TRANSITIONS FROM CHYMISTRY TO CHEMISTRY (1675–1750)

The Chymistry of "The Learned Dr Plot" (1640–96)

*by Anna Marie Roos**

ABSTRACT

In the seventeenth century, there were developing norms of openness in the presentation of scientific knowledge that were at odds with traditions of secrecy among chymists, particularly practitioners of chrysopoeia, or the transmutation of metals. This chapter analyzes how Dr. Robert Plot, the first professor of chymistry at Oxford, negotiated these boundaries within an institutional context. I first delineate his chymical and experimental practice, which incorporated procedures from medieval alchemical sources, particularly the Lullian corpus, as well as more novel practices from seventeenth-century chymistry. Then, I analyze how personal and institutional ambitions and economic considerations shaped to what extent Plot negotiated the boundaries between secrecy and the public dissemination of chymical knowledge.

INTRODUCTION

In the seventeenth century, there were developing norms of openness in the dissemination and presentation of scientific knowledge that were at odds with traditions of secrecy among chymists,[1] particularly practitioners of chrysopoeia, or the transmutation of metals. Between these two standards a tension arose, evidenced by early modern writers' "vociferous criticisms" of chymical obscurity, with different strategies developed for negotiating the boundaries between secrecy and openness.[2] Newton and Boyle were both "in fearful awe" of the power of transmutation, concerned, for example, about its potential to disrupt economic and social stability, and thus kept their work secret.[3] Newton sequestered his more public research in physics and mathematics from his private chymical investigations.[4] Boyle, however, while keeping his chrysopoeia secret by using codes, ciphers, and the "principle of disper-

* Lincoln School of Humanities, University of Lincoln, Brayford Pool, Lincoln LN6 7TS, United Kingdom; aroos@lincoln.ac.uk.

[1] Use of the term "chymistry" is guided by Lawrence Principe and William Newman, "Alchemy vs Chemistry: The Etymological Origins of a Historiographic Mistake," *Early Sci. & Med.* 3 (1998): 32–65. States of secrecy in early modern science have recently served as the theme of the June 2012 issue of the *British Journal for the History of Science*, edited by Koen Vermeir and Dániel Margócsy.

[2] Lawrence Principe, "Robert Boyle's Alchemical Secrecy," *Ambix* 39 (July 1992): 63–74, on 63. See Principe, *The Aspiring Adept: Robert Boyle and His Alchemical Quest* (Princeton, N.J., 1998); William Newman, *Gehennical Fire: The Lives of George Starkey, an American Alchemist in the Scientific Revolution* (Chicago, 1994).

[3] Lawrence Principe, "The Alchemies of Robert Boyle and Isaac Newton," in *Rethinking the Scientific Revolution,* ed. Margaret Osler (Cambridge, 2000), 201–20, on 209.

[4] B. J. T. Dobbs, *The Foundations of Newton's Alchemy* (Cambridge, 1975), 94.

sion" or scattering logically connected parts of a procedure disconnectedly through printed text(s), published other forms of chymical knowledge widely.[5] Similarly, while Nicolas Lémery consciously and publicly excised material concerning metallic transmutation from the third edition of his enormously popular *Cours de Chimie*, he was simultaneously employing chrysopoetic "apparatus, practices, and skills" in his own work.[6] As William Newman has shown, the American alchemist George Starkey (1628–65) even went so far as to create an alter ego named Eirenaeus Philalethes. "Setting himself up as the middleman between his fictive adept and the Hartlib Circle, Starkey acquired a privileged position as the revealer of secret knowledge."[7] Not only did this mechanism enhance Starkey's prestige in learned circles, particularly in his communications with Boyle, but as a "metallurgist and inventor," Starkey could use his alter ego to protect his trade secrets.[8]

Less well studied, however, is to what extent other contemporaries negotiated these boundaries, particularly when they held a formal university appointment in chymistry. This is the case with Robert Plot, appointed as the first keeper of the Ashmolean, secretary of the Royal Society, and Oxford's first professor of chymistry. "The learned Dr Plot," as he was called, was a man of versatile talents, without whose flair for organization "the Ashmolean Museum might well never have come to Oxford."[9] Plot was educated at Magdalen Hall, Oxford, obtaining his BA (1661), an MA (1664), and a doctorate of civil law (1671). In 1667, Plot followed a course in practical chymistry given by William Wilden and was part of the group of natural philosophers who "congregated around Robert Boyle at Deep Hall until 1668."[10] Not just a chymist, Plot was also a natural historian, writing the *Natural History of Oxfordshire* (1677) and *Natural History of Staffordshire* (1686). He also founded the Oxford Philosophical Society (OPS), active from 1683 to 1688, the only university scientific society of this era for which we have extensive records. Plot directed its experiments, "occupying a position roughly comparable to that of Hooke in the Royal Society," and edited the *Philosophical Transactions of the Royal Society* from 1683 to 1684.[11]

Despite his importance to the development of early chymistry and natural history, there has been little historical analysis of his chymical work and practice, much less how he negotiated the boundaries between secrecy and dissemination of knowledge within and outside of the university and scholarly societies.[12] Some of this state of affairs may be because unlike Boyle, Plot did not publish any books about chymistry, his oeuvre confined to books concerning natural history and chorography (regional

[5] Principe, "Secrecy" (cit. n. 2), 63.

[6] William Newman, "From Alchemy to Chymistry," in *The Cambridge History of Science: Early Modern Science*, ed. Katharine Park and Lorraine Daston (Cambridge, 2006), 497–517, on 511 and 515.

[7] Newman, *Gehennical Fire* (cit. n. 2), 62.

[8] Ibid., 62–3.

[9] Ken Arnold, *Cabinets for the Curious* (Aldershot, 1988), 50.

[10] Anthony Turner, "Robert Plot (1640–1696)," *Sphaera* 4 (1996), http://www.mhs.ox.ac.uk/sphaera (accessed 23 October 2011).

[11] Stanley Mendyk, "Robert Plot: Britain's Genial Father of County Natural Histories," *Notes Rec. Roy. Soc. Lond.* 39 (1985): 159–77, on 164.

