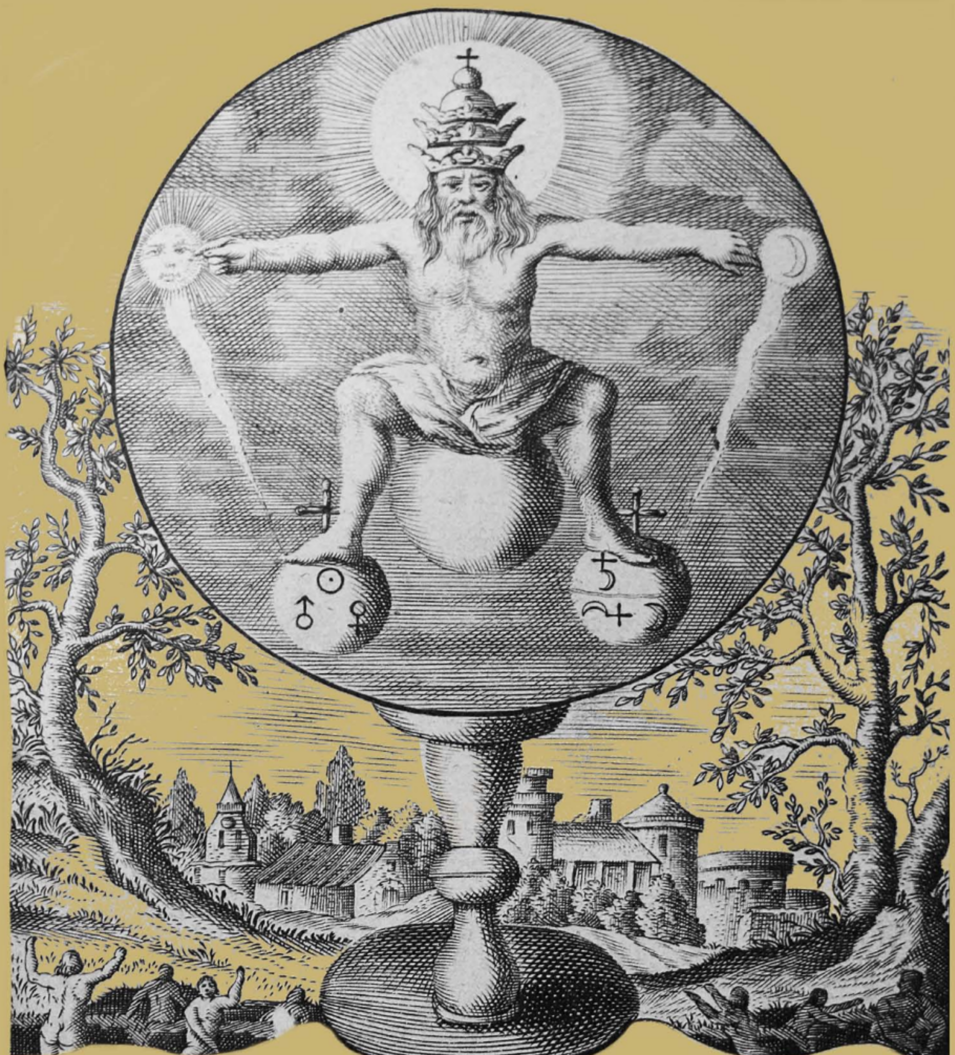
NEWTON
the Alchemist

SCIENCE, ENIGMA, AND THE QUEST FOR NATURE'S "SECRET FIRE"



WILLIAM R. NEWMAN

Newton the Alchemist

SCIENCE, ENIGMA, AND THE QUEST FOR NATURE'S "SECRET FIRE"

William R. Newman

PRINCETON UNIVERSITY PRESS
Princeton & Oxford

Published by Princeton University Press

41 William Street, Princeton, New Jersey 08540
6 Oxford Street, Woodstock, Oxfordshire OX20 1TR
press.princeton.edu

LCCN 2018953066

ISBN 978-0-691-17487-7
British Library Cataloging-in-Publication Data is available

Editorial: Al Bertrand and Kristin Zodrow
Production Editorial: Brigitte Pelner
Text and Jacket/Cover Design: Pamela Schnitter
Jacket/Cover Credit: From the title page of Johann de Monte-Snyders's *Metamorphosis Planetarum*, 1964
Production: Jaqueline Poirier
Publicity: Alyssa Sanford
Copyeditor: Dawn Hall
This book has been composed in Garamond Premier Pro

Printed on acid-free paper ∞

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

Contents

Acknowledgments

Any book with a gestation period of fifteen years must necessarily owe many debts. Needless to say, human memory will fail to capture every obligation, but here I list the major contributors, beginning with the agencies that funded my research, and then passing to the individuals who have helped make *Newton the Alchemist* possible.

It is impossible to separate the research that went into *Newton the Alchemist* from the editorial work that undergirds the online *Chymistry of Isaac Newton* project (www.chymistry.org) at Indiana University, since the book could not have been written without the thorough acquaintance with Newton's chymical *Nachlass* that editing the texts has engendered. Beginning in 2003, the National Science Foundation has supported the *CIN* with four multiyear grants, NSF Awards 0324310, 0620868, 0924983, and 1556864. During this period the National Endowment for the Humanities also awarded a multiyear grant to the project. Beyond this support for the *CIN*, the immediate process of writing *Newton the Alchemist* was made possible by the following grants and fellowships, which allowed me to devote two successive academic years (2014–16) almost exclusively to research and writing: a National Humanities Center Fellowship, a Caltech/Huntington Library Searle Professorship, a Cain Fellowship at the Science History Institute in Philadelphia, an American Council of Learned Societies Fellowship, an American Philosophical Society Franklin Research Grant, an Indiana University New Frontiers Exploratory Travel Fellowship, and an Indiana University College Arts and Humanities Institute Research Travel Grant.

The present team of the *Chymistry of Isaac Newton* project, to whom I owe a heavy and ongoing debt, includes John A. Walsh, technical editor; Wallace Hooper, project manager and programmer/analyst; James R. Voelkel, senior consulting editor; Michelle Dalmau, head, digital collections services, Indiana University–Bloomington Libraries; William Cowan, head, software development (library technologies), IUB Libraries; Meagan Allen, editorial assistant and chemistry lab assistant; Meridith Beck Mink, consultant; and Cathrine Reck, consultant in chemistry. Indiana Libraries Technology Collaborators include Kara Alexander, digital media specialist; Nianli Ma, programmer/analyst, digital repository infrastructure; and Brian Wheeler, system administrator. Among the past participants in the project whose work included preliminary transcribing and encoding of the digital editions of Newton's work are Tawrin Baker, Nicolás Bamballi, Nick Best, Neil Chase, Archie Fields III, John Johnson, Joel Klein, Cesare Pastorino, Evan Ragland, Daniel Sanford, and Whitney Sperrazza. Past participants in website design and other digital matters other than editing include Allison Benkwitt, technical editorial assistant; Timothy Bowman, web programmer and site architect; Jonathan Brinley, technical editorial assistant; Ryan Brubacher, SLIS intern; Darick Chamberlin, illustrator; Mike Durbin, infrastructure programmer/analyst; Randall Floyd, programmer/database administrator; Lawrence Glass, programmer/analyst, editorial assistant; Julie Hardesty, interface and usability specialist; Kirk Hess, programmer/analyst; David Jiao, programming consultant; Stacy Kowalczyk, associate director for projects, IU Libraries; Tamara Lopez, project programmer/analyst, Newton site architect; Dot Porter, curator of digital research services; Alan Rhoda, technical editorial assistant; Jenn Riley, metadata librarian; John Rogerson, technical editorial assistant; and Lindley Shedd, digital media specialist.

Individuals who contributed directly to the book as opposed to the *CIN* include the following three referees for Princeton University Press, who each read the entire manuscript and devoted many hours to their careful and constructive comments: Lawrence Principe, Jennifer Rampling, and Jed Buchwald. The present structure and content of *Newton the Alchemist* owes a considerable debt to these referees, each of whom made distinctive contributions. I must particularly acknowledge my frequent and ongoing consultations with Principe on the translation of alchemical processes into operable chemistry, and my debt to Rampling for her perceptive comments on restructuring my text. Buchwald, finally, offered invaluable comments on the details of Newtonian optics. Other scholars who read individual chapters and provided important advice include Niccolò Guicciardini, Mordechai Feingold, Paul Greenham, Peter Ramberg, and Alan Shapiro. Still other historians aided me in locating crucial sources, including Hiro Hirai, Michael Hunter, Didier Kahn, Scott Mandelbrote, and Steven Snobelen. Additionally, I have benefited from the advice of a multitude of other scholars, including Michael Freedman, Rob Iliffe, Domenico Bertoloni Meli, Seth Rasmussen, Anna Marie Roos, Richard Serjeantson, Alan Shapiro, George Smith, and John Young. Finally, I owe debts to David Bish, Cate Reck, Joel Klein, and Pamela Smith for facilitating my laboratory work and in some instances working with me under the hood.

Symbols and Conventions

No doubt as a result of his commanding stature at the origin of modern science, excellent biographies of Isaac Newton are easy to find.[1] All of them deal to some degree with the famous physicist's scientific discoveries, at times extensively, and they all share an expressed desire to account for his decades of alchemical research. Yet no previous study of Newton, including several devoted entirely to his alchemical quest, does full justice to the subject. The present book makes no pretense of being another biographical treatment of the famous savant; instead, it seeks to illuminate the more than thirty years that Newton spent deciphering the secrets of the sages and putting them to the test in his laboratory. Although Newton did occasionally collaborate with others at the bench, he certainly did not advertise his interest in chrysopoeia, the transmutation of metals, to the learned world. To a greater degree than is found in other areas of his scientific work, we are dependent on Newton's own manuscripts for our knowledge of his alchemical activities. The relative paucity of external events requires us to enter into our subject's private world of thought and practice to a degree that is unusual even for scholarly monographs. Fortunately, Newton left a massive corpus of around a million words documenting the evolution of his alchemical research project. But in order to cope with this daunting material, the reader must be aware of a few hurdles.

First there is the issue of alchemy's colorful language and the graphic symbols writers on the subject employed over most of its history. Throughout this book, archaic terms such as "oil of vitriol" (sulfuric acid) and "salt of

[1] The best known modern biography of Newton, and justifiably so, is Richard S. Westfall, *Never at Rest: A Biography of Isaac Newton* (Cambridge: Cambridge University Press, 1980). In its 908 pages of closely spaced print, Westfall covers every aspect of Newton's life and work. For readers with less time to devote to Newton, Westfall published an abridged version of the biography as well, *The Life of Isaac Newton* (Cambridge: Cambridge University Press, 1993). Of almost equal fame is Frank Manuel, *A Portrait of Isaac Newton* (Cambridge, MA: Belknap Press of Harvard University Press, 1968). Although Manuel was more interested in fleshing out Newton's character than his scientific work, his biography does contain a chapter devoted to the famous natural philosopher's alchemy. Other sometimes overlooked but still valuable modern biographies include A. Rupert Hall, *Isaac Newton: Adventurer in Thought* (Cambridge: Cambridge University Press, 1996) and Gale E. Christianson, *In the Presence of the Creator: Isaac Newton and His Times* (New York: Free Press, 1984). Another twentieth-century biography worthy of note, particularly for its open-minded treatment of Newton's alchemy, is Louis Trenchard More, *Isaac Newton: A Biography* (New York: Charles Scribner's Sons, 1934). Unfortunately, More's biography appeared before the famous Sotheby's auction of 1936, in which the stupendous volume of Newton's alchemical and religious manuscripts was revealed to the world. Popularizing biographies abound as well, the best of which is James Gleick, *Isaac Newton* (New York: Pantheon Books, 2003).

tartar" (potassium carbonate) inevitably make an appearance. I have given parenthetical explanations of such terms of art at various points in *Newton the Alchemist* in order to keep them alive in the reader's memory. But outdated terminology is only one of the linguistic difficulties presented by Newton's alchemical quest. His use of exotic *Decknamen* (cover names) such as "the net" and "Diana's doves" presents a different and more complicated problem. Arriving at the meaning of such intentionally elusive terms is in fact a central problematic of *Newton the Alchemist*, and the process of decoding them has required a combination of replication in the laboratory and sustained textual analysis, some of it aided by computational tools. Chapter two begins laying out the problems and results of this modern process of decipherment, which ironically mirrors Newton's own decades spent decrypting the works of the adepts. While issues of archaic language and willful concealment by *Decknamen* can be dealt with as they occur in the narrative, a further issue of terminology requires that we meet it head on. I refer to Newton's habitual use, and even creation, of figurative alchemical symbols.

Following a tradition popularized by the Elizabethan alchemist John Dee and developed further by the Saxon schoolmaster and writer on chymical subjects Andreas Libavius, Newton devised a series of graphic symbols that he used for his own creations in the laboratory.[2] Building on the traditional planetary symbols long used by alchemists to depict the respective metals, Newton would attach a small "o" to indicate an ore or mineral of the metal in question. Thus iron, usually represented by the symbol for Mars, ♂, became iron ore with the addition of the "o." This modification could take several different forms. The editors of the *Chymistry of Isaac Newton* project have identified three different representations Newton used for iron ore: 🜜, 🜝, and ♂o.

On the same principle, Newton added the traditional star symbol for sal ammoniac (ammonium chloride), ✳, in order to indicate a sublimate fabricated by means of that material. Thus he combined the symbol for copper, the planet Venus, ♀, with ✳ to become ♀✳, a volatile copper compound. The clarity of this system is undercut by the fact that Newton does not restrict the ✳ symbol to ammonium chloride but employs it from 1680 onward to represent a volatile compound containing sal ammoniac and antimony, which he refers to as "sophic sal ammonic," "our sal ammoniac," or even "prepared sal ammoniac." When the traditional sal ammoniac star is combined with metals from 1680 on, it may represent either "vulgar" sal ammoniac or the sophic

[2] For Dee's attempt to base alchemical symbolism on his "hieroglyphic monad," a composite of the traditional planetary symbols plus a curly bracket placed horizontally at the bottom, see C. H. Josten, "A Translation of John Dee's *Monas Hieroglyphica* (Antwerp, 1564), with an Introduction and Annotations," *Ambix* 12 (1964): 84–221. An influential though dated study of Libavius may be found in Owen Hannway, *The Chemists and the Word: The Didactic Origins of Chemistry* (Baltimore: Johns Hopkins University Press, 1975). More on Libavius's use of Dee may be found in William R. Newman, "Alchemical Symbolism and Concealment: The Chemical House of Libavius," in *The Architecture of Science*, ed. Peter Galison and Emily Thompson (Cambridge, MA: MIT Press, 1999), 59–77. For a recent monograph on Libavius, see Bruce T. Moran, *Andreas Libavius and the Transformation of Alchemy: Separating Chemical Cultures with Polemical Fire* (Sagamore Beach, MA: Science History Publications, 2007). For some of Dee's alchemical sources, see Jennifer M. Rampling, "John Dee and the Alchemists: Practising and Promoting English Alchemy in the Holy Roman Empire," *Studies in History and Philosophy of Science* 43 (2012): 498–508.

variety. And as though this were not confusing enough, Newton sometimes follows other alchemical writers in employing ✳ to mean the star regulus of antimony, the crystalline form of the metalloid reduced from its ore.

Similar issues emerge with Newton's use of the traditional symbol for "antimony," ♁, or as we would say, the mineral stibnite, which is predominantly antimony sulfide in modern terminology (figure 1). The seventeenth century uniformly identified stibnite as antimony and used the term "regulus" (literally "little king") for the reduced metalloid. Newton occasionally joins the ♁ symbol with ✳ to produce ✳♁, again meaning a sublimate of sal ammoniac and stibnite. More typically, he combines it with the symbol for a metal, as in ✳☿, which represents a volatile compound (in the modern sense) of copper, antimony, and sal ammoniac (or sophic sal ammoniac). Further combinations can also occur, as when Newton adds the traditional symbol for salt, ⊖. Thus a volatile salt of copper containing also antimony and vulgar or sophic sal ammoniac receives the following symbol: ✳⊖. The same pattern is used with the other metals as well.

Below I list the alchemical symbols that occur in the present book, beginning with the more commonly used ones and then progressing to Newton's idiosyncratic versions. It is important not to be lulled into a false sense of

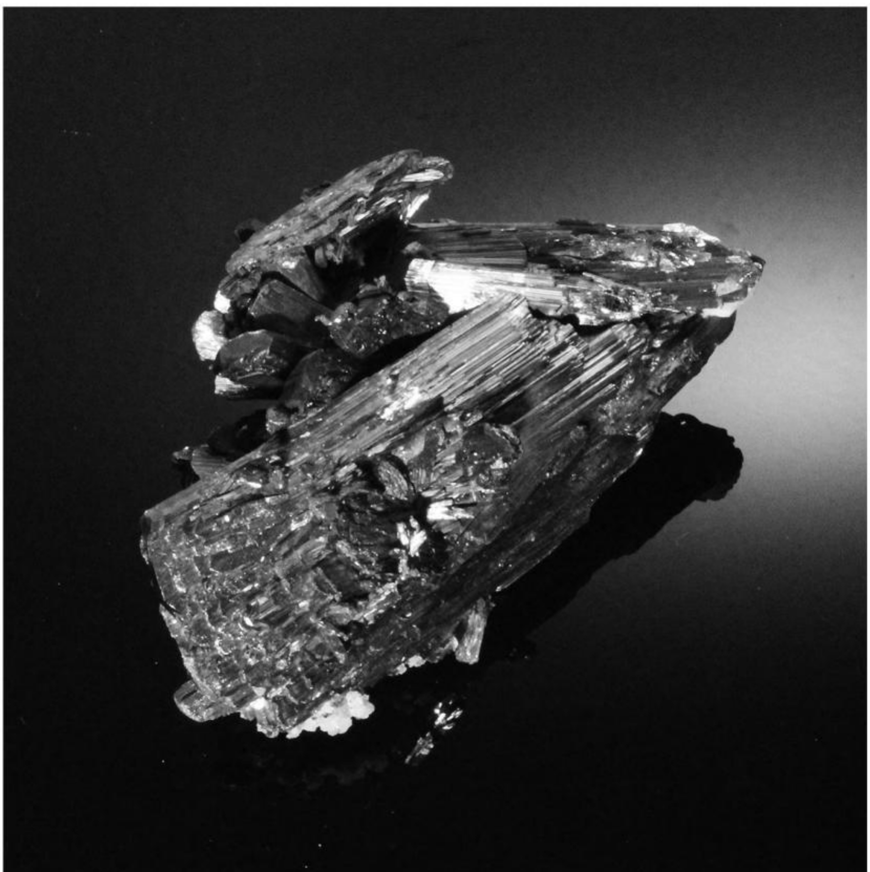


Figure 01. Stibnite from northern Romania. William R. Newman's sample. See color plate 1.

security when one encounters these glyphs. Newton was not doing modern chemistry, so one cannot expect his symbols always to refer to the same concrete, chemical referent in the way that a modern molecular formula always refers to precisely the same combination of atoms. The use of the ✳ symbol to mean both vulgar and sophic sal ammoniac is a case in point, but it is only one problem among many. Thus ✳⊖♀ may refer to more than one volatile salt made from copper, antimony, and sophic or vulgar sal ammoniac. Moreover, the symbol does not reveal anything about the material's mode of production. As we will see in the later part of this book, Newton's stock laboratory reagent, "liquor of antimony," was typically employed in making his volatile salts, yet he did not incorporate a specific symbol for it, perhaps on account of his viewing it as a processing agent rather than an ingredient, or even because of its very ubiquity. In short, the symbols generally represent what Newton considered the most salient ingredients of his laboratory products, but beneath this graphic shorthand lies all the ambiguity of the experimental record. One should note also that even in the case of the simple planetary symbols, Newton often prefixes the figure with the word "our," indicating that he does not have the common, "vulgar" referent in mind. Thus "our ♀" does not mean copper but either a compound of the metal or even some other substance entirely.

Chymical Symbols Used by Newton

℔	Pound
℥	Ounce
ʒ	Drachm
℈	Scruple
Gr	Grain
🝧	Crucible
🝭	Retort
🜂	Fire
🜁	Air
🜄	Water
🜃	Earth
☿	Mercury, either the supposed principle of metals and minerals, or vulgar quicksilver; also used for the sophic mercury.
🜍	Sulfur, the second principle of the metals, also vulgar brimstone.
⊖	Salt, the third metallic principle along with mercury and sulfur. Also common sea salt as well as other salts.
☉	Metallic gold, but also the putative internal sulfur of iron.
☽	Usually silver, but can also mean metallic antimony, and even sophic mercury.
♀	Copper, but it can also refer to what in modern chemical terms are copper compounds, especially, but not only, when preceded by "our." It can also refer to the "amorous," metallic component within stibnite, namely, regulus of antimony.

♂	Iron
♃	Tin
♄	Lead. Newton used this symbol mostly after the beginning of 1674. Before that time he typically used the unbarred version of it, ♄.
♄	Lead
♁	Stibnite (antimony sulfide), simply called "antimony" in the seventeenth century.
♃☾	Bismuth
✳	Sal ammoniac, either "vulgar" (NH_4Cl), or sophic, a compound or mixture of the former and either crude antimony or regulus of antimony. Sometimes ✳ is also used to designate the star regulus of antimony.
🜖 🜗	Vitriol, typically a sulfate in early modern chymistry, but to Newton it is used for multiple crystalline, obviously metallic salts, especially those with a styptic taste.
🝛	Amalgam
🜅 🜆 🜆	Aqua fortis (mainly nitric acid).
🜇 🜈 🜈	Aqua regia, in modern chemistry a mixture of nitric and hydrochloric acid, but to Newton, it is usually aqua fortis that has been "sharpened" by adding sal ammoniac.
🜷	*Spiritus vini*, that is, impure ethanol.
🜊	Vinegar
🜿	Tartar, also known as argol. Impure potassium bitrartrate deposited on the inside of wine casks.
⊖🜿ⁱ	*Sal Tartari* (salt of tartar). Mostly potassium carbonate made from tartar by calcination and leaching.
🜕	Saltpeter, mainly potassium nitrate. The same symbol is used for the Sendivogian aerial niter, a hypothetical material whose properties are modeled on those of saltpeter.
☿≏ ☿♌	Corrosive sublimate, that is, mercuric chloride.
♀	Copper ore
♂ ♂ ♂	Iron ore
♃ ♃	Tin ore
♄ ♄	Lead ore
♁	Antimony ore
♃☾ ♃☾	Bismuth ore
🜥	Regulus of antimony (reduced metallic antimony). A symbol devised by George Starkey, and used in Newton's copy of Starkey's *Clavis*, Keynes MS 18.
R	Also regulus of antimony.
✳♁ ✳♁	Sublimate of stibnite and sal ammoniac.
♁	Salt of antimony. The crystalline material formed by crystallizing Newton's liquor of antimony; also the same salt in solution in liquor of antimony.
♀	Copper "antimoniate" or "antimonial." Not an antimoniate in the modern sense, but rather a so-called vitriol of copper made by imbibing the metal with Newton's liquor of antimony and then crystallizing the solution.

 Salt of copper antimoniate. The above vitriol of copper when filtered and allowed to crystallize separately.

 Sublimate of copper antimoniate.

 Sublimate of salt of copper antimoniate.

 Alternative symbols for antimoniate sublimates of copper.

Other Terminological, Graphic, and Chronological Issues

In addition to the problem of Newton's alchemical terms and symbols, there are several other issues of language and convention to which the reader must be introduced. First, my use of the now archaic word "chymistry" is intended to alert the reader to the fact that there was no rigid, commonly accepted distinction between "alchemy" and "chemistry" in the seventeenth century. I need not belabor the point here, for the *Oxford English Dictionary* has recently affirmed it by recognizing the capacious character of the early modern discipline comprehended under "chymistry."[3] Accordingly, throughout the present book "chymistry" and "alchemy" are synonymous, both having the sense of a field that included the attempt to transmute metals alongside the disciplines that we would today call industrial chemistry and pharmacology.

