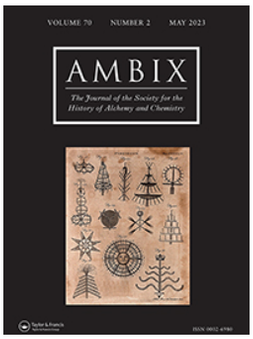

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TEXT AND COMMENTARY

Deciphering the *Hermeticae Philosophiae Medulla*: Textual Cultures of Alchemical Secrecy

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This article presents the decryption, historical analysis, and alchemical interpretation of an alchemical cipher found in a shared notebook of John and Arthur Dee (British Library MS Sloane 1902). The cipher is an early example of a Bellaso/Della Porta/Vigenère type, a strong encryption method which was historically deemed indecipherable. The essay explores the medical and alchemical context for the manuscript into which the cipher was copied and provides the transcription, plaintext solution (in Latin), and English translation of the encrypted text. Further, it interprets the enciphered text through the lens of alchemical practice and provides evidence for the dissemination of this cipher as part of a larger alchemical knowledge network.

Introduction

Alchemical ciphers are relatively understudied, both in cryptology as well as in scholarship on the history of alchemy. This is surprising, especially considering the great lengths to which many early modern alchemical practitioners went to prevent what they considered divine knowledge being revealed to undeserving laity. The current state of scholarship on alchemical ciphers is sparse, and when alchemical ciphers are mentioned in cryptological publications, it is simply to

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acknowledge that alchemical encipherment functions differently than well-studied modes of encryption, such as military or political encoding, without offering any analysis or theory as to how alchemical ciphering works in practice.[1]

This essay provides historical and alchemical context for an encrypted recipe contained within a ciphertext, *Hermeticae Philosophiae Medulla*, included in the medical notebook of John and Arthur Dee (British Library, Sloane MS 1902, fols. 13v–14r) and explains the function and decryption process for this polyalphabetic cipher. In the context of alchemy, ciphers are most commonly found in laboratory notes or medical notebooks.[2] The inclusion of this alchemical recipe for producing the Philosophers' Stone within the manuscript in which it was discovered illustrates the effort to simultaneously obscure and circulate alchemical and astrological medical knowledge among practitioners in the early modern period. The same encrypted recipe along with the Latin plaintext was subsequently found in a manuscript at the University of Edinburgh (MS Dc.1.30), along with dated laboratory notes describing the process. An additional reference to the unique passphrase used to decrypt the ciphertext can be found in a manuscript at the Bodleian Libraries (MS Ashmole 1423). The professional networks and connections between these three manuscripts together with an understanding of the circulation and use of polyalphabetic ciphers during this period sheds light on practical experimentation and the encryption of alchemical knowledge through the lens of *Hermeticae Philosophiae Medulla*.

Alchemical communication is rife with practices of secrecy, some of which are unique to alchemy (such as *Decknamen*), as well as commonly used technologies of secrecy that could be adapted to suit particular needs.[3] Much of alchemical obfuscation pertains to textual and linguistic practices, as well as visual culture. Rather than logical or numeric encryption (although this is common in anagrammatic pseudonomia contexts), alchemical secrecy tends to be qualitative rather than quantitative.[4] Qualitative practices of secrecy are not cryptographic devices, but symbolic methods of communication, such as mytho-alchemical allegory, emblems, and other visual iconography borrowed from esoteric traditions and applied to alchemical transmutation. While cultures of alchemical secrecy indeed include the quantitative search for mathematical patterns

[1] For an example of the cursory treatment of alchemical ciphers in cryptology scholarship see David Kahn, *The Codebreakers: The Comprehensive History of Secret Communication from Ancient Times to the Internet* (New York: Scribner, 1996): "[m]ysterious symbols were used in […] astrology and alchemy […] just as they were in cryptology. Like words in cipher, spells and incantations […] looked like nonsense but in reality, were potent with hidden meanings." Kahn, *The Codebreakers*, 91.

[2] William R. Newman and Lawrence M. Principe, "The Chymical Laboratory Notebooks of George Starkey," in *Reworking the Bench: New Studies in the History and Philosophy of Science and Technology*, ed. Frederic L. Holmes, Jürgen Renn and Hans-Jörg Rheinberger (Dordrecht: Springer Nature, 2003) vol. 7, 25–42.

[3] On the term *Decknamen* see Lawrence M. Principe, *The Secrets of Alchemy* (Chicago, IL: University of Chicago Press, 2012) and William R. Newman, "'Decknamen or pseudo-chemical language'? Eirenaeus Philalethes and Carl Jung," *Revue d'histoire des sciences* 49 (1996): 159–188.

[4] On the difference between alchemical cryptographic stylistic devices and numerical substitution ciphers see Richard Bean, Sarah Lang, and Megan Piorko, "Solving an Alchemical Cipher in a Shared Notebook of John and Arthur Dee," *Proceedings of the 5th International Conference on Historical Cryptology* (Linköping: Linköping University Electronic Press, 2022): 12–21. For an overview on alchemical language and secrecy see Sarah Lang, "A Machine Reasoning Algorithm for the Digital Analysis of Alchemical Language and its Decknamen," *Ambix* 69 (2022): 65–83.

in nature interpreted through alphanumeric knowledge charts, astrological horoscopes, cabbalistic mysticism, and Lullian diagrams, these textual trends cannot be systematically decoded as with cipher techniques.[5]

Alchemical qualitative devices of encryption serve a dual epistemic function as a special means of communicating knowledge that draws on multiple sensory experiences, such as the musical emblems from Michael Maier's *Atalanta fugiens* (1617), while the quantitative functioning inherent in numeric substitution ciphers lacks this epistemic advantage.[6] Additionally, there are textual practices of secrecy that can be discovered within publication information (or lack thereof) through material bibliographical analysis. An example of this can been seen with Arthur Dee's *Fasciculus Chemicus* (1631) where two issues of the same edition were printed consecutively: one dedicated to the students of chemistry that includes publication information on the title page, and another with a special dedication to the secret Brotherhood of the Rosy Cross that lacks publication reference.[7]

This article presents the plaintext solution and English translation of an encrypted alchemical recipe titled *Hermeticae Philosophiae Medulla*, or the Marrow of Hermetic Philosophy, found in a medical manuscript, Sloane MS 1902, which contains astrological and alchemical prognostications for health and death scribed by John Dee (1527–1608), and thereafter compiled and emended by his son, Arthur Dee (1579–1651). Unpacking the alchemical cipher within Sloane MS 1902 and tracing the copying of the cipher in additional manuscripts adds an important dimension to our understanding of the circulation of alchemical secrets within Anglo-Scottish knowledge-networks of the seventeenth century.

John and Arthur Dee's father-son medical notebook, held by the British Library, is a source of insight into the types of medical alchemy and astrology engaged in by physicians and adepts alike during the sixteenth and seventeenth centuries. This small composite manuscript (10 cm x 12 cm) made up of thirty-one folios of alternating paper and vellum, scribed in the hands of both Arthur and his famous father, has been almost entirely ignored in scholarly literature. A possible explanation for such lack of attention may be connected to the British Library catalog, which records only Arthur Dee as the author.[8] Clear distinctions can be made between the sixteenth-century handwriting of John Dee and Arthur Dee's seventeenth-century hand. Moreover, John's notes in Sloane MS 1902 are almost exclusively in Latin while Arthur writes in both Latin and

[5] For more on quantitative natural philosophy in alchemy see Peter J. Forshaw, "*Cabala Chymica* or *Chemia Cabalistica* – Early Modern Alchemists and Cabala," *Ambix* 60 (2013): 361–89; Lauren Kassell, Michael Hawkins, Robert Ralley, and John Young, "'Casebooks Project', A Critical Introduction to the Casebooks of Simon Forman and Richard Napier, 1596–1634": https://casebooks.lib.cam.ac.uk/about-us/casebooks-project (accessed 4 August 2022); Michela Pereira, *The Alchemical Corpus Attributed to Raymond Lull* (London: Warburg Institute, 1989).

[6] Tara Nummedal, "Sound and Vision: The Alchemical Epistemology of Michael Maier's *Atalanta fugiens*," in *Furnace and Fugue: A Digital Edition of Michael Maier's Atalanta fugiens (1618) with Scholarly Commentary*, ed. Tara Nummedal and Donna Bilak (Charlottesville: University of Virginia Press, 2020).

[7] Megan Piorko, "Seventeenth-Century Chymical Collections: A Study of Unique Copies of Fasciculus Chemicus," *The Papers of the Bibliographical Society of America* 113 (2019): 409–45.

[8] The British Library online catalogue: http://searcharchives.bl.uk/IAMS_VU2:LSCOP_BL:IAMS040-002114259 (accessed 6 September 2022).

English. Following the death of Arthur Dee, the manuscript found its way into the library of Sir Thomas Browne (1605–1682), along with a number of other alchemical manuscripts rescued from John Dee's library that Arthur had bequeathed to his friend.[9]

Elizabethan polymath John Dee and his infamous alchemical library have been examined by scholars extensively through the lenses of the history of science, bibliography, mathematics and navigation, patronage, as well as magic and esotericism.[10] However, his son, Arthur Dee, has not received the same level of scholarly attention, despite his prolific career.[11] Arthur was the first-born son of John Dee and Jane (Fromond) Dee, born on 13 July 1579 in Mortlake, Surrey on the very same day of the year as his father. That the two shared a birthday, and thus also shared a sun placement in their astrological nativities, would have been meaningful to John and likely contributed to his investment in Arthur's alchemical trajectory, which was markedly focused on Arthur above any of his other children. Upon Arthur's birth, John immediately drew his firstborn son's horoscope, along with a dark premonition for his life.

[Mars] in domo [Sol]^[is]
significat quod mors nati erit subita:
aut occidetur per ferrū, aut ignē:
et morietur extra patriam suam.
[symbol for ascending lunar node] in 8^[a] dom
horridā mortē prenunciat

Mars in the house of the sun
means that the death of [my] son will be sudden:
he will either be killed by iron, or fire:
and he will die outside of his own country.
An ascending lunar node in the eighth house
predicts a horrible death[12]

[9] For a list of manuscripts given to Browne by Dee see "Letter to Ashmole, Jan 25, 1658" in *The Works of Sir Thomas Browne*, ed. Geoffrey Keynes, 6 vols. (London: Faber & Gwyer Limited, 1931), vol. 6, 322.

[10] On John Dee see William Sherman, *John Dee: The Politics of Reading and Writing in the English Renaissance* (Amherst: University of Massachusetts Press, 1995); Stephen Clucas, ed., *John Dee: Interdisciplinary Studies in English Renaissance Thought* (Dordrecht: Springer, 2006); Deborah Harkness, *John Dee's Conversations with Angels: Cabala, Alchemy, and the End of Nature* (Cambridge: Cambridge University Press, 1999).