[12] Exceptions are Marcos Martinón-Torres, "Inside Solomon's House," *Ambix* 59 (2012): 22–48; F. Sherwood Taylor, "Alchemical Papers of Dr Robert Plot," *Ambix* 4 (1949): 67–79; K. Hoppen, "The Nature of the Early Royal Society Part II," *Brit. J. Hist. Sci.* 9 (1976): 243–73.

landscape studies). Unlike Newton, Boyle, or Starkey, Plot also did not leave behind a large corpus of chymical manuscripts. Material is confined to his correspondence,[13] MS Sloane 3646 in the British Library, which consists of a considerable amount of papers in his hand concerning his own experiments, and OPS meeting minutes.[14] By close analysis of these sources, we will remedy omissions in the literature about Plot and analyze the role of chymical secrecy in an institutional context.

In his "rules of Praticall Chimistry," most likely composed for his Oxford students, Plot wrote, "chymistry and Alchemy cannot be separated."[15] This chapter will first delineate his chymical and his experimental practice, which indeed incorporated procedures from medieval alchemical sources, particularly the corpus traditionally though wrongly ascribed to Raymond Lull (1232–1316), as well as more novel practices from seventeenth-century chymistry that, on the surface, had little to do with metallic transmutation but were intimately inspired by it. Then I will analyze how personal and institutional ambitions and economic considerations shaped to what extent Plot negotiated the boundaries between secrecy and the public dissemination of chymical knowledge. We will see that for Plot (as in the case of Starkey), the tension between secret and shared and private and public knowledge was informed by ambition and self-fashioning. However, Plot's strategy was also influenced by his legal knowledge of contracts of tender and his financial needs specific to his position as an Oxford professor. As chymistry was not yet part of the regular university curriculum at Oxford, Plot was expected to provide running laboratory expenses and his salary by privately selling his inventions, chymical medicaments, and secrets, which he did on contract. In the public sphere, Plot demonstrated his expertise by performing experiments concerning less lucrative though chymically interesting procedures for the Royal Society and OPS; he also intimated to their members that he possessed valuable secret knowledge but did not reveal it.

PLOT, CHYMICAL MENSTRUA, AND THE SPIRIT OF WINE

An analysis of MS Sloane 3646, written by Plot in the late 1670s and 1680s, shows that he was familiar with several chymical techniques and authors.[16] He included material concerning iatrochemistry and *chymiatria* (the preparation of medicines) including a defense of Tachenius's *Hippocrates chymicus* (1666), which combined Johannes Baptista Van Helmont's iatrochemistry with Sylvius de la Boë's (1614–72) theory of acids and alkalis in medical treatments, as well as "an example of the disease of the stone in Van Helmont."[17] In the OPS meeting minutes, Plot appended his own list of "chemical arcana and desiderata" featuring the synthesis of several Helmontian substances, including "Metallus Masculus" (a type of alkahest or

[13] Plot's correspondence is in the Bodleian Library in MSS Ashmole, Aubrey, Ballard, Lister, Tanner, and Wood, indexed in Early Modern Letters Online (http://emlo.bodleian.ox.ac.uk) and partially transcribed in R. T. Gunther, *Dr. Plot and the Correspondence of the Philosophical Society of Oxford: Early Science in Oxford* (Oxford, 1939). The OPS minutes are in Bodl. MS Ashmole 1810–2 and reprinted in Gunther, *The Philosophical Society: Early Science in Oxford* (Oxford, 1925).

[14] For a catalogue description of MS Sloane 3646, see Taylor, "Alchemical Papers" (cit. n. 12).

[15] British Library, MS Sloane 3646, 44r.

[16] Most of the manuscript is in Plot's writing, although there are chymical excerpts in other hands.

[17] Sloane 3646 (cit. n. 15), 58r–61v.

universal dissolvent), the "Asoph" (the ultimate arcanum, which contained the universal spirit of God), and his chemical arcanum against gallstones.[18] Overall, however, Plot's chymical manuscripts have more of the character of Boyle's than of Newton's; whereas Newton emphasized the written traditions of chymistry, "favoring an approach based on textual analysis and the drawing of compendia . . . thereafter complemented with laboratory experimentation," Boyle "favored a more empirical approach to learning" about chymistry, employing experimentation more immediately.[19] So, apparently, did Plot.

Most of Sloane 3646 is dedicated to Plot's own observations with an emphasis on praxis, which may be due to his role as a chymistry professor; in his "rules of Practical Chemistry," he stated, "because the Philosophers haue set forth theoreticall and practicall bookes we are to chuse the praticall because they are to be understood literally."[20] On the other hand, he noted that when chymical language was deliberately obscured by adepti to preserve secrets, that "the designe of the process will easily show whether these words or any of them are to be taken literally or no"; he advised that it was, for instance, easy to tell the differences between the wet way (*via humida*) to the Philosophers' Stone, which employs watery solvents, and the other major route of chrysopoeia, the dry way (*via sicca*), which uses no such watery corrosives.[21]

Plot also noted that he deciphered obscure published procedures to create his own secret chymical menstrua or solvents that were both medical and involved in transmutation of matter.[22] He defined a menstruum as "not a thing dissolving bodies superficially, or dividing them into the most minute parts by corrosion, but a liquor, remaining with the thing dissolved in it, inseparable and altering . . . the constitution of the thing dissolved by the addition of itselfe into a new thing which neither is nor can be again that which it was."[23] Menstrua were usually classified as corrosive dissolvents, especially those for "dissolving metal in the attempt to convert base metals into gold."[24] Plot's definition of the menstruum was more akin to that of an alkahest, a substance that could aid the practitioner to break down matter into its smallest parts to enable not only transmutation but also the creation of medicines from constitutive matter. Plot then asserted in a section "On the use of secret menstruum," that "In Chymistry unless a man know exactly the use of Menstruums, hee will without doubt never performe anything worthy of prayse."[25] "On the contrary if a man know nothing but that," he would be able to tell true medicine from false and understand the books of chymical adepti and "the progresses of our art."[26]

Plot thought this secret menstruum was to be found in spirit of wine "actuated and rectified to a preternatural subtlety" to create a substance described as the philosophical spirit of wine.[27] In particular, Plot's manuscript notes displayed experi-

[18] The desiderata are in the OPS minutes (17 March 1684/5) and reprinted in Gunther, *The Philosophical Society* (cit. n. 13), 130–2.
[19] Principe, "Alchemies" (cit. n. 3), 210.
[20] Sloane 3646 (cit. n. 15), 44r.
[21] Ibid., 44r–44v.
[22] Taylor, "Alchemical Papers" (cit. n. 12), 69.
[23] Sloane 3646 (cit. n. 15), 55r.
[24] *Oxford English Dictionary,* s.v. "menstruum," www.oed.com (accessed 27 October 2013).
[25] Sloane 3646, (cit. n. 15), 9r.
[26] Ibid.
[27] Taylor, "Alchemical Papers" (cit. n. 12), 69.

