his Trade.[117]

Given Newton's rejection of manufacturers' appeals, his answer to these queries may well have been a resounding no. As Warden of the Mint, he had no concern for the success of any business except for keeping the coinage as safe from counterfeits as possible.[118]

The Absence of Alchemy

Given the attention paid to alchemy in recent work on the history of early modern science, it makes sense to ask at this juncture whether alchemy played any role in the Restoration Mint. This question is plagued with problems of terminology. As William Newman and Lawrence Principe have argued, the divisions between what constituted "alchemy" and "chemistry" were not clearly defined through the end of the 17th century, and have proposed that historians adopt the term "chymistry" as a reflection of multiplicity of practices, theories, philosophical stances and purposes held by early modern thinkers and workers who were investigating the behavior and manipulation of physical substances.[119] The Mint setting seems an

[117] Ibid., 460r.

[118] Newton's memorandum is undated, but the preceding petitions are dated April 1699, when Newton was still Warden. He succeeded Sir Thomas Neale as Master upon Neale's death in December 1699.

[119] William R. Newman and Lawrence M. Principe, "Alchemy Vs. Chemistry: The Etymological Origins of a Historiographic Mistake," *Early Science and Medicine* 3, no. 1 (1998).

apt place to find one part of early modern chymistry—chrysopoeia, the branch of 17th century chymistry concerned with the transmutation of metals.

In the past decades, the work of many scholars has clearly established the importance of alchemical thought to the emergence of the new science in 17th century England. Lawrence Principe and William Newman demonstrated the importance of alchemical thought to the development of significant characteristics of modern chemistry, including matter theory.[120] Principe established the importance of Boyle's alchemical interests to his life work, while Betty Jo Dobbs had earlier showed Newton's extensive alchemical reading, and the importance of this investigation to his work in many subjects.[121]

The work of Newman, Principe, Dobbs, and others has often emphasized the conceptual aspects of alchemical and chemical investigations in the early modern period. While Principe and Newman demonstrated that early modern investigators pursued alchemy in laboratories as well as libraries, the practical side of early modern chymistry was often downplayed in their analysis, which focused more on intellectual lineages of modern thought. Tara Nummendal's recent work on alchemy in central Europe in the 16th and early 17th centuries has placed a greater emphasis on what she has called "practical alchemists" (in contrast to "philosophical alchemists"—a category in which Boyle and Newton would be more at home).[122] Those she labels as practical alchemists primarily focused on the productive power of a variety of alchemical/chymical techniques, and

[120] William R. Newman and Lawrence Principe, *Alchemy Tried in the Fire : Starkey, Boyle, and the Fate of Helmontian Chymistry* (Chicago: University of Chicago Press, 2002); William R. Newman, *Atoms and Alchemy : Chymistry and the Experimental Origins of the Scientific Revolution* (Chicago: University of Chicago Press, 2006); Principe, *Aspiring Adept*.

[121] Betty Jo Teeter Dobbs, *The Foundations of Newton's Alchemy: Or, "the Hunting of the Greene Lyon"* (Cambridge; New York: Cambridge University Press, 1975); Betty Jo Teeter Dobbs, *The Janus Faces of Genius: The Role of Alchemy in Newton's Thought* (Cambridge; New York: Cambridge University Press, 1991).

[122] Tara E. Nummedal, "Practical Alchemy and Commercial Exchange in the Holy Roman Empire," in *Mechants and Marvels: Commercy, Science, and Art in Early Modern Europe*, ed. Pamela H. Smith and Paula Findlen (New York: Routledge, 2002), 205. See also Nummedal, *Alchemy and Authority in the Holy Roman Empire*.

these practitioners marketed (and were hired for) their abilities to make medicines and improve mine production. Among the figures she studied are those who were specifically hired to perform transmutational activities, sometimes specifically with regard to providing materials for ducal mints.[123]

While Nummendal's analysis focused on the Holy Roman Empire before the Thirty Years' War, the continued prominence of philosophical alchemy in mid-to-late 17th century England does suggest that practical alchemists might be lurking in the English manuscripts as well. This, however, was not to be the case. Unlike Nummendal's courtly contractors, the workers at the 17th century English Mint are not referred to as alchemists.[124] The letters, minutes, accounts, and contracts I consulted refer to people by their specific occupation—melter, coiner, assayer, etc. Whatever professional affinity they may have felt, and, just as importantly, whatever theoretical ideas they may have held regarding the explanations for the physical processes that were part of their daily work, were not recorded for posterity. Nor does the term "chymistry" or its variants appear. Given the parallels between some alchemical skills, and the regular tasks of the Royal Mint, how can we explain the lack of overlap between the two after 1660?

Lawrence Principe has proposed that the disappearance of chrysopoeia from "the domain of serious inquiry" in European intellectual circles in the early 18th century was linked to a self-conscious attempt at professionalization of chemistry.[125] He argues that certain members of the

[123] Nummedal, "Practical Alchemy and Commercial Exchange in the Holy Roman Empire," 204. See also the case of Colonel Boon in Pamela H. Smith, *The Business of Alchemy: Science and Culture in the Holy Roman Empire* (Princeton, NJ: Princeton University Press, 1994), 72.

[124] Nummedal, *Alchemy and Authority in the Holy Roman Empire*, 15-16.