Several other terms may also confuse the reader unless they are dealt with forthrightly. The first of these, "menstruum" to mean a dissolvent, has a history in alchemy extending back at least to the early fourteenth century *Testamentum* of pseudo-Ramon Lull.[4] Hence chemists even in the nineteenth century commonly referred to menstruums when they meant the mineral acids and other corrosives or solvents. The second term, "reduction," is more problematic, as it has senses in chymistry and mineralogy that overlap and sometimes contradict its modern meaning in chemistry. The older use of reduction in chymistry simply means "to convert (a substance) into a different state or form," often with the idea that one is leading the material back to a previous, or more primitive condition.[5] This conforms to the sense of the Latin infinitive *reducere*, which means "to lead back." Hence an ore can be "reduced" to a metal by smelting, but the metal can also be "reduced" to a powdery "mineral" form by calcination. The mineralogical use of "reduction" also presents ambiguities, since metallurgical writers speak of reducing

[3] See the online version of the *Oxford English Dictionary*, accessed August 28, 2017, under "Chemistry." I quote the passage here: "In early use the terms 'chemistry' and 'alchemy' are often indistinguishable. Later (post-*c* 1700), *alchemy* began to be distinguished as referring to the pursuit of goals increasingly regarded as unscientific and illusory, such as the transmutation of metals into gold (see *Early Sci. & Med.* 3 32–65 [1998]). The use of the term *chemistry* to describe such practices became increasingly *arch.* and *hist*. Beginning in the late 20th cent. the otherwise obsolete spelling *chymistry* (cf. quot. 1994[2]) was deliberately adopted to differentiate the early, transitional science from the discipline of 'modern' chemistry as practised from the 18th cent. onward."

[4] For pseudo-Lull's use of the term *menstruum* in his own words, see Michela Pereira and Barbara Spaggiari, *Il Testamentum alchemico attribuito a Raimondo Lullo* (Florence: SISMEL, 1999), 28–29; for adjectival forms of the term consult Pereira and Spaggiari's index.

[5] *Oxford English Dictionary*, online edition, under "Reduce," III. 17. a.

both ores and metals.[6] In modern chemistry, on the other hand, the terms "oxidation" and "reduction" (paired as "redox"), refer respectively to the loss or gain of electrons. In the present book, I use reduction in the older senses unless specifically indicated.

Two additional terms of art require explanation as well. In modern English, "sublimation" refers to the passage from a solid directly to a vapor followed by its recondensation as a solid, while "distillation" designates the vaporization of a liquid followed by its return to the liquid state. In the seventeenth century, however, the two terms were often not kept rigorously distinct. Thus the 1657 *Physical Dictionary* defines "sublimation" as an operation in which "the elevated matter in distillation, being carried to the highest part of the helm, and finding no passage forth, sticks to the sides thereof."[7] In order to avoid imposing an imagined rigor on my sources, I have generally followed this period use of "sublimation." The final term that requires explanation is my use of the word "adjuvant." The English term originally meant anything that "serves to help or assist," but it has come to have a specific sense in pharmacology of "a substance added to a medicinal formulation to assist the action of the principal ingredient."[8] I use "adjuvant" to signify something similar to the latter meaning, but in the specific laboratory operation of sublimation, where Newton typically added a more volatile material to a more fixed one in order to induce the latter to sublime. The medieval alchemical author Geber referred to such aids to sublimation as "res iuvantes," which I have translated elsewhere as "adjuvants" and here employ for Newton as well.[9]

A further item requiring clarification is my way of representing Newton's scribal shorthand. Because the most important text is often found in the canceled passages of Newton's manuscripts, I have generally reproduced his chymical writings in the diplomatic form found on the *Chymistry of Isaac Newton* project (www.chymistry.org), where most of them are edited. This practice means that quotations often include struck-through text, indications of illegibility, and scribal abbreviations. It was common in the seventeenth century to use a standard set of symbols to abbreviate words. The most obvious one, perhaps, is the thorn, which looks like a "y" but represents the letter combination "th" and is normally followed by one or more superscribed letters. Thus Newton usually writes our "the" as "y^{e}" and our "that" as "y^{t}." The process of dropping the medial part of a word and presenting its terminal letter(s) in the form of a superscript appears in many other instances as well, without the thorn. Thus Newton often represents "what" as "w^{t}" and "which" as "w^{ch}." Another very common contraction is "sp^{t}" for "spirit." One could identify many other examples of this practice, but once the reader understands Newton's modus operandi, it is usually not difficult to extract his meaning. A second feature of scribal shorthand, the macron, also makes its appearance in Newton's handwriting. This consists of an overbar placed on

[6] *Oxford English Dictionary*, online edition, under "Reduce," III. 17. b.
[7] *A Physical Dictionary* (London: John Garfield, 1657), N_2.
[8] *Oxford English Dictionary*, online edition, under "Adjuvant."
[9] William R. Newman, *The Summa perfectionis of Pseudo-Geber* (Leiden: Brill, 1991), 354, 679n79.

top of a letter or letters to indicate that part of the word has been omitted. One widespread example of this practice in Newton's manuscripts appears in the contraction "Pher" for "philosopher"; slight variants of this form also occur. If the reader encounters a contracted passage that is not obvious, he or she can in most instances locate the text in the online *Chymistry of Isaac Newton* site and convert it to its normalized, expanded form by placing the cursor above the folio number and tapping the mouse. In the case of Newtonian passages edited by other scholars, as in the multivolume *Correspondence of Isaac Newton* begun by H. W. Turnbull, I have not changed the way in which the editors represent abbreviations. The conversion of Turnbull's "ye" and "yt" to their superscript forms would have required that I consult every manuscript in the original, since Newton is not consistent in his practice of superscribing the terminal letter(s) of a given contracted word.

Newton had another scribal habit that is of great significance as well, namely, his practice of reproducing his source and then placing his own interpretation of the quoted or paraphrased author within square brackets. This is often the only clue that we have to Newton's understanding of a given text, so it is obviously important to retain his brackets when quoting from his manuscripts. But this of course means that the normal use of editorial square brackets must be scrupulously avoided in order to prevent confusion between Newton's words and the editor's. Consequently, the editions of Newton's manuscripts on the *Chymistry of Isaac Newton* site employ angle brackets (< . . . >) to indicate all editorial interventions. The same practice has been adopted in this book. Moreover, in order to avoid confusion, passages from Newton's nonalchemical manuscripts that have been inserted in square brackets by other editors are here placed in angle brackets.

A final practice that requires explanation results from the confusing situation of seventeenth- and eighteenth-century British timekeeping. The British did not adopt Gregory XIII's calendrical reforms until the mid-eighteenth century, meaning that their calendar was ten days behind the one used on the European continent until 1700, on which date it fell yet another day behind. This could result in a confusion of years when a British date fell in late December. Moreover, the custom in the British Isles was to begin the new year on Lady Day, March 25, with the result that dates between our January 1 and March 24 would all fall in the previous year. In order to avoid confusing matters beyond repair, early modern British writers often gave the year in Old Style, Julian dating, followed by the New Style, Gregorian one. Thus in his laboratory notebooks, Newton refers to our January 1689 as "Ian. 1679./80." Where early modern authors employ this practice of providing both dates separated by a slash, I have reproduced it. All years that appear in the present book without a slash are Gregorian years unless noted otherwise; following the common practice, I have not modernized the dates of Julian days.

Abbreviations for Works Cited

All citations of Newton's chymical manuscripts at the Cambridge University Library (Additional MSS), Kings College (Keynes collection), the National Library of Israel (Var. and Yahuda MSS), and the Smithsonian Institution (Dibner collection) refer to the online editions published by the *Chymistry of Isaac Newton Project* (www.chymistry.org).

Babson—Huntington Library, Babson MS
BML—Boston Medical Library MS
Boyle, *Works*—Michael Hunter and Edward B. Davis, eds., *The Works of Robert Boyle* (London: Pickering and Chatto, 1999–2000), 14 vols. For citations of Boyle, I give the pagination of the modern edition followed by the date and pagination of the original printing
CIN—*Chymistry of Isaac Newton*, www.chymistry.org
CU Add.—Cambridge University Library, Additional MS (Portsmouth Collection)
Cushing—Yale University, Cushing/Whitney Medical Library MS
Dibner—Smithsonian Institution, Dibner MS
Dobbs, *FNA*—Betty Jo Teeter Dobbs, *The Foundations of Newton's Alchemy; or, "The Hunting of the Greene Lyon"* (Cambridge: Cambridge University Press, 1975)
Dobbs, *JFG*—Betty Jo Teeter Dobbs, *The Janus Faces of Genius: The Role of Alchemy in Newton's Thought* (Cambridge: Cambridge University Press, 1991)
Don.—Oxford University, Bodleian Library, Don. MS
Hall and Hall, *UPIN*—A. Rupert Hall and Marie Boas Hall, eds., *Unpublished Scientific Papers of Isaac Newton* (Cambridge: Cambridge University Press, 1962)
Harrison, *Library*—John Harrison, *The Library of Isaac Newton* (Cambridge: Cambridge University Press, 1978)
Keynes—King's College, Cambridge University, Keynes MS
Manuel, *PIN*—Frank Manuel, *A Portrait of Isaac Newton* (Cambridge, MA: Belknap Press of Harvard University Press, 1968)
Mellon—Yale University, Beinecke Library, Mellon MS
Newman, *AA*—William R. Newman, *Atoms and Alchemy* (Chicago: University of Chicago Press, 2006)
Newman, *GF*—William R. Newman, *Gehennical Fire* (Cambridge, MA: Harvard University Press, 1994)

Newman and Principe, *ATF*—William R. Newman and Lawrence M. Principe, *Alchemy Tried in the Fire* (Chicago: University of Chicago Press, 2002)

Newman and Principe, *LNC*—William R. Newman and Lawrence M. Principe, eds., *George Starkey: Alchemical Laboratory Notebooks and Correspondence* (Chicago: University of Chicago Press, 2004)

Newton, *Corr.*—H. W. Turnbull, ed., *The Correspondence of Isaac Newton* (Cambridge: Cambridge University Press, 1959–61), vols. 1–3; J. F. Scott, ed. (1967), vol. 4; vols. 5–7, A. Rupert Hall and Laura Tilling, eds. (1975–77)

Newton, *CPQ*—J. E. McGuire and Martin Tamny, eds., *Certain Philosophical Questions: Newton's Trinity Notebook* (Cambridge: Cambridge University Press, 1983)

NP—*The Newton Project*, http://www.newtonproject.ox.ac.uk/

OED—*Oxford English Dictionary*, online edition

Philalethes, *Marrow*—Eirenaeus Philalethes, *The Marrow of Alchemy* (London: Edward Brewster, 1654–55)

Philalethes, *RR*—Eirenaeus Philalethes, Ripley Reviv'd (London: William Cooper, 1678)

Philalethes, *SR*—Eirenaeus Philalethes, Secrets Reveal'd (London: William Cooper, 1669)

Principe, *AA*—Lawrence M. Principe, *The Aspiring Adept* (Princeton, NJ: Princeton University Press, 1998)

RS—Royal Society MS

Schaffner—University of Chicago, Regenstein Library, Schaffner MS

Shapiro, *FPP*—Alan Shapiro, *Fits, Passions, and Paroxysms* (Cambridge: Cambridge University Press, 1993)

Sloane—British Library, Sloane MS

Snyders, *Commentatio*—Johann de Monte-Snyders, *Commentatio de pharmaco catholico*, in Anonymous, *Chymica vannus* (Amsterdam: Joannes Janssonius à Waesberge and Elizeus Weyerstraet, 1666)

Sotheby Lot—*Catalogue of the Newton Papers Sold by the Viscount Lymington* (London: Sotheby, 1936)

Var.—National Library of Israel, Var. MS

Westfall, *NAR*—Richard Westfall, *Never at Rest: A Biography of Isaac Newton* (Cambridge: Cambridge University Press, 1980)

Yahuda—National Library of Israel, Yahuda MS

Newton the Alchemist

ONE

The Enigma of Newton's Alchemy

THE HISTORICAL RECEPTION

When Isaac Newton died in 1727, he had already become an icon of reason in an age of light. The man who discovered the laws governing gravitational attraction, who unveiled the secrets of the visible spectrum, and who laid the foundations for the branch of mathematics that today we call calculus, was enshrined at Westminster Abbey alongside the monarch who had ruled at his birth. Despite having been born the son of a yeoman farmer from the provinces, Newton was eulogized on his elaborate monument as "an ornament to the human race." Perhaps playing on the illustrious physicist's fame for his optical discoveries, the most celebrated English poet of his age, Alexander Pope, coined the famous epitaph "Nature and Nature's Laws lay hid in Night. God said, *Let Newton be!* and All was *Light*."[1] Thus God's creation of Newton became a second *fiat lux* and the man himself a literal embodiment of the Enlightenment.

Little did Pope know that in the very years when Newton was discovering the hidden structure of the spectrum, he was seeking out another sort of light as well. The "inimaginably small portion" of active material that governed growth and change in the natural world was also a spark of light, or as Newton says, nature's "secret fire," and the "material soule of all matter."[2] Written at the beginning of a generation-long quest to find the philosophers' stone, the summum bonum of alchemy, these words would guide Newton's private chymical research for decades. Even after taking charge of the Royal Mint in 1696, Newton was still actively seeking out the fiery dragon, the green lion, and the liquid that went under the name of "philosophical wine," a libation fit for transmutation rather than consumption.[3] Most compellingly of all, Newton was on the path to acquiring the scepter of Jove and the rod of Mercury, along with the twin snakes "writhen" around the staff that

[1] Alexander Pope, "Epitaph: Intended for Sir Isaac Newton, in Westminster Abbey," in *The Poems of Alexander Pope*, ed. John Butt (New Haven, CT: Yale University Press, 1963), 808. For Newton's eighteenth-century reputation more broadly, see Mordechai Feingold, *The Newtonian Moment* (New York: New York Public Library, 2004).

[2] Smithsonian Institution, Dibner MS 1031B, 6r, 3v.

[3] See chapter nineteen herein for Newton's late use of these terms.

would convert it into the wonder-working caduceus of the messenger god. All these exotic names referred to the material tools of the adepts, the *arcana majora* or higher secrets with whose help they hoped to transform matter from its base and fickle state into the immutable perfection of gold.

The omission of alchemy from Pope's eulogy was of course no accident. Even if the "wasp of Twickenham" had known of Newton's alchemical research, he would certainly not have used it as a means of lionizing the famous natural philosopher. By the 1720s the part of chymistry that dealt with the transmutation of metals, *chrysopoeia* (literally "gold making"), was coming under siege in many parts of Europe. But in the second half of the seventeenth century, when Newton did the bulk of his alchemical research, transmutation had formed a natural part of the chymical discipline, and indeed the term "chymistry" had long been coextensive with "alchemy." Both words had signified a comprehensive field that included the making and refining of pharmaceuticals and the production of painting pigments, fabric dyes, luminescent compounds, artificial precious stones, mineral acids, and alcoholic spirits alongside the perennial attempt to transmute one metal into another.[4] A slow process of separation was already underway by the final quarter of the century, however, and by the second and third decades of the *siècle des lumières* such chymical authorities as Georg Ernst Stahl and Herman Boerhaave, who had long upheld the traditional principles and purview of alchemy, were expressing their doubts about chrysopoeia in a highly public way.[5] Thus when the antiquarian William Stukely compiled a draft biography of Newton after his friend's death, he went so far as to suggest that Newton's work in chymistry had the potential of freeing the subject from an irrational belief in transmutation.[6] Ironically, Newton the alchemist had been transmuted into Newton the Enlightenment chemist.

Yet the celebration of the founder of classical physics as a beacon of pure reason had already begun to show signs of wear when David Brewster composed a biography in 1855 in which he was compelled to come to terms with the fact that Newton had studied alchemy. Brewster expressed his amazement that Newton "could stoop to become even the copyist of the most contemptible alchemical poetry," a fact that the Scottish scientist could only explain as the mental folly of a previous age.[7] The few lines that Brewster devoted to the topic were largely ignored until 1936, when the bulk of Newton's

[4] The archaic spelling "chymistry" has been adopted by scholars to signify this overarching field that combined medical, technical, and chrysopoetic endeavors in the early modern period. See the online *Oxford English Dictionary* under the term "chemistry," where further documentation is given (accessed June 9, 2017).

[5] For Stahl's gradual conversion to a critic of chrysopoeia, see Kevin Chang, "'The Great Philosophical Work': Georg Ernst Stahl's Early Alchemical Teaching," in *Chymia: Science and Nature in Medieval and Early Modern Europe*, ed. Miguel López Pérez, Didier Kahn, and Mar Rey Bueno (Newcastle upon Tyne: Cambridge Scholars, 2010), 386–96. For the similar process of disenchantment in the case of Boerhaave, see John Powers, *Inventing Chemistry: Herman Boerhaave and the Reform of the Chemical Arts* (Chicago: University of Chicago Press, 2012), 170–91.

[6] RS MS/142, folio 56v, from *NP* (http://www.newtonproject.sussex.ac.uk/view/texts/diplomatic/OTHE00001), accessed June 7, 2016.

[7] Sir David Brewster, *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton* (Edinburgh: Thomas Constable, 1855), 2: 375.

surviving manuscripts on alchemy and religion were auctioned by Sotheby's in London. Suddenly a very different Newton was thrust into the light, one who had written perhaps a million words on alchemy and even more on religious subjects ranging from biblical prophecy and the dimensions of Solomon's temple to the perfidy of the orthodox doctrine of the Holy Trinity. The cognitive dissonance that these manuscripts inevitably summoned up was captured by the economist John Maynard Keynes, who collected a large number of them for King's College, Cambridge. In his famous posthumous essay "Newton, the Man," published in 1947, Keynes wrote that

> Newton was not the first of the age of reason. He was the last of the magicians, the last of the Babylonians and Sumerians, the last great mind which looked out on the visible and intellectual world with the same eyes as those who began to build our intellectual inheritance rather less than 10,000 years ago. . . . He believed that by the same powers of his introspective imagination he would read the riddle of the Godhead, the riddle of past and future events divinely fore-ordained, the riddle of the elements and their constitution from an original undifferentiated first matter, the riddle of health and of immortality.[8]

In the same article, Keynes would add that Newton's alchemical manuscripts were "wholly magical and wholly devoid of scientific value." Yet despite the pejorative tone of these comments, Keynes was not operating in a naive or unreflective way when he dismissed Newton's alchemy as magic. His 1921 *Treatise on Probability* had argued against "the excessive ridicule" that moderns tended to levy on primitive cultures, and he even went so far as to locate the origins of induction in the magician's attempt to recognize patterns in nature. Keynes would support this claim with observations drawn from the Victorian masterpiece of Sir James Frazer, *The Golden Bough*.[9] Frazer's massively influential study of mythology had used the principle of sympathy (the belief that "like acts on like") to group a wide variety of practices under the rubric of "magic."[10] A similar approach emerges in "Newton, the Man," although it is obscured by the rhetorical brilliance of the essay, with its overriding goal of toppling the traditional image of Newton the rationalist. Like Frazer, Keynes assimilated various "occult" pursuits such as alchemy and the quest for secret correspondences in nature under the same amorphous category, labeling them as magical.[11] It is highly likely that Keynes had Frazer in the back of his mind when he unselfconsciously elided the borders between magic and alchemy, two disciplines that Newton for the most part kept rigorously distinct.

[8] John Maynard Keynes, "Newton, the Man," in *Newton Tercentenary Celebrations, 15–19 July 1946* (Cambridge: University Press, 1947), 27–34, see 27.

[9] John Maynard Keynes, *A Treatise on Probability* (London: Macmillan, 1921), 245–46.

[10] Frazer's *Golden Bough* was originally published in two volumes in 1890, but eventually swelled to twelve volumes. For his treatment of the principle of sympathy, see James Frazer, *The Golden Bough* (New York: Macmillan, 1894), 9–12.

[11] For my objections to this type of lumping approach when it comes to the "occult sciences," see William R. Newman, "Brian Vickers on Alchemy and the Occult: A Response," *Perspectives on Science* 17 (2009): 482–506.

The Keynesian picture of Newton as the last of the magicians rather than as the father of the Enlightenment amounted to a radical inversion of the Augustan view: no longer a herald of light, the founder of classical physics now looked back to a dark and fabulous past. This new image of a brooding and troubled Newton buried in the decipherment of riddles "handed down by the brethren in an unbroken chain back to the original cryptic revelation in Babylonia" would go on to exercise its own attraction. One can see the influence of Keynes very clearly in the work of two eminent Newton scholars of the late twentieth century, Betty Jo Teeter Dobbs and Richard Westfall. Both Dobbs and Westfall were pioneers in the scholarly study of Newton's alchemy, and their work has provided an indispensable basis for subsequent research in the field, including my own. One cannot doubt the seriousness of their scholarship, the years that they devoted to understanding Newton, or the significance of their contributions. Yet as we shall see, their embrace of the Keynesian perspective could at times exert its own smothering grip on their critical judgment.

Dobbs, whose 1975 *The Foundations of Newton's Alchemy; or, "The Hunting of the Green Lyon"* provided the first full-length study of Newton's alchemical endeavors, came to the eventual conclusion that alchemy for Newton was above all a religious quest.[12] Although she did not endorse Keynes's blanket assertion that Newton's alchemical writings were a worthless farrago, and even criticized the famous economist for his failure to consider Newton's alchemical experiments, Dobbs built on the idea that alchemy itself incorporated a fundamentally irrational core. Her *Foundations of Newton's Alchemy* contains a largely approving exposition of the analytical psychologist Carl Jung's position that alchemical imagery embodied an "irruption" of the mind's unconscious contents and that alchemy was largely a matter of "psychic processes expressed in pseudo-chemical language," implying that something other than scientific or even material goals were the main driving force behind the aurific art.[13] Dobbs's 1991 *The Janus Faces of Genius: The Role of Alchemy in Newton's Thought* dropped this explicit adherence to Jung's analytical psychology, but nonetheless developed a favorite thesis of Jung's, namely, that the alchemical search for the philosophers' stone was primarily a quest to reunite man with the creator, a form of soteriology. Hence *The Janus Faces of Genius* gives the impression that Newton's alchemy was above all a vehicle for his heterodox religious quest, and that he thought of the philosophical mercury of the alchemists as a spirit that mediated between the physical and transcendent realms in a way analogous to the mediation of Jesus between God and man.[14]

Newton's alchemy also appears through Keynes-tinted glasses in the work of Dobbs's contemporary Westfall, though in a slightly different fashion.

[12] This is not the case in Dobbs's first book, however, where she in fact attacks Mary Churchill for overemphasizing the religious aspect of Newton's alchemy. See Dobbs, *FNA*, 15–16. As her study of Newton's alchemy extended itself over time, Dobbs came more and more to stress its putative religious goals.

[13] Dobbs, *FNA*, 25–43. Despite her affirmation of the Jungian approach to alchemy as "really promising," on page 25, Dobbs does exercise a degree of critical restraint when she correctly describes Jung's views on page 40 as "basically a-historical."

[14] Dobbs, *JFG*, 13, 243–48.

While Westfall seems to have remained impartial to the Dobbsian position that Newton's alchemy was coextensive with his private religion, he did see Newton's interest in the aurific art as a sort of romantic rebellion against the rationalist project of Cartesian physics, harking back to "the hermetic tradition" of late antiquity and the Renaissance.[15] To Westfall, alchemy and magic were characterized by a fascination with immaterial qualities, powers, sympathies, and antipathies, in short, the very antithesis of the Cartesian billiard-ball universe with its attempt to reduce nature to a succession of impact phenomena. Hence Westfall could argue that Newton's alchemy, although it lay outside the domain of rationalist natural philosophy, contributed in a major way to his mature theory of gravitation, and more broadly to his conviction that immaterial forces in general could operate at a distance. Westfall would explicitly argue that Newton's concept of force at a distance "derived initially from the world of terrestrial phenomena, especially chemical reactions." In fact, he even went so far as to claim that Newton's concept of gravitational attraction emerged only after "he applied his chemical idea of attraction to the cosmos."[16]

Westfall's claim that alchemy was behind Newton's theory of universal gravitation was adopted in turn by Dobbs in her *Foundations of Newton's Alchemy*, while her theocentric interpretation of his quest for the philosophers' stone dominated *The Janus Faces of Genius*. Largely as a result of these scholars' authoritative status, the view that Newton's theory of gravity owed a heavy debt to alchemy has become canonical in the popular literature.[17] Current scholarly treatments of the subject endorse the authoritative status of Dobbs and Westfall as well, restating the former's view that Newton aimed "to capture the essence of the Redeemer in a beaker" and asserting with both scholars that alchemy "may have helped him to conceptualize the idea of gravity."[18] It is not too much to say that the picture of Newton's alchemy as a largely theocentric pursuit that contributed to his science by allowing for a rebaptizing of magical sympathy as gravitational attraction has become the received view of the subject.