ments with menstrua described in the oeuvre attributed to the Majorcan philosopher and mystic Raymond Lull.[28] Although the historical Lull denied the possibility of transmutation, over 120 posthumous texts composed on the subject between the fourteenth and seventeenth centuries were attributed to him.[29] Michela Pereira has demonstrated that some of these works were circulating in England in the fourteenth century.[30] By the late seventeenth century, Johann Seger von Weidenfeld, the Lithuanian chymist and acquaintance of Boyle, had composed an English edition of *Four Books of Johannes Segerus Weidenfeld, Concerning the Secrets of the Adepts, or, Of the Use of Lully's Spirit of Wine* (London, 1685), which was disseminated widely and used extensively by American chymists such as Gershom Bulkeley (1636/7–1713).[31] Plot's manuscripts indicate that he, like his colleagues, was also interested in the "philosophical spirit of wine" (akin to ethanol), which was identified in the corpus of pseudo-Lull as the source of the universal quintessence or fifth element, the essence of all metals, and an incorruptible, pure, and original substance of the world.[32] It was believed this vital spirit of the cosmos could be extracted by means of distillation and other techniques.[33]

Plot wrote, "the spirit of wine being now prepared, wee have indeed the root and basis of all secret menstruums, yea also medicines"; for example, he noted that as a menstruum par excellence, it would dissolve volatile alkaline salts, such as salt of tartar, and when the mixture was distilled, the salt of tartar would be volatilized.[34] This was especially important to chymistry, as Van Helmont saw the ability to make the salt of tartar volatile and thereby achieve complete dissolutions as a means to produce a solvent with powers akin to the alkahest, the universal dissolvent of great use in transmutation. Because alkalis were not only caustic but also cleansing and purgative, they were thought to have dissolving qualities; if they were volatilized, their corpuscles had been reduced in size (volatility and particle size had been related in chymistry since the Middle Ages), and they would approach corpuscles of the alkahest in size.[35] But, "the practical problem is that alkalis . . . such as salt of tartar (potassium carbonate) are steadfastly non volatile. Salt of tartar can withstand hours of

[28] Sloane 3646 indicates that Plot's interest in Lull went beyond derivative transcription to active experimentation.

[29] Jennifer Rampling, "Establishing the Canon: George Ripley and His Alchemical Sources," *Ambix* 53 (2006): 189–208, on 191.

[30] Michela Pereira, *The Alchemical Corpus Attributed to Raymond Lull* (London, 1989), 3:3.

[31] Ibid., 3:22–3; Johannes Weidenfeld, *Four Books . . . Of the Use of Lully's Spirit of Wine* (London, 1685). For Bulkeley, see Newman, *Gehennical Fire* (cit. n. 2), 44–6, and Thomas W. Jodziewicz, "A Stranger in the Land: Gershom Bulkeley of Connecticut," *Trans. Amer. Phil. Soc.* 78 (1988): 1–106, on 19.

[32] Rampling has discussed a chymical practice advocated by George Ripley, using sericon, a lead compound that when dissolved in spirit of wine (or vinegar) formed sugar of lead. This sugar of lead was thought to combine the mineral and vegetable qualities of materials and was thought could be used to prepare elixirs or to produce a composite water that could transmute base metals into gold. Although Plot wished to achieve a similar objective, his procedure uses strong acids and spirit of wine and is chymically distinct from Ripley's; both authors interpreted the Lullian corpus a bit differently, Plot's interpretation emphasizing the medieval interest in corrosives (discussed below). Rampling, "The Catalogue of the Ripley Corpus: Alchemical Writings Attributed to George Ripley (d. ca. 1490)," *Ambix* 57 (2010): 125–201, on 129–30.

[33] William Newman and Anthony Grafton, "Introduction: The Problematic Status of Astrology and Alchemy in Premodern Europe," in *Secrets of Nature: Astrology and Alchemy in Early Modern Europe,* ed. William Newman and Anthony Grafton (Cambridge, Mass., 2001), 1–37, on 24.

[34] Sloane 3646 (cit. n. 15), 17r, 20r.

[35] William Newman and Lawrence Principe, *Alchemy Tried in the Fire* (Chicago, 2002), 138.

red heat without evaporating in the least."[36] Treating salt of tartar with philosophical spirit of wine was widely seen by chymists as a means of volatilizing salt of tartar. Plot went on to assert that the true philosophical spirit of wine could "dissolve mineralls . . . joyne them to itselfe, make them volatile," creating a menstruum akin to the alkahest.[37] With such an alkahest, it was possible not only to carry out chymical analysis but, by "stopping the process at the right point, and distilling off the alkahest, the 'first essence' of the dissolved substance would be left behind as a crystalline salt."[38] This salt contained the concentrated medicinal properties of the substance. So the philosophical spirit of wine could create a powerful tool for transmutation and *chymiatria* alike.

So how did Plot define the regular and the philosophical spirit of wine? He first describes regular spirit of wine, or ethanol, the twice-distilled product of vinous fermentation. Regular vinous distillation produced what Plot called "common brandy," which would then be mixed with different herbs to produce compound liqueurs.[39] However, this was different from the philosophical spirit of wine, the menstruum that would reveal the true spirit of metals. Ever sensitive to the obscurity of chymical writing, Plot warned, "Every thing in the practick writings are to be taken secundum litteram except the word wine or some word synonimous with it as Lunaria."[40]

In the pseudo-Lullian corpus, the *lunaria* is described as follows:

> our Menstruum rectified and actuated, or the heavenly lunaria, which among the Philosophers is called Vegetable Mercury, produced from Wine red or white . . . it behooves us to draw out our Menstruum . . . from the Impurities and Phlegm of Wine, through the agency of an Alembic, and to actuate it in distillation with appropriate Vegetables; such as are Apium sylvestre, [Wild parsley], Squilla [sea onion]. . . . Then the Menstruum itself must be circulated continually in a vessel intended for this purpose for the space of ten days in hot Dung steeped in wine in a water bath [bain marie].[41]