[125] Lawrence M. Principe, "A Revolution Nobody Noticed? Changes in Early Eighteenth-Century Chymistry," in *New Narratives in Eightennth-Century Chemistry: Contributions from the First Francis Bacon Workshop, 21-23*

Académie des Sciences sought to distance themselves from the image of "chymists as a herd of dreamers, fools, mountebanks, and poisoners," when the reorganizations of 1699 created a permanent institutional home for chemists.[126] The solution that he proposes is tied to the specific French context, but does not answer the question of why chrysopoeia disappeared throughout Europe at this time. He references anti-alchemical language in Sprat, as indicating concerns about the image of chemistry at the Society, but as the Society did not establish any sort of permanent chair for chemistry at this juncture, nor did it rely on state funding, the parallel lacks explanatory force.[127]

In England, unlike France, the chrysiopoetic aspect of alchemy was against the law until 1688. A statute enacted under Henry IV (1403/4) had banned the "multiplication of gold and silver" as a felony (usually punished by death) and it was not repealed until William and Mary took the throne. Interestingly, the Act of repeal suggests that, at least by 1688, "multiplication of gold and silver" was understood primarily in a mining and metallurgical context. In offering reasons for the repeal, the Act asserted that the old statute had led those with "great Skill and Perfection in the Art of Melting and Refineing of Metalls and otherwise improving them and their Ores...and extracting Gold and Silver out of the same" to put their skills to use only in "Forreigne parts" out of fear of punishment. The alienation of such important knowledge was a "great Losse and Detriment [to] this Realme," and thus the statute of Henry IV was repealed. The only caveat inserted in the repeal was a reassertion of the Crown's traditional right to ownership

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April 2005, California Institute of Technology, Pasadena, California, ed. Lawrence M. Principe (Dordrecht: Springer, 2007), 7.

[126] Ibid., 11.

[127] Ibid., 11, note 47. Sprat's account was an intentional apologetic text for the Society, and can only be used cautiously to understand the attitude of the Royal Society as a corporate body. P.W. Wood, "Methodology and Apologetics: Thomas Sprat's *History of the Royal Society*," *British Journal for the History of Science* 13, no. 43 (1980).

of these precious metals, and more specifically, any gold or silver obtained by methods of multiplication were only to be used for "the Increase of Moneys." Anyone with any such metals was to repair to "their Majestyes Mint within the Tower of London" where they would be paid for their goods. The last section hinted at a more traditional alchemical understanding, as it explicitly forbids copper, tin, iron, or lead mines from being declared Royal Mines, even if a clever person was able to "extract" gold or silver from these base metal mines.[128]

While investigating the multiplication of gold and silver was technically illegal in England before the repeal, plenty of evidence exists to show the ban was not absolute, as the crown periodically issued patents to specific petitioners granting permission to practice alchemy. For example, barely fifty years after Henry IV's decree, his grandson Henry VI issued a license to three men to pursue alchemy "notwithstanding the said statute, or any other penal statute to the contrary, issued or provided against multipliers."[129] The potential benefits from alchemical research led other monarchs to issue similar licenses which "were granted on several occasions up to the first part of the 16th century."[130] Under Elizabeth I, trusted minister William Cecil supported alchemists, along with a variety of mineral and metallurgical projects, as he looked for new ways to increase England's mineral resources, including gold and silver.[131] In addition, an anecdote about a person approaching Sir Thomas Alesbury (joint commissioner for the Master of

[128] "William and Mary, 1688: An Act to Repeale the Statute Made in the Fifth Yeare of King Henry the Fourth against [the] Multiplying Gold [&] Silver [Chapter Xxx Rot. Parl. Pt. 4. Nu. 10.]," In *Statutes of the Realm: Volume 6, 1685-94*, ed John Raithby. (Great Britain Record Commission, 1819), http://www.british-history.ac.uk/statutes-realm/vol6/p95. Accessed November 10, 2015.

[129] Quoted in D. Geoghegan, "A Licence of Henry VI to Practise Alchemy," *Ambix* 6, no. 1 (1957): 16.

[130] Ibid., 10.

[131] Harkness, *The Jewel House*, 169-179.

the Mint from 1635-1643) for such a license suggests that such petitions were still occasionally issued in the years before the civil wars.[132]

Interestingly, criminal accusations concerning this activity are also absent from the records. During the Interregnum, Pierre Blondeau and the Corporation of Moneyers swapped charges of incompetence and criminal behavior, but the emphasis was on mechanical cheats and points of law and privilege, not metallurgical sleight of hand. In the one exception, Blondeau described testing coins produced with his machine to see if the depredations of washing would be readily visible (he assured his readers that they were). The Moneyers were thrown into a rage at Blondeau's claims of mastery of the coin-producing skills under their purview, and claimed his work was illegal because it took place outside the Mint. Nothing in their demands that he be thrown into Newgate prison, however, rest on any issues concerned with secret, suspect, or rare knowledge about the manipulation of matter.[133] Similarly, records of criminals prosecuted in the Old Bailey for coinage offenses between 1674 - 1700 show straightforward crimes of physical depredation: men and women who clipped bits off of gold and silver coins, or the less frequent counterfeiters who used poorer mixtures of gold and silver, or gilded base metals, and molds or presses to create false coins. Those who counterfeited were found guilty though the possession of "engines," molds, hammers, or presses to produce fake coins, and no evidence is mentioned of any alchemical *accoutrements*.[134] The technique known as "washing" coins—dissolving some of

[132] Samuel Hartlib, "Hartlib Papers 29/4/4a, Ephimerides 1654 Part 1," In *The Hartlib Papers.*, ed M. Greengrass, Leslie, M. and Hannon, M. (HRI Online Publications, Sheffield 2013), http://www.hrionline.ac.uk/hartlib. Accessed November 16, 2015.

