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ESSAY REVIEW

Newton's secrets revealed

William R. Newman: Newton the alchemist: science, enigma, and the quest for nature's "secret fire." Princeton: Princeton University Press, 2019, 560 pp, $39.95

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An icon of the Enlightenment and a canonical figure of the "scientific revolution," Isaac Newton has been much less praised in the historiography of science for his works on alchemy. Throughout the nineteenth and twentieth centuries, his writings on this theme have been subject to denial, misunderstanding and contrasting views. This range of attitudes reflected the many historiographical turns and misconceptions regarding the status of alchemy in the early modern sciences. In this regard, Betty J.T. Dobbs adopted a Jungian interpretation, viewing Newton's alchemical endeavor as a religious quest, while Richard Westfall put forth its roots in Renaissance Hermeticism as a hidden framework that shaped early modern science. If Karin Figala and David Castillejo have meanwhile offered more nuanced views on this topic, Newton's abundant *Nachlass* was still in need of comprehensive study according to the novel historiography of early modern "chymistry."

Contextualizing Newton's chymistry as scientific knowledge and practice was not only necessary, it was also arduous, with the aim of collecting his numerous manuscripts and deciphering their style and content. William R. Newman undertook this formidable task with *The Chymistry of Isaac Newton* project at Indiana University in 2003. Sixteen years later, his book *Newton the Alchemist* unveils Newton's chymical quest honed by a secret interest in the transmutation of metals.

In guiding the reader through the forest of Newton's manuscripts, Newman calls attention to the many textual and experimental practices behind their production. In this regard, the book's preamble highlights the paleographical skills that have been crucial to decoding a stream of specifically Newtonian abbreviations, superscripts, struck-through text, macrons, thorns and glyphs. The first chapter, in turn, describes a twofold method for reliably investigating Newton's texts. Remarkably, this methodology incorporates the old and the new. Based first on historical contextualization and close reading, it is also powered by the most recent tools of digital analysis and

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experimental reconstruction. Laboratory replication has been key for reconstituting Newton's experiments, while text encoding and mining have refined the decipherment of his coded language and the parsing of his million-word corpus. These digital tools are further described in *The Chymistry of Isaac Newton* web platform.

Before exploring Newton's undying interest in chymistry from the 1660s to about 1705, Newman dedicates four chapters to the broader context of his project. This starts in Chapter 2, with the key textual practices and literary genres in Newton's writings and sources. Such techniques comprised the coded language of *Decknamen*, stylistic techniques of deception, the alchemical genre of *florilegium* and the method of "conjectural process" (39). As Newman argues throughout the book, these textual features were not only subject to Newton's systematic decipherment, they were integrated in his own chymical works. Moreover, as explained in Chapter 3, Newton's use of chymical allegories was distinct from his religious views and conception of history. In contrast with his lexicon of prophetical symbols and biblical language, Newton's allegorical terminology reflected the versatile language of alchemical adepts, including the analogies between mythological figures and chymical materials.

By using this allegorical language as a conventional style proper to chymical prose, Newton devised an original account of metallic regeneration. As shown in Chapter 4, his interpretation was rooted in earlier conceptions of sulfur and mercury as the principles of metals. Fueled by the knowledge of Central European miners in the Renaissance, these theories conceived metallic growth as a process of generation and corruption within the subterranean world. In setting up this context, Newman introduces a series of late Renaissance chymists who were crucial to Newton's conception of metallic generation. Above all, it was according to the Polish Michael Sendivogius and the German Johann Grasseus that Newton viewed the subterranean generation of metals as coming from the constant circulation of sulfurous and mercurial vapors, or "spirits" (165). Newton also drew his account of metallic decay from the German Basil Valentine (Johann Thölde) who, along with Eirenaeus Philalethes (George Starkey), was one of the many pseudonymous authors that entered in Newton's sources.

Newman then envisages the young Newton's interest in chymistry during his studies at Grantham and Cambridge. In Chapter 5, we learn that his study of chymistry was essentially bookish between 1659 and 1669. At that time, Newton read English books of secrets and natural magic as an introduction to practical operations including "vulgar chymistry" (90) and engineering marvels. In the same period, Newton developed his interest in the transformation of metals (*chrysopoeia*) by reading Basil Valentine's *Last Will and Testament* and *Twelve Keys*. Newman traces the provenance of Newton's reading materials in his English circle, comprising members of the Cambridge Platonists related to Anne Conway, and possibly Frederic Slare, Boyle's chymical assistant and a member of the Royal Society.

Newton's interest in the aurific art thus predated his study of Boyle's chymistry. As Newman reveals in Chapter 6, his early point of intersection with Boyle resided in his conception of color and refraction. If Newton's optics has usually been treated in relation to the physical theories of Boyle, Hooke and Huygens, Newman shows that it was also linked to the chymical conception of analysis and synthesis. Indeed, Boyle's idea of retrieving and reassembling the constituent particles of compounds inspired Newton's multiple analyses and syntheses of light on the basis of immutable spectral colors. This original theory of color went against the scholastic views on mixture and the homogeneity of bodies.