We have seen why the philosophical spirit of wine was important to *chymiatria* in that it could be harnessed to make the alkahest, which in turn could make medicine. Why was the philosophical spirit of wine specifically important to transmutation or chrysopoeia? Pseudo-Lull's work *Liber de secretis naturae seu de quinta essentia* (ca. 1350–1400) was concerned with the question of how perfect metals such as gold and silver could unite in a new individual substance together with the philosophical spirit of wine, called *menstruum vegetabile*.[42] Pseudo-Lull also revealed that he saw the purpose of alchemy as *vegetare seu transmutare* (to vegetate or transmute) and

[36] Ibid.
[37] Sloane 3646 (cit. n. 15), 20r.
[38] Lawrence M. Principe, *The Secrets of Alchemy* (Chicago, 2013), 134.
[39] Sloane 3646 (cit. n. 15), 3r.
[40] Ibid., 44r.
[41] Raymond Lull, "Compendium Animae Transmutationis," in the *Theatrum Chemicum* (Strasbourg, 1659), 4:172–3; "menstruum nostrum rectificatum et acuatum, seu lunaria coelica quae apud philosophos vocatur Mercurius vegetabilis ortus à vino rubeo vel albo. . . . Sed tamen oportet princeps serenissime prius nostrum menstruum per . . . sordibus vini et phlegmate extrahere per officium alembici, et acuatur in destillatione cum vegetabilibus pertinentibus, quae sunt, Apium sylvestre, Squilla . . . Ex altera parte ipsum menstruum in vase circulationis rotetur continue spacio decem dierum in fimo calido, vinatico, balneo Mariae."
[42] Michela Pereira, "Vegetare seu Transmutare: Vegetable Soul and Pseudo-Lullian Alchemy," in *Arbor Scientiae,* ed. Fernando Reboiras, Pere Varneda, and Peter Walter (Turnhout, 2002), 93–119, on 97.

the Philosophers' Stone as *vegetatum* (a living substance).[43] To harness this transformative principle to make the Philosophers' Stone, the use of animated substances, particularly oils from vegetative substances, was important.

Plot thus followed suit. As pseudo-Lull advised in the *Compendium*, Plot described in his notes doing circulatory distillation of ethanol or spirit of wine with such "hott and oily vegetables" as black pepper; the vegetables were thought to actuate or enliven the distilled wine with their properties.[44] Indeed, all the vegetables pseudo-Lull listed either have a distinctive smell or had potent medical properties. Most of the vegetables were "hot" in quality, pungent and spicy in taste; in Galenic medicine, hot herbs and medicines stimulate and warm the metabolism and disperse chills. These qualities may have led to the belief that they were especially efficacious chymically; it did not hurt matters that many of the plants, including the resin of euphorbia, are soluble in alcohol. This distillation process of the spirit of wine with the vegetables would then produce the "lunaria." Weidenfeld, a commentator on the Lullian corpus who was contemporary to Plot, advised "the Oyl drawn out of Oyly Vegetables is by distillation together with the Spirit of Philosophical Wine, circulated into a Magistery by which the Spirit of wine is multiplied."[45]

The *lunaria* or philosophical spirit of wine was widely considered among chymists to consist not only of aqueous principles but also oily ones; Weidenfeld advised the spirit of wine distilled with vegetables "doth by simple digestion divide into two distinct parts, two Oils or Fats, whereof one is the Essence of the thing, the other the Body."[46] And indeed Plot does create something that he refers to in his notes as his *Magisterium V[ini],* as "oleose perfectly dissolved . . . the use of it is to be a more powerful Menstruum than [ordinary] Spirit of Wine."[47] For Pseudo-Lull and his followers, "this oil or oily moisture," called *unctuositas,* was a basic principle, "the unifying principle of cohesion of living and non living beings, an equivalent of the medieval concept of *humidum radicale* as the support of life."[48] In Pseudo-Lull's *Testamentum*, there was an identification of the oil distilled from vegetables with chymical transmutation.[49]

However, Plot did not stop with the oleose qualities of the *lunaria*: he had a way to the preparation of his own *magisterium vini* that was "more secret," concluding from his experiments that "this process ought to be managed with manifest Acids."[50] In his idea of using acids to make his own menstruum of the spirit of wine, Plot was clearly influenced again by pseudo-Lull. Lull's corpus was heavily indebted to the corpuscular matter theory in Geber's *Summa perfectionis*, and Geber's theory was "immensely appealing to the self-styled atomists and corpuscularians of the seventeenth century."[51] While Plot's manuscripts do not indicate that he speculated about corpuscularianism in his use of an acid to make philosophical spirit of wine, Plot inherited a clear conviction "from medieval alchemy, that processes such as . . . dissolution in corrosives provided ocular testimony to the analysis of matter" into its most pure and

[43] Ibid., 97–8.
[44] Sloane 3646 (cit. n. 15), 17r.
[45] Weidenfeld, *Four Books* (cit. n. 31), 17.
[46] Ibid.
[47] Sloane 3646 (cit. n. 15), 3r.
[48] Pereira, "Vegetare" (cit. n. 42), 105.
[49] Ibid., 105–6.
[50] Sloane 3646 (cit. n. 15), 20r.
[51] William Newman, *Atoms and Alchemy* (Chicago, 2006), 43–4.

basic form.[52] Hermann Kopp claimed that Lull supposedly described the heating of ethanol with sulfuric acid or vitriol to produce *oleum vitrioli dulce verum* (diethyl ether; Claus Priesner, however, stated that "only the residue, and not the distillate, is described"; there is thus doubt whether ether was formed or escaped unnoticed.)[53]

Nevertheless, oily or unctuous substances combined with acids were considered important for chrysopoeia. The *Epistola accurtacionis lapidis,* attributed to Lull, provided a further explanation:

> there exists a great affinity between the Spirit of Vitriol, and the Nature of Gold. . . . For this reason the Spirit of Vitriol being joined with the Spirit of Aqua ardens [spirit of wine] inspissates [thickens or condenses] it, and makes it quickly adhere to Gold, so as to be fixed with it; this is a very excellent way of Abbreviation.[54]

The product of the distilling of the oil of vitriol with spirit of wine was an unctuous substance that could combine with gold, creating a substance that could abbreviate transmutation.