[133] Corporation of Moniers in the Mint and Thomas Violet, *The Ansvver of the Corporation of Moniers in the Mint, at the Tower of London, to Two False and Scandalous Libells Printed at London...* (London: Printed for the Corporation of Moniers, 1653).

[134] See, for example, "Old Bailey Proceedings" December 1677 (t16771212-7); "Old Bailey Proceedings" January 1678, trial of Shoomaker (t16780116-7); TNA MINT 15/19, 1686, List of Tools and Materials Taken from Clippers and Coiners in Several Counties of England. When Blondeau's coins were first made current, proclamations from

the silver or gold by immersing it in the appropriate chemical solution—was closest to the practice of the alchemist, but such activities were rare. Indeed, one piece of evidence suggests that washing coins was the most expensive and laborious way of cheating the currency, and therefore unlikely to be pursued by those with other means.[135] All crimes against the currency could be punished by death, so the harsh penalty for transmutation was not an especial deterrent.

While men with interests in alchemical theory and practice could be found in the Royal Society, and in the court of Charles II, there is no evidence that alchemy was viewed as a practical solution to England's monetary problems of the second half of the 17th century. Mint manuscripts from the Restoration show a concern with establishing and maintaining a trustworthy gold and silver coinage through the introduction of new manufacturing practices and greater control of crimes against the currency. Although a shortage of gold and silver in 17th century England meant the Mint operated only sporadically, usually deriving its raw material from other coins, such as the recalled harp and cross coins and French silver from the sale of Dunkirk in 1662, efforts to maintain a reserve of gold and silver for Mint production was focused on (failed) attempts to stop the illegal exportation of gold and silver.[136] Investigating new sources of precious metals did not fall under their purview.

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the Privy Council show an exclusive focus on controlling the physical machinery involved. See TNA MINT 1/1, 148-149.

[135] Blondeau's answers to objections made to his proposal in the Interregnum argued that washing his coins would be unlikely, because, among other reasons his own experiments had shown "that the ingredients that are requisiste, and the charge necessarie to bring again together the gold or silver, will cost more, or as much at least, as the profit of washing may come unto," although he obviously stood to benefit from making such a claim about his coins. Blondeau's "Answer" printed in Mint and Violet, *The Ansvver of the Corporation of Moniers in the Mint, at the Tower of London, to Two False and Scandalous Libells Printed at London,* 8; Malcolm Gaskill, *Crime and Mentalities in Early Modern England* (Cambridge: Cambridge University Press, 2000), 138.

[136] Challis, *A New History of the Royal Mint*, 339. Numerous petitions were issued on the subject of exportation such as England, Sovereign Wales, and King of England Charles II, *By the King. A Proclamation, against Exportation, and Buying and Selling of Gold and Silver at Higher Rates Then in Our Mint: As Also against Culling, Washing, or Otherwise Diminishing Our Current Moneys* (London : Printed by John Bill and Christopher Barker, printers to the King's most excellent Majesty, 1661. At the King's printing-house in Black-Friers., 1661). Writers of various stripes also weighed in on the subject. For example, Thomas Violet, *The Advancement of Merchandize or,*

The absence of alchemy at the Mint suggests that certainly by Newton's tenure, and probably before, metallurgy had separated from the dominant strain of English alchemical thought. While Boyle and others in the Restoration pursued transmutation alchemical research, their focus was never on any gold that might result from successful transmutations. Rather, as Lawrence Principe and other recent scholars have shown, Boyle pursued alchemical knowledge as a path towards greater natural philosophical and religious knowledge.[137] While rulers on the Continent continued to support alchemists with an eye for their ability to produce gold into the early years of the 18th century, in England (and then Britain) any shortage of bullion was viewed as a problem of trade and was to be dealt with by passing laws banning the export of silver and gold and by criminal prosecution those who defrauded the state through their actions—not alchemists, but coiners and clippers.[138]

Previous scholars, such as Charles Webster, have linked alchemical research with the radical thinkers and sectarians of the Interregnum, but alchemical thought and research was not monolithic, and could be found in Royalist circles as well (Sir Kenelm Digby, for example).[139] In addition, upon his Restoration, Charles II brought Niçaise Le Fevre from France as royal apothecary and professor of chemistry. While Le Fevre was primarily interested in medical alchemy, his book *Traite de la Chemie*, translated into English in 1662, spoke of transmutation

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Certain Propositions for the Improvment of the Trade of This Common-Wealth, Humbly Presented to the Right Honoroble the Council of State. And Also, against the Transporting of Gold and Silver. (London: Printed by William Du-Gard, Printer to the Council of State, anno Dom. 1651., 1651), 33-36; Samuel Fortrey, *Englands Interest and Improvement Consisting in the Increase of the Store, and Trade of This Kingdom* (Cambridge: Printed by John Field, 1663).

[137] Principe, *Aspiring Adept*.

[138] Ku-Ming (Kevin) Chang, "Toleration of Alchemists as a Political Question: Transmutation, Disputation, and Early Modern Scholarship on Alchemy," *Ambix* 54 (2007); Smith, *Business of Alchemy*. Sovereigns from Henry VII to Charles II periodically issued proclamations banning export of gold and silver.