The next two chapters investigate Newton's early theory of metallic generation between 1670 and 1674. As explained in Chapter 7, Newton followed Sendivogius, Philalethes and Grasseus in comparing the generation of metals to vegetative growth through the fertilizing action of a hidden aether or "aerial niter" (145). Under the assumption that alchemists sought to imitate nature, Newton attempted to reproduce this process in the laboratory by subliming metals into their primarily vaporous states. As argued in Chapter 8, Newton asserted the chymical nature of this process in two manuscript treatises: *Of Natures Obvious Laws* and *Humores minerales*. There, he distinguished the chymical phenomena of fermentation and putrefaction from some mere mechanism. A mechanical view implied the interaction of corpuscles subject to analysis and synthesis; for Newton, this entailed their retrievability without alteration. By contrast, fermentation and putrefaction involved core transformations driven by the seeds of the fertile aether, which were implanted in the smallest particles of matter. Such a conception of metallic "vegetation" (140) through fermentation and putrefaction allowed Newton to overcome the limitations of Cartesian corpuscularianism.

The subsequent chapters are devoted to Newton's first account of metallic transmutation in the late 1660s and early 1670s. As shown in Chapter 9, Newton's manuscript commentary on Sendivogius' *Novum lumen chemicum* attests to his systematic survey of chrysopoetic literature. This led him to first identify lead and antimony as the main principles of the "elixir" (184). Following Renaissance metallurgy and Pseudo-Paracelsus, Newton viewed these materials as the embryonic forms, or "first essences" (204), of metals. In this sense, lead was an immature type of gold that chymical operations brought to maturity. Newton applied this framework to Philalethes' conception of sublimation in *Secrets Reveal'd* by identifying the allegorical doves of Diana as lead- and antimony-based materials. As he soon realized this was a "drastic oversimplification" (196), he adjusted this view according to Philalethes' *Marrow of Alchemy* by incorporating additional ingredients, such as iron, copper and quicksilver.

Newman then tackles the middle period of Newton's chymical works between 1678 and 1684. As explained in Chapter 10, Newton withdrew from public activities at the Royal Society due to controversies about his optical theory and hence became increasingly involved in his chymical endeavors. Following the medieval genre of *florilegium*, he collected snippets of authoritative texts structured by thematic headings, as also illustrated by his *Index chemicus*. This enterprise revealed Newton's need to compile more texts, given his previous difficulties in identifying the first ingredients of chrysopoeia. He attempted to determine these materials according to Grasseus' metaphorical account of chrysopoeia in *Arca arcani*, especially the notion of *Gur*. In Chapter 11, we learn that Newton also summarized the chrysopoetic works of Johann de Monte-Snyders, a German "wandering adept" (223) and a follower of Basil Valentine. Along with Philalethes and Sendivogius, Snyders played a prominent role in Newton's synthesis of chymical operations into a "master process"

(246). As recounted in Chapter 12, these practical operations formed conjectural processes in Newton's manuscripts, to the extent that they described a modus operandi that needed to be tested in the laboratory.

The next six chapters explore Newton's chymical maturity between 1686 and 1696. Chapter 13 envisages Newton's Lullian turn, as he harvested alchemical texts attributed to the Catalan physician Ramon Lull to determine their relevance for his own chrysopoetic project. In the context of the Lullian revival in London, Newton was mostly inspired by Edmund Dickinson's conception of quintessence in *Epistola ad Theodorum Mundanum*. Coined by the French alchemist John of Rupescissa, the term *quintessence* designated the spirit of wine (*aqua vitae*) as well as a celestial substance enclosed in alchemical compounds. For Dickinson-Mundanus, this quintessence was a mercurial water that served as a chymical dissolvent (*menstruum*), which Newton identified as Van Helmont's *alkahest* and Flamel's *fermentum*. As revealed by Newton's manuscript *Opera*, this reasoning was pivotal in his experimental objective of obtaining a powerful *menstruum* to unlock metals for transmutation.

Chapter 14 brings us to the experimental side of Newton's chymistry, which was pursued in a laboratory located within his garden at Trinity College chapel. Whereas his notebooks and purchase lists point to the rich apparatus of this laboratory, the precise operations that he made there remain difficult to trace due to his coded language and lack of details on his goals and results. Remarkably, Newman succeeded in inferring the latter from the repetitive dimension of operations and by means of experimental methods including Latent Semantic Analysis and laboratory replication. The beautiful pictures of crystalline salts (vitriols) in the central pages of the book give us a taste of the replications that Newman and his team performed at the Indiana University Chemistry Department. From this experimental and textual analysis, we now know that Newton was attempting to make a "purple alloy" (306) of metallic antimony and copper. This led him to develop an original application of Boyle's, Philalethes' and Snyders' chymistry by operating multiple dissolutions, sublimations and distillations of metals while noting down parameters ranging from fusibility to color and weight.