Plot adapted the Lullian process, his notes showing that, like Lull, he used spirit or wine or ethanol but mixed it instead with double *aqua fortis*, a stronger version of nitric acid.[55] Although the theoretical basis of his work was taken from Lull, Plot's innovative use of nitric acid reflected a trend in seventeenth-century chymistry in which acids became more important as chemical reactions in solution began to predominate over older distillation processes; Newton himself made frequent use of mineral acids.[56] Using nitric acid, Plot created the sweet spirit of niter, or spirit of nitrous ether (ethyl nitrite).[57] Johannes Kunkel, in his *Epistola contra spiritum vini sine acido* (Leipzig, 1681), has generally been considered to be the first to observe that a liquid that swims on the surface of water may be obtained from this mixture, but this observation "remained unnoticed, because the nitric ether, largely used as a medicine, was obtained by distilling a considerable quantity of alcohol with a small quantity of nitric acid, and was, therefore, only obtained in dilute alcoholic solution."[58] In MS Sloane 3646, Plot listed several recipes for the process, including "spirit of wine: part 1. of Aqua fortis parts 4, destill nine times, or till the matter remaines in the bottom like an oyle, which destills by an Alembick with more aqua fortis."[59] Further

[52] Ibid., 44.

[53] H. Kopp, *Geschichte der Chemie* (Braunschweig, 1843–7), 4:299, cited by Claus Priesner, "Spiritus Aethereus—Formation of Ether and Theories on Etherification from Valerius Cordus to Alexander Williamson," *Ambix* 33 (1986): 129–52, on 129, n. 2.

[54] Raymond Lull, "Epistola accurtatoria ad Regem Neopolitanum," in Raymond Lull and Michael Toxites, *Raimundi Lullii Majoricani philosophi sui temporis doctissimi* . . . (Basel, 1600), 327–8: "et etiá[m] magna est concordia inter spiritum vitrioli et naturá[m] auri . . . Ideo spiritus vitrioli coniunctus spiritui aquae ardentis inspissat eum, et adhaerere facit eum citò auro, ut secum fixetur. Et crede mihi, quòd haec curtatio est praeexcellens in arte quantum ad aurum albricum."

[55] *Aqua fortis* was made by distilling niter and oil of vitriol together.

[56] Norma Emerton, *The Scientific Reinterpretation of Form* (Ithaca, N.Y., 1984), 184; William Newman, "Experiments in Mineral Acids," The Chymistry of Isaac Newton, http://webapp1.dlib.indiana.edu/newton/reference/mineral.do (accessed 5 March 2012).

[57] H. E. Roscoe and C. Schlorlemmer, *Treatise on Chemistry* (New York, 1884), vol. 3, pt. 1, 357, noted: "The compound formed by this action of nitric acid on alcohol is . . . not ethyl nitrate . . . but ethyl nitrite, one part of the alcohol being oxidized, and the nitrogen trioxide, thus formed, combining with another part of the alcohol in the following way: $2C_2H_5OH + N_2O_3 = 2C_2H_5NO_2 + H_2O$."

[58] Ibid., 357. Plot's experiments with the sweet spirit of niter were performed at the same time as Kunkel's work was published, making it difficult to attribute priority of discovery.

[59] Sloane 3646, (cit. n. 15), 21r.

down the page, he indicated to "destill aqua fortis from Vitriol and [salt] peter into the spirit of wine, afterwards digest and destill."[60]

Plot's experiment was dangerous, as a reaction of ethanol and nitric acid is exothermic and can become explosive if the concentration of nitric acid reaches over 10%.[61] Plot even noted that in his reading about making the philosophical spirit of wine, "they have almost in all places for pitty and charity sake admonished the unwary and ignorant to be cautious of themselves, yea alltogether abstaine from these ignivomous dragons, lightenings, and thunders, unless they know how to handle these beasts ingeniously and gently."[62] Plot then put the "distilled oleose" in a "Circulatory glasse"[63] or pelican to concentrate and refine it. He stated, "by circulating it in Balneo [in a water bath or bain marie] so long till you see in the glasse a separation that is a cleare oyle swimming on a Muddy water: which clear Oyle being taken by a separating funnell is our spirit or essence of wine."[64] This is the same reaction noted by Kunkel. Boyle, who was looking for a similar menstruum that contained the subtle essence and efficacy of its constituent parts but that would also be safe to use for medicines, made the sweet spirit of niter, utilizing a similar process:

> Take one ounce of strong Spirit of Nitre . . . and put to it by little and little (which caution if you neglect, you may soon repent it), and another ounce of such rectified Spirit of Wine . . . you may . . . unite them exquisitely into one liquour [of] . . . a Vinous tast[e], very pleasing, as if it belonged to some new or unknown Spice.[65]

PLOT'S SECRET CHYMISTRY

Boyle, unlike Plot, never indicated the sweet spirit of niter had anything to do with chrysopoeia and in 1676 freely published the preparation for it. Plot, however, apparently thought otherwise and was particularly concerned to keep the details of his search for the philosophical spirit of wine and other menstrua under cover, saving his "most secret secret of the more abstruse Chymistry or of the first and onely matter of Menstruums."[66] Plot's secrecy had largely to do with the economic necessities of his position. As no one formally read chemistry at Oxford before the late nineteenth century, Plot's chymistry chair was in keeping with the "seventeenth-century University's encouragement of what one might call 'mind-broadening' extracurricular subjects."[67] In this spirit, as part of his appointment in 1683, Oxford defrayed the initial cost of equipping his "public" laboratory in the basement of the Ashmolean (accessible at least to all members of the University) by providing the tin, copper, and iron vessels (e.g., an alembic, a reverberatory furnace, and an iron digester).[68] Plot lived, taught, and collected in the Ashmolean, from the time that it opened in 1683

[60] Ibid.

[61] Pierre Macquer warned to add the acid gradually to the ethanol. Pierre Macquer and Andrew Reid, *Elements of the Theory and Practice of Chymistry* (London, 1758), 2:255–6.

[62] Sloane 3646, (cit. n. 15), 20r.

[63] A retort having the neck bent back to reenter its lower part.

[64] Sloane 3646, (cit. n. 15), 20r.

[65] Robert Boyle, *Experiments, Notes, &c. about the Mechanical Origine or production of divers qualities* (London, 1676), 23–4.

[66] Sloane 3646, (cit. n. 15), 55r.

[67] Robert Williams, Allan Chapman, and John Rowlinson, *Chemistry at Oxford* (London, 2009), 40.