[139] Charles Webster, *The Great Instauration: Science, Medicine and Reform, 1626-1660* (London: Duckworth, 1975), 403.

as real though practically difficult.[140] Political divisions alone do not explain the absence of alchemy after the Restoration.[141]

While the question of what happened to practical alchemy in 17th century England requires further investigation, the evidence shows that it was no longer alive and well by the Restoration. Alchemical interests in England were to be linked exclusively to highly literate practitioners. Boyle himself drew the distinction between the two kinds of alchemical (chymical) practitioners, writing in *The Sceptical Chymist*, that he would "enjoy [the] Conversation...and thankfully be instructed" by chymists concerned with the spiritual and theoretical uses of alchemy. The same book was dismissive of "Chymists that are either cheats, or but Laborants," wanting to have nothing to do with "distillers, refiners and others, who were so preoccupied by hands-on processes that they lacked an interest in theory."[142] Although Boyle helped secure the repeal of the statute forbidding the multiplication of gold and silver, he was not concerned with practical matters involving gold and silver, such as the effect the gold supply would have on the functioning of the Royal Mint and the strength of English currency.[143]

While the virtuous adept was supposed to be disinterested in any monetary gains that might result from his work, the absence of alchemical gold-producing schemes in the discussions of English alchemy proponents of the later 17th century indicates that this disclaimer was more than just a trope. There was a true absence of interest in transmutational gold production *as* gold production. Despite its importance to the English state and the technical similarities between coin

[140] Nicaise Le Fèvre, *A Compendious Body of Chymistry*, trans. P.D.C. Esq. (London: printed for Tho. Davies and Theo. Sadler, 1662), 34.

[141] Chang, "Toleration of Alchemists as a Political Question."

[142] Michael Hunter, *Boyle: Between God and Science* (New Haven: Yale University Press, 2009), 119. Boyle's quote is from *The Sceptical Chemist*, found in Robert Boyle, Michael Cyril William Hunter, and Edward Bradford Davis, *The Works of Robert Boyle*, 14 vols. (London ; Brookfield, Vt.: Pickering & Chatto, 1999), 2: 213.

[143] Hunter, *Boyle: Between God and Science*, 234.

production and alchemical laboratory work, by second half of the 17th century, the serious pursuit of alchemical questions in England did not extend to the idea of alchemy as a method of large-scale gold production.

Conclusion

This dissertation has begun to answer two different but interrelated questions: *who* was studying the natural world in London between 1660 and 1700, and *where* within the city were they doing it? As the preceding chapters have shown, the cast of characters associated with the pursuit of natural knowledge in late 17th century London was larger and more socially diverse than previous historians have emphasized. Simultaneously, the places where questions about the natural world were investigated were more varied. Those in London, both inside and outside of the Royal Society, who participated in aspects of the new science—experimentation, manipulating natural substances in the "useful arts," and gathering observations and objects—found their investigations shaped by the urban environment. Fellows, virtuosi, curious investigators, and artisans of all kinds regularly contended with the messy, chaotic, dangerous, and happenstance nature of life in a growing metropolis, often squeezing experiment, observation, and collection into spaces designed for, and sometimes simultaneously used for, other activities. Activities, spaces, hazards, and developments unrelated to the new science provided unplanned opportunities for unexpected experiments, observations, or inventions.

This dissertation focused on illuminating the intricate, yet ordinary, details involved in pursuing the new science and studying nature in late 17th century London, details that often were the same for those wanting to enact a major reform of natural knowledge as for those unconcerned with such philosophical questions. In focusing on the workaday movement of people around Gresham College and the Royal Society, the daily weather logs of a little- known apothecary, the accidental and commercial processes necessary to create a collection, and the complicated relationship between Crown goals, moneyers' skills, and licit and illicit metallurgical knowledge, this dissertation contributes to the project of understanding how nature

was investigated, where these investigations took place, by whom, and for what purposes in late 17th century England. While the institutionalization of the new natural philosophy represented by the Royal Society was a crucial moment in the history of science, this dissertation has demonstrated that the study of nature stretched out beyond the Society's borders. The early Royal Society drew on skills, labor, and unexpected expertise outside its Fellowship to shape its investigations while skills similar to those valued by the Society's Fellows could be found in industries such as minting. At the same time, the experimentation, observation, and collection essential to the new science took place in small shops, Royal palaces, and the streets of the metropolis itself. The characters and locations of the new science were changing and varied, but throughout the city were found many who, like John Conyers, accumulated their own additions to a "Treasury of Learning" about the natural world.

While historians no longer speak of a straightforward scientific revolution in the early modern period, England in the late 17th century remains an important time and place for understanding the rise of the modern sciences. The Fellows of the Royal Society institutionalized a mechanical, experimental, observational, and mathematical approach to studying nature. They envisioned a grand reform of knowledge, and individual Fellows contributed lasting theoretical and experimental innovations to natural knowledge. Too often, however, the work and prolixity of these Fellows skews our view of who studied nature and why in Restoration London. While highly mathematical or abstract theoretical work might involve a set of skills held by only a limited number of highly educated elites, studying nature by direct involvement—through personal observation, work with natural and artificial materials, or use of instruments for experiment or observation—were more widespread practices.