[11] A handful of articles on Arthur Dee were published in *Ambix* in the 1960's and 1970's: N. A. Figurovski, "The Alchemist and Physician Arthur Dee (Artemii Ivanovich DII): An Episode in the History of Chemistry and Medicine in Russia," *Ambix* 13 (1965): 35–51; John H. Appleby, "Some of Arthur Dee's Associations before Visiting Russia Clarified, Including Two Letters from Sir Theodore Mayerne," *Ambix* 26 (1979): 1–15; John H. Appleby, "Arthur Dee and Johannes Banfi Hunyades: Further Information on their Alchemical and Professional Activities," *Ambix* 24 (1977): 96–109; John H. Appleby, "Dr. Arthur Dee: Merchant and Litigant," Ambix 57 (1979): 32–55. Lyndy Abraham published an edited edition of the English *Fasciculus Chemicus* (1650) that contains bibliographical errors. Lyndy Abraham, ed., *Fasciculus Chemicus* (London: Taylor & Francis, 1997). For the most recent scholarship on Arthur Dee see Megan Piorko, "Material Evidence in Alchemical Texts and Arthur Dee's Career as Royal Physician," in *Alchemische Labore. Alchemical Laboratories. Texte, Praktiken und materielle Hinterlassenschaften* (Graz: Graz University Library Publishing, 2023): 53–71; Megan Piorko, "Chymical Collections: Seventeenth-Century Textual Transmutations in the work of Arthur Dee" (PhD diss., Georgia State University, 2020); and Piorko, "Seventeenth-Century Chymical Collections."

[12] This and all subsequent Latin-English translations are original translations by Sarah Lang.

This astrological prognostication, included with the cipher in the father-son medical notebook, is central to the context of Sloane MS 1902. A second dark omen hung over Arthur's entrance into the world. In a strange coincidence, Arthur's maternal grandfather died within twenty-four hours of his birth.[13] Despite the morbid significance mapped onto Arthur's birthday and nativity by his father, John considered his first-born son to be his prodigy and trained his son in the art of alchemy from a young age. His father's alchemical endeavours permeated all aspects of Arthur's childhood, and clearly had a great impact on his own alchemical career.[14] Arthur Dee received his medical degree from the University of Basel in 1609.[15] Before Arthur could return home to England a doctor, his father died in Mortlake in December of 1608. After a ten-year legal battle with the Royal College of Physicians in defence of the legitimacy of his medical practice, King James recommended Arthur Dee as Physician to Tsar Mikhail Romanov in Moscow. Arthur resentfully embarked on the journey to his new home in Moscow in 1621 at the mature age of forty-two, in what must have seemed to him a fulfillment of his father's dark prophecy for his life.

The folios that comprise Sloane MS 1902 are based on a collection of horoscopes and astrological medical notes scribed by John Dee, to which Arthur subsequently added his own alchemical remedies and recipes. Medical miscellanies, recipe books, notebooks, and commonplace books were prevalent during the early modern period. They satisfied a particular problem created by the print revolution – the need to organise an overwhelming influx of new knowledge.[16] Only recently has scholarship devoted much attention to physician's notebooks, which prove to be an invaluable resource related to how early modern medical practitioners understood, analysed, and synthesised the array of information they received from print and manuscript sources, as well as their own experience.[17] The medical knowledge contained within Sloane MS 1902 combines the Galenic philosophy of astrological effects on the human body, called *iatromathematics*, with the revolutionary idea that physical ailments could be treated chemically, known as *iatrochemistry,* established by Swiss physician Theophrastus von Hohenheim (1493–1514), better known as Paracelsus.[18] The combination of the ancient art of iatromathematics and the new Paracelsian iatrochemistry in the pages of Sloane MS

[13] John Dee, *The Private Diary of Dr. John Dee and the Catalog of his Library of Manuscripts*, ed. James Orchard Halliwell (London: Printed for the Camden Society, by J. B. Nichols and Son, 1842), 6.

[14] *The Private Diary of Dr. John Dee* contains many anecdotes about Arthur's youth as the son of a travelling alchemist and scryer. Additionally, a short biography of Arthur Dee in the front flyleaves of his scribal copy of *Benjamin Lock his Picklock to Riply his Castle* (Wellcome Library MS 436) describes a young Arthur playing with gold created by his father through the alchemical process of transmutation.

[15] "Announcement of Arthur Dee's thesis from University of Basel (1609)," Saxon State and University Library Dresden Archive, 1.B.3963,286.b.

[16] Ann Blair, *Too Much to Know: Managing Scholarly Information before the Modern Age* (New Haven, CT: Yale University Press, 2010).

[17] Anke Timmerman, "Doctor's Order: An Early Modern Doctor's Alchemical Notebooks," *Early Science and Medicine* 13 (2008): 25–52.

[18] On Paracelsus see Bruce T. Moran, *Paracelsus: An Alchemical Life* (London: Reaktion Books: 2019).

1902 presents a celestial alchemical understanding of man's relationship to nature and the cosmos through a shared concern with heavenly projections.[19]

While the scope of entire manuscript concerns astrological medical prognostication, it is comprised of individual leaves of paper that were originally scribed outside of the context of the manuscript, and thus result in a composite manuscript containing various notes, charts, and aphorisms on this theme. Additionally, some of the leaves were scribed on both recto and verso by turning over the leaf lengthwise in order to write on the other side, resulting in some pages being oriented upside-down in the codex form in which the manuscript exists today. An especially interesting aspect of the materiality and production of Sloane MS 1902 is that it is evident that Arthur was actively consulting and adding to the manuscript in its codex form throughout his career. To fully appreciate the inclusion of the alchemical recipe encrypted in this manuscript, it is necessary to understand the influence and relationship between the *Hermeticae Philosophiae Medulla* in the context of the notebook as a whole, as the cipher does not stand alone but is inextricably tied to the manuscript contexts in which it was discovered. What follows is (1) a description of Sloane MS 1902, (2) our results of solving the cipher and (3) a translation of the Latin plaintext to English. The essay concludes by drawing connections between other medical manuscripts that refer to this cipher as well as proposing a method for the practical application of the alchemical recipe based on archival evidence of the historical actors connected to the *Medulla*.

Production and description of Sloane MS 1902

The leaves of this tiny square manuscript are glued to tabs, rather than sewn together, to create the codex. After the loose leaves were assembled into codex form, an owner (probably Hans Sloane) wrote page numbers on the top right on the recto of each leaf. Folios 1–2, 5–8, 31, and the back flyleaves are paper, with the remaining leaves written on vellum. Additionally, many of the folios are written on both recto and verso on related topics, and folios 11v–14r, part of 27v, 28r, and 29v are oriented upside-down from the rest of the pages in the codex. This reflects the composition of the manuscript as a collection of John Dee's loose notes, subsequently bound together with supplemental information added by Arthur Dee. As such, it is more fruitful to examine its pages as two sides of a single leaf that correspond to one another, rather than as a codex with continuous information from the left page to the right, as modern readers are inclined to do.

The manuscript is bound in a Sloane collection binding with a gold gilt Sloane library stamp on the front and the shelf marks "BRIT. MUS. – S.L. 1902/ASTROLOGICAL NOTES" gilded on the spine. The rising popularity of iatrochemistry was integral to paradigm shifts in early modern medical philosophy, which is

[19] William R. 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 R. Newman and Anthony Grafton (Cambridge, MA: MIT Press, 2001), 1–38.

evident from the descriptive marginalia found on the front flyleaves of Sloane MS 1902, "Fasciculus remediey paracelsi/Petrus Bayrus." What follows is a bibliographical description of the contents of this manuscript, including the encrypted plaintext and its English translation.

Fols. 2–4, 9r are *Tabulae astrologicae*. Fols. 3 and 9r contain charts for the seven astrological symbols representing Saturn, Jupiter, Mars, Sol, Venus, Mercury, and Luna corresponding to specific parts of the body over which each planet exerts influence. This chart is replicated twelve times for each of the twelve zodiac signs and the respective parts of the body over which they rule. The charts on fol. 4 categorise the twelve zodiac signs in relation to their elemental properties of fire, earth, air, and water and as they are ascribed to either night or day. The groups of three signs and their respective element are designated a bodily manifestation, such as "Hot and dry cholerick bitter," followed by an astrological placement and description, "femme meridignall [of the] night." Below the elemental categories, the twelve zodiac signs are organised into their seasonal placements of mutable, fixed, and cardinal, or what Arthur Dee refers to as "Comon." In the margins of these pages are notes predicting illness, conception, and fortune relating to planetary placements and the optimal time of day and astrological house for which each zodiac sign has the most influence.

Fols. 5–8 appear to have previously been part of a single, larger sheet of paper that was subsequently cut into smaller pages to fit the codex Sloane MS 1902. Fol. 5 contains natal information for eight of Arthur's children: Arthur, Maria, Rowland, Frances, William, John, Isabell, and Anna. Fols. 6–8 elucidate astrological signs for predicting death in planetary ascensions, lunar placements, and placements in the eighth house of copulation and financial assets and in the sixth house of health and service. Fols. 6r through 8r are written continuously on both sides in John Dee's hand under the heading *Signa Mortis* or Signs of Death.

Fols. 9v–10r, 11r are *decumbitures* (horoscopes drawn at the time of death) for Arthur's sister Margaret Dee and his parents Jane Dee and John Dee. Below the decumbiture of his father, Arthur wrote the date 24 July 1634 and a short note that his wife, Isabella, died.[20] This note provides a timeframe for the production and use of Sloane MS 1902 by Arthur as circa 1634.

Fol. 10v depicts a "Zodiac Man." The Zodiac Man trope can be traced to the medieval *Melothesia* tradition and is an iconographic representation of the celestial influences on various parts of the body that are described in the *Tabulae astrologicae* found on fols. 2–4, 9r.[21]

[20] These horoscopes are listed as "nativities" in the British Library catalog record but are in fact decumbitures.

[21] On the concept of "melothesia" see Markham Judah Geller, *Melothesia in Babylonia: Medicine, Magic, and Astrology in the Ancient Near East* (Berlin: De Gruyter, 2014).

Fols. 11v–13r are filled with excerpts from canonical alchemical tracts attributed to the thirteenth-century physician and religious reformer Arnold of Villanova and sixteenth-century alchemist Dionysius Zacharias. Fol. 13r also contains the Latin passphrase to solve the ciphertext on the following pages.

Fols. 13v–14r contain an encrypted recipe for the Philosophers' Stone titled, *Hermeticae Philosophiae Medulla* [Figures 1 and 2] with an adjacent *tabula recta*. These pages present the ciphertext and table featuring a complex alphabetic substitution method of encryption. The leaves of this manuscript are bound upside-down in the manuscript, as is evident by the page number "13" appearing in the bottom left corner of Folio 13r, oriented upside-down from the text on the page. A transcription and translation of the ciphertext will follow.

Fols. 14v, 23–27 are medical aphorisms for different planetary placements. Folio 14v contains the remedy "For A Burning or Scalding dyp a cloth in good Inke and bathe yt therewith." These pages are written in English (and thus can be attributed to Arthur) in the form of a repetitive formula: [planetary symbol] in [zodiac sign] on topics ranging from "To know in what parte of the body [the] disease or most payne lyeth" and "To know whether the woman be quick with chylde or not."

Fols. 15–22 can be considered John Dee's version of an astrological *Ars Moriendi*.[22] These pages contain Latin numerated aphorisms and astrological medical projections dealing with death including the relationship between diseases and the planetary placements, health and sickness/death, dying in a reclining position, and healing or salvation. Under the section on health and sickness/death Arthur has added a list of "violent stars."

Fol. 28r is Arthur Dee's natal horoscope created by his father on the day he was born through which John prophesized his first-born son's violent death abroad. At the centre of his natal chart Arthur accepts his fate, making a note that this nativity was made by his intelligent father and that with great good comes much bad.