[68] Plot to Arthur Charlet, 5 October 1695, Bodleian MS Ballard 14, 16r, printed in Gunther, *Dr. Plot* (cit. n. 13), 404–6.

until 1690. However, for running expenses and his own salary, he was expected to rely on instructional fees and upon the sale of chymical preparations and medicines that he could manufacture in the laboratory, assisted by an operator and chymical demonstrator named Christopher White, who also was expected to supply his own laboratory equipment.[69] Simply put, Plot needed funds and hoped that the manufacture of menstrua as well as instructional fees could support his academic post. His philosophical spirit of wine was equivalent to a valuable trade secret that he could not only use to make medicines but also to engage in *chrysopoeia*. Unlike Boyle, who was independently wealthy and publicly denied any personal interest in financial by-products of such processes, and Newton, whose position as Lucasian Professor at Cambridge was in no way dependent on his chymical research, Plot needed to make a living.[70]

Plot was also ruthlessly ambitious in pursuing gain. Although he had a reputation for being outwardly genial, he was thought quite grasping in character; "a willingness even to embrace Catholicism in order to obtain advancement was imputed to him."[71] In 1689, James Bobart, who directed Oxford's botanical gardens, remarked that Plot's ambitions meant that he was not entirely dedicated to his post: "he does noe good in his station, but totally neglects it, wandring abroad where he pleases."[72] Edward Lhwyd, who served as Plot's deputy keeper of the Ashmolean and was considered by Hans Sloane to be "the best naturalist in Europe," was continually doubtful that Plot would treat him fairly; in particular, Lhwyd worried Plot would not give him the amount of the museum's takings promised to him during his seven years of service as deputy keeper.[73] Lhwyd wrote to his friend Martin Lister, "And then I hope the Dr will let me have the one half of the money receiv'd (for as to the whole which he promisd us at London, I know him better than to expect any such matter).[74] After Plot resigned his post as Professor and Keeper in 1690 to marry a Kent heiress, Lhwyd remarked to Lister, "I think he's a man of as bad Morals as ever took a Doctors degree. I wish his wife a good bargain of him; & to my self that I may never meet with the like again."[75] Lhwyd went on to complain that Plot had been reimbursed for an "Arabick Monument" that Plot had presented as his supposed charitable donation to the University.

Papers in MS Sloane 3646 also give us a sense of Plot's lofty and grasping ambitions for his laboratory and chymical work. Plot wrote a draft petition to the King seeking assistance to create an endowed Hermetic "Colledge" that made direct reference to Sir Francis Bacon's Solomon's House in Bensalem as described in the *New Atlantis*. This institution would be partially based upon Plot's experiences in the Royal Society and involve members of the "Colledge of physicians" as well as those who belonged to the "Society of the Sophic" or chymical adepti.[76] In his petition, Plot then mentioned a menstruum recently discovered as "being the same or equivalent to . . . the grand liquor Alkahest . . . an inestimable dissolvent"; Plot compared it to

[69] Gunther, *Dr. Plot* (cit. n. 13), 355.
[70] Principe, *Aspiring Adept* (cit. n. 2), 185.
[71] *Oxford Dictionary of National Biography,* s.v. "Plot, Robert (*bap*. 1640, *d*. 1696)," by A. J. Turner, http://www.oxforddnb.com/view/article/22385 (accessed 8 February 2014).
[72] Edward Lhwyd to Martin Lister, 15 August 1689, Bodleian MS Lister 35, 134–5.
[73] Thomas Hearne, *Hearne's Collections*, ed. Thomas Doble (Oxford, 1701–7), 1:244.
[74] Lhwyd to Lister, September 1689, Bodleian MS Lister 3, 165–6.
[75] Lhwyd to Lister, 17 January 1691, Bodleian MS Lister 36, 8r.
[76] Hoppen, "Nature" (cit. n. 12), 260.

that used by Paracelsus to prepare "noble and generous medicines."[77] Plot claimed the "Sophi" valued it at "thousands of pounds the pint"; whether this was a vain boast, or he really was in contact with other trusted adepti, is unclear. Although we do not know precisely this substance's composition—perhaps it was even his own sweet spirit of niter—clearly Plot identified it as a menstruum of great importance. He indicated to the King that the proposed hermetic institution could manufacture his menstruum, thus restoring "the true legitimate physicians (who are not like farryers to practice with a bundle of receipts, but are taught in the experimentall schoole of nature) . . . to their . . . due repute."[78]

Apart from royal patronage, Plot realized his chymical secrets could be valuable currency to those less exalted than the King. MS Sloane 3646 shows that he entered into several chymical contracts with unnamed individuals, before and during his time in post in Oxford.[79] First, dated 1677, there is a tripartite agreement in blank, which is a template contract related to the making and sale of "Dropps and Chymicall Medicines," in which all parties agree to provide equal shares in setting up a laboratory and split the profits accordingly.[80] As Plot had a doctorate in civil law, it is not surprising he was using legal safeguards for his secret processes. In another undated agreement in Plot's hand, it was proposed that for the "competent sum of money" of £350, his partners would be given the recipe for Plot's secret menstruum, which they would use to prepare the alkahest and the Grand Arcanum to use in chrysopoeia, subsequently sharing the proceeds with Plot.[81] To sweeten the deal, for a mere £50 more, Plot's partner would be shown how to prepare "noble Medicines"; Plot continued, "and if we consider what estates some ordinary fellows from trifleing things have purchased, witness Russel with his powder, Daffy with his elixir, Bromfield with his pills, then how much more probable will it be to raise considerable advantage from some of the choycest medicines."[82] (Plot here was referring to a number of popular patent medicines.) He noted, "doubtless in a little time great profitts may be made" and then indicated that if his partner would "manage the Laboratory he will have (over and besides the share in the advantage aforesaid) £20 a year allowed him by the rest of the partners for the management thereof."[83] As a further inducement, Plot indicated that the King had promised him a patent for a preparation that secured ships "from the worme."[84] Plot then concluded, "Then what would any rational man have more."[85]

In this contract, Plot was careful to distinguish himself from "vain boasting chymists," saying any fraud perpetrated on his part would be a "blott in his Eschution," an appropriate metaphor, as Plot would later become registrar of the College of Heralds.[86] A note below the agreement indicated that the other party promised "that not any Aqua fortis, nor any other corrosive liquor is us'd through out the whole work of the Elixir."