Understanding the ways in which the knowledge and study of nature changed during the early modern period requires that we consider the full spectrum of ways in which the natural world was investigated—hands-on manipulation as well as mathematics, collections as well as corollaries. What changed over these centuries was not only how natural philosophers thought about the natural world, but also how they approached learning about it. The practices that gained ascendance in this period were not created *de novo* for the new intellectual enterprise of the Royal Society elites, and the work of studying nature involved many hands. By tracing the manipulation and investigation of nature through many archives and many corners of late 17th century London, this dissertation has demonstrated that the hands-on pursuit of natural knowledge was intertwined with ordinary aspects of many people's lives. The Royal Society was merely the most formal group of late 17th century Londoners interested in experiential investigation of the natural world. The ways in which practices of investigating nature did not straightforwardly map onto theoretical commitments, broader philosophical interests, or even ideas about practical applications, however, demonstrates the complicated mixture of ideas and techniques that constituted early modern science, a complexity that needs to be reflected in the history of this period.

Appendix 1:

Preliminary Catalogue of John Conyers's Collections

The following catalogue is compiled from passages in Conyers's notebooks where he devotes significant time to discussing items he has found in London, records of items purchased from Conyers by William Courten, and references to specific items made by Conyers's contemporaries.[1] The manuscript source for each reference is indicated. Most descriptions were translated into modern American English, to ease readability, with occasional quotes where the 17th century descriptions are particularly lucid or informative. I have maintained Conyers's descriptive terms (such as Roman, Briton, gold, copper) without regard to what terms modern archeology would assign to these items.

To ease readability, I have divided the materials into a few categories, but have kept such organization to the minimum, so as not to impose modern categorization onto these materials, which may have been arranged in any number of ways. There are undoubted repeats in this table, as it is impossible to determine from Conyers's largely undated entries when he is referring to the same potsherds or coins. Except in the cases of the elephant's teeth, boar's tusks, stone axe, and his weather instruments, which are identifiable as separate items across manuscripts, I have generally not compacted entries, preferring to list individual references independently. Readers should keep in mind the high possibility of repeats, particularly in the antiquarian and coin categories.

Additionally, as Chapter 4 discussed, early modern collections, Conyers's among them, were not static entities. While Conyers did own all of the items below at some point between

[1] A transcription of Sloane Ms. 958 f. 105r-109v; 113v can be found in J. Burnby, "John Conyers, London's First Archaeologist," *Transactions of the London & Middlesex Archeological Society* 35 (1984): 73-78. I have used Burnby's transcription to clarify my own reading on a few points on these pages.

1670 and his death in 1694, it is not possible at this time to determine which ones he owned at the same time.

Naturalia

'Elephant' teeth (both fragments and whole teeth) and shoulder blade bones found near the Pindar of Wakefield in 1673 and near a 'drying house' in 1679.	Sloane 937, f. 166r Landsdowne 808, f. 77v-78r Sloane 3961, 53r-53v Sloane 919 f. 11v, 12r Hooke, *Diary*, 104.
1 piece of a mushroom sponge	Sloane 3961, 53r
1 piece of a spleen stone	Sloane 3961, 53r
1 large *Lapis Judaicus*	Sloane 3961, 53r
1 Oxfordshire cockleshell	Sloane 3961, 53r
2 Bore's Tusks found near Cheapside	Sloane 3961, 53r
1 piece of Agate, white and green	Sloane 3961, 53r
1 piece of crystal, with a red streak	Sloane 3961, 53r
1 square white Agate with markings	Sloane 3961, 53r
1 stone of a fruit	Sloane 3961, 53r
1 agate eyestone very fine	Sloane 3961, 53r
1 small agate with 2 eyes	Sloane 3961, 53r
1 piece of a stone Astroites	Sloane 3961, 53v
1 spleen stone hatchet	Sloane 3961, 53v
1 piece of triangular crystal, "called the English pearl"	Sloane 3961, 53v
1 Flint Echinus in its bed	Sloane 3961, 53v.
1 piece of stone like rawne	Sloane 3961, 53v
3 pieces Astroites in stone	Sloane 3961, 53v
1 piece of amber with a fly in it	Sloane 3961, 53v.
1 Agate flint with spots like cut Tobacco	Sloane 3961, 53v
1 piece of a flint Astroites	Sloane 3961, 53v
1 branch of fern upon a pebble	Sloane 3961, 53v
1 large spleen stone pebble	Sloane 3961, 53v.
1 piece of flint, red and white, with knops like pearl	Sloane 3961, 53v
1 piece maple wood knopped	Sloane 3961, 53v
1 Jagged bladder stone	Sloane 3961, 53v
1 large piece of serpentine stone	Sloane 3961, 53v
Bore's teeth	Sloane 958, f. 113v
Oyster shells & other shells	Sloane 958, f. 113v
Misc. animal horns (hartshorn, old heifers, boars tusk and jawbones)	Sloane 958 f. 109v
[the material medica in his shop???]	

Pictures

List dated 1672, when they were seized for payment of a debt. It is not known if he recovered them.