But there are compelling reasons for doubting this interpretation. The once popular notion that alchemy was inherently unscientific—already present in the work of Keynes and advanced by successive Newton scholars—has been largely debunked by historians of science over the last three decades. Indeed, the historiography of alchemy has recently undergone a sort of renaissance that

[15] In his 1971 book *Force in Newton's Physics*, Westfall explicitly linked gravitational force to alchemy and to what he called "the hermetic tradition," a term that clearly betrays the influence of Frances Yates's 1964 *Giordano Bruno and the Hermetic Tradition*. See Richard Westfall, *Force in Newton's Physics* (London: MacDonald, 1971), 369.

[16] Richard Westfall, "Newton and the Hermetic Tradition," in *Science, Medicine, and Society in the Renaissance*, ed. A. G. Debus (New York: Science History Publications, 1972), 2: 183–98, see 193–94.

[17] See for example Michael White, *Isaac Newton the Last Sorceror* (New York: Basic Books, 1997), 106, 207, and throughout. The view that Newton's concept of gravitational attraction owes an important debt to alchemy even receives support in the current Wikipedia entry on Newton. See https://en.wikipedia.org/wiki/Isaac_Newton, accessed January 22, 2016.

[18] Paul Kléber Monod, *Solomon's Secret Arts* (New Haven, CT: Yale University Press, 2013), 104.

has reversed the picture of the aurific art as an atavistic outlier.[19] It is now well known that such luminaries of the scientific revolution as Robert Boyle, G. W. Leibniz, and John Locke were all seriously involved in alchemy; Newton was no anomaly.[20] All of these figures engaged in the broad spectrum of chymical practice, seeing it as a fruitful source of pharmaceutical and technological products and yet hoping as well that it might reveal the secret of metallic transmutation. Chymistry was a natural and normal part of the progressive agenda of seventeenth-century science. Hence the need that Dobbs and others felt to locate Newton's motives for studying alchemy in extrascientific areas such as soteriology and the quest for a more primitive Christianity has lost its force. We are now free to study Newton's alchemy on its own terms and to arrive at a much clearer picture of the field's relationship to his other scientific pursuits. As I show in *Newton the Alchemist*, the claims that Westfall (and subsequently Dobbs) made for an alchemical origin to Newton's theory of gravitational attraction are actually quite weak; in reality, the connection between alchemy and Newton's better known scientific discoveries lies elsewhere, above all in the realm of optics.[21]

Nonetheless, when first confronted by the sheer volume of Newton's million or so words on alchemy, one can only sympathize with the attempts of Westfall and Dobbs to cast about for a means of interpreting this intractable material. Finding the source of Newton's belief in forces acting at a distance in alchemy or linking the subject to his Antitrinitarian Christianity are both ways of rationalizing the immense amount of time and work that he devoted to the aurific art. Nor are these the only motives that historians have claimed to lie buried within the chaotic mass of Newton's alchemical papers. Karin

[19] For a good overview of the current scholarly position of chymistry and some reflections on the earlier historiography, see the four recent essays by Lawrence M. Principe, William R. Newman, Kevin Chang, and Tara Nummedal collected and introduced by Bruce Moran for the "Focus" section of *Isis*: Bruce T. Moran, "Alchemy and the History of Science," *Isis* 102 (2011): 300–337. Additionally, one should consult Moran's *Distilling Knowledge: Alchemy, Chemistry, and the Scientific Revolution* (Cambridge, MA: Harvard University Press, 2005); Newman's *Promethean Ambitions: Alchemy and the Quest to Perfect Nature* (Chicago: University of Chicago Press, 2004); Nummedal's *Alchemy and Authority in the Holy Roman Empire* (Chicago: University of Chicago Press, 2007); and Principe's *Secrets of Alchemy* (Chicago: University of Chicago Press, 2013). Another helpful study is Jennifer M. Rampling, "From Alchemy to Chemistry," in *Brill's Encyclopedia of the Neo-Latin World*, ed. Philip Ford, Jan Bloemendal, and Charles Fantazzi (Leiden: Brill, 2014), 705–17. In the context of the recent historiography of chymistry, one cannot pass over the magisterial study of Paracelsianism in France by Didier Kahn, *Alchimie et Paracelsisme en France à la fin de la Renaissance (1567–1625)* (Geneva: Droz, 2007).

[20] Boyle's career-long involvement in the quest for chrysopoeia forms the subject of Principe, *AA*. A recent article that presents and critiques the earlier historiography of Leibniz's involvement with alchemy may be found in Anne-Lise Rey, "Leibniz on Alchemy and Chemistry," in the online *Oxford Handbook of Leibniz* (http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199744725.001.0001/oxfordhb-9780199744725-e-32), accessed June 9, 2017. For Locke and chrysopoeia, see Peter R. Anstey, "John Locke and Helmontian Medicine," in *The Body as Object and Instrument of Knowledge*, ed. Charles T. Wolfe and Ofer Gal (Dordrecht: Springer, 2010), 93–120. See also Guy Meynell, "Locke and Alchemy: His Notes on Basilius Valentinus and Andreas Cellarius," *Locke Studies* 2 (2002): 177–97.

[21] Dobbs herself argued for an influence from alchemy on Newton's optics, but her claims have been debunked by Alan Shapiro. See Dobbs, *FNA*, 221–25, and Shapiro, *FPP*, 116n48. The interaction between Newtonian optics and chymistry that I envision is quite distinct from the one Dobbs maintained. See the present book and also William R. Newman, "Newton's Early Optical Theory and Its Debt to Chymistry," in *Lumière et vision dans les sciences et dans les arts*, ed. Danielle Jacquart and Michel Hochmann (Geneva: Droz, 2010), 283–307.

Figala, who did exemplary work in digging up Newton's chymical collaborations and making sense of the bibliographical entries in his notes, arrived at a grand but poorly substantiated thesis that explained the bulk of Newton's alchemy in terms of specific gravity. Basing herself on Newton's view that ordinary matter consists of corpuscles that are themselves mostly made up of empty space, Figala developed mathematical schemes linking the supposed amount of void and matter in materials to the traditional alchemical principles mercury and sulfur.[22] The problem with her interesting idea is that Newton nowhere makes this linkage himself; in fact, a close reading of his alchemical laboratory notebooks shows that he rarely even mentioned specific gravity in the context of his chymical experimentation. The only way to reconstruct the supposed system Figala found is by assuming that Newton left it entirely implicit, and that the historian must reconstruct it from tacit clues by a process that altogether resembles second-guessing. But this in turn requires that we ignore more obvious approaches taken by Newton, such as his deep concern with the affinities between chemicals that guide their bonding and dissociation.

Yet another approach to Newton's alchemy may be found in *The Expanding Force in Newton's Cosmos* by David Castillejo, which provides an extreme instance of the Keynesian perspective.[23] To Castillejo, Newton's optics, dynamical physics, prophecy, and the interpretation of the dimensions in Solomon's Temple are all part and parcel of the same project as his alchemy. Here we see the Babylonian magus again regarding the cryptogram of the universe and searching for the hidden clues that God has implanted in the cosmos. Castillejo's research led him to the conclusion that Newton had discovered a "single expansive force" that contrasted with the "contractive force" of gravity and operated at all levels of being. To Castillejo's Newton, the same mathematical relations governing this expansive force are operative in the dimensions of Solomon's Temple and in the corpuscular structure of matter at the microlevel. And for Castillejo, Newton's expansive force is coterminous with the cause of fermentation, which the physicist claimed to be a fundamental force of nature in his *Opticks*. Despite several significant contributions that lie buried in *The Expanding Force in Newton's Cosmos*, much of the numerology that Castillejo claims to find in Newton's work, he has forcibly imposed on the text. It is a peculiar irony that both Castillejo and Figala seem to be unriddling Newton's alchemical papers in much the same way that Keynes claimed Newton to be unriddling the cryptogram of nature itself.

The Tower of Babel presented by the wildly divergent claims of Dobbs, Westfall, Figala, and Castillejo should alert us to the gargantuan difficulties residing in Newton's alchemical *Nachlass*. Although the material is voluminous and disordered, with few obvious indications of the times at which the different papers were composed, these are the least of the problems.

22 Karin Figala, "Newton as Alchemist," *History of Science* 15 (1977): 102–37, see especially 113–28.

23 David Castillejo, *The Expanding Force in Newton's Cosmos* (Madrid: Ediciones de arte y bibliofilia, 1981), 17–30, 105–17.

The greatest difficulty stems from the fact that Newton was writing only for himself, and as he progressed more deeply into the literature of alchemy, he assumed the voices and literary techniques of the authors he was reading. As I describe at length in the present book, he took from his sources a veritable language of cover names or *Decknamen* (to employ the German term adopted by historians of alchemy) for the materials with which he was working. Decoding these terms presents difficulties that are grueling at best, since even when we understand a particular author's original meaning, Newton's interpretation often differs strikingly from that of his source. As a result, our hard-won knowledge of other seventeenth-century chymists and their techniques can mislead us as often as it helps us in deciphering Newton's laboratory records and reading notes. A case in point may be found in Newton's pervasive use of the American chymist George Starkey, who wrote elegant Latin treatises on chrysopoeia under the pseudonym of "Eirenaeus Philalethes" (a peaceful lover of truth). Although modern scholarship has probed the depths of Starkey's alchemy and acquired a clear understanding of his processes, the celebrated physicist held an idiosyncratic interpretation of the Philalethan corpus that can only be deciphered by careful analysis of Newton's notes and experiments, and sometimes by disregarding Starkey's original sense.

The Method of the Present Work

How then can we extricate any stable meaning from the shifting and cacophonous world presented by Newton's note taking, derived as it was from the enigmatic utterances of authors whose works were written over a range of cultures and centuries? There is in fact a way, and one that previous scholars have not sufficiently used. I refer to a twofold method that incorporates rigorous textual analysis with laboratory replication of Newton's alchemical experiments. The close analysis of documents needs no justification, having a long and distinguished pedigree extending back to the philological efforts of the nineteenth century and before. "Experimental history," on the other hand, is only now coming into its own among scholars. This is the branch of historical endeavor that involves replication, or if one prefers, "reworking" or "reconstruction" of old techniques and experiments. Just as experimental archaeologists have long been reproducing the techniques that allowed premodern cultures to create the artifacts that populate current-day museums, so historians of science have in recent years come to see the need for a "hands-on" approach to the study of old experiments. The history of chemistry has proven to be a particularly rich area of study for experimental history, and it dovetails closely with the long-standing field of conservation science, a discipline that has traditionally given rigorous attention to the material composition of painters' pigments. Newton's experimental notebooks cry out for this approach, because of the wealth of technical, even artisanal detail that they contain and because of the tacit laboratory-based skill on which they rely. Without some mastery of seventeenth-century chymical techniques, the scholar simply cannot make serious headway against the flood of *termini technici* that make up Newton's notebooks. A recent issue of the journal *Ambix* devoted to experimental history indicates that reproducing experiments can result in "the uncovering of details, difficulties, and solutions left unrecorded or only hinted at by the original experimenter."[24] While endorsing this sentiment, I would go even further in the case of Newton's experimental work in alchemy. Because of his perennial use of *Decknamen* and proprietary names for materials, one cannot even identify the basic subjects of his experimentation without firsthand knowledge of the materials that were available to him. Newton's idiosyncratic terms such as "liquor of antimony" and "sophic sal ammoniac" could in principle mean many different things; only by carefully analyzing his comments and actually putting them to the test in a laboratory can we determine the precise sense of his words.

At the same time, the new digital edition of Newton's extensive alchemical laboratory records on Indiana University's *Chymistry of Isaac Newton* site (www.chymistry.org) has also allowed me to provide the first comparative, in-depth study of these essential documents. Two of them, Cambridge University Additional manuscripts 3973 and 3975, are found in the collection of Portsmouth manuscripts in the Cambridge University Library; the third is a single sheet belonging to the collections of the Boston Medical Library.[25] These remarkable notebooks chronicle Newton's laboratory experimentation for a period of at least three decades. The importance of the first two documents has long been recognized, but Newton's use of his proprietary *Decknamen* and the absence of explicit goals and conclusions in the notebooks render it extraordinarily difficult to make sense of them. Nonetheless, laboratory replications performed on a number of the experiments have led to the unraveling of many of their secrets. Understanding Newton's experiments in turn provides a link to both the Helmontian chymistry of his contemporaries such as Robert Boyle and George Starkey and to the mythological and allegorical output of chrysopoetic authors such as the obscure Johann de Monte-Snyders.

An additional key to Newton's laboratory practice is the remarkable and hitherto unstudied letter written to him by his friend and alchemical collaborator Nicolas Fatio de Duillier in August 1693.[26] In this document, Fatio quotes Newton's Latin directions for making the products that underlie the latter's famous—and famously indecipherable—*Praxis* manuscript, which is

[24] Hjalmar Fors, Lawrence M. Principe, and H. Otto Sibum, "From the Library to the Laboratory and Back Again: Experiment as a Tool for Historians of Science," *Ambix* 63 (2016): 85–97, see 94.

[25] One must not neglect to mention the important article by A. Rupert Hall and Marie Boas Hall, "Newton's Chemical Experiments," *Archives internationales d'histoire des sciences* 11 (1958): 113–53. The Halls analyzed CU Add. 3975 and 3973, but were unaware of the Boston Medical Library manuscript. Moreover, they were hampered by an unnecessarily negative view of alchemy and relied on purely "armchair" chemistry for their interpretations, replicating none of Newton's experiments. Their contemptuous perspective on alchemy led to a misunderstanding of Newton's goals, and their untested guesses about his laboratory work resulted in many misidentifications of his materials and products.

[26] William Andrews Clark Memorial Library, MS F253L 1693. I thank Scott Mandelbrote for originally bringing this letter to my attention.

sometimes described as his most important alchemical writing. Directions for making such desiderata as volatile Venus, sophic sal ammoniac, the scythe of Saturn, and the sword ("fauchion") of Mars all appear in Fatio's letter, but in a simplified form intended for replication by experimenters lacking Newton's years of experience with these materials. Along with Newton's laboratory notebooks, Fatio's letter makes it possible to reassemble the processes that Newton thought would lead eventually to the summum bonum of alchemy, and indeed the key to nature itself, the philosophers' stone. Using these documents as a guide, I have replicated a number of the stages in Newton's master process, and the results show why one of the most perspicacious experimenters of all time thought that his alchemical laboratory work was leading to success after decades of unremitting labor at the bench.

The physical replication of Newton's experiments is therefore a necessary tool for understanding his alchemical writings. But of course it is only one instrument among many that we must employ in a coordinated effort to extract meaning from these extraordinarily difficult texts. Another essential feature of our analysis relies on Newton's habit of providing the plain sense of a particular passage that he has extracted from his sources in square brackets or parentheses. These bracketed or parenthetical interpolations often act as a sort of Rosetta stone for arriving at Newton's understanding of a particular text. Although the Newton scholars mentioned above were all aware of this annotating practice, they did not make a systematic study of the way in which Newton's bracketed interpretations grew and developed over time. Thanks to the recent emergence of digital, searchable editions of Newton's manuscripts, however, this has become far more feasible. The *Chymistry of Isaac Newton* site has put about three-quarters of Newton's alchemical manuscripts online in edited form, and *The Newton Project* at Oxford University (http://www.newtonproject.ox.ac.uk) has performed a similar service for his religious writings. These digital editions have made it far more feasible to find bracketed expressions and detect parallel passages among widely distributed Newtonian manuscripts, thus allowing us to draw hitherto unsuspected comparisons among his writings. Advanced computational techniques available only for digital corpora such as latent semantic analysis have also facilitated this goal.[27] As a result, *Newton the Alchemist* is the first book to provide a picture of Newton's alchemy as it transformed from its earliest stages in the 1660s up to its full maturity and even after his transfer to London in 1696.

Although many problems remain, we are now well on our way to understanding why the warden and then master of the Royal Mint in his spare time jotted alchemical pseudonyms on his papers related to the Great Recoinage at the end of the seventeenth century.[28] Employing the common

[27] The *CIN* site features a Latent Semantic Analysis functionality, which allows parallel passages (even fuzzy ones) to appear automatically. See www.chymistry.org under "Online Tools." This tool was designed and implemented by Wallace Hooper.

[28] Babson 1006, 1r. It is of course possible in principle that Newton was reusing old paper on which his alchemical pseudonyms had been previously recorded. Even if that should turn out to be the case, however, we know from other sources that Newton was actively collaborating on an alchemical project with the London

early modern practice of hiding one's identity behind an anagram, Newton created two columns of alternative pseudonyms based on the Latin form of his name, "Isaacus Neuutonus." One of these, "Venus ac Jason tuus" conjures up both the classical goddess of love and the Argonaut who circled the globe in search of the golden fleece, a common symbol for the alchemical magnum opus. Although Newton famously eschewed the charms of Venus, his notes reveal that he was still dreaming of the philosophers' stone in the midst of his mission to purify the currency of England and to punish those who debased its coinage. His involvement with alchemy was still active around the time of his elevation to president of the Royal Society in 1703 and even persisted through his acquisition of a knighthood in 1705. Behind the authoritarian visage that controlled the Mint and dominated the Royal Society, the quest that ravished Newton as a young scholar intent on acquiring the caduceus of Mercury was still intact, and for all we know, his interest in the subject never died. Even in his old age, Newton told the husband of his niece, John Conduitt, that "if he was younger he would have another touch at metals."[29]

What Did Newton Want from Alchemy? A Road Map for the Reader

The proper understanding of Newton's alchemy presents an enduring puzzle to contemporary scholarship in much the same way that the decipherment of hieroglyphics or the solution to the Greek script known as Linear B challenged Egyptologists and Hellenists in the nineteenth and twentieth centuries. Although Newton's peculiar alchemical "language" was the creation of one man building on his forebears rather than the dialect of an entire civilization, the linguistic difficulties that it presents share some similarities with these ancient scripts, particularly in Newton's creation of the idiosyncratic graphic symbols introduced in our foreword. Yet Newton's alchemy, even though it offers serious difficulties of language, cannot be deciphered by linguistic means alone; it requires a knowledge of materials, technologies, and tacit practices as well as underlying theories submerged beneath the written word. No book that does full justice to the difficulties presented by Newton's generation-long experimental research project centered on alchemy can be light reading. Newton's purpose and methods were obscure enough to mislead four dedicated scholars, as we have seen, each of them blinkered by a preconceived thesis. In order to avoid adding to the collective misunderstanding of Newton's goals and methods, I have made an effort to assess the evidence in all of its details. This is the only way to arrive at any degree of certainty as to what Newton was doing for over thirty years in his study as he devoured alchemical books and manuscripts, and then tried

---

distiller William Yworth in the first decade of the eighteenth century, well within his Mint period. See chapter nineteen of the present book as well as Karin Figala and Ulrich Petzold, "Alchemy in the Newtonian Circle," in *Renaissance and Revolution: Humanists, Scholars, Craftsmen, and Natural Philosophers in Early Modern Europe*, ed. Judith Field and Frank James (Cambridge: Cambridge University Press, 1997), 173–91.

[29] Keynes 130.05, 5v. Accessed from *NP* on January 22, 2017.

to test his understanding of them experimentally. The reader who wants to understand Newton's alchemy rather than merely assimilating one of the preexisting views on the subject must therefore be willing to engage with Newton's language, ideas, and practices over a range of genres and in considerable detail. In order to appreciate the whole we must understand its parts, even if it proves to exceed their sum.

The scope and detail of the present book call for a preliminary road map of its contents. Because of the daunting character of traditional alchemical language, which was often expressed in the form of enigmas, the next chapter begins with a consideration of literary deception in alchemy, devoting considerable space to Newton's understanding of the riddling language of the "adepts," the mysterious practitioners of alchemy who had, at least in principle, mastered the secret of chrysopoeia. This exercise requires that we understand the place occupied by the figure of the alchemical adept in the imagination of early modern Europeans and the remarkable powers that the possessors of the grand elixir were thought to possess, powers that not only included the ability to transmute base metals into noble ones but also a parallel skill in verbal deception. According to the prevailing early modern view, the very fact of their dominion over nature forced the adepts to hide behind a veil of secrecy, because of the danger that would accrue to them if the world knew of their abilities and because it was necessary to prevent the accession of the unworthy to their ranks. To the mind of Newton, the adepts were tricksters, not because they lacked the ability to carry out their marvelous transmutations, but because they veiled their knowledge under a sophisticated language of metaphor, allusion, and outright doublespeak. Not that they spoke in gibberish; to the contrary, the intelligent and properly trained student could penetrate behind their fuliginous tropes, but only if God willed it. It was Newton's belief that in his case God did so will.

But however much divine assistance might contribute to one's alchemical success, doing alchemy did not contribute to one's divinity. Newton's private belief in the infallibility and elect status of the adepts did not entail that he viewed alchemy as a path to religious salvation. In fact, references to the aurific art in the vast corpus that Newton devoted to religious topics, consisting of about four million words, are vanishingly small. And like his chymical forerunner Joan Baptista Van Helmont, Newton thought that success at chymistry must be "bought with sweat," the unavoidable, and often mundane labor of the laboratory.[30] Chapter three provides a close analysis of several related themes, considering, for example, the relationship between Newton's exegesis of biblical prophecy and his method of interpreting the textual riddles presented by writers on the philosophers' stone. At the same

[30] Joan Baptista Van Helmont, *Ortus medicinae* (Amsterdam: Ludovicus Elsevier, 1652), 560, #55: "Carbones emant, & vitra, discantque prius, quae nobis dedere, & vigalatae ex ordine noctes, atque nummorum dispendia, dii vendunt sudoribus, non lectoribus solis, artes." See also Newman, "Spirits in the Laboratory: Some Helmontian Collaborators of Robert Boyle," in *For the Sake of Learning: Essays in Honor of Anthony Grafton*, ed. Ann Blair and Anja-Sylvia Goeing (Leiden: Brill, 2016), 2: 621–40. For the most recent sustained look at Van Helmont's life and work, see Georgiana D. Hedesan, *An Alchemical Quest for Universal Knowledge* (London: Routledge, 2016).

time, the chapter also examines Newton's views on ancient wisdom and mythology in their relation to the aurific art, since many alchemists believed that the entertaining tales of the Greek and Roman pantheon contained veiled instructions for preparing the great arcanum. Previous scholarship has tended to assume that Newton too upheld the belief that ancient mythology was largely encoded alchemy, but as chapter three argues, this would have presented a sharp conflict with his views on ancient chronology and religious history. Further evidence shows that Newton may well have considered the mythological themes transmitted and analyzed by early modern alchemists as conventional puzzles reworked from antique sources rather than as true expressions of ancient wisdom. Nonetheless, they were conundrums to be solved if one wished to advance to the mirific tool of the adepts, the philosophers' stone.

With chapter four I also provide necessary background for the reader, but this time it concerns issues of historical context rather than language. As I argue at some length, Newton's belief that metals are not only produced within the earth but also undergo a process of decay, leading to a cycle of subterranean generation and corruption, finds its origin in the close connection between alchemy and mining that developed in central Europe during the early modern period. Alchemy itself acquired a distinct, hylozoic cast that the aurific art, at least in its more scholastic incarnation, had largely lacked in the European Middle Ages. Despite a common scholarly view that holds alchemy to have been uniformly vitalistic, the early modern emphasis on the cyclical life and death of metals was not a monolithic feature of the discipline across the whole of its history, but rather a gift of the miners and metallurgists who worked in shafts and galleries that exhibited to them the marvels of the underground world. Newton, writing for the most part in the last third of the 1600s, was the heir of a unique blend of mining lore and alchemy that had reached its efflorescence almost a century before. The fourth chapter concludes by describing additional sources used by Newton, such as his favorite chymical writer over the *longue durée*, Eirenaeus Philalethes, and also the pseudonymous early modern author masked beneath the visage of the fourteenth-century scrivener Nicolas Flamel.

In chapter five we examine the young Newton from his education at the Free Grammar School in Grantham during the 1650s up to his student years at Trinity College, Cambridge, beginning in 1661, in order to see how his interest in chymistry originated and developed. The standard view is that Newton was stimulated to his early interest in chymistry by the works of Robert Boyle. But my recent discovery of an anonymous and hitherto unexamined manuscript, *Treatise of Chymistry*, provides new evidence to show that Newton was already compiling chymical dictionaries before reading Boyle's works on the subject. Very likely his earliest chymical interests stemmed from his adolescent exposure to writers in the traditions of books of secrets and natural magic such as John Bate and John Wilkins, although he fell under Boyle's spell in due course. Chapter five then passes to what are probably Newton's earliest notes on chrysopoeia, namely, his abstracts and summaries of the works attributed to the supposed fifteenth-century

Benedictine Basilius Valentinus. Finally, the chapter tries to pin down some of the early contacts in Cambridge and London who transmitted the manuscripts and other texts to Newton that provided a major part of his alchemical knowledge. We are able to provide new information here too, although much of course remains dark.