Fols. 28v–31 contain various excerpts on practical alchemical experimentation with antimony and sulphate of potash (here called "tartarum vitriolatum"), astrological projections about fortune, esoteric interpretations of alchemical transmutation, as well as a small doodle possibly representing the metaphorical alchemical process being described. Fol. 31 contains the reference: "vide Libau: de Extract […] fol. 244."[23]

[22] On the late-Medieval Christian tradition of *Ars Moriendi* see John R. Decker, "Between Conversion and Apostasy, Moriens's Struggle and the Fate of the Soul," in *The Turn of the Soul*, ed. Lieke Stelling (Leiden: Brill, 2012).

[23] This is likely a reference to "*De Extractis*," the second tract in Andreas Libavius, *Alchemia* (1597), which begins on page 241.

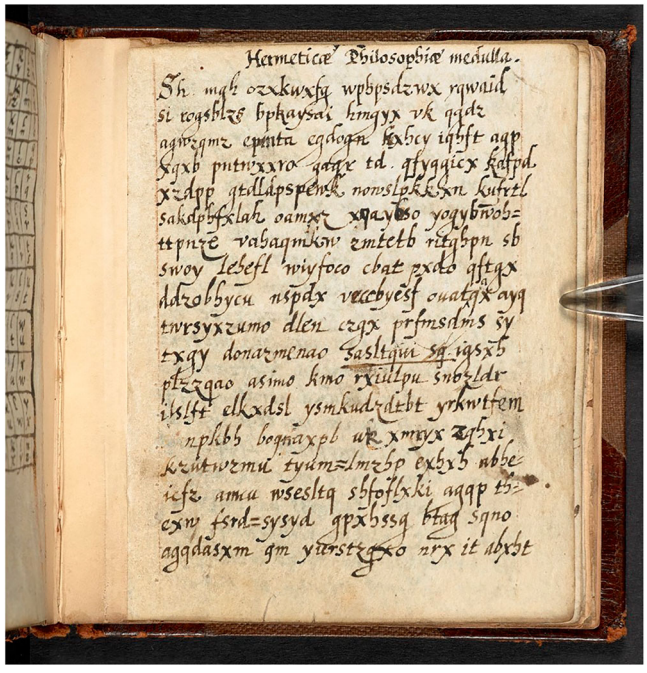

FIGURE 1. British Library Sloane MS 1902 fol. 13v. Page 1 of the encrypted alchemical recipe *Hermeticae Philosophiae Medulla,* oriented upside-down in the codex.

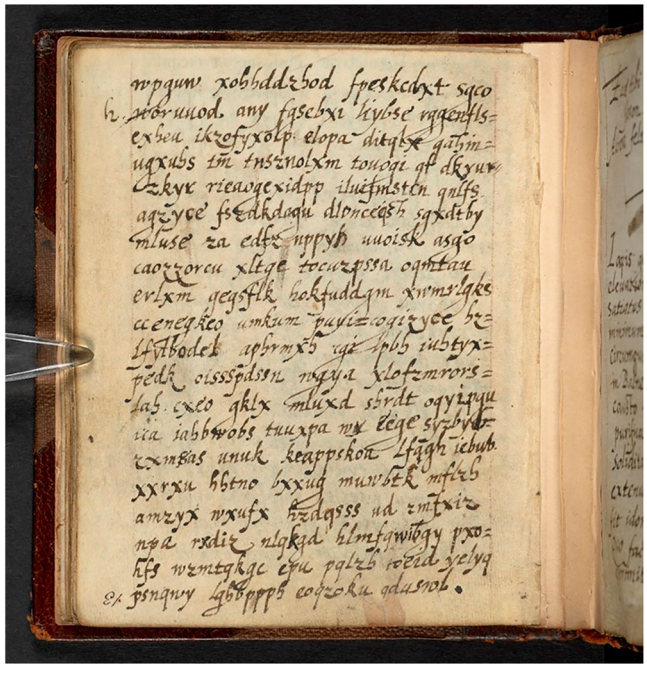

FIGURE 2. British Library Sloane MS 1902 fol. 13r. Page 2 of the encrypted alchemical recipe *Hermeticae Philosophiae Medulla,* oriented upside-down in the codex.

The Marrow of Hermetic Philosophy

The following is a literal transcription of the encrypted text as it was copied onto fol. 13 and bound in Sloane MS 1902 by Arthur Dee. It is followed by the Latin plaintext that we generated by decrypting the ciphertext transcribed below, which is the solution to the ciphertext.[24] Finally, we have provided an original English translation of the encrypted recipe.

Ciphertext

Hermeticae Philosophiae medulla.
Sh mgh ozxkwxfg wphpsdzwx rqwaid
si rogsblzs bpkaysai hmgyx uk qgdz
agwzqmz epmta egdogn kxhcy iqhft agp
xqxb pntwxxro gagr td qfyqgicx kafpd
xzdpp gtdldpspewk nowslpkkxn kufrtl
sakdphfxlah oamxz xqaybso yogybwoh=
ttpnze uahaqmkw zmtetb ritghpn sb
swoy lehefl wiyfoco cbat pxdo qftgx
ddzobhycu nspdx ueccbyesf ouat[^a]qx ayq
twrsyxzumo dlen czgx prfmsdms sy
txgy donazmenao sasltqui sg igsxh
plzzqao asimo kmo rxiulpu snozldr
ilslft elkxdsl ysmkudzdtbt yrkwtfem
npkbh bognaxpb uk xmryx zghxi
kzutwzmu tyum=lmzhp exhxh abhe=
icfz amcu wsesltq shfoflxki agqp th=
exw fsrd=sysyd gpxhssg btag sqno
agqdasxm qm yurstzgxo nrx it abxht
[page break]
wpguw xohhddzhod fpcskcdxt sgco
[h]~~w~~oruuod any fgsebxi liybse rggenfls=
exheu ikzofyxolp elopa ditqlx qahin=
ugxuhs tm tnsznolxm touogi qt dkyur
zkyr rieaogexidpp iluifmstcn qnlfs
agzyce fszdkdagu dlonceqsh sgxdtby
mluse za edfz nppyh uuoisk asgo
caozzorcu xltge tocuzpssa oqmtau
erlxm gegsflk hokfuddgm xwmrlgks
ccenegkeo umkum puyi=cogizyce hz=
lfytbodel aphrmxh cgi lpbh iuhtyx=
pedk oissspdssn wgya xlofzmrors=

[24] The cipher and plaintext solution included in University of Edinburgh, MS Dc.1.30 corroborates our solution.

lah cxeo gklx mluxd shrdt oqyipgu
ica iahbwobs tuuxpa w~~u~~[y] eege syzbyc=
zxmcas unuk keappskoa lfagh icbub
xxrxu hhtno bxxug muwbtk mflzh
amzyx wxufx hzdqsss ud zmfxiz
npa rxdiz nlqkgd hlmfqwibgy pxo=
hfs wzmtqkgc cpu pqlzh toeid yelyq
psnqwy lghbppph eoqzoku qduswl

Latin plaintext

Hermeticæ Philosophiæ medulla
In ovo diaphano Hermetice clauso ex Mercurii partibus novem, et Lunae Vulcani vires nondum passae, parte una, fiat amalgama,
quod in Athanore super ignem naturaliter digerentem, tam diu continuetur, donec materia ignis beneficio corvinum induat colorem, et ille rursus cygneum, quod fere infra trilunium fieri consuevit:
materia sic albificata ovum sine amotione ab igne, tempestive aperias,
ac solis foliati parte una materiae – immersa, quanta poteris dexteritate, firimiter denuo recludas, ac eodem ignis regimine decoquere sinas, quousque
tota materia intensius quam antea nigra fiat, nigredo vero illa transeat in albedinem.
Hic si operi finem imposueris, Tincturam Lunae habebis, sed praestat operi(s) continuatione, splendidum solis solium conscendere, et albedinis illius, in rubedinem conversionem praestolari:
idque tribus plerumque triluniis evenire solet, et tuum habebis Elixir vere solificum, cuius beneficio miseria omnis fugatur, et paupertas;
aegrisque quocumque morbo laborantibus restituitur sanitas.
Quo vero perficitur, eodem etiam modo multiplicatur, nisi quod solis locum Elixire uso supplere debeas, ad opus abbreviandum fiat proiectio unius super decem, prima tamen semper super solem facta.
Perfice et fruere.
Deo dando gratias, proximoque egenti benigus esto.
Sic alter Iason aurea felici portabis uellera colcho.

English translation[25]

Marrow of Hermetic Philosophy
In the hermetically sealed translucent egg, make an amalgam of nine parts Mercury and Luna which has not yet suffered the forces of Vulcan, one part.
If one continues digesting it in the Athanor over natural fire for so long until the material takes on the colour of the raven thanks to the fire, and in turn the

[25] Original translation by Sarah Lang.

colour of the swan, which usually happens after around a little less than a *trilunium*.
Once the matter is thus whitened, you shall open up the egg at the proper time without removing it from the fire.
And after one part of the matter is immersed in gold foil, with as much dexterity as you can, close it again and let it cook in the same manner until the whole *materia* becomes more intensely black than before, but this blackness goes over into whiteness.
If you end the work here, you will have Tincture of Luna, but it is better to climb up to the shiny throne of Sol by continuing the work and to await the conversion of its whiteness into redness.
And this usually occurs in three *trilunia* in most cases and then you will have a truly gold-making elixir with the help of which the miserable poverty is driven out and the sick who labour under whichever illness are restored to health.
In the same way, truly, that it is perfected, it is multiplied unless you have to replace some gold for the used Elixir. To shorten the work, the projection shall be done one over ten, but the first time it is always done over gold.
Perfect it and enjoy,
thanking God, be kind to your neighbour in need.
Like a new Jason you will carry the Golden Fleece away from the lucky Colchian.