Queen Elizabeth	Sloane 2031, 34v
The Cobbler and his child	Sloane 2031, 34v
Landscape of 6 milk-maids and cows	Sloane 2031, 34v
Adam and Eve	Sloane 2031, 34v
A woman washing herself	Sloane 2031, 34v
A woman beating her husband	Sloane 2031, 34v
Richard II	Sloane 2031, 34v
Rotterdam[?]	Sloane 2031, 34v
3 miscellaneous pictures	Sloane 2031, 34v
Henry the 8th	Sloane 2031, 34v
A storm at sea	Sloane 2031, 34v
A landscape	Sloane 2031, 34v
A Gentlewoman	Sloane 2031, 34v
"le Papa Bon Companie"	Sloane 2031, 34v
Major Poyne[Payne?]	Sloane 2031, 35r
King James the 1st	Sloane 2031, 35r
King Charles the 1st	Sloane 2031, 35r
A large Picture of Solomon's Wisdom	Sloane 2031, 35r
Savages or Satyrs in Peril	Sloane 2031, 35r
A woman giving her father suck	Sloane 2031, 35r
Oliver's Picture[2]	Sloane 2031, 35r
A Hen & Chickens	Sloane 2031, 35r
Friars, a Nun, and [illegible word]	Sloane 2031, 35r
A Turkish woman with flowers	Sloane 2031, 35r
A Picture of St Jerome	Sloane 2031, 35r
A little Picture of a Woman marked 1577	Sloane 2031, 35r
A fuller and his money bags	Sloane 2031, 35r
A Picture of Mrs. Ann ———	Sloane 2031, 35r
A young [girl?]	Sloane 2031, 35r
Henry the 7th	Sloane 2031, 35r
Stenlier[?]—Gardnier	Sloane 2031, 35r
Cardinal Woolsey[3]	Sloane 2031, 35r

[2] Perhaps a portrait of Oliver Cromwell.

[3] Presumably Thomas Wolsey, minister to Henry VIII.

Antiquarian (non-coin)

6 pieces of red earth sacrificing cups	Sloane 3961, 53r
1 Lamp	Sloane 3961, 53r
1 Talisman in steel	Sloane 3961, 53r
1 Ancient Armillia	Sloane 3961, 53v
1 Talisman upon an Helitrope	Sloane 3961, 53v
1 Agate with a hare on one side & a golden lion on the other side	Sloane 3961, 53v
2 Roman stiles to write with	Sloane 3961, 53v
1 piece of a brass fibula	Sloane 3961, 53v
1 small brass Priapus that the Ancients hung about their children's necks	Sloane 3961, 53v.
1 one Larger [Priapus?]	Sloane 3961, 53v
1 Lachrymal urn	Sloane 3961, 53v
1 Egyptian beetle of Agate	Sloane 3961, 53v.
3 Tesseras of the Ancients & a broken piece of an Armilla	Sloane 3961, 53v
Brass rings, large and small	Sloane 937, f. 179r
Unidentified "brass instruments"	Sloane 937, f. 179r
Twisted brass wire	Sloane 937, f. 179r
Antique spurs	Sloane 937, f. 180v
A large spur	Sloane 937, f. 180v
Rowels and daggers[4]	Sloane 937, f. 180v.
Keys	Sloane 937, f. 180v.
Knives	Sloane 937, f. 180v.
Scissors	Sloane 937, f. 180v
Arrow shafts	Sloane 937, f. 180v
Files	Sloane 937, f. 180v
Punches	Sloane 937, f. 180v
Nails	Sloane 937, f. 180v
Miscellaneous pieces of antique iron	Sloane 937, f. 181v
British flint weapon "dexterously shaped by their extraordinary art"	Landsdowne 808, f. 77v
Roman Ivory work & great Pins made of Bone & bodkins great numbers of each	Sloane 958, f. 113v
Roman beads of green and blue enamel	Sloane 958, f. 113v
Roman fibulae	Sloane 958, f. 113v
Roman earthenware with inscriptions	Sloane 958, f. 113v
Roman glass	Sloane 958, f. 113v
Antique daggers	Sloane 958, f. 113v
Antique large spur rowels[5]	Sloane 958, f. 113v

[4] The meaning of 'rowel' here is unclear; it could be almost anything circular.

Antique arrow and dart shafts	Sloane 958, f. 113v
Antique keys, scissors, and knives	Sloane 958, f. 113v
Roman tiles, potshards, and bricks	Sloane 937, f. 176r
A glass vial formerly containing a clear liquid	Sloane 937, f. 177v
Roman glazed potsherds of red clay	Sloane 937, f. 177v.
Tiles & brick	Sloane 937, f. 177v.
Red earthen Potsherds from the Romans, some with inscriptions such as “de Primani:” “de Parici:” “Quintimani” “Victor:” “Janus & Reciniox:”	Sloane 958, f. 105r
Black pots with inscriptions	Sloane 958 f. 106r
Gilded earthenware	Sloane 958 f. 106r
Gilded British lamps	Sloane 958, f. 106r
Lamps of red clay	Sloane 958, f. 106r
Lamps formed from a coarse, whitish-yellow clay	Sloane 958, f. 106r
Gilded urns	Sloane 958, f. 106r
Red clay urns	Sloane 958, f. 106r
Black urns	Sloane 958, f. 106r
Whitish-yellow urns	Sloane 958, f. 106r

Roman tile shards	Sloane 958, fl. 106v
Pots drawn on Sloane 107r	Printed in Burnbey, p. 69
A small Ceres figure “the bigness of 1 quarter of a pint Pewter pot, and about that height”	Sloane 958 f. 108r
A Bacchus figure, about the same size as the Ceres	Sloane 958 f. 108r
Brass pins	Sloane 958 f. 108r
Arrowheads, intact beneath a stony rust-like layer	Sloane 958 f. 108r
Brass or Copper scales, about an inch and a half broad, decorated with an eagle and an inscription “in Large Saxon letters”	Sloane 958 f. 108r
A copper cross	Sloane 958 f. 108r
A oval scale with the inscription “Sigillum Rogeri de Remtum (?)” in old Saxon or Latin letters	Sloane 958 f. 108r
Miscellaneous potsherds and tiles	Sloane 958 f. 108v

[5] Here, a small spiked revolving wheel or disc attached to the end of a spur. "Rowel, N.," In *OED Online*. (Oxford University Press., September 2015), http://www.oed.com/view/Entry/168185. Accessed November 05, 2015.