Although Boyle's early influence on Newton already emerged briefly in the previous chapter, the next provides a sustained treatment of the self-styled English "naturalist" and his contribution to Newton's optical research. It is little appreciated that Boyle's analytical approach to chymistry had a profound impact on Newton's optics in the second half of the 1660s, the period that Newton considered "the prime of my age for invention."[31] As chapter six argues at length, Newton transferred Boyle's analysis and resynthesis or "redintegration" of materials such as niter to the realm of light. It was the decomposition of white light into its spectral colors and the subsequent recomposition of whiteness from the spectrum that provided Newton with one of his most cogent demonstrations that white light was actually a heterogeneous mixture. Chapter six establishes the influence of Boyle's chymistry on Newton's experimental methodology, using primarily terminological clues to reveal Newton's borrowings from Boyle's redintegration experiments. At the same time, the chapter also presents Boyle's and Newton's work against the backdrop of scholastic matter theory and optics in order to underscore the epoch-making character of the new color theory, which resulted in the overthrow of two millennia of research on the subject.

The seventh and eighth chapters consist of a detailed analysis of Newton's two early theoretical treatises, *Humores minerales* and *Of Natures obvious laws & processes in vegetation*, both probably written between 1670 and 1674, the very period when Newton was first making a name for himself at the Royal Society with his invention of a reflecting telescope and his controversial publication of his new optical theory. Both *Humores minerales* and *Of Natures obvious laws* employ alchemical theory to describe the process of metallic and mineral generation in the subterranean world. It is here that Newton claims in unforgettable language that the earth resembles "a great animall ^or rather inanimate vegetable" that inhales subtle ether and exhales gross vapors or "airs."[32] I argue that these works provide the theory on which he bases much of his subsequent experimental practice in the domain of chymistry. In particular, the emphasis that these two texts place on reactions in the vapor or gaseous state helps to explain the strikingly heavy emphasis that Newton gave to sublimation of various materials in his experimental practice. *Of Natures obvious laws* is also interesting for its careful attempt to disentangle natural processes that rely on mechanical interactions from those that employ "vegetation," the principle of generation, growth, and putrefaction depending on hidden *semina* or seeds buried within matter.

[31] CU Add. 3968.41 f.85r (= frame 1349 of http://cudl.lib.cam.ac.uk/view/MS-ADD-03968/1349, accessed May 16, 2016).

[32] Dibner 1031B, 3v.

Newton's higher goals for chymistry attempt to harness the power of these latent sources of activity for the purpose of transmutation.

With the ninth chapter we pass from theory to practice. Beginning with Newton's very early interpretations of the Polish alchemist Michael Sendivogius in the manuscripts Babson 925 and Keynes 19, the chapter shows that the brash young Cantabrigian initially thought the secret of chrysopoeia to be attainable by means of two ingredients alone, namely stibnite or crude antimony and lead. Much of his focus on antimony stems from his recent reading of the 1669 text by Philalethes, *Secrets Reveal'd*, which describes the use of that material in fairly clear terminology. The great significance that Newton idiosyncratically attaches to the metal lead in this early phase, however, has gone unnoticed by previous scholars and adds a hitherto unsuspected dimension to his aurific quest. His subsequent exposure to additional alchemical texts, especially in the extended corpus of Philalethes, soon made him understand that he had oversimplified matters. Other metals were also involved in the processes of Philalethes, especially copper. Was lead also part of the Philalethan modus operandi, or had Newton misinterpreted the American adept? In order to resolve this question, Newton turned to the same theories of metallic generation beneath the earth that had inspired *Humores minerales* and *Of Natures obvious laws*. By deepening his understanding of subterranean mineral generation, Newton believed he would be in a better position to replicate nature's processes of growth and transformation in the laboratory.

Newton's abrupt realization that his earliest understanding of the alchemical masters was erroneous also led him to adopt a form of textual interpretation that had hitherto been largely absent from his notes. In a word, he appropriated a venerable genre among medieval and early modern alchemical writers, the *florilegium* or collection and reorganization of snippets and *dicta* of the adepts for the purpose of comparing them to one another and extracting their sense. At this point, roughly corresponding to Newton's withdrawal from public scientific life between 1676 and 1684 after growing disillusioned with the public response to his radical optical theory, he had more than ample time to focus on the decryption of alchemical texts. Working through multiple treatises and winnowing out all but the information that he deemed most crucial, Newton would then group the resulting snippets with those from other texts that he thought threw light on them. This old alchemical practice has made it extremely difficult for modern scholars to determine where Newton's own beliefs begin and where those of his sources end. Patient comparison of Newtonian borrowings to the original texts and to one another, facilitated by digital searching and other computational techniques, has allowed me to obviate this problem, at least for the most part. Chapter ten provides a sustained look at an important florilegium from the period 1678–86 (Keynes 35), which shows the hitherto unsuspected influence on Newton of the German chymist Johann Grasseus.

Another author who acquires newfound significance in Newton's florilegia is Johann de Monte-Snyders, an extraordinarily obscure writer of two published texts. New information that I have unearthed on Snyders shows that he fell squarely into the mold of the self-styled wandering adept, traversing central Europe and performing demonstrations of his aurific prowess, no doubt in the hope of obtaining patronage. His life and influence serve as the subject of chapter eleven. In order to illustrate the way in which Newton tailored the writings of Snyders to fit his own conception of the alchemical magnum opus, the chapter also explores other contemporary accounts of Snyders's processes and shows that Newton's interpretation did not fit the standard view. The German adept exercised more impact on Newton the alchemist than any other author short of Philalethes. By giving a close reading to several important manuscripts, particularly Keynes 58, where Newton describes his plan for experiments that will lead to the scepter of Jove and the caduceus of Mercury, chapter twelve in turn shows how Newton combined his understanding of Snyders with motifs and practices drawn from Philalethes.

The same creative reworking of an earlier author forms the subject of chapter thirteen, which examines Newton's take on the substantial alchemical corpus ascribed to the high medieval Mallorcan philosopher Ramon Lull.[33] One can date his newfound interest in the pseudo-Lullian corpus to the publication of Edmund Dickinson's 1686 *Epistola ad Theodorum Mundanum*, which Newton read soon after its publication. This places Newton's Lullian turn to the very period when he was composing his masterwork, the 1687 *Principia*, after the astronomer Edmund Halley famously encouraged him to put his gravitational theory into written form. Influenced by the work of Dickinson, a prominent physician in Oxford and London, Newton came to believe that Lull's comprehensive description of the quintessence or spirit of wine (our ethyl alcohol) was actually an encoded discussion of the "first matter" or initial ingredient out of which the philosophers' stone, by a long and laborious process, should be made. Newton's ideas on this subject fill a complicated florilegium found in several manuscripts, which links Lull's work to that of Van Helmont, and which in turn presents detailed discussions of the alkahest or universal dissolvent. Also employing Van Helmont's foremost English expositor George Starkey, Newton attempts to determine the precise difference between the Lullian quintessence and "the immortal dissolvent," that is, the alkahest. This florilegium, simply titled *Opera* (Works) by Newton, contains hidden riches, such as a fascinating discussion of the affinities between chemical species that would undergo extensive treatment in *Query 31* of Newton's famous 1717 *Opticks*.

In chapters fourteen, fifteen, and sixteen, we arrive at Newton's experimental notebooks, containing dated chymical laboratory records from 1678 to 1696, which he kept largely distinct from his reading notes. While the two Cambridge collections, CU Add. 3973 and 3975, have been examined by previous scholars, the two sides of the single sheet composing Boston Medical Library B MS c41 c contain very early experiments that

[33] The extensive corpus of alchemical treatises attributed to Ramon Lull forms the subject of Michela Pereira, *The Alchemical Corpus Attributed to Raymond Lull* (London: Warburg Institute, University of London, 1989).

complement the Cambridge records in important ways.[34] All of these texts reveal Newton's extraordinary precision in experimentation and the single-minded discipline that guided his repeated variations on the same basic sets of laboratory protocols. The same exactitude in recording his experiments makes it possible to identify a number of Newton's proprietary *Decknamen* by an approach that combines textual decipherment with laboratory replication. This twofold method has allowed me to identify Newton's all important "standard reagent," the acid "menstruum" that he variously calls liquor, spirit, vinegar, and salt of antimony. With this material in hand, I have been able to produce "vitriols," that is, crystalline salts, of copper and several cupriferous minerals, in the hope of replicating Newton's "volatile Venus," a major desideratum of his alchemical research. The work of replication is ongoing, but already one can see how Newton planned his experiments and reasoned out his conclusions. His notes on the work of a contemporary chymist, David von der Becke, show that Newton was using his knowledge of chymical affinities in combination with a corpuscular theory to predict the course of reactions and to plan individual experiments. But he typically performed these operations with his chrysopoetic sources firmly in mind; in the end, most of the experiments in his laboratory notebooks consist of attempts to reverse-engineer the products allusively described in Newton's readings. Chapter sixteen concludes by examining precisely one such product, the "net of Vulcan" found in the works of Philalethes and elaborated at considerable length by Newton.

Despite the fact that Newton kept his cards close to his chest when discussing matters related to chrysopoeia, he did nonetheless engage in a variety of collaborative chymical projects. Chapter seventeen discusses one of these in considerable detail. The first of the collaborations took place in 1693, when Newton's Genevois friend Nicolas Fatio de Duillier encountered a French-speaking alchemist in London, apparently a Huguenot serving in King William's forces in the Low Countries. By examining Fatio's hitherto unstudied letter to Newton from the summer of 1693 in conjunction with Newton's manuscript "Three Mysterious Fires" (now found at Columbia University), I show that the latter text represents the fruit of an elaborate set of procedures devised by Newton in conjunction with Fatio and his Francophone friend. These processes were related to another set of operations from Newton that Fatio recapitulates in the aforementioned 1693 letter. As I argue in chapter seventeen, the procedures that Fatio quotes from Newton provide an important key for understanding both Keynes 58 and the laboratory notebooks. In a word, they are simplified procedures for making such important desiderata as the caduceus of Mercury and the scythe of Saturn, *Decknamen* that arise in the records of Newton's experimentation and reading notes.

The cover names employed in Keynes 58 and the materials alluded to by Fatio also make a sustained appearance in Newton's famous *Praxis* manuscript (Huntington Library, Babson 420), which chapter eighteen analyzes

[34] Boston Medical Library B MS c41 consists of three separate manuscripts, all by Newton, kept in separate envelopes. "B MS c41 c" refers to the single, folded sheet that begins "Sal per se distillari potest."

in the light of Newton's work with his young friend. Scholars have traditionally viewed *Praxis* as the culminating record of Newton's alchemical career; at the same time, some have seen its seemingly incomprehensible processes and profusion of *Decknamen* as proof that Newton was undergoing a mental crisis around the time it was written. After all, *Praxis* refers to Fatio and might even have been composed in Newton's "black year," 1693, when he angrily (if briefly) isolated himself from his friends and complained of symptoms that were subsequently interpreted as a "derangement of the intellect." Hence I devote considerable space to the analysis of this challenging text and argue that it is in reality quite comprehensible in the light of Newton's epistolary exchanges with Fatio and other collections such as Keynes 58.

Fatio was not the only chymist with whom Newton collaborated in his maturity. After his move to London in 1696, Newton was evidently approached by the obscure "Captain Hylliard," who wrote a brief alchemical manifesto that the now famous intellectual and Mint official copied. Chapter nineteen provides an extensive analysis of the episode with Hylliard and also describes Newton's extended collaboration with the Dutch distiller William Yworth, which also took place after Newton's move to London. Beyond casting new light on the processes behind Yworth's *Processus mysterii magni* and linking them to Newton's late florilegia, the chapter also uses a recently discovered manuscript in the Royal Society archives to show that the document actually contains the record of a live interview between Newton and Yworth.

The final three chapters of *Newton the Alchemist* continue the story, already begun in chapter six, of the relationship between Newton's private chrysopoetic ventures and public science in the seventeenth and early eighteenth centuries. The interaction between chymistry and optics did not end with Newton's transfer of Boyle's redintegration experiments into the realm of light and color. Chapter twenty shows that Newton developed a theory of refraction based on the chymical principle sulfur, which he described in the first edition of his famous *Opticks* (1704). The chapter also finds that the seeds of this theory extend back to Newton's 1675 *Hypothesis of Light*, where he explicitly abandons the Sendivogian theory of an aerial niter that he had affirmed in *Of Natures obvious laws*. Newton replaced the aerial niter, which had accounted for phenomena ranging from combustion and respiration to the fertilization of the earth, with a growing reliance on sulfur. Although he had reasons of his own for making this shift, Newton was also influenced by parallel developments in European chymistry, a field that was rapidly moving toward what would eventually be known as phlogiston theory. Another trend that would soon acquire great significance in Europe and England was the increasing emphasis chymists placed on affinity among different materials. Affinity also enters into Newton's sulfurous theory of combustion and into the *Opticks*' explanation of refractive power in a major way. Chapter twenty-one presents this topic by building on Newton's increasing interest in sulfur, placing his theories in the context of developments within the chymical community of the late seventeenth and early eighteenth centuries. The chapter provides a new look at Newton's developing ideas about affinity and his role in the eighteenth-century development of affinity tables, the graphic representations of selective attractions by materials that cause those with less affinity to precipitate. Finally, chapter twenty-two considers Newton's relationship with Boyle in the light of both men's attempts to arrive at a "sophic mercury" that would in principle dissolve gold into its primordial constituents and make it possible for the noble metal to "ferment," as Newton says in his short text of 1692, *De natura acidorum*. The two major English representatives of public science in the seventeenth century had very different ideas about the path to chrysopoeia, though both, in the end, were alchemists in the fullest sense of the term.

Returning then to the variations on a Keynesian theme with which I began this chapter, one can see how *Newton the Alchemist* changes our understanding of the celebrated natural philosopher. Already as a very young man, even before he had absorbed the chymical knowledge of Boyle, Newton enlisted himself in the school of the adepts. Yet alchemy was not an alternative religion for Newton, nor was it the origin of his theory of gravitation. The short-range forces operating in the chymical realm were objects of study in themselves, just as gravitational attraction was. In the later editions of the *Opticks* Newton even erects the active principle behind the phenomenon of "fermentation," by which he here means chemical reactions in general, to the status of a fundamental force like magnetism and gravitation. But these theoretical speculations, important as they were, represent very little of the immense work that Newton devoted to alchemy. To see these published ruminations as the end goal of Newton's decades of alchemical research would be a disingenuous and misleading perspective. Although he employed theories of alchemical origin as a means of understanding and enlarging natural philosophy, the countless hours he spent deciphering alchemical texts and putting his conclusions to the test in his laboratory had a more practical goal. In a word, the founder of classical physics aimed his bolt at the marvelous menstrua and volatile spirits of the sages, the instruments required for making the philosophers' stone. Difficult as it may be for moderns to accept that the most influential physicist before Einstein dreamed of becoming an alchemical adept, the gargantuan labor that Newton devoted to experimental chrysopoeia speaks for itself. The chymical tools envisaged by Newton, had he been able to acquire them, would have handed him the power to alter nature to its very heart. These were the secrets that the "true Hermetick Philosopher" must keep hidden lest they cause "immense dammage to ye world," as he said to the Secretary of the Royal Society in 1676.[35] The core of Newton's labors at deciphering the documents of the adepts lay in his own undying quest to join their number.

[35] Newton to Henry Oldenburg, April 26, 1676, in Newton, *Corr.*, 2: 2.

TWO

Problems of Authority and Language in Newton's Chymistry

THE CONCEPT OF THE ADEPT

Newton's engagement with chrysopoeia lasted well over thirty years and resulted in the writing of about a million words of text. His substantial chymical *Nachlass* presents interpretive difficulties that are perhaps unique within the corpus of the famous natural philosopher. In order to come to terms with this refractory material, we must first address some of the characteristics that make it unusual. Primary among them is the cluster of difficulties surrounding the concept of the "adept." Like many students of chymistry in the early modern period, Newton held an exalted view of the supposed masters of the aurific art, the adepts, or "adeptists" as they were often called in seventeenth-century English. According to a wide variety of sources, these men (for they were almost always men) were thought to hold a privileged position in the world. They made up an elect band of *filii doctrinae*, or "sons of art," who had received the philosophers' stone as a divine dispensation, a *donum dei* or "gift of god."[1] Some of this perspective seeps through, albeit in the cautious and attenuated form appropriate to public discourse, in a fragmentary passage that Newton related in old age to the husband of his niece, John Conduitt:

> They who search after the Philosopher's Stone by their own rules obliged to a strict & religious life. That Study fruitful of experiments.[2]

[1] An excellent synopsis of this exalted view of the adepts collected from various authors may be found in W. C., *The Philosophical Epitaph of W. C. Esquire* (London: William Cooper, 1673), 4, 6–8, 21–22, 28, 30, 32, 34, and throughout. For recent work on William Cooper and W. C., see Lauren Kassell, "Secrets Revealed: Alchemical Books in Early Modern England," *History of Science* 49 (2011): 61–87.

[2] Newton to Conduitt, as quoted in Manuel, *PIN*, 173. Manuel gives no folio number for the passage, but Scott Mandelbrote has kindly told me that it is found on folio 9r of Keynes 130.6, which has not yet appeared on the Newton Project site. It is seldom noted that Conduitt's recollections also contain some reservations, seemingly stemming from the aged Newton, regarding the quest for chrysopoeia. Keynes 130.07 twice links the "Philosopher's stone <or> Grand Elixir" to enthusiasm. It is not difficult to understand why the by-now-celebrated president of the Royal Society and master of the Royal Mint would not wish to associate himself publicly with enthusiasts, particularly since chrysopoeia was falling increasingly into disrepute across Europe by the 1720s. See Keynes 130.07, 7r, edited in *NP* at http://www.newtonproject.ox.ac.uk/view/texts

The philosophers' stone, which was the special privilege of the adepts, had astonishing powers: not only could a tiny portion of it transmute a mass of metal into gold or silver, it could also cure diseases of the most dire sort. Being the chosen sons of divine wisdom, the adepts were at heart a benevolent group, who wished to help their fellow humans. But they were continually frustrated in this wish by the venality, cruelty, and suspiciousness of humankind, which made a wholesale dispensing of their gifts impossible.[3] What would happen if the philosophers' stone were made public to the masses? The economic basis of society, gold and silver, would at once collapse, leading to chaos, war, and tyranny. As if to reinforce the baseness of human nature, it was widely believed that the mere rumor of one's being an adept could result in torture and murder from the inevitable attempt of the hoi polloi to extract the philosophers' stone by force. Being an adept was not only lonely, it was dangerous.

The privileged but precarious lives of the adepts received attention from a variety of sources. On the one hand, alchemical texts themselves, such as the popular *Secrets Reveal'd*, a translation of the Latin *Introitus apertus ad occlusum regis palatium* by the famous American adept Eirenaeus Philalethes, contained stories of persecution at the hand of the unenlightened mob.[4] And yet these accounts were not limited to narratives of special pleading by the sons of art themselves. There were numerous stories of alchemists who had really been detained by rulers in order to gain access to their technical knowledge. Perhaps the most famous of these is the veridical account of Johann Friedrich Böttger; imprisoned for at least a decade by the Elector of Saxony, August der Starke, Böttger did eventually manage to employ his chymical skills in making a highly profitable porcelain.[5] Although Böttger patently lacked the philosophers' stone, other stories of successful wandering adepts were passed on in "transmutation histories," a genre filled with seemingly verifiable names and places that could vouch for the transmutational prowess of the alchemical elixir.

From the perspective of seventeenth-century alchemical aficionados, then, the adepts occupied an isolated and problematic position in society. Forced to remain anonymous, and yet constrained by their very status as a divine elect devoted to the good of mankind, they were required to distribute their secret wisdom with the utmost care. They could of course restrict

/diplomatic/THEM00169, consulted June 13, 2017. Whatever Newton actually said to Conduitt, the testimony of his laboratory notebooks and correspondence shows without any possibility of doubt that he himself sought the philosophers' stone for well over three decades.

[3]See "An Essay Concerning Adepts" (1698) by the anonymous "Philadept," reprinted in Gregory Claeys, *Restoration and Augustan British Utopias* (Syracuse, NY: Syracuse University Press, 2000), 209–33, consult especially 210–11. A discussion of this treatise is found in J. C. Davis, *Utopia and the Ideal Society: A Study of English Utopian Writing, 1516–1700* (Cambridge: Cambridge University Press, 1981), 355–67.

[4]Philalethes (Starkey) referred to the *Introitus* as "my little Latin Treatise, called Introitus apertus ad occlusum Regis palatium" in his later collection, *RR*, 7. Thus although the English version of the text, *SR*, might appear at first to be the original text, it is in reality a translation and reworking of the Latin *Introitus*.

[5]Georg Lockemann, "Böttger, Johann Friedrich," *Neue Deutsche Biographie* 2 (1955), online version, at https://www.deutsche-biographie.de/gnd118512846.html#ndbcontent, accessed January 3, 2017. See also the entertaining account in Janet Gleeson, *The Arcanum* (New York: Warner Books, 1998).

the transmission of their arcane knowledge to the spoken word, but that would mean that only a handful would receive the benefit of the adepts' largesse. Thus they felt a moral duty to describe their art in writing, so that others might gain access to their secrets. But this could not be easy; as the celebrated Flemish chymist Joan Baptista Van Helmont said, the art could only be bought with sweat, the product of intense labor. There was a twofold moral imperative at play, and one that was in a state of perpetual tension. On the one hand, the adepts should make the riches of alchemy accessible in their writings, but on the other, those writings had to be so difficult to decipher that they would delude and discourage the unworthy. The adepts were forced to walk a tightrope where the abyss on one side was a misanthropic stinginess and on the other the subjection of the world to a tyranny made possible by the limitless resources of the philosophers' stone.

This was the common picture of the adepts and their mode of communication among alchemical sympathizers in early modern Europe. The very word "adept" meant one who had attained the highest understanding of nature possible; it derives from the Latin word for "having arrived" (*adeptus* from *adipiscor*). Hence to be an adept was to have arrived at an infallible comprehension of nature, even if this state of wisdom had been preceded by a long period of erroneous belief. Such an understanding required that one also be immensely intelligent, of course, which had its own ramifications in the realm of alchemical literature. Since the adepts were fantastically clever, and constrained by their vows to repulse the rabble from acquiring an entry into the secrets of the art, they developed a set of literary techniques that made it almost impossible to do so. In order to make sense of Newton's alchemical writings we will in due course acquaint ourselves with the full panoply of these techniques of concealment, since he, perhaps even more than most followers of the aurific art, believed in the tremendous powers of literary trickery that alchemy laid claim to.

But first I must address an obvious problem. Is it really the case that Newton accepted the full picture of a hidden class or stratum of adepts as I have presented it? The answer lies readily at hand, perhaps surprisingly so. Despite its daunting length, Newton's chymical corpus contains only the barest handful of criticisms directed at his sources. In one early manuscript, he mentions that the writer Bernard of Trier did not become an adept until late in life, and therefore wrote obscurely lest others attain the art at a younger age than he did. The same manuscript passes on a common criticism that Geber, the author of the high medieval *Summa perfectionis*, was so obscure that he could only be understood by fellow adepts. In an early manuscript, Newton also points out that the Italian poet Giovanni Aurelio Augurelli seemed to cast doubt on the art in the last four lines of his *Chrysopoeia*. But the soon-to-be-famous scientist adds that Augurelli's disclaimer was an intentional way of avoiding the accusation of being an adept![6] None of these

[6]Huntington Library, Babson MS 419, 1r–1v. Newton says the following about Augurelli: "Johannes Aurelius Augerellus ^[italus] poeta suavissimus Chrysopœiam scripsit in cujus 4 ultimis versiculis videtur opus falsitatis arguere, sed astute fit ne Adeptus esse suspicetur."

comments reflect a distrust of the authors' knowledge, but merely of their means of communication.