[77] Sloane 3646, (cit. n. 15), 76r.
[78] Ibid., 76v.
[79] Taylor, "Alchemical Papers" (cit. n. 12), 75.
[80] Sloane 3646 (cit. n. 15), 81–2.
[81] Ibid., 77–8.
[82] Ibid., 78v.
[83] Ibid.
[84] Shipworms are mollusks, usually *Teredo navalis*, notorious for boring into and destroying wood immersed in seawater. *Encyclopedia of Life*, s.v. "*Teredo navalis*," http://eol.org/pages/439957/details (accessed 28 June 2013).
[85] Sloane 3646 (cit. n. 15), 78v.
[86] Ibid., 77v.

Corrosive liquors like *aqua regia* (a mixture of nitric and hydrochloric acids) was well known as a "vulgar menstruum" that would dissolve gold, and it was often fraudulently passed off as a more exalted substance in the path to the Philosophers' Stone.

F. Sherwood Taylor speculated that Plot's use of legal safeguards in his contracts was due to the fact that Plot only possessed a bare chymical secret and that he thus was unsure of success.[87] However, it seems rather that Plot's caution was due to the fact that he saw it merely as a commercial, albeit risky, venture. Plot first acknowledged that "no man upon a bare supposition" should hazard the money, especially "if it were upon a person who had no other way of livelyhood."[88] He then compared the chymical quest to investing in the voyages of ships that could come back laden with treasure from the New World. He wrote, "How many vessels richly fraught, loaden with the Eastern and Western treasures whose owners and venturers have like their sayles swelled with expectation of great advantage, have yet by storms been driven upon rocks?"[89] It is interesting to speculate whether Plot had in mind Francis Bacon's emblem in the frontispiece of his *Instauratio magna* (1620), in which a ship sailed out between the "Pillars of Hercules" at the western end of the Mediterranean Sea, serving as a metaphor for discovery with its rewards and risks. As Tara Nummedal has shown in her analysis of chymistry and fraud in the Holy Roman Empire, such contracts were common. Adepti could "point to their contracts as proof that they were . . . genuine practitioners," and by addressing the concerns of patrons and practitioners, contracts like Plot's "played a central role in facilitating chymical practice as not just private study, but as a collaborative entrepreneurial endeavor."[90]

In MS Sloane 3646, there followed another draft agreement, dated ca. 1683, the year of Plot's appointment as professor of chymistry at Oxford. Here Plot promised to "shew" another individual the secrets of chrysopoeia in exchange for his usual fee of £350 and "half the charges of the worke," though he noted "no great varietie of furnaces nor much charge is required."[91] Plot was apparently also not only using corrosives in his work with philosophical wine but engaging in mercurialist chrysopoeia, in which the key to attaining the Philosophers' Stone is preparing a philosophical mercury from ordinary mercury via purification and animation. Plot indicated in the agreement that the person he was dealing with in making "this great Arcanum should be willing to worke some part at my laboratory here, and the rest in his Laboratory in the country when he shall go down, which perhaps may be shortly" and "should be enjoyned to faithful secrecy."[92] As Taylor has indicated, the dating of the contract to 1683, the fact that Plot wrote of "my laboratory here" and the other party was about to "go down," may suggest Plot wrote from his Oxford Laboratory at the Ashmolean.[93]

There is other evidence that suggests this agreement was made when Plot was in his official capacity as professor of chymistry. Plot promised in his agreement to show his fellow adept the meaning of the alchemical "wolfe," a common symbol for the antimony ore, stibnite (Sb_2S_3).[94] As I have shown elsewhere, Plot speculated in

[87] Taylor, "Alchemical Papers" (cit. n. 12), 76.
[88] Sloane 3646 (cit. n. 15), 77v.
[89] Ibid.
[90] Tara Nummedal, *Alchemy and Authority in the Holy Roman Empire* (Chicago, 2007), 116.
[91] Sloane 3646 (cit. n. 15), 80r; Taylor, "Alchemical Papers" (cit. n. 12), 75.
[92] Sloane 3646 (cit. n. 15), 80r.
[93] Taylor, "Alchemical Papers" (cit. n. 12), 69.
[94] Sloane 3646 (cit. n. 15), 79r.

his *Natural History of Oxfordshire* (1677) that fossils were not the result of animal or plant remains but were formed by the interaction of salt crystals to form their different shapes.[95] He then postulated that the regulus or stellate form of antimony could be the source of star-shaped fossils, such as pointed sea lily fossils and sea urchins, so he clearly was au fait with antimonial chymistry.[96] In a recent archaeological analysis of early modern crucibles found in Plot's laboratory, Marcos Martinón-Torres has also found a thin corroded layer of antimony oxide (Sb_2O_3) and lime (CaO), together with silica (SiO_2) and small amounts of potash (K_2O).[97] This could have been due to the making of the emetic medicament of the glass of antimony, or "this antimony could also be linked with the roasting or calcination of the mineral stibnite, with a view to producing antimonial mercury," a form of "incalescent" or philosophical mercury that also interested Boyle and Newton.[98] Martinón-Torres argues that the crucibles are "likely to date" from the late seventeenth century and are thus "connected" to Plot's work; Plot's manuscript contract and references to antimony in his *Natural History* support this archaeological evidence.[99]

PLOT'S PUBLIC CHYMISTRY

Although a professor at Oxford, Plot was also clearly a chymical entrepreneur both before and after his appointment, the terms of his university post requiring that he make the Ashmolean laboratory profitable. Concerned as he was to keep his trade secrets, part of the chymical work he did at Oxford was very public, involving not only his lectures to students but also research collaboration between the OPS and the Royal Society. While the Ashmolean was being built from 1679 to 1683 and Oxford was making provisions for a meeting room for the OPS, Plot exchanged correspondence with natural philosophers in London. He worked in earnest to link the OPS with the Royal Society and regularly gave the Royal Society accounts of the scientific proceedings of Oxford's "ingenious assembly," which discussed problems of meteorology, physiology, chymistry, and mineralogy. Plot's colleague Martin Lister told him in a letter of October 1683, "I can assure you the best of our Entertainment [in the Royal Society] . . . was your Letter. Your new Oxford Society will be of great use, it will excite this other here, and emulation is the great promoter of learning."[100] In this manner, Plot became familiar with experiments being done at the Royal Society, experiments that he himself was also performing.