Spur rowells as broad as your hand & broader	Sloane 958 f. 108v
Keys covered in “a bluish petrified rust”	Sloane 958 f. 108v
Daggers crusted with a bluish rust	Sloane 958 f. 108v
Various potsherds of red earth and marked and colored earthenware	Sloane 958 f. 108v
Fragments of green red, and white stones, like the stones “used in the mosaic work of St. Edward the Confessor’s monument at Westminster”	Sloane 958 f. 108v
Roman pots	Sloane 958 f. 109r
Roman glass beads, blue, yellow	Sloane 958 f. 109r
Roman pins made of bone or ivory	Sloane 958 f. 109r
Brass objects embossed with glass	Sloane 958 f. 109r
Crucible that was used to melt glass	Sloane 958 f. 109r
Glass drops	Sloane 958 f. 109r
Necks of glass cruets	Sloane 958 f. 109r
Iron turned to perfunctory rust	Sloane 958 f. 109r
Potts with inscriptions ('claudio' and 'januarius or janus')	Sloane 958 f. 109v
Roman pottery with figures on them—lion’s head, woman's head; some with covers	Sloane 958 f. 109v
The ‘ears’ of six gallon pots	Sloane 958 f. 109v
Large potsherds	Sloane 958 f. 109v
Tiles made by the ancient Britons	Sloane 958 f. 109v
Roman tiles and Bricks	Sloane 958 f. 109v
"Petrified matter with Pins in it, taken from Fleet Ditch	Sloane 937, f. 168v
“Roman” Shield	Levine, *Dr. Woodward’s Shield*[6]
Roman bricks from a church in Old Fish Street “lined with stucco, painted red with fresco, [and] with bole armeniac”[7]	Aubrey’s *Monumenta* Britannica, p. 500[8]

[6] Joseph M. Levine, *Dr. Woodward's Shield : History, Science, and Satire in Augustan England* (Berkeley: University of California Press, 1977).

[7] Reddish clay from Armenia. Also used medicinally and as a styptic. "Bole, N.2," In *OED Online*. (Oxford University Press, September 2015), http://www.oed.com/view/Entry/21071. Accessed November 05, 2015; "Ammoniac, Adj. And N.," In *OED Online*. (Oxford University Press, September 2015), http://www.oed.com/view/Entry/6460. Accessed November 05, 2015.

[8] John Aubrey and John Fowles, *Monumenta Britannica: Or, a Miscellany of British Antiquities*, 1st subscription ed., 2 vols. (Sherborne Eng.: Dorset Pub. Co., 1980).

Roman Coins and Medals

Miscellaneous Roman Coins	Sloane 937, f.175v
A copper coin "as bigg as halfe crowne" Emperor Nero on one side, plain triumphal arch on the other	Sloane 937, f. 178r
Old Roman Coins of Brass, Copper, coarse gold	Sloane 937, f. 181r
Miscellaneous brass coins in various states of preservation; some quite corroded, others still showing some inscriptions: "one Hadrian & on the reverse a large ship rowed" others showing Constantine, Claudius, and Romulus and Remus and the wolf	Sloane 958, f. 105v
Assorted Roman coins primarily of copper and brass. Of various sizes: "some as big as near a 5 shilling piece," some the size of a crown piece, some the size of the English half pennies and farthings issued in the 1670s, some "as small as the farthing made in King Charles the first his reign"	Sloane 958 f. 108r
A large brass coin with Vespasian on one side Judea Capta on the other	Sloane 958 f. 108r & 108v
Coins that seemed to be "Copper within & brass without" possibly due to reactions with the soil and water in which they lay.	Sloane 958 f. 108r & 108v
One coin from the time of Julius Cesar	Sloane 958 f. 108v
Coins uncovered from the site of St. Paul's, "covered with a thick green rust"	Sloane 958 f. 108v
Roman coins	Sloane 958 f. 108v
Copper & brass Roman Coins	Sloane 958, f. 113v
2 gr. of chios s2s	Sloane 958, f. 113v
1 Traian R. Dacia August. Prot uincias.c	Sloane 3961, 52r
1 Nero R. Pontif M.D.	Sloane 3961, 52r
1 Nerua R. Adlocutio	Sloane 3961, 52r
1 Vespa[?]ian R Fides Publica	Sloane 3961, 52r
1 seuerina R Iuno Regina	Sloane 3961, 52r
1 Vespasian R Aequitas Augusti is	Sloane 3961, 52r
1 Seuerus 1s2s6) Genio Populi Romani	Sloane 3961, 52r
1 Allectus R Pax Ang G1s Dido R Equus	Sloane 3961, 52r