In Chapter 15, Newman shows another important source in Newton's chymical practice: the *Epistola ad Langellotum* by the German chymist David von der Becke. This text expanded on the Helmontian assimilation of tartar salt with sal ammoniac as a fermenting agent to obtain volatile mineral acids. Following this account, Newton sought to make antimony-based "sophic" salt (337) to sublime minerals and metals into more volatile substances. As explained in Chapter 16, his experimental focus on volatile salts stemmed from the making of "Vulcan's net" (360) by means of stibnite, iron and copper following Philalethes' *Marrow of Alchemy*. If the fragmentary sources do not allow us to trace Newton's degree of success, his manuscripts reveal that he was still experimenting on copper around 1695.

To refine his experimental understanding of chrysopoeia, Newton forged ties with a series of collaborators in London. His manuscript *Three Mysterious Fires* disclosed the most prominent one: Nicolas Fatio de Duillier, a Swiss mathematician who worked with Newton between 1689 and 1694. As Newman recounts in Chapter 17, Fatio entered the Royal Society in 1688. With the aim of helping to write the second edition of the *Principia*, he corresponded with Newton about chymistry and medicine, among other subjects. Not only did Fatio have access to Newton's chymical secrets, he also shared useful recipes of Mercury's caduceus based on alternative ingredients (*succedanea*). As Newman contends in Chapter 18, Newton was highly dedicated to his collaboration with Fatio even during the "dark year" of his *Praxis* (1693). Such an intense activity possibly exposed Newton to neurological disorders typical of mercury poisoning. In Chapter 19, we learn that Newton carried on with his chymical endeavor after obtaining the position of warden at the Mint. Newton's connection with amateur chymists in London showed through his transcription of Captain Hylliard's texts on Helmontian chymistry, which was then popular in England. Newton's manuscripts also integrated the ideas of the distiller and pharmacist William Yworth, whom he hired to make chymical preparations in a special apparatus designed for high-temperature distillation.

The last three chapters explicate the connection between Newton's chymistry and physics despite the secrecy surrounding his chrysopoetic quest. As shown in Chapter 20, Newton's conception of fermentation and aerial niter shaped his understanding of combustion. Interestingly, Newton had progressively abandoned this framework from his *Hypothesis of Light* (1675), as he ascribed combustion to the acid nature of sulfur and its "attraction" (446) for the inflammable particles of materials. Heralding Stahl's notion of phlogiston and Geoffroy's theory of elective affinity in eighteenth-century chymistry, Newton's account of sulfur and combustion also extended to refraction in his 1704 *Opticks*.

Chapter 21 further explores how Newton's conception of acid sulfur applied to his "shell" theory of matter. Along the lines of Van Helmont, Newton ascribed chymical change to the corpuscular layering of acid (sulfur) and earth (mercury). In the case of transmutation, this process occurred through the acid particles of the sophic *menstruum*, which caused the putrefaction and fermentation of metals due to its affinity with their smallest particles. Applying to the microstructure of matter, fermentation caused active powers that were traditionally ascribed to hidden or "occult" properties. As Newman claims, Newton attributed such a force an equal importance to that of gravity, following his "straightforward demarcation" (470) between chymistry and physics. Moreover, Chapter 22 argues, Newton's conception of chrysopoeia as a core process of fermentation led him to disqualify Boyle's approach to incalescent mercury in the *Philosophical Transactions*. If Newton deemed this preparation a superficial process akin to the illegitimate practice of metallic "multiplication" (489), this did not prevent him from requesting Boyle's recipes (shortly after the latter's death) for his lifelong project to collect the secrets of nature.

Most evidently, *Newton the Alchemist* makes a monumental contribution to the historical studies on Isaac Newton. But the significance of this book goes well beyond this achievement. In contextualizing Newton's manuscripts in earlier forms of knowledge and science, Newman operates a vertiginous recapitulation of the research on chymistry, to which he has chiefly contributed over the past decades. Indeed, the book crystallizes the development of chymistry in the Holy Roman Empire and on the fringes of Eastern Europe, its roots in medieval alchemy and Renaissance metallurgy, its often pseudonymous authorship, its close connection with corpuscular theories of matter, its constant tension between openness and secrecy, as well as its protean language and imagery. As Newman delineates the ramifications of these themes among many others in Newton's works, he also demonstrates the epistemic role and cross-disciplinary nature of chymistry within the early modern sciences.

Moreover, by weaving the semantic field of deciphering and unriddling into the narrative, Newman operates a fascinating *mise en abyme* between Newton's and his own explorations. This reflexive dimension highlights the many skills involved in the historian's research practice, from codicology and paleography to emerging tools of investigation. In this regard, digital and replicative techniques prove to be essential to elucidate the reading practices and tacit knowledge behind Newton's chymistry. However, whereas experimental replication is extensively discussed in Chapter 1, digital analysis is presented more succinctly. It would have been helpful to provide a detailed appraisal of text mining, particularly the lesser-known Latent Semantic Analysis, given its increasing importance in historical research. A bibliography and list of the manuscripts under discussion would also have been appreciated. These minor points aside, *Newton the Alchemist* represents an important landmark in our understanding of the early modern sciences.