Decrypting the Philosophers' Stone[26]

The cipher contained in Sloane MS 1902 is a polyalphabetic substitution cipher type, which consists of substituting one letter for another following a predetermined scheme.[27] Simple substitution ciphers are monoalphabetic, meaning that a fixed set of numbers, symbols, or letters are assigned to the alphabet of the plaintext, in which there is a single corresponding symbol attached to each letter in the alphabet that does not change throughout the ciphertext. Monoalphabetic ciphers were historically the most widely used method of textual encryption, despite being especially vulnerable to frequency analysis because the statistical letter frequencies are distinctive and the substitutions constant. One means of complicating a substitution cipher, for the purpose of added secrecy, is through the use of several alphabetic tables instead of one, adding variation to the substitutions.[28]

This type of polyalphabetic encryption became popularised in early modern Europe with the publication of cipher manuals. Early modern cryptological manuals (such as those produced by Italian publishers Giambattista Della Porta

[26] On the cryptological process for solving the cipher containing a detailed description of the cipher table and its cryptological function see Bean, Lang, and Piorko, "Solving an Alchemical Cipher."
[27] Benedek Láng, *Real Life Cryptology: Ciphers and Secrets in Early Modern Hungary* (Amsterdam: Amsterdam University Press, 2018), 31–49.
[28] Elonka Dunin and Klaus Schmeh, *Codebreaking: A Practical Guide* (London: Robinson, 2020), 163.

and Leon Battista Alberti as well as those produced in German speaking lands by Johannes Trithemius and Gustavus Selenus) pushed the boundaries of the symbolic and monoalphabetic ciphers of the Middle Ages to invent more complex methods of concealment for their political purposes.[29]

In modern cryptological scholarship polyalphabetic substitution ciphers are known as Vigenère types after the sixteenth-century French cryptographer Blaise de Vigenère, who published this type of cipher in 1586. The polyalphabetic method of encryption was pioneered by Giovani Battista Bellaso in 1552, first published as a series of pamphlets between 1553–1564. Despite earlier publications by Bellaso, polyalphabetic substitution ciphers were not widely used until the mid-seventeenth century, when they were popularised as Della Porta ciphers following his 1563 publication *De Furtivis,* which illustrated the use of this type of cipher without crediting Bellaso. While Vigenère did acknowledge the work of Bellaso in his publication, Vigenère remains the cipher's namesake today.[30] Both Della Porta and Vigenère borrow from Bellaso the concept of employing a key word in combination with a cipher table (*tabula recta* or "Porta table") to create a polyalphabetic cipher, which became characteristic of the "Vigenère type" of polyalphabetic ciphers thereafter. Della Porta also published alchemical treatises (such as *De distillatione libri XI*, 1608), which may have drawn alchemical practitioners to his previous publications on polyalphabetic encryption. Thus, the inclusion of *Hermeticae Philosophiae Medulla* cipher in Sloane MS 1902 is a relatively early and rare example of a Bellaso/Della Porta polyalphabetic type.[31]

Our initial assumption for the cryptanalytical process for *Hermeticae Philosophiae Medulla* was that the cipher table was used in both the encryption of the plaintext solution and the decryption of the adjacent ciphertext.[32] The basis for this attack was a classic weakness of the Della Porta cipher: each half of the alphabet can encipher only to the other half and vice versa. For the given cipher table, the letters A to M can encipher, or decipher, only to the letters N to Z, and the converse.[33] However, the cipher table in Sloane MS 1902 contains a crucial error. The first row corresponding to (AB) should be 24 letters in alphabetical order, but the letter following "l" in the top register is "n" rather than "m." This initial mistake causes a ripple effect that renders this cipher table unusable as

[29] Katherine Ellison, *A Cultural History of Early Modern English Cryptography Manuals* (London: Routledge, 2017); Katherine Ellison and Susan Kim, eds., *A Material History of Medieval and Early Modern Ciphers: Cryptography and the History of Literacy* (London: Routledge 2018).

[30] Augusto Buonafalce, "Bellaso's Reciprocal Ciphers," *Cryptologia* 30 (2006): 39–51.

[31] Kahn, *Codebreakers*, 151 documents the use of a Della Porta style cipher in practice in 1589.

[32] This is accomplished by writing the ciphertext out at various widths and calculating the average "index of coincidence" (IC) of the columns. After the width is determined, each column in the cipher table can then be solved as an independent monoalphabetic substitution cipher. Abraham Sinkov, *Elementary Cryptanalysis* (New York: Random House, 1968).

[33] The cipher table presented in Sloane MS 1902 is in the standard Della Porta format in which the index of letters used on the left-hand column is in alphabetical order. Notably, the ciphertext and table in Sloane MS 1902 substitutes the letters "j" and "v" for "i" and "u" respectively. Thus, the alphabet used in the cipher table is only 24 letters long.

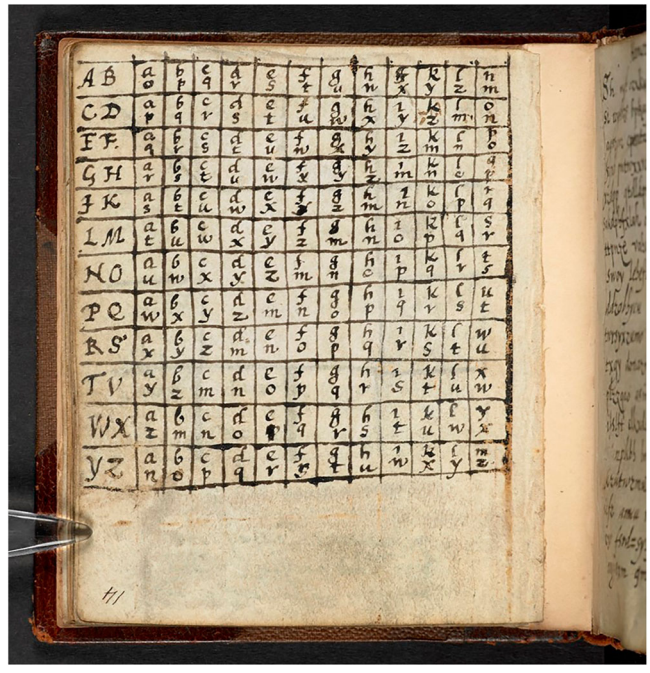

FIGURE 3. British Library Sloane MS 1902 fol. 14r. *Tabula recta* for the encrypted alchemical recipe *Hermeticae Philosophiae Medulla,* oriented upside-down in the codex.

corresponding letters are off by one register throughout. As such, it must be concluded that Arthur Dee copied the cipher table and encrypted ciphertext from an external source, rather than it being an original cipher created by Arthur Dee, as the cipher table in its erroneous form could not have been used to encrypt the adjacent recipe.[34]

Unlike the *tabula recta* found in Sloane MS 1902 [Figure 3], which has been amended for an English language context, Della Porta's version only contains eleven reciprocal alphabets as it was intended exclusively for the Latin alphabet, which does not include letters "k" and "w." The inclusion of these letters in the Sloane MS 1902 table must have been intentionally adapted for use with English or German languages, despite the plaintext being Latin. To determine whether the plaintext would be in Latin or English (the two most plausible options given the producers of Sloane MS 1902), word statistics were calculated. The average word length in the ciphertext is 5.8 characters, much longer than the average length of English words.[35] The longest ciphertext word is fourteen letters, which

[34] The converse is also true that the table could not be used to decrypt the ciphertext. A slightly modified cipher table would have been effective for encipherment or decipherment. Bean, Lang, and Piorko, "Solving an Alchemical Cipher."

[35] The mean length of words in Project Gutenberg English books is 4.4 while that of the Latin books is 5.6: https://www.gutenberg.org/ (accessed 6 September 2022).

again is unusually long for English. Thus, it was determined that the plaintext would likely be Latin.

A digital approach to solving a polyalphabetic cipher involves searching for repeated occurrences of letters within the ciphertext using computational cipher solving tools.[36] Alternatively, key phrase guessing may be an effective means of manually decrypting a polyalphabetic cipher, although the strength of the cipher increases with the length of the key.[37] For a particularly long word in a Della Porta ciphertext, only a few possible Latin words might correspond. By locating the most frequent Latin word that could possibly correspond to a ciphertext word, it was possible to derive part of the key phrase for the cipher. Then, the cipher key can be used for selecting which of the rows of the cipher table will be used for each letter in the ciphertext. The key phrase can then be reused as needed until the entire ciphertext is solved by repeating the letters of the key consecutively for the length of the entire text. Due to this feature of repetition in the key, polyalphabetic ciphers are somewhat resistant to errors because the redundancy of the underlying language is preserved.

In this case, the substring of the letters "cepneip" is clearly repeated throughout the implied key. Then, through an iterative process of extending the key left and right, the key length was determined to be forty-five letters: "tlecnwgtlctppcwtgcggnlelrptwccltwgnngt**cepneip**." Each letter in the key is adjacent to corresponding letters in the cipher table which comprise the Latin phrase *Sic alter Iason aurea felici portabis uellera* ***colcho***, or "Like a new Jason you will carry the Golden Fleece away from the lucky Colchian." The encrypted key phrase can be found in the last line of the ciphertext of *Hermeticae Philosophiae Medulla* as well as scribed on the page adjacent to the ciphertext [Figure 4], further corroborating our results.

By applying the Latin plaintext key phrase *Sic alter Iason aurea felici portabis uellera colcho*, it is possible to solve for the first line of plaintext using a simplified and corrected *tabula recta*. Since the first letter of the plaintext key is "s," locate the "RS" row in the table. Within that row, find the first letter of the ciphertext and its corresponding plaintext solution letter. In this case it is also "s" and in the "RS" row "s" corresponds to "i." The next letter in the plaintext key is "i" and the second letter in the encrypted text is "h." Within the "IK" row of the cipher table, the letter "h" corresponds to the letter "n." Repeat the key phrase as necessary [see Tables 1 and 2].

[36] The statistical model used to solve this cipher analysed sets of Latin texts from Project Gutenberg: https://www.gutenberg.org/; Perseus digital library: http://www.perseus.tufts.edu/hopper/; and Arthur Dee, *Fasciculus Chemicus* (Paris: Nicolas de la Vigne, 1631). The cryptanalytical methodology that was ultimately successful was to build a statistical model for the Latin language consisting of a frequency count of "hexagrams," or six letter contiguous blocks of Latin letters, and a list of Latin words contemporaneous with the ciphertext to determine an association for frequency of use. Bean, Lang, and Piorko, "Solving an Alchemical Cipher."

[37] For example, letter sequences of length five or more would be unlikely to recur by chance. This attack method uses the "Kasiski examination," which functions to determine the length of the cipher key. Helen F. Gaines, *Cryptanalysis: A Study of Ciphers and their Solution* (New York: Dover Publications, 1956); Abraham Sinkov, *Elementary Cryptanalysis* (New York: Random House, 1968).

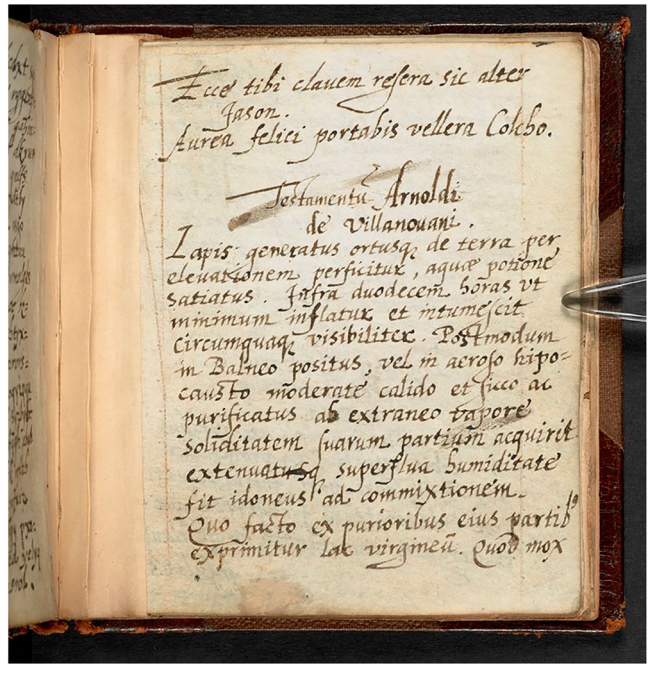

FIGURE 4. British Library Sloane MS 1902, fol. 12v. Page containing the key phrase of the encrypted alchemical recipe *Hermeticae Philosophiae Medulla,* oriented upside-down in the codex.

TABLE 1.

SIMPLIFIED AND CORRECTED *TABULA RECTA*.