Other Coins and Medals

Coins that were worn "bright like gold" by the movement over gravel in the water they had lain in. Possibly from the reign of Henry 8th.	Sloane 937, f. 178 v
"a hat full" of coins	Sloane 937, f. 179r.
Medals with the crucifix & Ave Marie on one side, crosses on the other	Sloane 958 f. 108v
Ship counters marked with Saxon letters	Sloane 958 f. 108v
More recent copper coin with "cross on one side & flower de luce [=fleur de lis] on the other"	Sloane 958 f. 108v
"Medals of the 24 Latin letters"	Sloane 958 f. 108v

Natural Philosophical Instruments and Equipment

Loadstones	Landsdowne 808, f. 74r
Quicksilver baroscope	Sloane 839, f. 62
Common weather glass "with green water & open bolt-head set in it"[9]	Sloane 839, f. 62
8 different variations on glass orb containing a sponge, each with differently shaped openings	Sloane 839, f. 62; on the origin of these see Sloane 919, f. 27r
Piece of sponge	Sloane 839, f. 62
Two-stemmed thermoscope—two small bolt heads nested one within the other	Sloane 839, f. 62
Glass bubbles floating in a urinal of water with spirit of salt added to it.	Sloane 839, f. 62 Sloane 958, f. 122R, 122V
A hygroscope measuring change in humidity via change in size of crack in a panel of deal wood	Sloane 839, f. 62
Bolt-head filled with spirit of wine	Sloane 839, f. 62
Common weather glass filled with oil of almonds, dyed red	Sloane 839, f. 62
The "3-stems"—three bolt-heads, one foot in length, nested together, set in water	Sloane 839, f. 62 Sloane 958, f. 123v Sloane 919, f. 21r-22r
A Hygroscope made of a silk bag containing earth from the field in which the 'elephant' bones were found, stored in a tin box with	Sloane 958, f. 112r

[9] This is water colored with verdigris, perhaps to make reading the liquid level easier. The term "bolt-head" was used by Conyers (as it was in Royal Society circles) to refer to any number of globular glass flasks with long tube necks. The flask portion could be small—as in a modern thermometer bulb—or much larger, depending on what the experimenter desired. They were originally used in distillation. "Bolt-Head | Bolt's-Head, N. ," In *OED Online*. (Oxford University Press, September 2015), http://www.oed.com/view/Entry/21154. Accessed November 05, 2015.

holes punched in the lid.	
A Hydroscope made of cat gut	Sloane 958, f. 131r
A bolt-head filled with sand then stopped with a sponge, all set into a glass of water "like a common weather glass"	Sloane 958, f. 129v
A glass tube filled with dry sand, the end placed in a pint of water, the whole thing hung from a balance to measure the changing weight of the sand/water combination with changing humidity.	Sloane 958, f. 129v
A set of nested iron circles, which were magnetized and tied together with silk thread, so as to enable each piece to move freely	Sloane 852, f. 29r, 28v, 31r
Loadstone	Sloane 852, f. 31r
A loadstone "found in England" with part of the exterior covered with "petrified crystal-like stones"	Sloane 852, f. 32v
Pewter ounce measure	Sloane 919, f. 118v, 122r
Stone slabs	Sloane 919, f. 118v-124r
Tin cones	Sloane 919, f. 118v-124r
Pewter plates	Sloane 919, f. 118v-124r
Short glass tubes	Sloane 919, f. 125v-126v
A piece of black marble	Sloane 816, f. 129r
A piece of deal wood	Sloane 816, f. 144v
A piece of sea coal	Sloane 816, 162r
A piece of cork	Sloane 816, f. 178v
A piece of aspen	Sloane 816, f. 178v
A piece of wool	Sloane 816, f. 181v
A piece of sealing wax	Sloane 816, f. 183r
A hygroscope	*Philosophical Transactions*[10]
A water pump	*Philosophical Transactions*[11]
A speaking trumpet	*Philosophical Transactions*[12]

[10] John Coniers, "A Description of Mr. John Coniers, Apothecary and Citizen, His Hygroscope, in Two Several Contrivances; Together with Some Observations Made Thereon: Communicated in a Letter to the Publisher, Octob. 23. 1676," *Philosophical Transactions* 11 (1676).

[11] John Conyers, "A Letter of Mr. John Conyers, Citizen of London; the Author of the Hygroscope Described in Numb. 129; in Which Letter Is Contained a Draught and Description of a Very Useful and Cheap Pump, Contrived by the Said Mr. Conyers; a Trial of Which Was Also Made at the Repairing of the New Canal of Fleet-River in London, and Elsewhere," ibid. 12 (1677-1678).

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Conyers's handwritten copy of "Memorandum hacklyes voyages ab fletcher." The copy includes the text, as well as maps and illustrations.	Sloane 61
Logic: Treatises and notes on logic (Latin)	Sloane 958: ff. 4-104
Sections of *Klinike, of the diet of the diseased*, by James Hart (1633)	Sloane 2031, f. 45r and following
Conyers's notebooks of his own measurements, natural philosophical and historical observations	Sloane 919 Sloane 937 Sloane 916 Sloane 839 Sloane 816 Sloane 852 Sloane 958

[12] John Conyers, "Extract of a Letter from Mr. John Conyers, of His Improvement of Sir Samuel Moreland's Speaking Trumpet,Etc.," *Philosophical Transactions* 12 (1677-1678).

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