This collaborative work included experiments with the spirit of wine. We recall that Kunkel had written a treatise on this subject in 1681, and in 1684, he was in correspondence with the Royal Society concerning the reaction of spirit of wine with syrup of violets (an indicator of acidity/alkalinity), milk, and water. The OPS received a letter from Francis Aston, the Royal Society secretary, on 18 November 1684, "giving an account of severall experiments mentioned in a book lately writ-

[95] Robert Plot, *The Natural History of Oxfordshire* (Oxford, 1677), 111; A. M. Roos, "Salient Theories in the Fossil Debate in the Early Royal Society," in *Controversies within the Scientific Revolution,* ed. Victor Boantza, Marcelo Dascal, and Adelino Cattani (Amsterdam, 2011), 151–70.
[96] Plot, *Oxfordshire* (cit. n. 95), 122–3.
[97] Martinón-Torres, "Inside Solomon's House" (cit. n. 12), 46.
[98] Ibid.
[99] Ibid., 22.
[100] Bodleian MS Ashmole 1813, 64r.

ten by Kunckell."[101] Frederic Slare, the chemistry curator at the Royal Society, performed several of the experiments to test Kunkel's results. As Birch reported in the meeting minutes, the spirit of wine and milk indeed curdled, syrup of violets and spirit of wine turned green, and spirit of wine and water mixed together grew hot, an accurate observation as the reaction is exothermic.[102] On 9 December 1684 and 12 May 1685, the OPS repeated the experiments but found that the syrup of violets and spirit of wine turned red rather than green, indicating an acid component to the mixture rather than an alkali. (In Boyle's *Experiments and Considerations Touching Colours* [1664], he established an early pH indicator, in which liquids of a deep blue or purple color would turn red when an acid was added or green at the addition of an alkaline.) The OPS minutes reported, "but spirit of wine was so farr from turning it [syrup of violets] green, as Kunkel saies . . . that it made it immediately become as red, as when Acids were mingled with it, or that of Vinegar."[103] These experiments may have indicated to Plot an affinity between spirit of wine and its ability to be turned into a philosophical spirit of wine with acidic substances.

There were also several reported attempts by the OPS made to volatilize alkali salts such as salt of tartar, sal ammoniac, and hartshorn by adding them to spirit of wine "without any visible motion of the mingled liquors."[104] We recall that the ability to make salt of tartar volatile was seen as a means to produce a solvent akin to the alkahest. In the case of the society's experiments, they had little luck, as salt of tartar is insoluble in ethanol, sal ammoniac [ammonium chloride] only sparingly soluble, and ammonium bicarbonate [salt of hartshorn] is not. Although this may have led Plot to question whether spirit of wine could be involved in the volatilization of alkali salts, he may have reasoned that the regular spirit of wine was utilized in the trials at the OPS, not the secret philosophical spirit of wine or other chymical menstrua that he had created and was trying to sell.

While Plot would not reveal the particular secrets of his chrysopeia, it was certainly not a secret to his colleagues that he was interested in such processes. On 17 March 1684/5, Plot presented to the OPS a "wish list" of "arcana and desiderata in chymistry."[105] And, in its meeting of 18 November 1685, the Royal Society meeting minutes reveal that the "secretary was desired to procure a copy of Dr Plot's Desiderata in chemistry," and the list was also presented to the Dublin Philosophical Society.[106] Much of the list was devoted to aspirational processes and products of chrysopoeia and *chymiatria*, including:

> to make a Universall Medicine
> a Mercury which . . . may be melted into Gold
> to make Aurum Potabile (potable gold, a panacea).

Plot's desiderata list was nothing new. Bacon had already printed the idea of the wish list in his *Advancement of Learning*.[107] As Vera Keller has argued, Bacon in-

[101] Gunther, *The Philosophical Society* (cit. n. 13), 104.
[102] Thomas Birch, *History of the Royal Society* (London, 1756–7), 3:328.
[103] Gunther, *The Philosophical Society* (cit. n. 13), 148.
[104] Ibid.
[105] Ibid., 130–2.
[106] Birch, *History* (cit. n. 102), 4:409.
[107] Vera Keller, "The New World of Sciences," *Isis* 103 (2012): 727–34, on 730.

tended his desiderata to be fulfilled gradually and collaboratively for collective advancement, rather than presenting claims about what any self-interested individual could do.[108] Boyle also wrote a desiderata list not limited to chymistry but devoted to natural philosophy as a whole. Like Bacon's, Boyle's list was not predictive but a tool of skepticism concerning our ability to know the "limits of the real," suspending "objects in a state of continued doubt that invited further investigation."[109] Whilst Plot's desiderata could, in Keller's terms, be seen as a communal wish list presented to three scholarly societies, allowing them to attempt seemingly impossible feats without claiming ability to achieve any results, Plot's item 32 is "to make Lully's lunaria."[110] As we have seen, Plot did not think this process impossible. Plot also had on his wish list items that were not *chrysopoetic*, for instance, "staining marble black," and he met with artisans about how to accomplish this goal. In a Royal Society meeting of 25 May 1681, Plot related that one Mr. Bird, an Oxford mason, "had very much perfected the invention of staining . . . but he could not yet find out a way of staining a perfect black."[111] Undaunted, Plot later sent a letter to the Royal Society on 10 November 1683 that contained an account of him having tinged white marble a quarter of an inch deep.[112] Unlike Boyle, who was testing limits of knowledge in a philosophical sense for Baconian "experiments of light," Plot's motivation was largely economic and practical: Bacon's "experiments of fruit."

In the seventeenth century, despite the fact that chymical procedures were increasingly made available to larger audiences, the secrecy of the adepti still survived. But this secrecy was maintained for different reasons, depending on the chymist's circumstances. In the case of Plot, his maintenance of the boundaries between public and private knowledge was informed by his desire to preserve trade secrets that not only would fund his livelihood as Professor of Chymistry, but that also would enhance his scholarly prestige. Plot's contemporary, Thomas Hearne, recalled that Plot had failed to return a fossil that he borrowed from Magdalen College, claiming it "was a Rule among Antiquaries to receive and never restore."[113] As a chymist, Plot also was content to receive knowledge, but generally he would only restore it for a price.

[108] Ibid., 728.
[109] Ibid., 732.
[110] Ibid.
[111] Birch, *History* (cit. n. 102), 4:88.
[112] Ibid., 4:225.
[113] Hearne, *Hearne's Collections* (cit. n. 73), 1:67.