When we turn from Newton's criticisms of stylistic obscurity to those of content, the number of rebukes is so small as to be almost nonexistent. Another early manuscript, this one found in the heterogeneous collection of twelve sheaves kept in the National Library of Israel that goes by the shelf mark Var. 259, contains two negative comments. The initial one is directed at Eirenaeus Philalethes's *Marrow of Alchemy*, which Newton presents here twice in his own abridged versions. The first such synopsis bears the comment "a fals Poem" after the title, but Newton then deleted the criticism with a strike of the pen.[7] In fact, the *Marrow of Alchemy* went on to become one of his favorite and most enduring sources. The second denial of adept status is more serious. After extracting some passages from Jean Collesson's *Idea perfecta philosophiae hermeticae*, Newton struck them through and added, "I believe him not to be an adept" (*Credo hic nihil adeptus*).[8] And yet in later manuscripts, such as Newton's mature *Index chemicus*, we find him citing Collesson as an authority, suggesting that this was merely a youthful flirtation with skepticism.[9] Newton's mature manuscripts reveal only one seeming criticism of a self-styled possessor of the alchemical summum bonum. The bizarre anonymous text *Manna*, which cobbles together allegorical passages from the better known *Arca arcani* by Johann Grasseus and treats them literally, elicits only the tamest of rebukes from Newton. To *Manna*'s description of the regimens or stages required to complete the maturation of the philosophers' stone, Newton responds, "Thus this author, but something lamely."[10] Other texts equally worthy of Baron von Münchhausen extract no critical response at all. The *Epitome of the Treasure of Health*, a picaresque work in which the pseudonymous author "Edwardus Generosus" claims to have used the philosophers' stone for such noble purposes as freezing fleas in his bed and downing birds that are attracted to its chill-inducing beams, appears in Newton's *Index chemicus* and other late collections alongside such sober chymists as Jean Beguin and Nicolas Lemery, implicitly sharing their authority.[11]

What are we to make of this seemingly facile acceptance on Newton's part? It cannot be denied that in the privacy of his laboratory he admitted the reality of the philosophers' stone along with the class of enlightened individuals who possessed it. While there may have been some willing suspension of disbelief at work in Newton's note taking, it does not appear that he was troubled by exuberant claims of thaumaturgy such as those of Edwardus Generosus. Edwardus was an adept, and this meant that he should have extraordinary powers over nature. It does not follow, however, that Newton read every detail of such authors as literally true. An adept could always be

[7] Var. 259.7.2r.

[8] Var. 259.9.3r.

[9] Keynes 30/5, 6r, 8v, and 10r.

[10] Keynes 21, 14v.

[11] Keynes 22, 6v (freezing fleas) and 12r (downing birds); Keynes 30/1, 22r, 23r (Edwardus Generosus), 11r (Beguin), 36r, 55r (Lemery).

hiding the most important facts beneath a facade, even when the text contained no obvious allegory. Had not Geber, at the end of his *Summa perfectionis*, admitted that he had hidden the transmutative elixir "where we have spoken more openly," in other words where he employed seemingly plain speech?[12] Since the masters of the philosophers' stone could not, by virtue of their status as adepts, be wrong, it followed that apparent errors or obsolete techniques in their chymistry could only be red herrings planted in the midst of their wisdom to delude the unwary. One main purpose of Newton's remarkably exact experimental notebooks found in Cambridge University's Portsmouth collection was precisely that of arriving at a correct interpretation of the chymistry hidden beneath such delusory literary practices. This was also the primary goal of the successive drafts of the *Index chemicus* that Newton finalized around the end of the seventeenth century. Akin to a modern concordance where headwords are presented in the context of authorial snippets, the *Index chemicus* swelled to almost a hundred folios in its final version. The end of this endeavor was a tool that would allow easy comparison of different authors' views on particular *lemmata*. More often than not, Newton considered the headwords that his authors supplied him to be allusive terms hiding a secret meaning, or as historians of alchemy say, *Decknamen* (cover words).

The absolute authority of the adepts was both abetted by their practice of secrecy and diluted thereby. Apparent mistakes or outdated technologies could be written off as misleading *Decknamen*, a practice that Newton himself employed in his interpretation of Geber's *Summa perfectionis*, where he creatively transforms the medieval alchemist's mineral "marchasita" into bismuth and "magnesia" into antimony.[13] While this practice excused the adepts of any potential error or obsolescence, however, it also meant that their original meaning could easily be lost. As the present book reveals, this was very frequently the case in Newton's interpretations, sometimes amazingly elaborate in their fineness of detail, of his alchemical reading matter. Before we can proceed to the particulars of his chymistry, however, we must now look more deeply at the full armamentarium of deceptions Newton's literary sources employed.

The Tricks of the Adepts: Traditional Techniques of Deception in Newton's Sources

One of Newton's most frequently cited authors is the American chymist George Starkey, who wrote a number of chrysopoetic treatises under the nom de guerre of Eirenaeus Philalethes (A Peaceful Lover of Truth). Born in Bermuda and educated in the 1640s at the fledgling Harvard College,

[12] William R. Newman, *The Summa perfectionis of Pseudo-Geber* (Leiden: Brill, 1991), 785.

[13] See Newton's copy of *Gebri Arabis Chimiae . . . a Caspare Hornio* (Leiden: Arnoldus Doude, 1668) (= Stanford University, Barchas QD 25. G367), where he has interpreted and updated Geber's minerals on the flyleaves. Neither bismuth nor antimony played a major role in medieval alchemy, but in the sixteenth and seventeenth centuries they were both subjects of great interest.

Starkey experienced an astonishing success upon his immigration to London in 1650.[14] Almost immediately, he became the client and unofficial chymical tutor of one of the best connected men in England and Ireland, the young Robert Boyle. Thanks to a succession of letters that Starkey wrote to Boyle between 1651 and 1652, we have a very clear idea of his chymical work, which ranged from attempts at chrysopoeia to the preparation of medicaments by chymical means, and even extended to the formulation of such products as perfumes and artificial ice. Among Starkey's remarkable letters is one that has achieved considerable fame in modern times precisely because Newton copied out a Latin translation of it at some point in his career. The letter, composed in April or May 1651, relates Starkey's method of providing Boyle with a "Key into Antimony" by making a "sophic mercury," that is, a special, penetrative form of quicksilver that could supposedly decompose gold into its components (sulfur, salt, and mercury), and then encourage the metal to ripen into the philosophers' stone, which Starkey believed to be gold "digested" into the final degree of its maturity. It was once thought by Newton scholars that the "Clavis" (Latin for "Key") was an original composition by Newton, and that it could therefore serve as an Ariadne's thread into his laboratory practice.[15] Although we now know that to be false, Starkey's letter to Boyle is tremendously valuable all the same for the clear way in which it decodes the works that he wrote under the sobriquet of Philalethes into replicable chymical practice.

In his 1651 letter to Boyle, Starkey describes a way of making quicksilver form an amalgam with the metalloid antimony, which is not an easy thing to do. First Starkey refines crude antimony ore, known today as stibnite, by heating it to a temperature above its melting point (620°C) with stubs of horseshoe nails and saltpeter. The iron combines with the sulfur in the stibnite to form a slag containing ferrous sulfide, and the metallic antimony sinks to the bottom of the crucible as a "regulus" (little king). If the shiny, silvery antimony is allowed to cool slowly under the slag, it can solidify as the so-called star regulus of antimony, an attractive and much-prized formation (figure 2.1). Starkey says that one part of star regulus should be fused with two parts of refined silver, which he refers to at the very end of the Latin text making up the "Clavis," as "the doves of Diana" ("Dianaes doves").[16] He then washes quicksilver with vinegar and salt to purify it and grinds the cleansed quicksilver with the silver-antimony alloy. After multiple washings and reiterate distillations, which Starkey refers to as "eagles" because they make the volatile quicksilver "fly," the sophic mercury is complete. Modern laboratory replications have shown that a small amount of gold heated with such an "acuated" or sharpened mercury will indeed form interesting dendritic formations when heated in a sealed flask, though alas, it does not become the philosophers' stone.[17]

[14] For Starkey's life, see Newman, *GF*.

[15] Dobbs, *FNA*, 133–34, 175–86, 229–30; Westfall, *Never at Rest*, 370–71. For Starkey's authorship of the *Clavis*, see William R. Newman, "Newton's Clavis as Starkey's 'Key,'" *Isis* 7 (1987): 564–74.

[16] Starkey to Boyle, April/May 1651, in Newman and Principe, *LNC*, 23.

[17] Lawrence M. Principe, *The Secrets of Alchemy* (Chicago: University of Chicago Press, 2013), 158–66.

FIGURE 2.1. The star regulus of antimony, so called because of its fern- or star-like crystalline surface. The pattern is produced when the regulus of metallic antimony is allowed to cool slowly under a thick layer of the slag left after its reduction from stibnite. Prepared by William R. Newman in the laboratory of Dr. Cathrine Reck in the Indiana University Chemistry Department.

The clarity of Starkey's 1651 letter to Boyle is matched by the obscurity in which he deliberately masked his processes in the corpus of Eirenaeus Philalethes. According to Starkey's elaborate mystification, Philalethes was a still-living adept whose abode was New England, and who had authorized Starkey to distribute his work to a small number of trusted friends. In the following, I will therefore generally refer to Philalethes instead of Starkey when speaking of the works that the Harvard graduate wrote under his chosen pseudonym. One of these works (actually a collection of disparate treatises), written under the name of Eirenaeus Philalethes, was *Ripley Reviv'd*, published in 1678—thirteen years after Starkey's death in the Great Plague of London. Philalethes gives an interesting rationalization of his concealment in the beginning of his commentary on the fifteenth-century English alchemist George Ripley's *Compound of Alchemy*. The passage is revealing for its playful yet sarcastic tone; one gets a definite sense that the adept Philalethes enjoys teasing and titillating his eager audience:

> Such passages as these we do oftentimes use when we speak of the Preparation of our *Mercury*; and this we do to deceive the simple, and it is also for no other end that we confound our operations, speaking of one, when we ought to speak of another; For if this Art were but plainly set down, our operations would be contemptible even to the foolish.[18]

Although benevolent in principle, the adepts were not easy company. As Philalethes expresses it, he has aimed his obscurity at simpletons and fools. If the would-be alchemist fails to arrive at the philosophers' stone by Philalethes's methods, the blame lies only with the practitioner's inadequate brain. By implication, more ingenious souls will be able to penetrate to the bottom of the convoluted game erected around the very processes described in Starkey's letter to Boyle.

If we examine Philalethes's work alongside several other sources used by Newton, it emerges that these authors really did write both to reveal and to conceal, as they claimed. The alchemical language of the period is often a matter of encoded meaning whose sense is conveyed by sophisticated clues rather than the meaningless and garbled farrago that it sometimes appears to be. One of the traditional techniques Philalethes made use of is the twofold expansion and compression of language that I have elsewhere given the Greek names *parathesis* and *syncope*. The first of these practices involved stuffing one's speech with unnecessary synonyms for the same materials or processes, whereas the second consists of the opposite, namely, deliberate suppression of information. An excellent example of parathesis occurs in a passage much beloved by Newton and taken from the Philalethan *Secrets Reveal'd* (1669). Like much else in the corpus of Philalethes, this paragraph describes materials that are necessary for the making of the sophic mercury, which we have encountered already:

> our Water is compounded of many things, but yet they are but one thing, made of divers created substances of one essence, that is to say, There is requisite in our Water; first of all Fire; secondly, the Liquor of the Vegetable Saturnia; thirdly, the bond of ☿: The Fire is of a Mineral Sulphur, and yet is not properly Mineral nor Metalline, but a middle betwixt a Mineral and a Metal, and neither of them partaking of both, a Chaos or Spirit;

[18] Eirenaeus Philalethes, "An Exposition upon Sir George Ripley's Epistle to King Edward IV," in *RR*, 25.

because our Fiery Dragon (who overcomes all things) is notwithstanding penetrated by the odour of the Vegetable Saturnia; whose blood concretes or grows together with the juyce of Saturnia, into one wonderful body; yet it is not a body, because it is all Volatile; nor a Spirit, because in the Fire it resembles a Molten Metal. It is therefore in very deed a Chaos, which is related to all Metals as a Mother; for out of it I know how to extract all things, even ☉ and ☽ without the transmuting Elixir: the which thing whosoever doth also see, may be able to testifie it. This Chaos is called, our Arsenick, our Air, our ☽, our Magnet, our Chalybs or Steel; but yet in divers respects, because our Matter undergoes various states before that the Kingly Diadem be brought or cast forth out of the Menstruum of our Harlot. Therefore learn to know, who the Companions of Cadmus are, and what that Serpent is which devoured them, what the hollow Oak is which Cadmus fastened the Serpent through and through unto; Learn what Diana's Doves are, which do vanquish the Lion by asswaging him: I say the Green Lion, which is in very deed the Babylonian Dragon, killing all things with his Poyson: Then at length learn to know the Caducean Rod of Mercury, with which he worketh Wonders, and what the Nymphs are, which he infects by Incantation, if thou desirest to enjoy thy wish.[19]

An acquaintance with Starkey's 1651 letter to Boyle allows us to decode this fustian passage easily. "Our water" is of course the sophic mercury itself, which is made of three things, a fire, the liquor of "Vegetable Saturnia," and "the bond of Mercury." The "fire" or "Fiery Dragon" refers to the putative sulfur contained in the iron horseshoe nails used in the refining of stibnite to arrive at the star regulus of antimony; the "Saturnia" is the stibnite itself; and the mysterious "bond of Mercury" is simply the quicksilver that must be distilled from the alloy of refined silver and antimony. The chaos, "Arsenick," air, "our ☽," magnet, and chalybs or steel all refer to the star regulus of antimony, which is a shiny, crystalline, metalloid material that volatilizes at high temperature and yet can fuse over a fire to look like a molten metal. The *Decknamen* employed here are not arbitrary: chaos refers to the idea that antimony is the Ur-mineral out of which the other metals arise, as Philalethes himself says: even Sol (gold) and Luna (silver) can be extracted out of it. Arsenic and air both connote the volatility of the antimony regulus. The Moon ("our ☽") summons up the silvery appearance of the regulus, while magnet and chalybs encode a theory that the mercurial component of the antimony attracts a sulfurous component from iron during its refinement, just as the magnet attracts steel and vice versa. The kingly diadem is also the regulus, because of its crystalline appearance, and the menstruum of the harlot is the ore of antimony, stibnite, out of which the metalloid must be smelted with the help of the iron from the horseshoe nails. In the process, the stibnite releases its slag, which Starkey implicitly compares to the harlot's catamenia. The companions of Cadmus are the horseshoe nails, and the serpent is again the stibnite that must be refined. Diana's doves are the two

[19] Philalethes, *SR*, 4–6.

portions of silver that must be added to the star regulus so that quicksilver will amalgamate with it, the green lion and Babylonian dragon again refer to antimony (which is poisonous), and the caducean rod of Mercury is simply the completed sophic mercury. In this passage alone, then, at least twelve different *Decknamen* are used for antimony, including both its unrefined ore and the star regulus. Since Philalethes views the regulus as existing *in potentia* in the crude antimony or stibnite, the terms for both the refined metalloid and the ore are more or less interchangeable. As the author puts it, the "Matter undergoes various states," not to mention multiple names.[20]

Despite the terminological hypertrophy of Philalethes's description, the passage from *Secrets Reveal'd* also displays the contrasting literary artifice, syncope. This is particularly evident when Philalethes claims that "our water" is made of three things—fire, Saturnia, and the bond of Mercury. Even after we have deciphered these *Decknamen* and arrived at their concrete referents, we would still be unable to make the sophic mercury. The reason for our failure would lie in the fact that Philalethes has mentioned only iron (or rather its hidden sulfur), stibnite, and quicksilver. He has intentionally left the essential ingredient silver, which must be alloyed with the star regulus in order to make the quicksilver amalgamate, out of his description.

An additional and related point of confusion emerges from Philalethes's term "mercury," which has a profusion of meanings in alchemical literature. As he says in *Ripley Reviv'd*, "Philosophers have hidden much under the *Homonymium* of Mercury."[21] The term could simply mean quicksilver, of course, but it could also refer to the mercurial principle that, along with sulfur, was traditionally thought by alchemists to compose metals. The situation became far more complex when the immensely influential Swiss chymist Paracelsus added salt to the two principles in the early sixteenth century and argued that not only metals but also all bodies were composed of mercury, sulfur, and salt, and that these three could be extracted by "anatomizing" or analyzing the materials in question.[22] In addition, "mercury" was a term used to describe a host of materials that participated in quicksilver's liquidity and volatility, such as ethyl alcohol. Nor did a material have to share those particular properties in order to qualify as a "mercury," since just as it was possible to "fix" quicksilver by rendering it solid and nonvolatile (as in "red precipitate," our mercuric oxide), so it should be possible to render other "mercuries" solid as well. The thing that is particularly interesting about Philalethes's point, however, is that he explicitly identifies "mercury" as a homonym, one of the literary devices traditionally taught in the discipline of rhetoric. Philalethes's creator Starkey was the product of a scholarly

[20] I count them as follows: Saturnia, chaos, arsenic, air, Luna, magnet, chalybs, harlot, diadem, serpent, green lion, Babylonian dragon.

[21] Philalethes, "An Exposition upon Sir George Ripley's Preface," in *RR*, 25.

[22] See William R. Newman, "Alchemical and Chymical Principles: Four Different Traditions," in *The Idea of Principles in Early Modern Thought: Interdisciplinary Perspectives*, ed. Peter Anstey (New York: Routledge, 2017), 77–97. The works of Paracelsus have recently become much more accessible to English speakers with the following collection of translated texts: Andrew Weeks, *Paracelsus: Essential Theoretical Writings* (Leiden: Brill, 2008).

environment that valued textual analysis to the highest degree. The son of a Scottish minister who wrote elegant Latin poetry, Starkey attended Harvard College at a time when grammar, rhetoric, and dialectic, the traditional trivium of the medieval universities, were still unchallenged in their dominance on the human intellect. Starkey's aptitude and training in these verbal arts emerges clearly from his mastery of literary artifice.

But it is possible, of course, to overstress the Daedalean gifts of Philalethes. The techniques mentioned so far, employment of *Decknamen*, parathesis, syncope, and the related verbal parsimony implied by the use of homonyms, have a long lineage in the history of alchemy. The same is true of another widely used technique explicitly employed by the Islamic writers of the Middle Ages who wrote under the collective pseudonym of Jābir ibn Ḥayyān. Originally referred to in Arabic as *tabdīd al-ʿilm* (dispersion of knowledge), this involved the splitting of a recipe or narrative into different parts, followed by its distribution over disparate sections of a book or books.[23] The practice was adopted by the Latin author of the famous *Summa perfectionis*, one of the most influential alchemy books of the European Middle Ages, who called himself Geber (after Jābir). In the *Summa perfectionis*, Geber describes the technique as follows:

> Lest we be attacked by the jealous, let us relate that we have not passed on our science in a continuity of discourse, but that we have strewn it about in diverse chapters. This is because both the tested and the untested would have been able to take it up undeservedly, if the transmission were continuous.[24]

Echoing the Latin of Geber, the practice of "dispersion of knowledge" came to be known as *dispersa intentio*. It has even been shown that Newton's correspondent Robert Boyle, that seemingly modern proponent of open speech, used *dispersa intentio* when writing about the higher secrets of chymistry such as the sophic mercury and the marvelous dissolvent or alkahest of Paracelsus and Van Helmont.[25]

We have now examined a substantial number of the techniques of concealment employed by Philalethes and other alchemists read by Newton. Understanding their use of *Decknamen*, along with parathesis, syncope, and *dispersa intentio* is not enough, however, to gain a true appreciation of the fiendish complexity in which the self-styled adepts could and did cloak their work. One of Newton's favorite sources in the late phases of his career, the well-known physician of Oxford and London Edmund Dickinson, wrote a work in 1686 consisting of an epistolary exchange between the doctor and an anonymous adept referred to as "Theodorus Mundanus" (Earthly Gift of God). Dickinson is no critic of chrysopoeia; in fact, his part of the exchange consists largely of a sustained plea that Mundanus reveal his secrets. And yet Dickinson goes on at length railing against the "jealousy" and stinginess of

[23] Paul Kraus, *Jābir ibn Ḥayyān: Contribution à l'histoire des idées scientifiques dans l'Islam* (Cairo: Imprimerie de l'institut français d'archéologie orientale, 1943), 1: xxxi–xxxiii.

[24] Newman, *Summa perfectionis*, 785.

[25] Principe, *AA*, 147–48.

the adepts. They invite the unwitting to their art with sweet promises, and then they obfuscate their victims with impenetrable metaphors, harsh allegories, unheard of tropes, and altogether horrid, tortuous, and barbarous locutions. With their "tropes, metaphors, allegories, enigmas, barbarous terms and neologisms," the alchemists hide their knowledge like a squid enveloped in its own ink. Using their "keen and crafty intellect" (*acutum ac subdolum ingenium*), the adepts perversely substitute words and processes for one another, creating hidden nets and snares that trap and delude the unwary. The famous thirteenth-century Mallorcan philosopher Ramon Lull (actually a school of alchemical writers using his name) is so obscure, Dickinson continues, that one needs Aristarchus to expound his work and Oedipus to hear the exposition. And yet despite the devious ingenuity of Lull and his followers, none of them has excelled at this game or imposed more cunningly and subtly on his readers than the "very celebrated philosopher Philalethes." In fact, Dickinson may well be right, for there is yet another level of concealment Philalethes used that we have not so far examined.[26]

The Higher Reaches of Literary Concealment: Graduated Iteration

The reader who has followed our discussion to this point could easily receive the impression that the literary techniques of alchemical deception were complicated and difficult, but that their fixity of meaning made them decipherable in the way that a riddle typically has but one solution. It is true that many alchemical writers had a particular process or set of operations in mind and that their texts could be decoded into a description thereof, but it does not follow that other, more misleading decipherments were impossible. To the contrary, they were encouraged. Philalethes's work again provides us with an excellent example of this point, and one that is particularly relevant to the understanding of his acolyte Newton. The following passage shows that Philalethan *Decknamen* such as "the Moon," "the doves of Diana," and "Venus" in reality had multiple chymical referents:

> In this our work, our Diana is our body when it is mixed with the water, for then all is called the Moon; for Laton is whitened, and the Woman bears rule: our Diana hath a wood, for in the first days of the Stone, our Body after it is whitened grows vegetably. In this wood are at the last found two Doves; for about the end of three weeks the Soul of the Mercury ascends with the Soul of the dissolved Gold; these are infolded in the everlasting Arms of Venus, for in this season the confections are all tincted with a pure green colour; These Doves are circulated seaven times, for in seaven is perfection, and they are left dead, for they then rise and move no more; our Body is then black like to a Crows Bill, for in this operation all is turned to Powder, blacker than the blackest.[27]

[26] Edmund Dickinson, *Epistola ad Theodorum Mundanum* (Oxford, 1686), 11, 34–36, 39, and 40.
[27] Philalethes, "An Exposition upon Sir George Ripley's Epistle to King Edward IV," in *RR*, 24–25.

It is the series of "regimens" that form the immediate topic of Philalethes's discussion here. In such classics as *Ripley Reviv'd* and *Secrets Reveal'd* the "American philosopher," as Philalethes was sometimes called, describes a set of stages through which the sophic mercury is supposed to pass once it has been amalgamated with gold and kept for a long while in a heated, sealed flask. Although these vary from author to author, one common early modern conception was to model the stages or "regimens" on the planets in the geocentric system. Thus *Secrets Reveal'd* indicates that there are seven regimens, each with its own characteristic color and appearance, in the order of Mercury, Saturn, Jupiter, Luna, Venus, Mars, and Sol. The two end points, Mercury and Sol, correspond to the insertion of the sophic mercury-gold amalgam into its flask, and the final production of the philosophers' stone. The regimens follow one another in a succession of color changes if the heating instructions are performed correctly. Although Philalethes speaks of many intermediate colors, Saturn is primarily black, Jupiter multicolored, Luna white, Venus green, Mars orange, and Sol red. The regimens require differing amounts of time to run their course, but on average *Secrets Reveal'd* allocates each of them about thirty to fifty days.[28]

Although these descriptions owe more to fantasy than to actual laboratory experience, they form a significant part of Philalethes's alchemy. It is therefore extremely interesting that Philalethes has here imposed an entirely new set of meanings on the Moon, the doves of Diana, and Venus, differing remarkably from those that we examined already. As we saw in his description of the chaos from *Secrets Reveal'd*, he employed the term "our Luna" there to mean the silvery regulus of antimony used to make the sophic mercury. The term "our" distinguishes the regulus from ordinary silver, which *Secrets Reveal'd* simply calls "Luna" in the way that a medieval alchemist such as Geber would have done. In the above passage from *Ripley Reviv'd*, however, the moon means neither silver nor the silver-like regulus, but something else entirely. It is now "our body when it is mixed with the water," in other words, the amalgam of the sophic mercury and gold that is sealed up and heated at the beginning of the regimens. During this stage, "Latona," an old term for "latten" or brass here used as a *Deckname* for gold because of its yellow color, is whitened in the formation of the white amalgam. So "our Diana" is here the amalgam containing gold, and most importantly, "Diana's doves" no longer refer to the two parts of silver that must be alloyed with antimony regulus so that quicksilver will amalgamate with it. Instead, the term "dove" now connotes the volatility of the heated amalgam in a sealed flask during its maturation to the philosophers' stone! Thus the doves must be circulated by reiterate distillation in their closed vessel during the course of the regimens.