Key		a	b	c	d	e	f	g	h	i	k	l	m
AB	1	o	*p*	q	r	s	t	u	w	x	y	z	n
CD	2	*p*	q	r	s	t	u	w	x	y	z	n	o
EF	3	q	r	s	t	u	w	x	y	z	n	o	*p*
GH	4	r	s	t	u	w	x	y	z	n	o	*p*	q
IK	5	s	t	u	w	x	y	z	n	o	*p*	q	r
LM	6	t	u	w	x	y	z	n	o	*p*	q	r	s
NO	7	u	w	x	y	z	n	o	*p*	q	r	s	t
PQ	8	w	x	y	z	n	o	*p*	q	r	s	t	u
RS	9	x	y	z	n	o	*p*	q	r	s	t	u	w
TU	10	y	z	N	o	*p*	q	r	s	t	u	w	x

TABLE 2.

KEYPHRASE AND CORRESPONDING SOLUTION HIGHLIGHTED.

Keyphrase	sic alter iason aurea felici portabis uellera colcho
Ciphertext: *Hermeticae Philosophiae Medulla.*	sh mgh ozxkwxfg wphpsdzwx rqwaid si rogsblzs bpkaysai hmgyx uk qgdz [...]
Plaintext Latin solution	in ouo diaphano hermetice clauso ex mercurii partibus nouem

Obviously, Arthur Dee would not have had access to modern computer science statistics-based methods employed to decrypt this cipher. However, the underlying logic of the patterns found in this cipher also hold up when executed scribally with pen and paper. Additionally, the key phrase and resulting plaintext hold mythoalchemical meaning that can be used to infer meaning from the Latin plaintext solution and key phrase. Due to the complexity of polyalphabetic ciphers, they can only have one plaintext solution. This cipher style follows rules, and statistically it is not possible to generate any random text – only one statistical pattern will match. While it is true that in the context of pseudo-cryptography, non-systemic assumptions can lead to the production of arbitrary text, proper cryptographical systems are complex, systematic, and do not allow for the production of random text.

Scribal circulation of *Hermeticae Philosophiae Medulla*

After decrypting the ciphertext of *Hermeticae Philosophiae Medulla* in Sloane MS 1902, we discovered the existence of a second seventeenth-century manuscript containing the ciphertext followed by the Latin plaintext, matching our decryption results (MS Dc.1.30).[38] This manuscript also contains laboratory notes, further corroborating our plaintext decryption as well as shedding light on scribal knowledge networks within seventeenth-century alchemical practice.

The following sections of this essay provide examples of historical transmission of variant flawed key phrases created and disseminated through scribal error, illustrating the impossibility of solving the ciphertext of *Hermeticae Philosophiae Medulla* with a faulty key phrase copied from another source as well as the role of mythoalchemy in understanding the practical instructions contained within this heavily veiled alchemical recipe for the Philosophers' Stone.

A copy of this ciphertext, *tabula recta*, and the Latin plaintext can be found in a manuscript housed at the University of Edinburgh (MS Dc.1.30). This manuscript is described in the catalog as a "commonplace book on alchemy" produced by Patrick Ruthven c. 1629. Little is known about the life of Ruthven. He received his medical and alchemical training while imprisoned in Scotland by James VI, who executed his father William, first Earl of Gowrie in 1584, the year Ruthven was born. He practiced medicine after his release from prison and died in London in 1652. The majority of his medical writings are compiled in MS Dc.1.30.[39] Unlike the pocket-sized Sloane MS 1902, MS Dc.1.30 is a large manuscript (13.25in x 8.25in) comprised of 124 folios filled with alchemical medical remedies, drawings, and notes of laboratory

[38] The cipher contained in MS Dc.1.30 was discovered and brought to our attention by Sergei Zotov, PhD Candidate, Centre for the Study of the Renaissance, University of Warwick.

[39] Mysteriously, there is no provenance or acquisition record for MS Dc.1.30. See R. Ian McCallum, "Patrick Ruthven, Alchemist and Physician," *Proceedings of the Society of Antiquaries of Scotland* 134 (2004): 471–90.

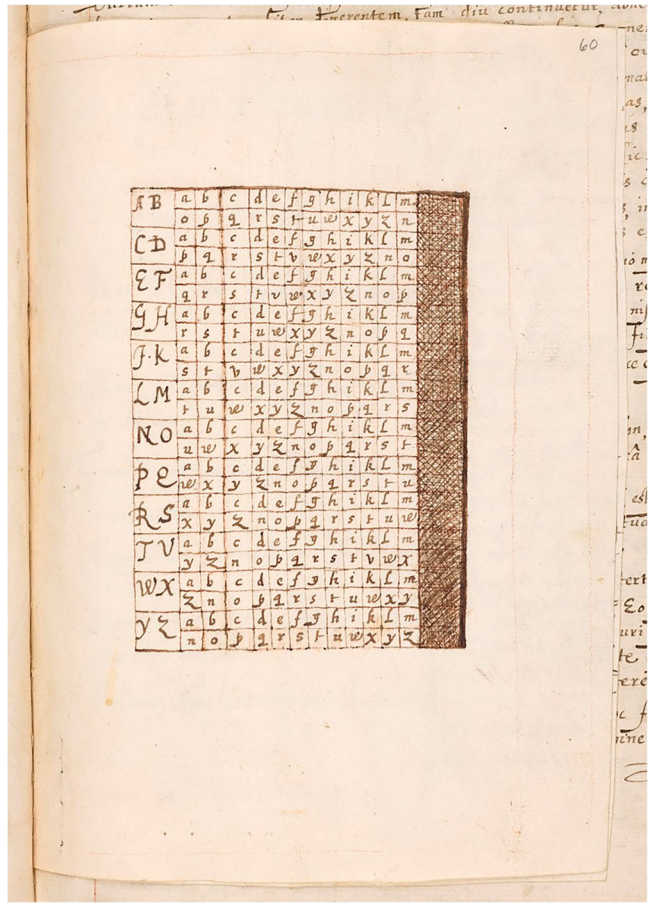

FIGURE 5. University of Edinburgh MS Dc.1.30 fol. 60r. *Tabula recta* of the encrypted alchemical recipe *Hermeticae Philosophiae Medulla.*

experiments, esoteric alphabetic and numeric charts, and excerpts from scribally circulated alchemical tracts almost exclusively in the hand of Ruthven.

However, both the cipher table [Figure 5] and encrypted text [Figure 6] found in MS Dc.1.30 contain divergences from those copied into Sloane MS 1902. Unlike the one found in Sloane MS 1902, the *tabula recta* adjacent to the ciphertext in MS Dc.1.30 is accurate and could have been used to decrypt and encrypt the ciphertext. Within the ciphertext, the differences between the two manuscript copies are exclusively letters that can be easily confused for one another in early modern paleography, such as g/q, h/b, and l/t.[40] Corrections were made to MS Dc.1.30 between rows of ciphertext and in the margins. In some cases, both manuscripts have the same ciphertext correction. For example,

[40] For a table with frequency counts by letters based on two transcriptions and the final text see Bean, Lang, and Piorko, "Solving an Alchemical Cipher."

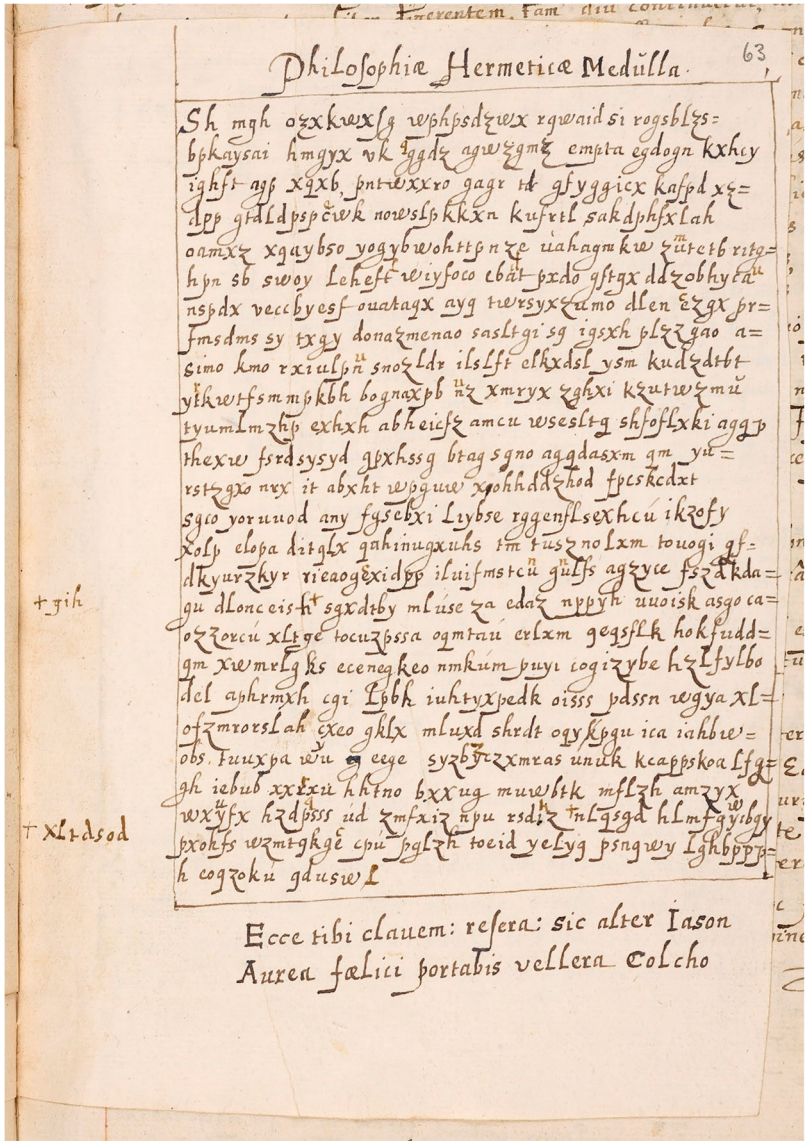

FIGURE 6. University of Edinburgh MS Dc.1.30 fol. 63r. Encrypted alchemical recipe *Hermeticae Philosophiae Medulla* with correct key phrase below.

towards the end of both ciphertexts the encrypted word "wu" is clearly corrected to "wy." This type of correction indicates that both scribes subsequently corrected the encrypted text after decrypting the recipe, and that Sloane MS 1902 and MS Dc.1.30 were likely copied from a shared source that contained the errors present in both encryptions. Ultimately, the evidence from the mistakes found in both manuscripts support the argument that both Ruthven and Dee copied the cipher in its entirety (*tabula recta*, ciphertext, and key phrase) from

an external source circulated via manuscript, and neither scribe was responsible for the original encryption of this recipe.

The Latin plaintext in MS Dc.1.30 [Figure 7] contains an original title that is not present in the ciphertext, *Verum veriûs verissimûm absque dolo vel aenigmate probatûm* or "The truest truth proven without deceit by an enigma." Another addition unique to MS Dc.1.30 can be found in the plaintext key phrase copied under the Latin plaintext (fol. 64r). Here, the key phrase is written as *Ecce tibi clavem; refera, sic alter Iason, Aurea, faelici portabis vellera* ***dextra***, rather than *Ecce tibi clavem refera Sic alter Iason aurea faelici portabis uellera* ***colcho***, which changes the meaning from "See here for you the key Like a new Jason you will carry the Golden Fleece away from the lucky Colchian" to "Like a new Jason, you will carry the Golden Fleece to the lucky one." However, the original term key phrase with "colcho" is encrypted in the ciphertext and decrypted in the key phrase below the ciphertext of MS Dc.1.30 and is also present in Sloane MS 1902. The function of replacing "colcho" with "dextra" only in the plaintext is not clear. This error in the key is enough to generate the effect described earlier. Minor variations such as this in any of the aspects involved in the de- and encryption processes (ciphertext, key, or table) result in random letters as output text when trying to solve the cipher. Thus, it would not be possible to solve the cipher with this adapted key.