In *Ripley Reviv'd*, the circulation of Diana's doves will eventually lead to the regimen of Venus with its green color, and thus the doves are "infolded in the everlasting Arms of Venus." But in *Secrets Reveal'd*, where the doves are also "folded in the everlasting Arms of ♀," Philalethes says that

[28] Philalethes, *SR*, 90–109.

this operation pertains to the initial making of the sophic mercury, not to the regimen of Venus.[29] At this point in *Secrets Reveal'd* it appears that "Venus" refers neither to the regimen of that planet nor to the traditional alchemical referent associated with it, namely, copper. Instead, Venus here means once again the regulus of antimony that combines with silver at high temperature in order to make a proper alloy for amalgamation in the production of the sophic mercury. The same use of Venus to mean antimonial regulus can also be found in another Philalethan treatise, *The Marrow of Alchemy*, where the combination of iron and the "reguline" component hidden within the black ore of antimony is described as a copulation of Mars with "our Venus."[30] Hence it is clear that "Venus," for Philalethes, can mean at least three things in an alchemical setting: its traditional referent, copper, the "amorous" mercurial component in stibnite that combines with the putative sulfurous ingredient in iron to yield antimony regulus by smelting, and the venereal regimen with its green coloration. Thus there is an unexpected fluidity to Philalethes's language: although his *Decknamen* are not arbitrary, they change their meaning with context.

Are there any rules or hints that govern this more advanced use of alchemical language? In fact there are, but another of Newton's alchemical sources states it more concisely than Philalethes. The learned author Alexandre-Toussaint de Limojon de Saint-Didier, a French diplomat who died by shipwreck in 1689, became one of Newton's favorites during the late part of his chrysopoetic career.[31] Limojon, or "Didier," as Newton typically calls him, describes an iterative approach where chymical processes are repeated in order to "graduate" or improve a product by further isolating it or leading it to a greater stage of maturity. Geber, for example, had spoken of three stages of transmutative perfection that were to be attained by three respective medicines or elixirs. A medicine of the first order produced a mere semblance of transmutation, as when copper is turned to gold-colored brass. A second-order perfection can induce permanent change, unlike those of the first order, but the change does not affect all of the qualities of the substance. Imagine silver, for example, that had been made to resemble gold in every quality but one—its specific gravity. Finally, a medicine of the third order can genuinely transmute a lesser metal into gold, at least according to Geber. So how does one turn a first-order medicine into a second- or third-order one? Primarily by reiterate volatilization and fixation, in other words, the same processes that were initially employed, but now repeated multiple times. The mystification enters when the same name is used for processes and products at all three levels of perfection. Thus, Didier says, in a translation from his *Lettre Aux vrays Disciples d'Hermes* made by Newton:

> The operations of y^e^ 3 works are analogous so that Philosophers æquivocate often in speaking of one when they seem to speak of y^e^ other. In every

[29] Philalethes, *SR*, 52.

[30] Philalethes, *Marrow*, part 2, book 1, stanza 56, p. 14.

[31] For Alexandre-Toussaint de Limojon de Saint-Didier, see Joseph-François Michaud, *Biographie universelle, ancienne et moderne* (Paris: L. G. Michaud, 1819), 24: 502.

work y^{e} body must be dissolved wth y^{e} spirit & y^{e} head of y^{e} crow cut off, & black made white & white red.[32]

In other words, precisely the same language can be used interchangeably to describe processes and products in each of Didier's three works, which are perhaps modeled on those of Geber. As the parathesis in Philalethes's description of chaos showed, this parsimony is by no means due to the alchemists' having a limited supply of words at their disposal. It is instead a consciously employed linguistic tool. Since this technique involves repeated use of the same term at different stages in the progress toward the alchemical magnum opus, an appropriate term for it is "graduated iteration." At an early stage of the operations aiming for the philosophers' stone, namely, the preparation of the sophic mercury, the terms "Luna" or "Moon," "Diana's doves," and "Venus" have an entirely different sense from the one that they acquire after the sophic mercury has been sealed up with gold for its long digestion in a gentle heat that will lead, Philalethes says, to his summum bonum.

In *Ripley Reviv'd*, Philalethes builds on the principle of graduated iteration by employing a device from the *Compound of Alchemy* by the fifteenth-century English alchemist George Ripley.[33] The figure in question is a wheel that the alchemist must turn multiple times in order to complete his progress toward the philosophers' stone:

> Our Operation is but turning as it were of a Wheel, which runs one half of its circulation directly backwards to its first progress. . . . For our Wheel goes round, and when it is come thither whence it set forth, it begins again. Thus is made a third Solution, Sublimation and Calcination into a red *Elixir*, which is the Sabboth of Nature and Art; at which being arrived, there is no farther progress without a new Marriage, either by Ferment or otherwise, according to the rule of Nature and Art: so that indeed all our work is three Rotations, and every Rotation hath three Members, Solution, Sublimation, and Calcination.[34]

As Philalethes says, the wheel must be turned three times, and each rotation consists of solution, sublimation, and calcination. In the 1695 edition of Philalethes's *Opera omnia* (Complete Works), the wheel is pictured graphically as a compass-like vertical circle mounted on a tree (figure 2.2). The regimens are represented by the planetary symbols on the periphery

[32] Keynes 21, 1v.

[33] For Ripley, see Jennifer M. Rampling, "Transmuting Sericon: Alchemy as 'Practical Exegesis' in Early Modern England," in *Chemical Knowledge in the Early Modern World*, ed. Matthew Eddy, Seymour Mauskopf, and William Newman, *Osiris* 29 (2014): 19–34; Rampling, "Depicting the Medieval Alchemical Cosmos: George Ripley's *Wheel* of Inferior Astronomy," *Early Science and Medicine* 18 (2013): 45–86; Rampling, "Transmission and Transmutation: George Ripley and the Place of English Alchemy in Early Modern Europe," *Early Science and Medicine* 17 (2012): 477–499; Rampling, "The Catalogue of the Ripley Corpus: Alchemical Writings Attributed to George Ripley (d. ca. 1490)," *Ambix* 57 (2010): 125–201; Rampling, "Establishing the Canon: George Ripley and His Alchemical Sources," *Ambix* 55 (2008): 189–208. Rampling is currently composing a book on Ripley that will no doubt cast much new light on this influential figure.

[34] Philalethes, "An Exposition upon the First Six Gates of Sir George Ripley's Compund of Alchymie," in *RR*, 178–80.

for example, "Venus ac Iason tuus" (Venus and your Jason); "Venus Isaacus Nuto" (Venus, I, Isaac, am weak); "Novus ventus Isaac" (Isaac the new wind); "Si Venus acusat uno" (If Venus reprimands someone); and "Vniones acuat usus" (Use may sharpen unions/pearls). On balance, it seems most likely that these colorful phrases were more or less arbitrary in meaning, and that their formation was simply governed by Newton's imagination and the letters at hand in his name. Their real significance lies in the allegiance that they demonstrate between Newton and the adepts, well after his publication of the *Principia* and almost at the point of his becoming warden and master of the English Mint. It is particularly telling that in another manuscript where Newton uses "Jeova Sanctus Unus," the phrase appears on the same page as a list of the adepts with the dates at which they acquired the philosophers' stone or first committed their discoveries to writing. Thus Philalethes and Sendivogius are accompanied by "1645" and "1590," rather than the initial publication dates of their first books (1667 and 1604).[39] Was Newton perhaps wondering when his turn would come, and the adept in training would finally arrive at the success that had eluded him for over two decades?

Problems of Genre: The Alchemical Florilegium and the Conjectural Experiment

Newton's attempt to create an alchemical persona cloaking his identity leads into another problematic area of language that we have yet to examine. In the privacy of his laboratory, Newton not only adopted the view that the genuine adepts of the aurific art were infallible, he also went so far as to assume their favorite mode of exposition—the *florilegium*. Late medieval and early modern alchemy is filled with such titles as *Rosarium philosophorum* (philosophers' rose garden), *Lilium inter spinas* (lily among thorns), and *Flos florum* (flower of flowers), all names that typically connote a collection of "flowers" or a *florilegium*. Although not every florilegium openly advertised its compilatory nature in this blatant fashion, they did all share the characteristic of serving as repositories of snippets and summaries from previous authors' works. This was the root sense of the term "florilegium," which literally meant a collection of "the flowers of literature," also the original sense of the still commonly used word "anthology." The writers of these compilations had a clear idea of what they were doing, as expressed confidently in the following passage from "Toletanus," a fourteenth-century writer in the genre:

> We call this collection the *Rosarium* because we have plucked the roses out of the books of the philosophers as if freeing them from their thorns. In it we will succinctly pass on whatever we deem necessary for the attainment of this work, with clear speech and in correct order, word for word, with all its sufficient explanations.[40]

[39] Keynes 13, 4r.

[40] My translation from the *Rosarium philosophorum* of "Toletanus" as quoted in Joachim Telle, *Rosarium philosophorum: Ein alchemisches Florilegium des Spätmittelalters* (Weinheim: VCH, 1992), 2: 172.

This statement of purpose could almost pass for the method that Newton adopted for his personal chrysopoetic expositions throughout most of the 1680s and 1690s. As with Toletanus, Newton was extremely concerned to arrive at a correct order for the welter of refractory *Decknamen*, operations, and regimens that he encountered in his alchemical reading. In doing so, he was undisturbed by the polyphony ensuing from a concatenation of multiple sources, whose words he would often summarize or paraphrase. As a result of this wholesale incorporation of dicta (sayings), it is extremely easy to lose the sound of Newton's own voice among the diverse authors whose "flowers" he has plucked and sorted into a new arrangement. Fortunately, the difficulty abates somewhat when we understand that Newton often inserts his own interpretations within square brackets in the midst of the extracted dicta of the adepts. Yet even here there is room for caution. As Newton internalized ever more chymical texts over the decades of his study, his own voice merged with theirs to the point that he seems no longer to have felt the need, at least in some instances, to provide the "vulgar" or commonplace referents to *Decknamen* in his interpretive brackets. Examples of this trend can be found in Newton's late text *Praxis*, composed after 1693 and found in Babson 420. Here we find terms such as "spirit of mercury," "the extracted seed of common gold," "mercurius duplatus" (doubled mercury), "earth of Mars," and "the Caduceus and cold, saturnal fire" all enclosed within square brackets.[41] Such puzzling terms of art typically derive from Newton's chymical reading rather than being coined by him. Although these expressions may have been perfectly clear to Newton, they all refer to derived products that went through multiple stages of preparation before acquiring their names. Even if Newton may not have used them with the intention to deceive, they are every bit as unintelligible to the casual reader as the green lion and the white fume. At this mature point in his career Newton had grown so fluent in the language of alchemy that his square brackets effectively translated one *Deckname* into another *Deckname*.

In addition to Newton's bracketed comments, there is another important and less obvious feature that distinguishes his chymical florilegia from those of his forebears. Unlike the multitudes of *Rosaria* and *Lilia* that populated the chrysopoetic landscape, Newton's florilegia did not have an audience in mind other than their creator. The late medieval and early modern alchemical florilegium had become a literary genre in its own right, and one suspects that many of the compilers never saw the interior of an alchemical workspace or laboratory. Such impressive artistic productions as the anonymous sixteenth-century *Splendor solis*, itself erected on the foundation of the *Rosarium philosophorum*, provided visual and literary value independent of their ability to advise on the subject of actual experimentation.[42] This was obviously not the goal behind Newton's years of sifting and compiling texts. We must constantly bear in mind that his extracting of textual dicta

[41] Babson 420, 5r–7v.

[42] For *Splendor solis*, see Jörg Völlnagel, *Splendor solis oder Sonnenglanz: Studien zu einer alchemistischen Bilderhandschrift* (Altenburg: Deutscher Kunstverlag München Berlin, 2004).

went hand in hand with genuine work at the bench; in fact, the records of his chymical experimentation reveal the same unremitting commitment to exactitude that we find in other examples of Newton's scientific endeavor, such as optics.

Newton's experimental laboratory notebooks form the object of sustained study later in this book, so I will not discuss them in detail here. It is important to note, however, that impressive as his records of experimentation are, Newton did not invent the genre of the chymical laboratory notebook. In this he was preceded by others, among English-speaking authors especially by Starkey and also by Thomas Vaughan, the latter of whom wrote alchemical treatises in the 1650s under the similar-sounding pseudonym of "Eugenius Philalethes."[43] The origins of this genre would require concerted research among the chymists and physicians of the earlier seventeenth century, though it is clear that Starkey's education at Harvard College played a part in the development of his notebooks' form and style, as did his knowledge of the chymical writer Angelus Sala.[44] What is of particular interest here is Starkey's highly self-conscious method of reflecting on his chymical activities. Not only did he describe the operations that he carried out in the laboratory, he also provided systematic, dated assessments of his progress over the years. Additionally, his analyses of previous chymists' works record numbered *Observationes* (observations) accompanied by well-reasoned *Conclusiones probabiles* (probable conclusions), and even *Δευτέραι Φρόντιδες* or "second thoughts" emerging from repeated experimentation on the same subject.[45] But what particularly stands out for its relevance to Newton is Starkey's explicit descriptions of so-called *Processus conjecturales* (conjectural processes). Typically couched in the imperative or subjunctive mood, these are experiments that Starkey has planned, but not yet performed. Whether consisting of attempts to improve the refining of crude antimony, the sublimation of the star regulus with "stinking spirit" (an ammonia compound), or a better way to make Starkey's medicament "ens veneris" (essence of copper), these "conjectural processes" were meant to be tested; they were not themselves final products.[46]

Although Newton knew only a tiny and unrepresentative fragment of Starkey's notebooks (the *Experiments for the Preparation of the Sophick Mercury* published in 1678), he too devised conjectural processes. In fact, like the genre of the alchemical florilegium, this was a long-established practice in the discipline. The successive iterations of processes leading to "medicines" of the first, second, and third orders in the Geberian tradition represents something along the same lines as the conjectural process. If it is possible to make an ersatz silver that looks like the noble metal, and further treatment allows this product to pass certain assaying tests (for example the touchstone),

[43] For Vaughan's laboratory notebook, see Donald R. Dickson, *Thomas and Rebecca Vaughan's Aqua vitae, non vitis* (British Library MS, Sloane 1741) (Tempe: Arizona Center for Medieval and Renaissance Studies, 2001).

[44] Newman and Principe, *ATF*, 172–79.

[45] Newman and Principe, *LNC*, 331–32, 138, 142–44, 177.

[46] Newman and Principe, *LNC*, 139, 145, 166.

then the alchemist might well reason that even further laboratory procedures would lead the metal to the perfection of genuine silver. The resulting series of operations is anything but blind empiricism or copying; it represents the conscious planning and recording of processes that anticipate a very particular outcome. The difference between this practice in the published classics of chrysopoeia and in the private notebooks of Newton and Starkey is that Newton and Starkey acknowledged the incomplete status of their ongoing research projects and intended to complete and test them at a future date.

An understanding of the conjectural process is therefore a convenient—even an essential—requirement for making sense of Newton's chymical *Nachlass*. One sees this very clearly, for example, in Keynes 58, a manuscript that preserves three successive drafts of Newton's attempt to work out processes largely (though not exclusively) based on the mid-seventeenth-century German chymist Johann de Monte-Snyders. Beginning with a group of materials that have undergone previous laboratory processing, namely, salts of iron ore and copper ore, along with the green lion and its blood, Newton subjects these substances to a complicated series involving well over thirty independent operations (figure 2.3). The final results, he says, will be such desiderata as "Venus the daughter of Saturn," "Jove's eagle," "Jove's lightning bolt," "Jove's scepter," and "the rod" or caduceus of Mercury. Does this mean that Newton actually succeeded in making these exotic chymical products? A careful examination of the manuscript shows that in itself it implies nothing of the sort.

The practical part of Keynes 58 is written in the imperative language of the recipe. Newton says to dissolve and digest the salts of iron and copper and then to subject them to further operations. Nowhere does he indicate that he has already carried out this sequence of processes, nor does he describe actual products that he has made. Instead, he provides unequivocal clues to the fact that this is largely a series of conjectural processes. Thus, at an advanced stage, he says "Ioves scepter probably is Salt of his eagle extracted out of y^e^ minera w^th^ y^e^ Lyons blood." What Newton is doing is deciphering a chain of operations that he believes himself to have found in his sources. This is primarily a textual procedure on his part, though aided by his actual experimental understanding, just as Starkey's conjectural processes embodied an implicit working knowledge born out of his years of experience as a practical chymist. While originating from the textual process of decipherment guided by a general, practical knowledge of chymistry, however, Newton's conjectural processes were designed to undergo specific and rigorous tests. This in fact was the primary goal of the experiments recorded in the two large collections of his laboratory records kept in the Cambridge University library, in the form of the manuscripts CU Add. 3973 and CU Add. 3975. The processes there involving such nostrums as "Vulcan's Net," "Diana," "Venus," and "the trident" all bear witness to Newton's attempts to replicate and refine the substances described by Philalethes, Sendivogius, and Snyders (as Newton called Monte-Snyders).[47]

[47] See CU Add. 3975, 43r, 54v, 71v, and 72r for examples of the net; 62r for Venus; and 138v for the trident; see CU Add. 3973, 16r–16v for Diana.

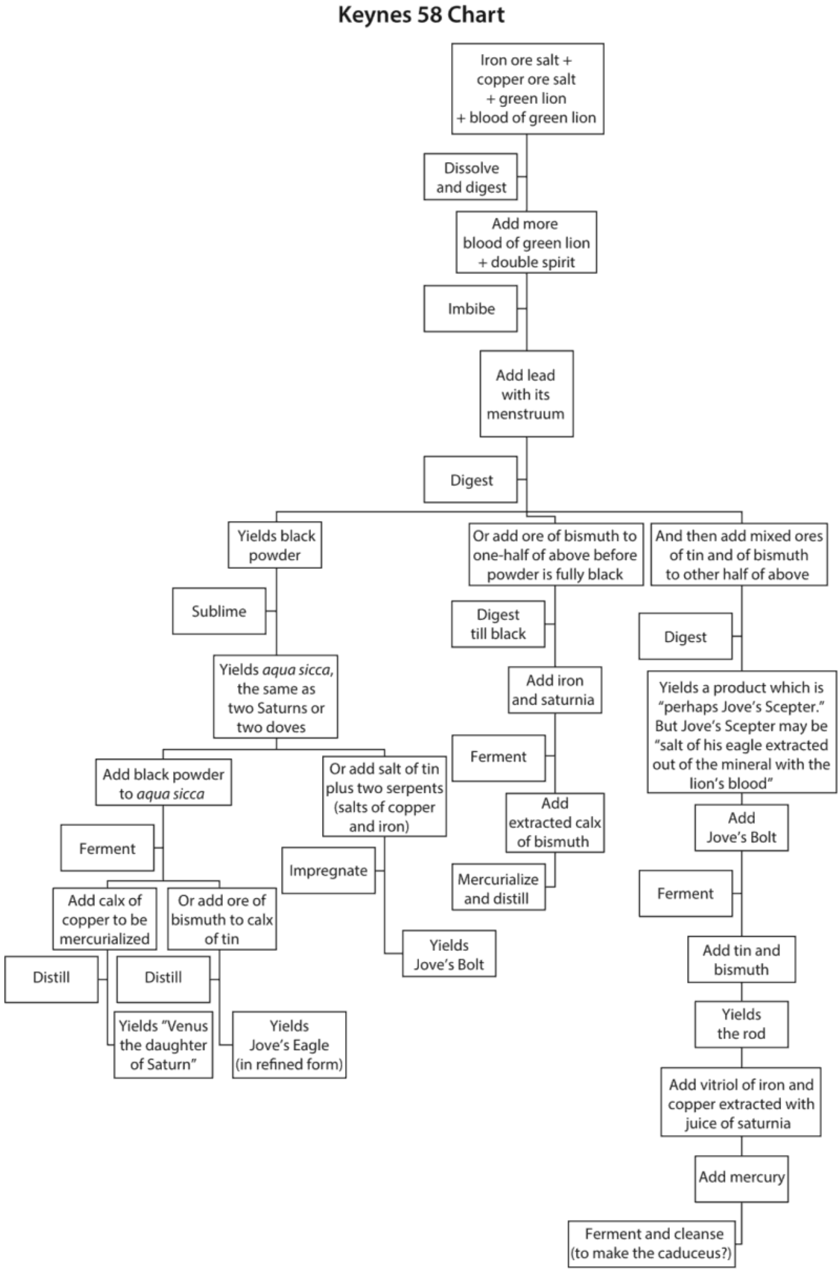


Figure 2.3. Chart showing the order of alchemical operations as conceived by Newton and described in Keynes 58.

The most highly developed extant specimen of Newton's attempt to work out the processes of the adepts is the *Praxis* text found in Babson 420, probably composed in the 1690s. Far from representing a mental or emotional breakdown on Newton's part, as Richard Westfall suggested, *Praxis* is actually an extended network of carefully constructed conjectural processes combining operational material derived from the panoply of

In this chapter we have traced a host of related linguistic and interpretive issues that emerge from Newton's self-identification as a would-be adept. From the beginning of his serious chymical studies in the 1660s, he seems to have been confident that he belonged among the elite sons of wisdom who had been chosen to receive the philosophers' stone as a *donum dei*, a gift of the Creator himself. This does not mean that Newton ever deluded himself into believing that he had actually succeeded in attaining that summum bonum, however. The most striking thing about his chymical corpus is the remarkable contrast between the years of elaborate speculation that went into his decipherment of alchemical sources and the extraordinary rigor of his chrysopoetic experiments. Despite his private acceptance of extravagant "authorities" such as Edwardus Generosus and the author of *Manna*, Newton remained wedded to the most stringent methods of the "experimental philosophy" and refused to believe that he had succeeded at the aurific art until experiment might tell him otherwise. His growing sophistication in understanding alchemical techniques of deception such as graduated iteration, as well as his adoption of the florilegium genre and the conjectural experiment, point to Newton's remarkable ability to absorb and dominate disparate areas of activity while reserving the prerogative of critical judgment. In a word, throughout his decades-long romance with alchemy, and despite his enduring assurance that he belonged among the ranks of the adepts, there can be no doubt that Newton remained Newton.[50]

[50] In a recent article, Cornelis J. Schildt has reached a somewhat similar conclusion regarding Newton's debt to the concept of alchemical adepthood, though with different implications. Schildt argues that Newton's parsimonious method of imparting his optical discoveries was influenced by the alchemical emphasis on secrecy. As Newton described his *New Theory about Light and Colors* to Henry Oldenburg, "I designed it onely to those that know how to improve upon hints of things." See Schildt, "'To Improve upon Hints of Things': Illustrating Isaac Newton," *Nuncius* 31 (2016): 50–77.

THREE

Religion, Ancient Wisdom, and Newton's Alchemy

Introduction

Newton's long project of decoding the language of the adepts brings to mind another major undertaking on his part that also involved the "translation" of allusive, mysterious terms into their referents in the mundane sphere.[1] I refer to his extensive work on the interpretation of biblical prophecy, a topic whose consideration points to the vexed issue of the relationship between Newton's alchemy and his personal religion. Few topics in Newton scholarship have led to more misleading claims than the assertion that he viewed his alchemy as part and parcel of his heterodox, Antitrinitarian Christianity. Largely an artifact of the tendentious Jungian view that alchemy over the *longue durée* was essentially a form of soteriology, the position that Newton's alchemy was an appendage to his religion or even an alternate form of it reached its apogee in the 1990s, and has since become a received position in the literature.[2] In reality, Newton's writings on prophecy, biblical history, and the iniquity of orthodox Trinitarian doctrine contain virtually no references to chymistry.[3] Despite the fact that alchemical writings frequently contain appeals to divinity, Newton's extracts, synopses, and notes drawn from chrysopoetic writers seldom expand on religious motifs found in his sources. On the rare occasions when Newton does take up a reference to God in his alchemical notes, he makes it clear that what interests him is the

[1]Paul Greenham, in an interesting and sophisticated recent dissertation, has coined the expression "descriptive-translational" for Newton's approach to prophetic interpretation and has drawn an extensive comparison between this and his decipherment of alchemical imagery into laboratory practice. See Greenham, "A Concord of Alchemy with Theology: Isaac Newton's Hermeneutics of the Symbolic Texts of Chymistry and Biblical Prophecy" (PhD diss., University of Toronto, 2015), 95–229.

[2]For a sustained critique of the Jungian position regarding alchemy, see Lawrence M. Principe and William R. Newman, "Some Problems with the Historiography of Alchemy," in *Secrets of Nature: Astrology and Alchemy in Early Modern Europe*, ed. William R. Newman and Anthony Grafton (Cambridge, MA: MIT Press, 2001), 385–431. A critique of the claims of integration between alchemy and primitive Christianity made by B.J.T. Dobbs and Mary Churchill may be found in Newman, "A Preliminary Reassessment of Newton's Alchemy," *Cambridge Companion to Newton* (Cambridge: Cambridge University Press, 2016), 454–84.

[3]See the Newtonian texts on religious topics, consisting of some four million words, collected and edited by the online *NP* at http://www.newtonproject.ox.ac.uk/texts/newtons-works/religious (accessed June 13, 2017). The only clear exception to this compartmentalization is found in Huntington Library, Babson MS 420, which I discuss later in this chapter. See also Rob Iliffe, "Abstract Considerations: Disciplines and the Incoherence of Newton's Natural Philosophy," *Studies in History and Philosophy of Science* 35 (2004): 427–54.

hidden, materialist meaning of the text. Newton did not read alchemical authors as a means of acquiring spiritual truths; rather, he extracted experimental meaning from them even when they employed the idiom of divinity. A good example of this may be found in his early interpretation of the *Novum lumen chemicum* by the Polish alchemist Michael Sendivogius. If we look at the first folio of Keynes MS 19, found at King's College, Cambridge, the following excerpt taken directly from Sendivogius leaps to the eye:

> Tract 6. From one two arise, from two one. One is God, the son was born from this God: One has given two, two gave one holy spirit. b.[4]

The "b" in this extract refers to Newton's own decoding of the Polish alchemist's words. Now surely, one might think, a man of Newton's pious sensibilities would have had some reaction to this rumination on the threefold nature of God. But instead, he laconically ignores the religious sense of the passage and gives it a transparent, even prosaic chymical meaning, writing:

> b. ☿ in digesting gives ⊙, ☿ & ⊙ In digesting give the Elixir.[5]

Here Newton has decoded Sendivogius's Father, Son, and Holy Spirit to mean material substances, namely, mercury, gold, and the elixir or philosophers' stone. This is part of a straightforward attempt to derive a laboratory operation out of Sendivogius's obscure words, and it displays the same pattern of converting allusive texts into laboratory processes that one encounters innumerable times in Newton's notes. Very likely Newton did privately believe that the adepts had received their special gifts as a divine dispensation, but from this it does not follow either that he pursued alchemy as a means to religious salvation or as a way of demonstrating "divine activity in the world."[6] Neither consequence would have flowed as a necessary result from the Protestant ethos of Newton's upbringing, or from specific doctrines of individual election to which he may have been exposed.

But even if the excessive claims of a deep integration between Newton's alchemy and his personal religion are untenable, this does not exclude some measure of interaction between the two fields. What connections then, if any, did Newton actually advocate between biblical interpretation and his chrysopoetic quest? A deeply religious thinker, Newton expressed his views on the omnipotence and ubiquity of God in such scientific venues as the "General Scholium" to the later editions of the *Principia* and in *Query 31* of the 1717 *Opticks*. He was certainly willing to combine natural philosophy and religion in general, but does it follow that he was motivated to do so in the particular case of alchemy? The topic cannot be addressed without considering his interpretation of ancient mythology as well, since

[4]Keynes 19, fol. 1r: "Tract 6. Ex uno fiunt duo ex duobus unum. Vnus est Deus, ex hoc Deo filius est genitus: Vnus dedit duo duo unum dederunt spiritum sanctum. b." This is a slightly abbreviated paraphrase of Sendivogius's words from "Tractatus sextus" of the *Novum lumen chemicum* as printed in Nathan Albineus, *Bibliotheca chemica contracta* (Geneva: Jean and Samuel de Tournes, 1654), 25. At this early stage of his career, Newton was relying on Albineus's collection for the text of Sendivogius.

[5]Keynes 19, "b. ☿us digerendo dat ⊙, ☿ & ⊙ digerendo dant Elixar."

[6]Dobbs, *JFG*, 116.

Newton himself drew connections between sacred history and the myths of pre-Christian peoples. It is today well known that he believed in a virtuous, primitive religion shared in varying degrees by multiple ancient peoples long before the arrival of Jesus.[7] And of course early modern alchemy was replete with topoi drawn from classical myth, as in the work of the Holstein chymist Michael Maier, whose books Newton carefully read and annotated.[8] Was he therefore intent on extracting a primeval religious wisdom from alchemical texts, an age-old knowledge that had been known to those closer to the primordial revelation, but attenuated or even lost over the course of time?[9] And finally, in the event that he did not obtain specific religious doctrines from chymical writers, did he perhaps employ the same interpretive methodology tacitly when approaching biblical prophecy, ancient mythology, and alchemy?

Newton's Method of Prophetical Interpretation and Alchemy

In order to begin with the firmest evidence, we will commence with the last of the questions posed above, namely, the issue of Newton's analysis of prophetical literature, for which he actually went so far as to devise an explicit set of guidelines. Our ultimate goal will be the exploration of connections with his alchemy, but first we must examine the prophetical rules on their own terms. A well-known manuscript now found in the National Library of Israel, Yahuda MS 1, contains Newton's "Rules for interpreting and methodising the Apocalypse." A degree of controversy has emerged about these rules on account of some similarity between them and Newton's *Regulae philosophandi* (rules for philosophizing) in his *Principia*. The similarity, which may be superficial in any case, probably results from the fact that both sets of rules share a common if distal source in the scholastic and humanist techniques that Newton imbibed as part of his early education.[10] For Newton's prophetic rules, however, the influence of his Cambridge contemporary Henry More and the famous early seventeenth-century exegete of prophecy Joseph Mede were more significant sources. For our purposes, it is unnecessary to delve into these repositories, the most important of which is probably Mede's *Clavis apocalyptica* (1627) and the *Commentarius* (1632) that Mede wrote on the same subject. Under the influence of Mede, Newton drew as well on the *Oneirocriticon* or dream book of "Achmet ibn Sirin," a

[7] The literature on this topic has swelled to a degree that only partial justice can be done to it here. For the latest word (and additional bibliography), the reader should consult Jed Buchwald and Mordechai Feingold, *Newton and the Origin of Civilization* (Princeton, NJ: Princeton University Press, 2013), and Rob Iliffe, *Priest of Nature: The Religious Worlds of Isaac Newton* (Oxford: Oxford University Press, 2017).

[8] For Maier's influence on Newton, see above all Karin Figala, John Harrison, and Ulrich Petzold, "De Scriptoribus Chemicis: Sources for the Establishment of Isaac Newton's (Al)chemical Library," in *The Investigation of Difficult Things: Essays on Newton and the History of the Exact Sciences in Honour of D. T. Whiteside*, ed. Peter M. Harmon and Alan E. Shapiro (Cambridge: Cambridge University Press, 1992), 135–79.

[9] This is the position of Churchill and Dobbs; see Newman, "Preliminary Reassessment," 458–62.

[10] See Raquel Delgado-Moreira, "Newton's Treatise on Revelation: The Use of a Mathematical Discourse," *Historical Research* 79 (2006): 224–46.

Byzantine work that tries to arrive at simple, straightforward interpretations of prophetical images by compiling a sort of encyclopedia of them.[11] With the authority of Mede and Achmet backing him, Newton argued in Yahuda 1 that the symbolic language of scripture, and of Revelation in particular, was meant to encode specific historical events, often of a political nature.

The first of Newton's rules for interpreting prophecy reveals that the discounting of "private imagination" was one of his principal concerns. Having been brought up during the sectarian strife of the English Civil War, Newton wanted to limit the flexibility of prophetic speculation to a bare minimum. As he says, "Too much liberty in this kind savours of a luxuriant ungovernable fansy and borders on enthusiasm." How, then, should one avoid the slippery slope leading to enthusiasm and unbridled fantasy? As Newton announces at the beginning of his second rule, the answer lies in the principle of parsimony. He thus advises, "To assigne but one meaning to one place of scripture; unles it be by way of conjecture." At first this seems entirely straightforward, but the phrase "by way of conjecture" leads into a substantial qualification that he adds after the fact as an insertion on the next page. The inserted passage is a complicated one that requires our full attention:

> unless it be perhaps by way of conjecture, or where the literal sense is designed to hide the more noble mystical sense as a shell the kernel from being tasted either by unworthy persons, or untill such time as God shall think fit. In this case there may be for a blind, a true literal sense, even such as in its way may be beneficial to the church. But when we have the principal meaning: If it be mystical we can insist on a true literal sense no farther then by history or arguments drawn from circumstances it appears to be true: if literal, though there may be also a <by *redundant*> mystical sense yet we can scarce be sure there is one without some further arguments for it then a bare analogy. Much more are we to be cautious in giving a double mystical sense. There may be a double one, as where the heads of the Beast signify both mountains & Kings Apoc 17.9, 10. But without divine authority or at least some further argument then the analogy and resemblance & similitude of things, we cannot be sure that the Prophesy looks more ways then one.[12]

As one can see, Newton thinks that prophecies are written in a parabolic style in order to deceive and repel those who are unworthy of them, just as alchemical treatises employ riddles and *Decknamen* to restrict access to the "sons of wisdom" alone. The contrast that Newton erects between the "literal" sense and the "mystical" meaning of a passage does not make appeal to mysticism in the modern sense but distinguishes between the obvious or commonplace interpretation and the hidden meaning that the prophets intended. Thus Newton says, a prophetical passage may contain a literal

[11] Kristine Haugen, "Apocalypse (a User's Manual): Joseph Mede, the Interpretation of Prophecy, and the Dream Book of Achmet," *Seventeenth Century* 25 (2010): 215–39.

[12] Yahuda 1, 12r–12v. All passages from Yahuda 1 are taken from the normalized text in *NP*.

In the first instance, Newton follows up on the idea that the viridity of the green lion refers to its immaturity rather than its color, but generalizes this to every sort of matter brought back to a crude state, not just antimony. Clearly this alone opens the door to a host of chymical referents. In the second example, however, he goes even further, now taking greenness to refer to the actual color of the "lion," which here signifies the green hue that appears within the sealed flask during the regimen of Jove. Obviously, this is a radical departure from all the previous interpretations, in which "green" did not refer to a color, but to a state of immaturity. Nor is Newton done yet. He follows this with yet another entry for "Leo viridis," in which he says the reader should consult the *Index chemicus*'s entry for the term "fumus albus" (white fume). If one turns to the corresponding entry in the *Index chemicus*, yet another nest of *Decknamen* emerges, in which the green lion again appears prominently in still further contexts.[16]

None of this seems very close to the lexical approach that Newton takes for prophetical interpretation in his "Rules for interpreting and methodising the Apocalypse." Where his goal in Yahuda 1 was to arrive at a univocal or bisemic reading insofar as possible, his aim in the *Index chemicus* was something quite different. As a concordance, the *Index chemicus* was intended to gather together as many meanings for a given term as possible, not to reduce them into one. Newton knew very well that Philalethes had used the term "green lion" to mean different things in different contexts, just as he had used the terms "moon," "doves of Diana," and Venus to signify both ingredients of the sophic mercury and products that emerged later in the series of chymical operations leading to the philosophers' stone. The practice of graduated iteration alone, not to mention other forms of equivocation, made it quite literally impossible to reduce the alchemical terms of Newton's sources to single concrete referents, a fact that he obviously understood. It would therefore be misleading to suppose that Newton's rules of interpreting prophecy, at least as they are found in Yahuda 1, provide evidence for an integral relationship between his chymistry and his understanding of biblical hermeneutics.

Newton and the Mythographers

A related area where issues of authority and textual interpretation butt heads with chymistry and religion lies in Newton's interpretation of ancient mythology. Since the early Middle Ages, one current in alchemical writing had focused on the interpretation of ancient mythology as encoded alchemy.[17] Michael Maier had made a specialty of this approach, arguing that the turpitude of the Greek gods and heroes, as well as the outlandishness of their exploits, made it unlikely that the accounts of their deeds were intended as literal accounts; instead, they were allegorical descriptions of

[16] Keynes 30/1, 40v.

[17] Robert Halleux, *Les textes alchimiques* (Turnhout: Brepols, 1979), 144–45.

alchemy.[18] Maier's claim opened up vast landscapes for those enamored of textual decipherment, since if ancient mythology really were veiled chymistry, it would logically follow that the mythographers were employing the very techniques of deception that we have recounted in the previous chapter. At some point after 1687, Newton copied out a long passage from Maier's *Symbola aureae mensae*, a sort of bio-bibliography of chrysopoeia organized around twelve chymist-representatives of their respective nations.[19] The passage, which reappears with only minor variations multiple times in Newton's alchemical *Nachlass*, gives a good sense of Maier's approach to classical mythology:

> The ancient poets, as we elsewhere show, <when they spoke of> the descent to the deep places dedicated to Pluto and Proserpina understood nothing other than the seeking out of the metals in their hidden mines, as appears in Orpheus, Hercules, Theseus, Pirithous, and others. Thus Virgil when describing the descent of Aeneas to the underworld is imitating this, and he adds a metallic allegory to it, namely that a golden bough is hiding among dark woods, which bough has golden leaves and pliant golden twigs, that is, in the mines spread out beneath the earth in the manner of trunks, branches, and roots. A whole grove covers this because shadowy woods always surround places that are mineral-bearing unless they are chopped down. But not before it is given, etc., that is, no one can enter the depths of the earth [or the center of a metal ^by means of putrefaction] unless he has plucked this golden bough apart. Maier, *Symbola aureae mensae*, book 4, page 180.[20]

As one can see from Newton's close paraphrase, Maier interprets the descent into Hell in Book 6 of Virgil's *Aeneid* as an encoded description of the subterranean world of minerals and metals. To Maier, Virgil's golden bough is actually an allusion to massive underground formations of ores and minerals that grow in the form of branches and trees, a concept that the German chymist inherited from Paracelsus and his followers. The idea of mineralogical growth and development was encouraged, of course, by the fact that native metals are sometimes found in the form of dendrites. Newton too was enamored of this idea, but if we look at the passage more closely, it is clear that he has employed his own meta-interpretation of Virgil's text. In his usual fashion, Newton inserts his own thoughts within square brackets into

[18] Michael Maier, *Arcana arcanissima* (s.l.: 1614), A[1r]–[A4r].

[19] Keynes 48, 28v, cites the anonymous text *La lumière sortant par soi-même des ténèbres*, which was first published in 1687. Newton's pagination agrees with that of the 1687 text; his copy is found at Trinity College; see Harrison, no. 1003.

[20] Keynes 48, 21v–22r: "Antiqui Poetæ (ut alibi ostendimus) per descensum ad Infera loca Plutoni et Proserpina dicata nihil aliud intellexerunt quam metallorum in mineris suis abditis fecisse lustrationem ut patet in Orpheo, Hercule Theseo Pyrithoo et alijs. Sic Virgilius describens Æneæ descensum ad inferos id imitatur et metallicam allegoriam illi adjungit, nempe quod in arbore opaca hoc est mineris instar arborum ramorum et radicum sub terra dispersis latet aureus ramus qui et folijs et lento vimine aureolus sit. Hunc tegit omnis lucus quia semper umbrosa nemora præcingunt loca mineralium feracia nisi excisa fuerint. Sed non ante datur &c id est nemo in terræ in trina loca [seu metalli centrum ^per putrefactionem] accedere possit nisi descerpserit hunc aureum ramum. Maier Symb. aur. mens. lib. 4. p. 180."

the textual passage that he is interpreting. Thus to Newton, Aeneas's descent into Hell is not merely an allegory of the subterranean mineral world, but a veiled guide to alchemical practice. As Newton says, "no one can enter the depths of the earth [or the center of a metal ^by means of putrefaction] unless he has plucked this golden bough apart." Hence the Golden Bough is actually a *Deckname* or cover name for an alchemical substance. This secret material, moreover, is the key to decompounding metals by means of putrefaction, a conditio sine qua non in Newton's alchemy for the production of the philosophers' stone.

This raises interesting questions relating to the issues of authority and language. Did Newton really think that Virgil wrote the *Aeneid* as a way of revealing his own alchemical knowledge to the sagacious while concealing it from the vulgar masses? Or was Newton knowingly entering into a restricted, conventional genre of alchemical riddle solving that did not necessarily commit him to the belief that the ancients actually wrote their epic poems as a means of veiling their alchemical wisdom? The answer is not straightforward, and it leads to larger issues relating to the compartmentalization of Newton's thought.[21] Just as Newton employed very different approaches to the decipherment of prophecy and alchemical *Decknamen*, so he may have considered ancient myth quite differently in different contexts. To a degree that seems unusual even for the polymaths of the seventeenth century, Newton was willing to enter into different genres and adopt their mode of reasoning and presentation. Hence it does not automatically follow that a willingness on Newton's part to adopt the notion of chrysopoetic secrets buried in classical mythology extended beyond his alchemical studies to penetrate into his understanding of the ancient world more generally. As it happens, we are able to probe this issue in a rather decisive way, for alchemy was not the only area in which Newton attempted to extract the secrets of mythology.

Newton's exegetical endeavors extended well beyond alchemy to include the supposed wellsprings of his own innovations in physics. This area of Newton's thought has received considerable attention from modern historians and will therefore require that we examine their contrasting views. Since the 1960s it has been well known that Newton composed a set of mythological interpretations that he initially intended to incorporate into the second edition of the *Principia*. Newton meant for these so-called Classical Scholia to accompany propositions 4 through 9 of *Principia* Book III, and to provide evidence that the ancients, and perhaps even Aristotle, were largely in agreement with Newtonian physics.[22] Hence, Newton extracted textual material from classical mythology and the ancient doxographers to claim a widespread ancient belief in four key doctrines: (1) that matter is atomic and moves through void spaces by means of gravity; (2) that gravitational force acts universally; (3) that gravity diminishes in the ratio of the inverse square

[21] On this topic see Iliffe, "Abstract Considerations," 427–54.

[22] Niccolò Guicciardini has kindly alerted me to a passage in CU Add. 3970 where Newton attributes an understanding of inertia to Aristotle. The passage is reproduced in Hall and Hall, *UPIN*, 310–11.

of the distance between bodies; and (4) that the true cause of gravity lies in the direct action of God. The "Classical Scholia" received their first extensive modern scrutiny in "Newton and the Pipes of Pan," an influential and brilliantly written article published in 1966 by J. E. McGuire and P. M. Rattansi.

Here we must recapitulate Newton's discussion of the harmony of the world that gave the two authors their title. Relying partly on Natale Conti's sixteenth-century *Mythologiae*, Newton discusses the seven pitches of the ancient pipes supposedly invented by Pan and notes that each pitch was assigned to a planet. But then he turns the myth to his own purposes by linking the ancient tradition of *musica mundana* (celestial harmony) to the principle that gravitational attraction between bodies diminishes in proportion to the square of their distance from one another. Reading Book II of Macrobius's commentary on the *Somnium Scipionis*, Newton encountered the arresting but erroneous story that Pythagoras discovered the mathematical basis of the octave, fourth, and fifth by passing a blacksmith's shop where a group of smiths were beating the same piece of metal with hammers whose weights were in the ratios of the musical intervals—one, two, three, and four. The regular succession of the pitches supposedly led Pythagoras to the discovery of an inverse proportionality between pitch and weight such that two hammers, one weighing twice as much as the other, would produce the interval of an octave when struck on the same metal. In reality Newton knew perfectly well that no such simple proportionality would exist in the case of successively striking hammers of different weights. But weight did enter into the production of harmonic intervals in a different way. Following contemporary work in acoustics, Newton realized that in the case of strings stretched by hanging weights, the pitch was proportional to the square root of the weight.[23] From his perspective, the garbled account of Pythagoras's discovery of the musical intervals was an excellent example of the ancient *sapientes* (wisemen) hiding their wisdom from the vulgar. Pythagoras and his followers deliberately introduced error into their experimental report in order to delude the unworthy. Similarly, when Macrobius and other doxographers reported that the harmonic intervals could be found by relating a central earth to the moon, sun, and other planets, they were hiding their genuine heliocentric knowledge beneath the delusory veil of geocentric astronomy. To Newton, Pythagoras and his followers were writing all of this to drop hints of the inverse square law. As the English natural philosopher puts it:

> Therefore, by means of such experiments he <Pythagoras> ascertained that the weights by which all tones on equal strings <were made audible (*audirentur*),> were reciprocally as the squares of the lengths of the string by which the musical instrument emits the same tones. But the proportion discovered by these experiments, on the evidence of Macrobius, he

[23] For Newton's knowledge of contemporary harmonics, see the careful and lucid article by Niccolò Guicciardini, "The Role of Musical Analogies in Newton's Optical and Cosmological Work," *Journal of the History of Ideas* 74 (2013): 45–67, see 62–65.

applied to the heavens and consequently by comparing those weights with the weights of the Planets and the lengths of the strings with the distances of the Planets, he understood by means of the harmony of the heavens that the weights of the Planets towards the Sun were reciprocally as the squares of their distances from the Sun.[24]

While focusing mainly on the "Classical Scholia" and Newton's claim that his discoveries were practically as old as the human race itself, McGuire and Rattansi also presented the argument that the English natural philosopher saw ancient wisdom as a unified whole in the tradition of the Italian Neoplatonists and their heirs at Cambridge, particularly Henry More and Ralph Cudworth. Hence for McGuire and Rattansi, Newton's exegetical efforts were aimed at extracting and reassembling a holistic and primal wisdom, essentially the *prisca sapientia* of the Neoplatonic tradition. Alchemy, natural philosophy, and biblical hermeneutics were all paths to the recovery of this ancient wisdom. Like John Maynard Keynes in his essay "Newton the Man," McGuire and Rattansi saw Newton as "the last of the magicians," not as an early modern natural philosopher trying to find a distinguished ancient pedigree for his work.

The position of McGuire and Rattansi has been challenged more recently by Paolo Casini, who argues that the two scholars failed to recognize a *specific* tradition of mythological interpretation to which the "Classical Scholia" belong. Instead of seeing the "Classical Scholia" as the work of "a theosophist and a neo-Platonist," to use his terminology, Casini situates them in the tradition that led Copernicus to see Pythagoras and Philolaus as his heliocentric forebears in the famous *De revolutionibus orbium caelestium*. This astronomical tradition was still alive and well in the seventeenth century, a fact made evident by such synthetic depictions as Giovanni Battista Riccioli's presentation of the heliocentric cosmos as the *Systema Philolai, Aristarchi, et Copernici* (World System of Philolaus, Aristarchus, and Copernicus) in his *Almagestum novum* of 1651.[25] In Casini's view, then, Newton's "Classical Scholia" belong to "a particular tradition" that is not that of the traditional *prisca sapientia* in the broad sense, but rather a "Copernican" variant already being used by astronomers to "vindicate the validity" of their alternatives to the geocentric universe of Ptolemaic astronomy.[26] Thus Casini argues forcefully that the function of mythology in the "Classical Scholia" was primarily one of legitimation by means of invoking ancient authority. He is eager to clear Newton of any deep-seated interest in the mythology that might seem to appear there.[27]

[24] J. E. McGuire and P. M. Rattansi, "Newton and the 'Pipes of Pan,'" *Notes and Records of the Royal Society of London* 21 (1966): 108–43, see 116–17. The translation is a slightly modified version of the one given by McGuire and Rattansi. There is a long treatment of this theme in Yahuda 17.3, complete with a discussion of the inverse square law, which was unknown to McGuire and Rattansi.

[25] Giovanni Battista Riccioli, *Almagestum novum* (Bologna: Benatius, 1651), 102.

[26] Paolo Casini, "Newton: The Classical Scholia," *History of Science* 22 (1984): 1–58, see 10.

[27] See Casini, "Newton: The Classical Scholia," 15, where the Italian scholar explicitly sets out his goal of clearing Newton of the imputation of being a "charlatan."