The key phrase for the ciphertext is adapted from the last lines of Giovanni Aurelio Augurello's (1441–1524) mythoalchemical *sermo*,[41] "Alberto Vonico, Tarvisino Equiti et lureconsulto χρυσοποιία (chrysopoeia)" also known as "Chrysopoeia Minor."[42] The word "dextra" is not present in the published poem. Additionally, the published poem has been adapted for the cipher context by changing "devexi" (I have robbed away) to "portabis" (you will carry).[43] The poem in its entirety is a first-person narration of the voyage of a lost traveller who attains the Golden Fleece by tending to sheep in a cave, and could function as a veiled mythoalchemical explanation of a chrysopoeic process. Although the last lines of this poem reference the myth of Jason and the Argonauts, in the version copied into MS Dc.1.30 the verse is adapted to describe Jason carrying the Fleece to lucky Colchis where in the classical version of the myth Jason steals the Fleece from Colchis, thus allowing for a new mythoalchemical interpretation.[44]

Through this lens, the poem "Chrysopoeia Minor" can be understood as an *aition* (a genre of origin stories popular in Antiquity) for the Golden Fleece,

[41] A *sermo* is a type of hexameter poem.

[42] "Sermo XVII" in Augurello, *Carmina* (Venetiis, 1505). On the *sermo* "Chrysopoeia Minor" see Matteo Soranzo, *Giovanni Aurelio Augurello (1441–1524) and Renaissance Alchemy* (Leiden: Brill, 2020), 35–39, 86–88; and 110–21.

[43] This change to the Latin "portabis" deteriorates the grammar of the poem, rendering it somewhat obscure.

[44] On the mythoalchemical trope of the Golden Fleece see Zweder Rudolf Willem Maria Von Martels, "Alchemy Revisited," *Proceedings of the International Conference on the History of Alchemy at the University of Groningen* 33 (1989): 250–58; Antoine Faivre, *The Golden Fleece and Alchemy* (Albany: State University of New York, 1993).

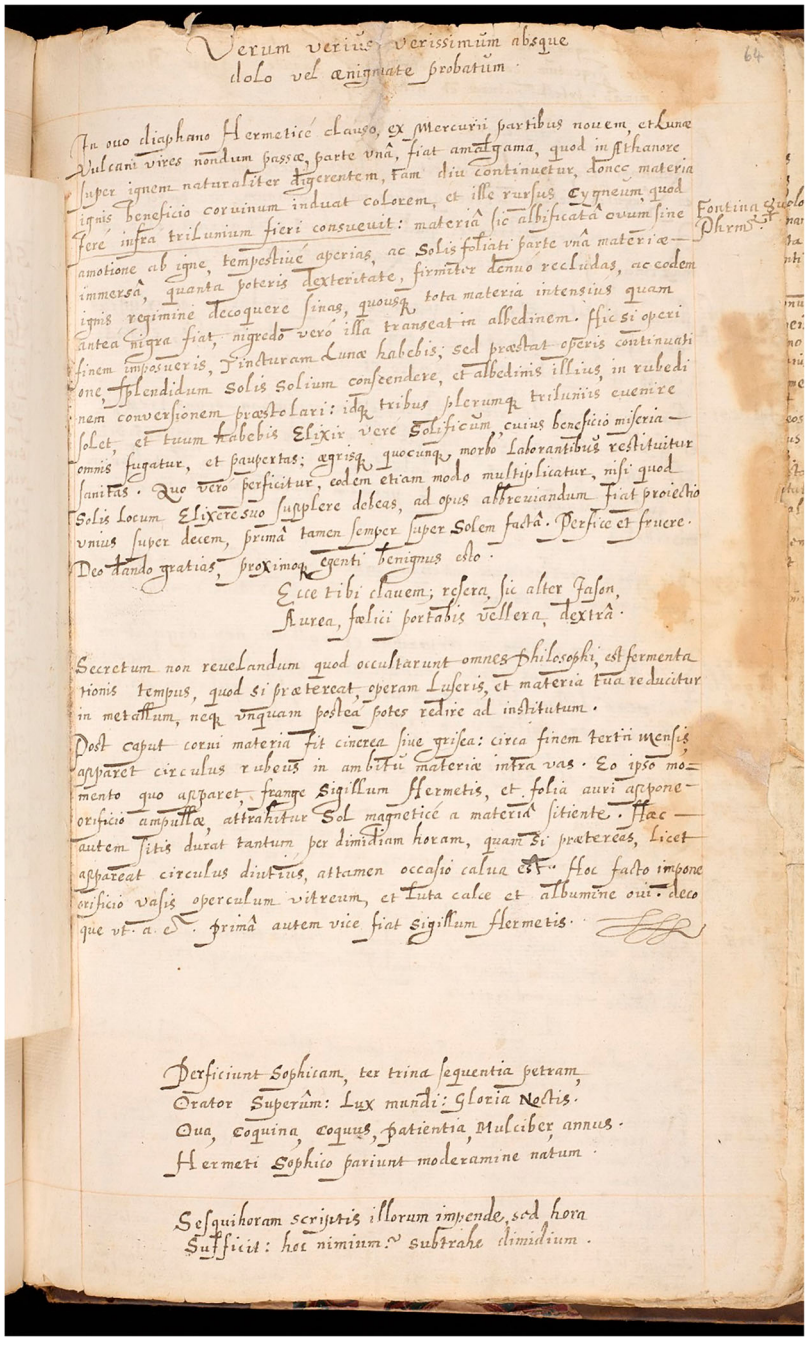

FIGURE 7. University of Edinburgh MS Dc.1.30 fol. 64r. Latin plaintext of the alchemical recipe *Hermeticae Philosophiae Medulla* with an original title above and additional practical instructions as well as an altered key phrase below.

created by Augurello to suit his own mythoalchemical needs.[45] While the last two lines of the poem refer to Jason and the Golden Fleece, the overall narrative of *Chrysopoeia* does not align with the traditional myth of Jason and the Argonauts. Rather, Augurello likely interprets the Golden Fleece to be a mythical animal skin, which could represent the material used to produce a book containing alchemical secrets. The poem mainly depicts a voyager tending to a sheep over an extended period of time. This might refer to the alchemical *arbor philosophorum* (or "tree of Diana"), a crystalline growth emerging from an amalgam of mercury and silver, which visually resembles a "woolly" crystal.[46] The decision to employ this extraordinarily long key phrase indicates that it holds special meaning for the encrypted recipe, beyond the mythoalchemical symbolism of the Golden Fleece. It also points the reader to Augurello's poem. This could be a clue as to why the encrypted recipe seems to begin after a significant part of the experiment has already been completed. There is evidence that Ruthven (or his original source) had knowledge of unwritten or inferred parts of the recipe, as the additional text following the Latin plaintext of *Hermeticae Philosophiae Medulla* in MS Dc.1.30 refers to "three vials" not mentioned in the encrypted recipe.

Yet another reference to the cipher key phrase can be found in a manuscript at the Bodleian Libraries, that provides further context for the seventeenth-century circulation of the *Hermeticae Philosophiae Medulla* in English and Scottish alchemical networks. MS Ashmole 1423 contains six separate alchemical tracts scribed in the same hand and bound together as a codex. The first tract is an English alchemical treatise on the Philosophers' Stone attributed to George Marrowe (scribed in 1596, supposedly from an original copy written in 1437) [Figure 8]. George Marrowe was an Augustinian monk of Nostall Abbey in Yorkshire.[47] It is likely more than a strange coincidence that the author of an English work describing the Philosophers' Stone, the topic of the recipe encrypted in Sloane MS 1902 and MS Dc.1.30, was named Marrowe. The title of the recipe (*Hermeticae Philosophiae Medulla*) can be translated as Marrow of the Hermetic Philosophy, possibly a textual play on the name of the monk from Nostall Abbey. Two other alchemical treatises follow Marrowe's, attributed to Roger Merryfoot and Peter Percy. The rest of MS Ashmole 1423 includes a collection of alchemical recipes from the late-sixteenth century, alchemical recipes from the late-fifteenth century, and the sixth tract is the *Liber aureus* containing alchemical poems, recipes, and notes.[48]

[45] Nikolaus Thurn suggests that Augurello uses mythoalchemical allegory to present a practical alchemical recipe. Nikolaus Thurn, "Die Chrysopoeia des Giovanni Augurello," in *Die Poesie der Dinge: Ziele und Strategien der Wissensvermittlung im lateinischen Lehrgedicht der Frühen Neuzeit,* ed. Ramunė Markevičiūtė and Bernd Roling (Berlin: De Gruyter, 2021), 61–77.

[46] On the Tree of Diana see "The Chymistry of Isaac Newton Project": https://webapp1.dlib.indiana.edu/newton/reference/chemLab.do (accessed 6 September 2022).

[47] "The trewe coppie of an auncyent boke written on parchement by George Marrowe, monk of Nostall Abbey in York sheire, anno D'ni 1437," Bodleian Libraries MS Ashmole 1406, fol. 4r.

[48] The final tract is scribed in an earlier, fifteenth-century hand.

FIGURE 8. Bodleian Library MS Ashmole 1423, fol. 1v. Title page of the George Marrowe manuscript.

MS Ashmole 1423 has an impressive provenance. John Dee once had MS Ashmole 1423 in his possession as is evident by a short table of contents on the first page of the sixth tract in the manuscript, which he signed "Jo. Dee. A° 1563." Seventeenth-century English astrologer and physician Richard Napier also owned Ashmole MS 1423, and heavily annotated and signed his name throughout the text. Finally, Elias Ashmole, seventeenth-century antiquarian and publisher of the English edition of Arthur Dee's *Fasciculus chemicus* (1650) acquired Richard Napier's manuscript collection in 1669, including MS Ashmole

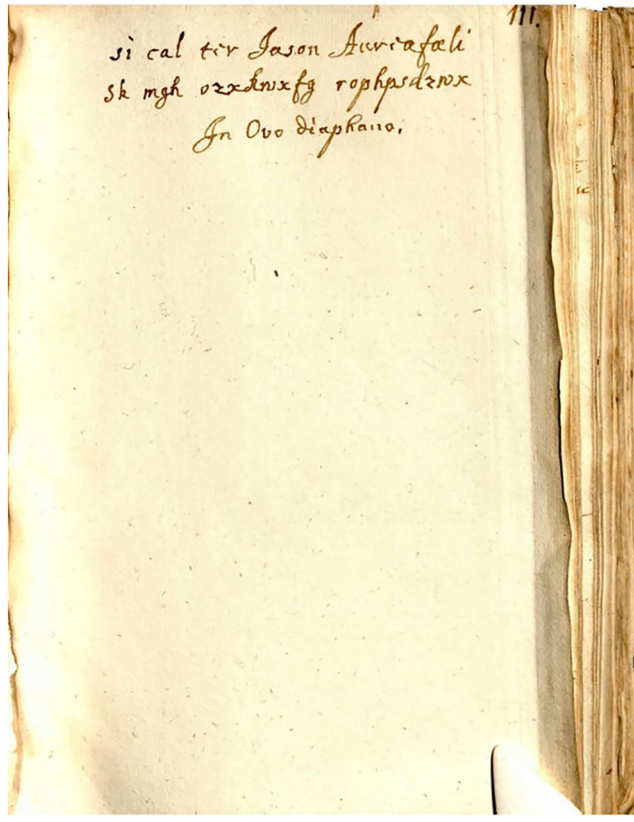

FIGURE 9. Bodleian Library MS Ashmole 1423 fol. 72r. Three incipits for the key phrase, the first line of the Latin plaintext and the ciphertext of *Hermeticae Philosophiae Medulla* written in Elias Ashmole's hand.