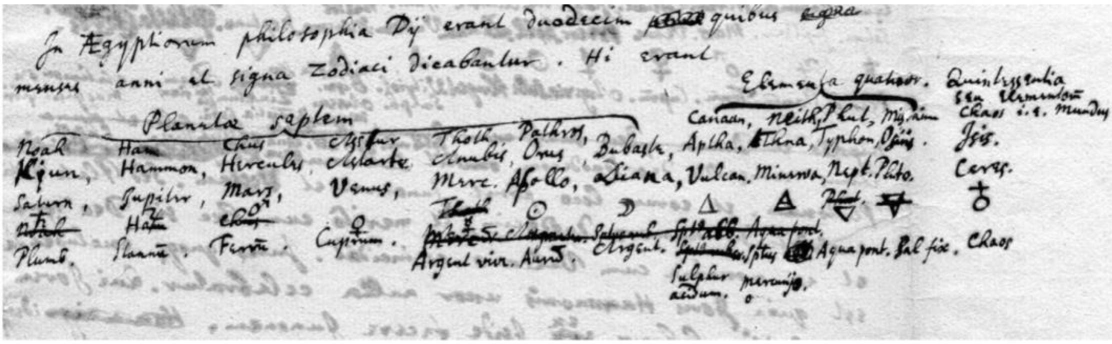


FIGURE 3.1. Detail from Huntington Library, MS Babson 420, 1v. Newton's chart labeled "Seven Planets, Four Elements, [and] Quintessence" above, followed by five successive horizontal rows of correspondences respectively showing Old Testament figures; Egyptian gods; Greco-Roman gods; the seven Ptolemaic planets, four elements, and Earth; and the seven metals, along with "acid sulfur, spirit of mercury, pontic water, fixed salt [and] chaos."

in the Huntington Library (figure 3.1).[34] This tabular representation connects the twelve gods of the Egyptians and Greeks with the twelve signs of the zodiac. The complex web of correspondences also includes Noah, Ham and his four sons, Canaan's sister-wife Astarte, Mizraim's consort Isis, her three children, and the goddess Neith.[35] These in turn are linked to the seven planets, four elements, and the planet Earth. Finally, at the bottom one sees the seven metals known to the ancients along with five specifically alchemical materials—"sulphur acidum, Spiritus mercurii, Aqua pontica, Sal fixus, Chaos" (acid sulfur, spirit of mercury, pontic water, fixed salt, chaos). In Dobbs's interpretation of this image, the column at the far right is uniquely privileged, as the Quintessence is another name for the philosophers' mercury, the Christ-like spirit that unites the cosmos in her analysis.[36] The key fact for Dobbs is that in the elemental world, the symbol for this material is the *salvator mundi* symbol of Christ, the redeemer of the fallen world. Of course the circle surmounted by a cross is also a traditional symbol for antimony, but to Dobbs this merely cements the strong association that she sees between Newton's alchemy and his religion. For Dobbs, then, the Quintessence was for Newton both "the fire at the heart of the world" and "the creative fire at the heart of matter" acting in accordance with "the Arian Logos still active in the creation of the world."

All of this might seem compelling were it not for an additional factor that Dobbs overlooks. As Jed Buchwald and Mordechai Feingold correctly point out in their recent *Newton and the Origin of Civilization*, the euhemerist reading of ancient mythology that permeates the *Theologiae gentilis origines philosophicae* is at odds with the alchemical reading of myth conveyed by Newton's sources, in particular Michael Maier.[37] Maier rejected the claim that Osiris had really been an Egyptian king or deity, whereas Newton

[34] Babson 420, 1v.

[35] For these biblical figures, see Buchwald and Feingold, *Newton and the Origin of Civilization*, 147.

[36] Dobbs, *JFG*, 162.

[37] Buchwald and Feingold, *Newton and the Origin of Civilization*, 148.

in the *Theologiae gentilis origines philosophicae* and elsewhere accepted his historicity. It is true that Newton's *Index chemicus* paraphrases Maier on the subject of the Egyptian king by saying "Osiris, Isis, and Typhon are a fixed salt, white spirit, and red spirit," but here Newton is trying to get to the bottom of alchemical processes, not reconstruct ancient history.[38] In short, Newton's alchemical reading of mythology in the *Index chemicus* and elsewhere in his alchemical corpus was a different project from his reconstruction of ancient history and even distinct from his decipherment of Pythagorean enigmata as prefigurations of early modern physics and astronomy. Thus there is a general problem inherent in Dobbs's approach, which employs the Keynes-tinted spectacles donned by McGuire and Rattansi: although the same "Sumerian" magus may be peering out and unraveling the secret of the universe, he is coming to radically different conclusions when he employs alchemical interpreters of myth as opposed to chronologizing ones.

Nonetheless, by focusing on Babson 420, Dobbs provides a challenge. In concentrating on this manuscript, she presents us with one of very few instances where Newton's historico-mythological studies actually do intersect with his alchemy. And yet if we examine Babson 420 more closely, this instance also fails to support Dobbs's claim that Newton's alchemy formed an integral part of his interpretation of ancient religion.

Let us begin with the first words on Babson 420, at the very top of folio 1r:

The Elements of Metals are Red Spirit	White Spirit	Pontic Water	Fixed Salt	
The Elements of Minerals are Sulfur	Arsenic	Tutia	Red Earth	
Vitriol	Marchasite	Zinc		
	Bismuth[39]			

Given the small size of Newton's hand here and the cramped character of the text, it is quite possible that he added these words after writing the heading below, "In Aegyptiorum Philosophia, Dii erant Duodecim nempe . . ." (In the philosophy of the Egyptians there were twelve gods, namely . . .). In fact, it may well be that Newton began this page as a summary of the material on the twelve great gods of the ancients that occupies much of the *Theologiae gentilis origines philosophicae*, and then decided later that he needed to look more deeply into the nature of the four elements and the quintessence that correspond to the Egyptian gods Aptha, Neith, Typhon, Osiris, and Isis. Immediately after this heading announcing that there were twelve Egyptian gods, Newton gives two versions of the table not reproduced by Dobbs, one of which he has crossed out.[40] These are almost identical to the version published by Dobbs, but followed by six concluding lines, which consist of

[38] Keynes 30/1, fol. 87r: "Sunt igitur Osyris Isis et Typhon sal fixum & spiritus albus et rubrus."

[39] Babson 420, 1r top.

Elementa metallorum sunt spiritus ruber	spiritus albus	aqua pontica	sal fixus	
Elementorum minerae sulph.	arsen.	tutia	terra rubra	
vitriol	marcasit.	zinetum		
	bismuth.			

[40] Babson 420, 1r middle.

further observations about chymistry.[41] One should note that these six lines are smaller and lighter than the text and tables that precede them, and might well have been written around the same time as the chymical comments at the very top of the page. Newton in fact explains in these final lines why he has allocated different minerals to each of the four elements and to the quintessence. As he puts it there,

> Sulfur and vitriol abound in the same fiery spirit, which spirit is a chymical fire; arsenic is ^highly volatile; this and marcasite are the minerals of bismuth, which is referred to Jove, god of the air. Tutia is the mineral of zinc, which is referred to Venus or the philosophical water. For it is easily resolved into a water, and that water is quite fluid and penetrating. Adam is a ^subtle and fixed earth but is not every earth. Magnesia is not fire, air, water, or earth, but is all of these. It is fiery, airy, watery, and earthy; ^it is hot, dry, wet, and cold. It is a watery fire and a fiery water. It is a bodily spirit and a spiritual body. It is the condensed spirit of the world and the noblest quintessence of all things and therefore it is customarily signified with the character of the world.[42]

Newton's main intention here is to group different minerals under the four elements and quintessence. Hence sulfur and vitriol are igneous, because they are both sources of a fiery spirit; what Newton probably has in mind is sulfuric acid. Arsenic and marcasite are airy because they contain volatile components; Tutia, the mineral of zinc, is watery, because zinc is a highly reactive substance that can be dissolved easily in various menstrua or acids. The earth called "Adam," a traditional name for red clay, is fixed and hence referred to the element earth. We should note in particular what Newton has to say about magnesia, namely, antimony. It can be grouped under none of the individual elements because it has properties of them all: hence it is properly a fifth element unto itself, a quintessence. Like other alchemists of the time, Newton sees antimony as a primordial tellurian material from which other substances derive, but there is nothing in his comments about the primitive religion, the prytaneum, the Arian *logos*, or the redeemer. In short, where Newton had the opportunity to bring these topics into the discussion, he pointedly neglected to do so.

In a word, Newton's comments are undoubtedly alchemical and they do place alchemical ideas and material in the context of his discussion of the ancient religion. But what was his purpose in doing this? Was he trying to arrive at a unified picture of a theocentric cosmos where alchemy served as a key to understanding the relationship between god and man, as Dobbs

[41] Babson 420, 1r bottom.

[42] Babson 420, 1r–1v: "Sulphur et Vitriolum eodem spiritu igneo abundant qui spiritus est ignis Chmicus <*sic*>. ~~Marcasita et~~ Arsenicum ^est maxime volatile. Hoc et Marcasita sunt mineræ Bismuti quod ad Iovem ^Deum aeris refertur. Tutia est minera Zineti quod ad Venerem seu aquam philosophicam refertur. Nam et in aquam ~~penetrantem~~ facile resolvitur, et aqua illa est maximè fluida et penetrans. Adam terra ^subtilis et fixa est sed non omnis terra. Magnesia nec ignis est nec aer nec aqua nec terra sed omnia. Est igneus aereus, aqueus terreus. ^est calidus, et siccus ~~humi frigidus et~~ humidus et frigidus. Est ignis aquosus et aqua ignea ~~quare coropora uruntur et lavantur~~. Est spiritus corporalis et corpus spirituale. Est condensatus spiritus mundi, ^et rerũ oium quintessentia nobilissima ideoq; charactere mundi ~~insignitur~~ et insigniri solet."

argues? Why did Newton go to the trouble of composing these correspondence charts in the context of an alchemical manuscript, if not to argue that alchemy could be used to arrive at the primitive, uncorrupted Christianity of the ancients?

In reality, Newton probably had a much more modest goal for his alchemical jottings on the first folio of Babson 420 than the above questions might suggest. Let us return briefly to the *Theologiae gentilis origines philosophicae* and consider the way Newton's thoughts about Pythagoras evolved over time. In the notes to the document found in Yahuda 17.2, Newton says that Pythagoras created the music of the spheres merely in order to delude the vulgar and to spread heliocentric astronomy secretly to his acolytes. There is nothing here about the inverse square law that features so prominently in Newton's interpretation of the Pythagorean *musica mundana* in the "Classical Scholia" or in some of Newton's other notes (for example, Yahuda 17.3). The idea that Macrobius's recounting of the relationship between weight and pitch was really about the inverse square law is clearly a later lucubration on Newton's part inserted into his interpretation of Pythagoras after he had composed the *Principia*. As his own scientific discoveries progressed, so did his interpretation of ancient wisdom. We see a similar phenomenon occurring in Newton's materialist interpretation of the twelve great gods of antiquity. The very beginning of the *Theologiae gentilis origines philosophicae* found in Yahuda 16.2 announces that "Dij duodecim majorum Gentium sunt Planetæ septem cum quatuor elementis et quintessentia Terra" (the twelve greater gods of the pagans are the seven planets with the four elements and the quintessence earth). There is nothing here about the detailed chymical topics found in Babson 420, only the seven planets, four elements, and quintessential earth. The same thing is true throughout the document, though on 3v Newton uses the Latin term "Tellus" for the earth to indicate that he means the planet rather than the element. The case is the same for the notes found in Yahuda 17.2; again there are twelve physical bodies including the seven planets, four elements, and "tellus," no red and white spirits, pontic water, or fixed salt. I propose, then, that the first folio of Babson 420 represents a late stage in the evolution of Newton's thought, where he believed that he could squeeze out more information from the four elements and quintessence than he had been able to do in the *Theologiae gentilis origines philosophicae*. Whether this new alchemical interpretation was merely due to his reading of sources and ruminating on their meaning or owed a debt to the ongoing chymical research that Newton did in his laboratory is a question for future research. It seems clear, however, that his understanding of the ancient enigmata was deepening, at least in his own mind, in the same way that he was gaining an ever deeper understanding of the achievements of Pythagoras. To reiterate, Newton was using his alchemical studies in the service of his research on primitive religion in the same way that he used his physics and astronomy to flesh out the meaning of ancient mythology. This was a natural and obvious move for him to make, and it clearly does not support the view that Newton equated the antimonial quintessence of the final column of the genealogy of the gods with an Arian Christ.

Newton's interpretation of myth in the context of alchemy was not an integral part of his quest to arrive at the uncorrupted wisdom and religion of the ancients, at least not in the fashion Dobbs proposed. Admittedly, the first folio of Babson 420 finds him using alchemy as one of many tools to probe the religion of the ancients. But this is a very different matter from Newton's interpretation of myth as a succession of *Decknamen* in the *Index chemicus* and throughout his alchemical corpus more broadly. In his chrysopoetic interpretation of myth, Newton very rarely turns from the early modern chymists to their ancient sources. It is true, of course, that Newton may seem at times to be laboring to wrest the secrets of the ancients directly from their tightly clenched fists even if this means joining Aeneas in his hellish descent. As he put it in another manuscript:

> In nothing do they strive so bitterly as in hiding their golden bough, which the whole grove covers; nor does it yield to just any powers but it easily and willingly will follow him who knows the maternal doves.[43]

And yet a closer inspection shows that this is not an original observation of Newton's; rather, it is a verbatim extract from Jean d'Espagnet's 1623 *Arcanum hermeticae philosophiae*. Like most of the passages where Newton is interpreting ancient mythology alchemically, he is actually deciphering sixteenth- or seventeenth-century alchemists who had already done the mythological spadework. This is the same impulse that we examined earlier, where Newton's reading of Michael Maier led him to the conclusion that Aeneas's golden bough was a substance that would induce putrefaction in metals and cause them radically to dissolve. The reference in d'Espagnet's passage is to the two doves of Venus who revealed the golden bough to Aeneas by landing on it. Like the bough itself, the doves were thought by many early modern alchemists to stand for materials that were necessary to have in order to make the philosophers' stone. They become the two doves of Diana in the work of Philalethes, to which Newton dedicated untold hours of interpretation. Newton's golden bough is testimony to his ability to submerge himself in the thought-world of the alchemists and to become one of their number. But it is one thing to decipher self-styled adepts who were using mythology as a means of writing alchemical riddles, and quite another to believe that the bulk of classical mythology was itself encoded alchemy. Once we step outside Newton's chymical corpus, the evidence does not testify to a broader commitment on his part to the decryption of mythology as a quest for the elixir. Unlike Maier and various other contemporaries, Newton does not employ the alchemical reading of myth as a tool for understanding ancient religion, science, or chronology more widely.

To conclude this chapter, then, we saw first that Newton's decipherment of alchemical *Decknamen* was far more open-ended than his interpretations

[43] Keynes 59, 1r: "In nullo tam acriter contendunt quam in celando ramo ipsorum aureo, quem tetigit omnis lucus nec ullis cedit viribus, sed facilis volensque sequetur eum qui maternas agnoscit aves et geminæ cui forte columbæ, ipsa sub ora viri venere volantes. Arc. Herm. c 15." See Jean d'Espagnet, *Arcanum hermeticae philosophiae*, in [d'Espagnet], *Enchiridion physicae restitutae* (Paris: Nicolaus Buon, 1623), 17–18.

perpetual circulation lie the two traditional principles of alchemy—mercury and sulfur, which Newton seems to view as grosser forms of the very ether that preserves and refreshes the earth as a whole. As he puts it, the two "spirits," sulfur and mercury in a volatile form, "wander over the earth" and provide life to "animals and vegetables, and they make stones, salts, and so forth."

What is the origin of Newton's strange and visually striking theory? His use of the terms "mercury" and "sulfur" for the constituents of metals suggests that his sources lie in the literature of alchemy, and this of course comes as no surprise. We now know that Newton engaged in chymical research for over thirty years and that he transcribed and composed about a million words on the subject. The present chapter identifies his major sources and provides the dramatis personae for Newton's alchemical ideas more generally. But this consideration also allows us to make some general remarks on the development of alchemy from the Middle Ages up to Newton's time. The organismic theory Newton expressed was by no means characteristic of alchemy over its entire history. It was instead a product of the Renaissance. Those who have studied the subject of alchemy in the High Middle Ages will be more familiar with the simple sublimation-based theory of metallic generation that modeled metallogenesis on the reaction between sulfur and mercury that yields vermilion. Consider the following passage from the *De aluminibus et salibus*, a popular alchemical *practica* attributed to Rhazes that circulated widely in the thirteenth century and later:

> You should know that the mineral bodies are vapors which are thickened and coagulated according to the working of nature over a long time. What is first coagulated is mercury and sulfur. And these two are the elements of the mineral. And they are "the water" and "the oil," upon which a temperate concoction works with heat and humidity until they are congealed. And from them the <mineral> bodies are generated, and they are permuted until they become silver and gold in thousands of years.[3]

There is nothing here of the earth inhaling and exhaling, nor of a tellurian life cycle, nor even the idea that metals live, much less die, beneath the terrestrial surface. Instead, sulfur and mercury react with each other and thicken to produce mineral bodies, and eventually metals. One could adduce many other examples of this mechanistic approach to metallic generation in medieval alchemy, especially prominent in the Rhazean tradition and also in the works ascribed to Geber and Albertus Magnus. But instead, let us return to Newton in order to determine the sources of his view that the earth is a living—and ultimately dying—being. Here we will examine evidence

[3]Robert Steele, "Practical Chemistry in the Twelfth Century," *Isis* 12 (1929): 27: "Scias quod corpora mineralia sunt vapores qui inspissantur et coagulantur secundum mensuram servitutis nature in spatio longe. Et primum quidem quod coagulatur est mercurius et sulphur. Et sunt duo elementa minere. Et <non *delendum est*> sunt aqua et oleum, set unum generatur ab aqua et aliud ab oleo super quibus assiduat decoctio equaliter cum caliditate et humiditate donec congelata sunt. Et ex eis generantur corpora, et permutantur gradatim donec fiant argentum et aurum in millibus annorum." See also Julius Ruska, *Das Buch der Alaune und Salze* (Berlin: Verlag Chemie, 1935), 62, 95. There is no fully adequate edition of *De aluminibus et salibus* at present.

that Newton's sources for an earth that is constantly undergoing a cycle of birth and death do not stem from some timeless idea essential to alchemy but rather from the evolving beliefs of people associated with the central European mining explosion of the early modern period.

The protoindustrial revolution of mining and metallurgy during the fifteenth and sixteenth centuries in the Erzgebirge mountains of central Europe and elsewhere generated a literature of influential printed how-to books stretching from Ulrich Rülein von Kalbe's *Bergbüchlein* (Mining Booklet) of 1505 up to Georg Agricola's 1556 *De re metallica* (On Metallic Material) and beyond.[4] Only recently have scholars come to stress the fact that there was a fruitful interchange going on between alchemists and miners from the very beginning of the *Berg-* and *Probirbüchlein* (Mining and Assaying Booklet) genres. Rülein von Kalbe's *Bergbüchlein* already employs the sulfur-mercury theory, and this appears alongside other borrowings from alchemy in later booklets such as the *Rechter Gebrauch d'Alchimei* (the Correct Use of Alchemy) of 1531 and the *Alchimi und Bergwerck* (Alchemy and Mining) of 1534. But this interchange was far from being a one-way street. Not only did writers on mining and metallurgy borrow from alchemists, the chymists themselves also incorporated material from the rapidly expanding knowledge of subterranean processes that accompanied the European mining boom. It was the porous boundary between alchemy and the world of mining that led, I believe, to the new emphasis on a subterranean realm that experienced birth, death, decay, and rebirth just like the earthly surface early modern Europeans inhabited.

Among Newton's early modern sources there are many that describe the subterranean origin of the metals in terms that resonate with his own hylozoism. Newton was heavily influenced by the work of Michael Sendivogius, a Polish courtier and mining official in the entourage of the Habsburg Emperor Rudolf II, whose small but widely read literary corpus also imputes great significance to generative vapors circulating within the earth.[5] Sendivogius's earliest work, the 1604 *De lapide philosophorum tractatus duodecim* (Twelve Tracts on the Philosophers' Stone) was republished many times with

[4] For the early modern central European mining boom, see Adolf Laube, *Studien über den erzgebirgischen Silberbergbau von 1470 bis 1546* (Berlin: Akademie-Verlag, 1974). A still useful study of the early genre of German mining, assaying, and technical manuals may be found in Ernst Darmstaedter, "Berg-, Probir- und Kunstbüchlein," *Münchener Beiträge zur Geschichte und Literatur der Naturwissenschaften und Medizin* 2/3 (1926). More recent studies include Urs Leo Gantenbein, "Die Beziehungen zwischen Alchemie und Hüttenwesen im frühen 16. Jahrhundert, insbesondere bei Paracelsus und Georgius Agricola," *Mitteilungen, Gesellschaft Deutscher Chemiker / Fachgruppe Geschichte der Chemie* 15 (2000): 11–31; Christoph Bartels, "The Production of Silver, Copper, and Lead in the Harz Mountains from Late Medieval Times to the Onset of Industrialization," in *Materials and Expertise in Early Modern Europe*, ed. Ursula Klein and E. C. Spary (Chicago: University of Chicago Press, 2010), 71–100. For more on the connections between alchemy and practical metallurgy, see also Tara Nummedal, "Practical Alchemy and Commercial Exchange in the Holy Roman Empire," in *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe*, ed. Pamela H. Smith and Paula Findlen (New York: Routledge, 2002), 201–22.

[5] Rafał T. Prinke, "New Light on the Alchemical Writings of Michael Sendivogius (1566–1636)," *Ambix* 63 (2016): 217–43; see also Prinke, "The Twelfth Adept," in *The Rosicrucian Enlightenment Revisited*, ed. Ralph White (Hudson, NY: Lindisfarne, 1999), 141–92. This should be supplemented by Julian Paulus's entry on Alexander Seton, with whom Sendivogius is often confused, in Priesner and Figala, *Alchemie*, 335–36.

his humorous 1607 *Dialogus Mercurii, alchymistae et Naturae* (Dialogue of Mercury, an Alchemist and Nature), in combined form as the *Novum lumen chemicum* (New Light of Chymistry); he also wrote a well-received *Tractatus de sulphure* (Tract on Sulfur) in 1616, which is often collected with the foregoing titles. During his long and colorful life, Sendivogius managed to work his way up from an obscure, possibly peasant birth to become a respected counselor of two Holy Roman emperors, Rudolf II and Ferdinand II, as well as the Polish King Sigismund III. Not only did he perform public transmutations of metals, he was also employed as a metallurgical expert by the Polish magnate Mikołaj Wolski in an ambitious venture involving ironworks, and he may have been brought back to the imperial seat at the behest of Ferdinand II to oversee lead mines.[6]

Sendivogius developed an influential theory in the *Novum lumen chemicum*, in which saltpeter (*sal nitrum*) is used as a sort of model substance for explaining mineral growth and generation more generally.[7] The material that we now refer to as potassium nitrate (saltpeter or niter) does in fact effloresce on some soils and on cellar walls, so it was not an unreasonable exemplar for discussing mineral growth. Moreover, Sendivogius argues that saltpeter or niter within the earth attracts a celestial analogue, an "aerial niter" from the heavens in the same fashion that hygroscopic calcined tartar (anhydrous potassium carbonate) attracts humidity from moist air to form "oil of tartar." Sendivogius employed magnetic metaphors to make this attractive power of the *sal nitrum* still more compelling; thus he speaks elsewhere of the attracting sulfurous fatness as a *chalybs* (Latin for "steel"), which draws the mercurial moisture out of the air just as an ordinary piece of steel attracts and is attracted by a magnet (*magnes* in Latin). One could also argue, as Newton later did, that "spirit of niter," or nitric acid distilled out of saltpeter with the help of sulfates, gets its ability to dissolve metals from its attractive power.

The Polish chymist thought that *sal nitrum* contained a principle of life because of its absorption of a vital material from the heavens. This claim too could be justified by considering the properties of ordinary saltpeter. On the one hand, the substance can indeed be made to release the material that we now refer to as oxygen by means of moderate heating. On the other hand, the vital power imbedded in niter could also be used to explain the effectiveness of saltpeter in preserving meats. The idea that what keeps the body from decay after death must exercise the same agency during life has a long history in European alchemical literature, going back at least as far as the distillation of ethanol in the High Middle Ages. Finally, it was known in the seventeenth century that niter could be used as a fertilizer, a fact that we now impute to its high nitrogen content. But to Sendivogius, the ability

[6] Rafał T. Prinke, "Beyond Patronage: Michael Sendivogius and the Meanings of Success in Alchemy," in *Chymia: Science and Nature in Medieval and Early Modern Europe*, ed. Miguel López Pérez, Didier Kahn, and Mar Rey Bueno (Newcastle upon Tyne: Cambridge Scholars Publishing, 2010), 175–231, see 205–8.

[7] For an excellent treatment of Sendivogius's theories and their sources, see Didier Kahn, "Le Tractatus de sulphure de Michaël Sendivogius (1616), une alchimie entre philosophie naturelle et mystique," in *L'Écriture du texte scientifique au Moyen Âge*, ed. Claude Thomasset (Paris: Presses de l'Université de Paris-Sorbonne, 2006), 193–221.