1423.[49] A blank leaf between the Merryfoot and Percy treatises [Figure 9] contains the incipit of the cipher key, both in plaintext and enciphered, and of *Hermeticae Philosophiae Medulla*, written in Ashmole's hand.[50]

si cal tir Jason Auriafoeli
sh mgh ozxknxfg rophpsdzrox
In Ovo diaphano

The plaintext of the key phrase contains a misspelling of the word "alter" as "altir" and the spaces between the words do not correspond to the actual Latin plaintext. This suggests that Ashmole was trying to solve for a known key phrase as initially he attempts to mirror the spacing of the letters that comprise the first line of the ciphertext. However, the spacing of Latin plaintext key does not align with the

[49] Jennifer M. Rampling, *The Experimental Fire: Inventing English Alchemy, 1300–1700* (Chicago, IL: University of Chicago Press, 2020), 328–30.

[50] W. H. Black, *A Descriptive, Analytical, and Critical Catalogue of the Manuscripts Bequeathed unto the University of Oxford by Elias Ashmole Esq.* (Oxford: Bodleian Libraries Quarto Catalogues, 1845), 1150–54.

spacing of the Latin plaintext of the first line of the ciphertext. He must have realised his error, as is evident by the inclusion of the first line of Latin plaintext solution that correctly corresponds to the ciphertext scribed above it.

Richard Napier is also connected to the two manuscripts (Sloane MS 1902 and MS Dc.1.30) containing the ciphertext *Hermeticae Philosophiae Medulla*. Napier made a profession as an astrological prognosticator and saw clients such as Arthur Dee in regard to medical and personal issues. On 20 May 1602 at 4pm, Napier drew Arthur Dee's horoscope to answer the question of "wheath^[r] he shall obtayne his wifes Dowry not w^[th]out barbell." The answer was surely positive, as Arthur wed Isabella Prestwich in 1602 and the two subsequently had twelve children together. This transaction is one of many cases of Napier treating patients by drawing astrological horoscopes that can be found in his detailed casebooks.[51] It is possible that Richard Napier and the Napier family serve as a pivotal association in the scribal circulation of *Hermeticae Philosophiae Medulla* and the astrological and alchemical medical knowledge-networks that shared the cipher. Patrick Ruthven wrote the following medical documentation about his good friend and German physician Dr. Müller.

> Heer foloweth a discours that passed betwixt D. Müller, and Markestone, when the sayde Doctor was lyen sicke of the goute in Edinbroughe, and thought to have died, as the same was set downe by the sayd Markestone, and founde after his death amongst his papers … "Upon Saterday the 7th of November, 1607 years, I Jhon Napeir Fier of Markeston, came to confer with Mr. Daniel Müller, Doctor of Medicine, and student in Alchymie, aneint our phylosophicall matters, not knowinge that he was sicke,"

The person referred to as "Markestone" is mathematician Sir John Napier (1550–1617), cousin of Richard Napier.[52] Further, *Mark* means "marrow" in German. By using the moniker Markestone – or Marrow Stone – for John Napier, Dr. Müller may be signaling a connection between Napier and *Hermeticae Philosophiae Medulla:* The Marrow of Hermetic Philosophy.

Achieving the Philosophers' Stone: *Hermeticae Philosophiae Medulla* in practice

Beyond circulating the *Hermeticae Philosophiae Medulla* ciphertext through seventeenth-century knowledge networks, is there any evidence of the scribes of these manuscripts attempting to replicate the encrypted recipe? By analysing the entire contents of the manuscripts and comparing other manuscripts produced by these historical actors, it is possible to glean their attempts at practical alchemical experimentation with the goal of producing the Philosophers' Stone with the

[51] Lauren Kassell, et al., eds., 'CASE16969', The Casebooks of Simon Forman and Richard Napier, 1596–1634: A Digital Edition, fol. 51v: https://casebooks.lib.cam.ac.uk/cases/CASE16969 (accessed 1 December 2022).

[52] "Letter from Thomas Wright, Esq. F.S.A., to John Bruce, Esq. Treas. Accompanying the Exhibition of a Volume in the handwriting of Patrick Ruthven," *Archaeologia* 34 (1851): Appendix.

plaintext recipe. In addition to the encrypted recipe on fol. 64r of MS Dc.1.30, there is a paragraph below the Latin plaintext as well — a leaf of laboratory notes dated 1612 inserted into the manuscript in close proximity to the recipe (fols. 61r/v) that provide evidence of practical application of the *Medulla*. Arthur Dee also alludes to performing the experiment described in the encrypted recipe of the *Medulla* in his original manuscript, *Arca arcanorum* (1634), which he produced in celebration of his claim to have successfully achieved the Philosophers' Stone.

Patrick Ruthven's 1612 laboratory notes

In his laboratory notes, Patrick Ruthven (producer of MS Dc.1.30) records the experimental processes described in allegorical terms in the encrypted recipe. Significantly, the first lines of his additions to the recipe warn the reader that it is vital to keep the duration of the fermentation process a secret, and it is given in the encrypted recipe as *trilunium*. While the meaning of the term is not fixed and open to interpretation, the time periods mentioned such as the *trilunia* and references to temperature of "over a natural fire" describe a long-term digestion process over moderate heat, which may have been extrapolated from the allegory of tending to a sheep for a long period of time in *Chrysopoeia*. The sentence on digesting over natural fire should be taken to mean a very low heat, such as one generated by composting horse dung.

MS Dc. 1.30, fol. 61 recto
Secretum non revelandum quod occultarunt omnes Philosophi, est fermentationis tempus, quod si praetereat, operam Luseris, et materia tua reducitur in metallum, neque unquam postea potes redire ad institutum.
Post caput corvi materia fit cinerea sine grisea: circa finem tertii mensis apparet circulus rubeus in ambitu materiae intra vas.
Eo ipso momento quo apparet, frange sigillum Hermetis, et folia auri appone orificio ampullae, attrahitur Sol magnetice a materia sitiente.
Haec autem sitis durat tantum per dimidiam horam, quam si praetereas, licet apparet circulus diutius, attamen occasio calva est.
Hoc facto impone orificio vasis operculum vitreum, et Luta calce et albumine ovi. Decoque ut a c[flourish]. Prima autem vice fiat sigillum Hermetis.

A secret, hidden by all Philosophers, which should not be revealed, is the duration for the fermentation.
If you exceed it, you will lose the work and your matter will transform back into metal and thereafter you can never return to the plan.
After the head of the raven, the matter becomes ashen without grey:
Towards the end of the third month, a small red ring appears around the matter in the vessel.
In the moment that it appears, shatter the hermetical seal and place gold leaves into the opening (orifice) of the *ampulla,* Sol is magnetically drawn to the thirsting matter.

But this thirst only lasts for half an hour, if you go over that, it is possible that a circle may be visible longer, however, the opportunity is bald.[53]
After this is done, put the glass lid into the mouth of the vessel and seal with *lutum* of limestone and egg white.[54] Cook so that [a c]
But at the first change, the Seal of Hermes should be applied.

MS Dc. 1.30, fol. 61 verso
Anno 1612.
Maij 23 feci Conjunctione[m] in tribus Vitris.
Maij 30. Post Meridiem posui 3 Vitra.
in Athanor.
Junij 7. apparuerunt Collores flavi & Coe, ruleij mixtim.[55]
Augusti 22. Apparebatur Collor Niger
Augusti 29. In duobus Vitris tota materia erat niger perfecte.
In Tertio Vitro Materia incepit alterari.
Septembri 10. Apparebatur Color rubeus Majori Vitro.
In Minori vitro remanebatur materia adhuc Niger.
Septembri 19. ~~M~~ In Minori vitro rebatur Collor Viridis.
In Vitro albo Materia erat flava cum multis rotundis quasi perla

Year 1612
May 23rd: I made a conjunction in the three glass vessels
May 30th after noon: I put three vessels in the Athanor
June 7th colours appeared, yellow and dark blue mixed.
August 22nd: black colour appeared
August 29th: in two vessels all matter was completely black. In the third vessel, the matter has started to change.
September 10th: Red colour appeared in the larger vessel. In the smaller vessel, thus far the matter remained black.
September 19th: In the smaller vessel, green colour appeared.
In the white vessel, the matter was yellow with many pearl-like spheres

Based on Ruthven's supplemental laboratory notes, what follows is one possible interpretation of the recipe. The sentence speaking of nine parts Mercurius and one part Luna is a typical formula of recipes (i.e. "take nine parts … "). Here, Mercurius refers to common quicksilver/mercury and Luna is silver. Combining nine parts mercury and one part silver would yield a solid silver amalgam, an alloy of silver and mercury. If the silver is provided in the form of shards, these two substances

[53] The mythological Kairos is bald on the back of his head and represents an allegory for a moment that has passed.
[54] *Lutum* is a material that seals vessels. As such the sentence can be interpreted as "Seal with calx and egg white." Egg white was commonly used in sealing vessels. Calx can mean either 'limestone dust/meal/flour' or 'burnt limestone/chalk.'
[55] We have interpreted "Coe, ruleij" to mean *caerulij* (from *caeruleum* meaning sky blue, sea blue, green blue). This fits as a description of the reflection created by an oil film (yellow and blue).

would react immediately, even at room temperature, to create a grey solid. The mention of Vulcanus, the Roman patron God of those who work with fire, such as metallurgists and alchemists, could be a mythoalchemical reference to silver which has not yet gone through fire (freshly mined). After that, the first two steps for creating the Philosophers' Stone of the alchemical opus magnum are described in typical allegorical terms, such as the black raven for the *nigredo* symbolizing the death of the matter and the white swan for the *albedo* symbolising its purification.[56] If nine parts mercury and one part silver are kept on moderate heat for months, the changes in colour described in the recipe do not necessarily occur. However, if the resulting substance were to be slowly heated over the period of multiple months without performing the crucial step of hermetically sealing the vessel (philosophical egg) as the recipe demands, the mercury may evaporate and the leftover silver will form fine, black structures (black raven).[57] However, if the temperature rises above the melting point of the amalgam, the black colour will disappear and turn silvery like mercury, which might appear to be white matter (white swan).

Arthur Dee's Arca arcanorum (1634)

Dee is explicit in the dedication of his original manuscript, *Arca arcanorum* (1634), that he has successfully achieved the Philosophers' Stone, "I have at last (by divine help) solved the riddles of knowledge. An example of this, in this climax of my life, with some select manuscripts I dedicate (under your auspices) to devotees of alchemy." Across from the title page of *Arca arcanorum* is a colourful, hand-painted reproduction of an emblem from a Ripley Scroll, a famous alchemical scroll comprised of poems and emblems celebrating the alchemical Philosophers' Stone [Figure 10]. As Arthur Dee had a Ripley Scroll in his possession, and thus available to reference, it is likely that this emblem was specifically chosen and hand painted by Dee himself as a representation of his own success.[58] The emblem contains imagery of the biblical Garden of Eden, where the *prima materia* that alchemists sought was abundant. Within this depiction of original perfection, Adam and Eve are connected to their hermetic designations of feminine Luna and masculine Sol surrounded by flora and fauna representing alchemical processes, joined by an angel and a man in contemporary seventeenth-century dress mining for precious metals.

The story described in the Ripley Scrolls mirrors Arthur Dee's own alchemical quest: Ripley leaves England on a quest for alchemical enlightenment and finds it among continental Europe, just as Dee has done after he left London for Moscow. While in service to the Tsar, Dee published a book with Parisian printer Nicolas de la Vigne titled, *Fasciculus chemicus* (1631), a selection of excerpts

[56] Claus Priesner, "Farben", in Claus Priesner and Karin Figala, *Alchemie: Lexikon einer hermetischen Wissenschaft* (München: C.H. Beck, 1998), 131–33.

[57] The *sigillum Hermetis* (seal of Hermes) represents a method for hermetically sealing the orifice of a retort.

[58] "Letter to Ashmole, Jan 25, 1658," in Geoffrey Keynes, ed., *The Works of Sir Thomas Browne*, 6 vols. (London: Faber & Gwyer Limited, 1931), vol. 6, 322.

FIGURE 10. Sloane MS 1876, fol. 1v. Hand-painted frontispiece to Arthur Dee's original manuscript "Arca Arcanorum," preface dated 1634.

from well-known alchemical tracts curated in a particular order for successful alchemical transmutation. Coinciding with the scribal production of *Arca arcanorum*, Arthur Dee requested medical supplies from England to be delivered to him in Russia in June 1630, for which he did not receive royal approval until two years later in June of 1632,[59] thus providing a timeframe for Arthur Dee performing

[59] Appleby, "Dr. Arthur Dee: Merchant and Litigant," 47–48.

alchemical experiments in Russia between the years of 1632 and 1634. In 1635 Tsar Mikhail relieved Arthur of his Russian royal duties after fourteen years of service. He returned to England as Physician Extraordinary to Charles I until the outbreak of the English Civil War, at which time he retreated to Norwich. Arthur Dee died in September of 1651, one year after his *Fasciculus chemicus* was published as an English edition by Elias Ashmole (1617–1692).

Arthur Dee's two original texts, the printed *Fasciculus chemicus* (1631) and his manuscript *Arca arcanorum* (1634) are essentially his expertly curated collection of alchemical tracts, juxtaposed in a specific order for achieving the Philosophers' Stone. While these two texts are very similar in content, there are a few significant deviations between them. *Fasciculus chemicus* concludes with twenty-one *observanda*, whereas in *Arca arcanorum* (Dee's "Secret of Secrets") Dee has omitted ten of the original *observanda* and added fourteen new ones, many of which directly reference practical alchemical experimentation. The final *observandum* added to *Arca arcanorum* is especially significant in the context of the encrypted recipe.

Observandum 31
Hoc pro valedictione fideliter duco: Ungaria, me genuit.
Coelum et stellae tuentur me, et terra nutrit me, et quamvis mori cogor, et sepeliri, tamen Vulcanus me sedulo parit.
Ungaria inquam mea patria est: et mater mea totum includit mundum.

I carry this as a farewell: Hungary gave birth to me.
Heaven and stars protect me, and the earth nourishes me, and although I'm forced to die, and to be buried.
Still Vulcanus diligently spawns me.
Hungary, I say, is my home country and my mother includes the whole world.[60]

Here we note many references to the encrypted recipe of *Hermeticae Philosophiae Medulla*. Next to this new *observandum* Dee cites fifteenth-century alchemist Basil Valentine, author of the alchemical tract *Triumph Wagen Antimonii* (1604) or the *Triumphal Chariot of Antimony*, on the subject of a secret book containing the recipe for the Philosophers' Stone. Antimony was also Dee's choice of *prima materia*, which he procured from Hungary with the help of his Hungarian colleague Johannes Bánfi Hunyades.[61] Antimony shares the appearance of silvery shards of freshly mined silver, and as *Observandum* 31 also mentions Vulcanus, this could be Dee's interpretation of that stage in the encrypted recipe. Further, the material evidence of Sloane MS 1902 shows that Arthur Dee was actively engaging with,

[60] This poem is an alchemical version of the *incipt* of the famous funerary epitaph on the tomb of Virgil. "Mantua me genuit, Calabri rapuere, tenet nunc / Parthenope; cecini pascua, rura, duces." The Virgil reference was introduced by Michael Maier in his Latin translation of Basil Valentine's original tract *Zwölff Schlüssel* (1599) in Maier, *Tripus Aureus* (1618).

[61] C. H. Josten, ed., *Elias Ashmole: His Autobiographical and Historical Notes, his Correspondence, and Other Contemporary Sources Relating to his Life and Work*, 5 vols. (Oxford: Oxford University Press, 1967) vol. 4, 1373. In this letter Browne claims that Dee signed a contract with Johannes Bánfi Hunyades in London to return to Hungary for more *prima materia* two years before Hunyades' death, which was in 1646.

and contributing to, his medical notebook containing the *Hermeticae Philosophiae Medulla* recipe during the time that he was writing his magnum opus. His wife Isabella Dee died in Moscow on 24 July 1634, a date that Arthur recorded in Sloane MS 1902 under the decumbiture of his father who died the same day of the year in 1606.[62]

Conclusion: hiding and sharing alchemical secrets

Simone Zweifel has used the term "compilation network" to describe knowledge networks that drove the creation and circulation of early modern books of secrets.[63] *Hermeticae Philosophiae Medulla* can be analysed through such a lens, as an encrypted mythoalchemical allegory obscuring a practical recipe that was shared via manuscript among a group of physicians seeking alchemical-medical knowledge. However, there are practical aspects of the manuscript copies of *Hermetiae Philosophiae Medulla* that remain puzzling pertaining to the circulation of this cipher. For example, the cipher table in Sloane MS 1902 contains a mistake in the last letter in every row, rendering the table unusable for the decryption process. Conversely, a working cipher table was provided in MS Dc.1.30, but with a partially incorrect key phrase. Thus, these two manuscript copies are insufficient for cracking the code on their own and would have required knowledge from an external source (likely the original copy) to use this recipe. If the correct table from MS Dc.1.30 is used in combination with the correct key from MS Sloane 1902, it is possible to both encrypt the plaintext recipe and decrypt the ciphertext to get the results that we found independently through statistical analysis, and which were subsequently discovered in MS Dc.1.30.

A second question that remains is the function of copying an unsolvable ciphertext and table into a medical manuscript in the first place. In the example of MS Dc.1.30 the Latin plaintext is included with the encrypted ciphertext, so the cipher has already been solved. However, with the medical notebook compiled by Arthur Dee, the broken cipher table and ciphertext, paired with the key phrase, function as a practice of secrecy independent from the practical recipe. Additionally, the cipher discussed here is quite unique in that hardly any examples of polyalphabetic ciphers exist from the first half of the seventeenth century, when it was still common practice to use monoalphabetic ciphering systems despite their cryptographic vulnerability. Yet in this alchemical cipher, we find an early adoption of a quite complex polyalphabetic encryption following the conventions of Bellaso, as made popular by Della Porta and Vigenère. One possible explanation for the use of this mathematically and cryptographically advanced cipher method could be due to the involvement of many individuals in this compilation network well versed in mathematics, such as maritime navigator John Dee and professor of mathematics John Napier.

[62] British Library Sloane MS 1902, fol. 11r.

[63] Simone Zweifel, *Aus Büchern Bücher machen: Zur Produktion und Multiplikation von Wissen in frühneuzeitlichen Kompilationen* (Berlin: De Gruyter, 2021).

In both cases the act of copying the cipher into an alchemical medical manuscript is in itself a performative allusion to possessing the knowledge encrypted within the cipher, the ultimate alchemical achievement of the Philosophers' Stone. Beyond the theatrics and the performance of secrecy in the alchemical compilation networks of *Hermeticae Philosophiae Medulla*, this cipher illustrates the importance placed by alchemical adepts on both the recipe obscured within the cipher (secret as content) as well as the practice of sharing, decoding, and obfuscating secret alchemical knowledge (secrecy as practice). Alchemical rhetoric of secrecy played an important role in obtaining patronage for entrepreneurial alchemists, as practices of secrecy were integral to self-fashioning one's identity as an alchemist, and secrets could function as a form of currency in the "economy of secrets."[64]

Alchemical ciphers remain a relatively understudied topic, despite having much to offer our understanding of alchemical practices of knowledge production and circulation.[65] One barrier to research on alchemical ciphers is the lack of cooperation between disciplines; secrecy has either been treated solely as a cultural phenomenon or merely a puzzle to be solved by cryptologists without historical context. Interdisciplinary collaboration between historians, social scientists, linguists, and the cryptological community is crucial to advancing scholarship on practices of alchemical ciphering and understanding their meaning. A pivotal next step for future research on this topic is to compile lists of known alchemical ciphers and create a taxonomy of encryption methods for alchemical secrets.[66] Only after a significant quantity of alchemical ciphers and their respective contexts have been described and analysed, such as we have done here, can the phenomenon of alchemical cryptography be understood in a broader sense to address issues such as: What was a standard level of "cipher literacy" for an early modern alchemist?[67] Evidence of scribal circulation and early modern knowledge networks show that ciphers were not only popular among alchemical practitioners, but integral technologies of secrecy. Why then do alchemical ciphers remain an understudied topic, despite their relative frequency in alchemical manuscript culture? If this singular example of the alchemical cipher *Hermeticae Philosophiae Medulla* can yield such rich information on practices of secrecy and experimental allegory, there is potentially a gold mine of scholarship hidden in the pages of alchemical manuscripts.

[64] Important contributions to the limited scholarship on alchemical ciphering and practices of secrecy include Benedek Láng's study of a Hungarian cipher corpus in Láng, *Real Life Cryptology*and Koen Vermeir, "Openness versus secrecy? Historical and historiographical remarks," *British Journal for the History of Science* 45 (2012): 165–88. On the concept of "economy of secrets" see Daniel Jütte, *Das Zeitalter des Geheimnisses.Juden, Christen und die Ökonomie des Geheimen, 1400–1800* (Göttingen: Vandenhoeck & Ruprecht, 2011). On the concept of "entrepreneurial alchemy" see Tara Nummedal, *Alchemy and Authority in the Holy Roman Empire* (Chicago, IL: University of Chicago Press, 2007).

[65] Agnieszka Rec, "Ciphers and Secrecy among the Alchemists: A preliminary report," *Societas Magica Newsletter* 31 (2014): 1–6.

[66] The DECRYPT Project (Automatic Decryption of Historical Manuscripts) is working on a similar project: https://de-crypt.org/about.php (accessed 1 November 2022).

[67] On the concept of "cipher literacy" see Ellison, *A Cultural History of Early Modern English Cryptography Manuals*; and Ellison and Kim, *A Material History of Medieval and Early Modern Ciphers*, 17.

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