Philosophical Saltpeter: The Origins and Influence of Gunpowder Technology and the Paracelsian Aerial Niter

A THESIS
SUBMITTED TO THE FACULTY OF
THE UNIVERSITY OF MINNESOTA
BY

Quincy Marie Washa

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

Victor Boantza, Advisor

January 2019

© Quincy Washa 2019

Acknowledgements

I am grateful to all of those with whom I have had the pleasure to work with during my time at the University of Minnesota. This thesis is truly the outcome of inspiring classroom lectures, engaging discussions, and stimulating one-on-one conversations.

I would like to take this opportunity to express my gratitude to all of the History of Science, Technology, and Medicine Program faculty members for their help and support. I would like to express my special appreciation and thanks to my advisor Professor Victor Boantza for encouraging my research, his endless patience, valuable guidance, and insightful comments. I was greatly appreciative of his mentorship and advice throughout this process.

My sincere thanks also goes to the other members of my thesis committee, Professors Jole Shackelford and Alan Love, for sharing their expertise and sage guidance, both in the classroom and during the writing process. Thank you for letting my defense be an enjoyable moment, and for your perceptive comments and suggestions.

I also want to convey my sense of gratitude to all, who directly or indirectly, lent their hand in this venture.

Last but not least, I would like to express my deepest gratitude to my family and friends for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. I would especially like to thank my parents, whose love and guidance are with me in whatever I pursue. Thank you for always supporting me in everything I do.

Abstract

This thesis re-appraises how the creation and inclusion of niter theories and salt principles played into the reformation of early modern scientific philosophies, suggesting that the adoption of these theories by major figures of the period calls for closer attention by historians of science. In particular, it raises the question of why and how such a humble, earthly mineral took on a supernatural role and became a staple in some of the leading scientific philosophies of the early modern era. I show that salt, or more specifically saltpeter, would not have assumed this identity without the growing importance and popularity accorded to gunpowder weapons, beginning in the Renaissance. It was the hermetic alchemist, Paracelsus, who first developed a metaphysical notion of saltpeter and incorporated it into his natural cosmology. Historians of science, such as Allen Debus, Walter Pagel, and Henry Guerlac, have discussed Paraclesus' first claim to treatment of niter theories and their association with the observed effects of gunpowder. However, I argue that additional evidence, found in Paracelsus' writings, is needed to further demonstrate this historical connection and to identify differences in the understanding of Paracelsus' conception and employment of salt as one of three principles of matter, alongside sulfur and mercury, together forming his celebrated *tria prima*.

An examination of the parallel rise of gunpowder weapons and the utilization of saltpeter as their principle source of power showcases the philosophical links between science and emerging technologies in the sixteenth and seventeenth centuries. The transition of saltpeter from a primary component in a technological instrument to a conceptual manifestation of the fundamental structure of reality reflects an epistemological transfer of concepts from craft knowledge to metaphysical and philosophical beliefs. Such narratives may help us understand the development of early modern natural philosophers' beliefs about causality, agency, and creation.

Table of Contents

Acknowledgements i

Abstract ii

Table of Contents iii

Chapter 1: Paracelsus and the Neoplatonic and Hermetic Traditions of the Renaissance and Early Modern Period 1

1. Introduction 1
2. Concepts of the Macrocosm and Microcosm 4
3. Vitalism 11
4. Alchemy and the Chemical Philosophers 16
5. Paracelsus' *Tria Prima* and the Addition of Salt 21

Chapter 2: Gunpowder Technology and Its Cultural Influence 31

1. Introduction 31
2. Origins of Gunpowder and Its Introduction to the West 32
3. Rise of the Nation State and Gunpowder Wars 38
4. The State and Saltpeter 44
5. Science, Society, and Gunpowder 49

Chapter 3: Paracelsus, Gunpowder, and the Origins of a Universal Salt 54

1. Introduction 54
2. Paracelsus and Salt Reconsidered 55
3. Saltpeter and the "Gunpowder Theory" 67
4. The Impact of Paracelsian Salt Philosophies and His Followers 79

Concluding Remarks and Reflections on the Influence and Impact of Aerial Niter Theories on the Philosophy of Technology 90

1. Situating the Philosophy of Technology and Aerial Niter Theories 90
2. Conclusion 93

Bibliography 95

Chapter 1: Paracelsus and the Neoplatonic and Hermetic Traditions of the Renaissance and Early Modern Period

1. Introduction

Theophrastus Bombastus von Hohenheim (1493 – 1541), more commonly known as Paracelsus, has been canonized in historical literature as a dynamic and contestable personality who stands among the ranks of prolific thinkers and reformers of early modern Europe. An itinerate man of erratic disposition, he is broadly remembered as an eccentric physician-philosopher and alchemist who wrote extensively on the reformation of medical practices and man's interaction with nature. The breadth and extent of his voluminous works include extensive contributions to theology, epistemology, mineralogy, meteorology, natural magic and most notably chemical and alchemical philosophies reflecting his conceptions of matter and the structure of nature.[1]

Paracelsus adhered to a predominately spiritual and philosophical view of the universe, which was complemented by his novel chemical interpretations of life and creation. He assertively argued that the aim of alchemy was not transmutation of base metals into gold. Instead, he believed that alchemy was a way of understanding nature (he thought of God as a supreme alchemist), alongside a commitment to the preparation of chemical medicines. He rejected the intellectual customs of medical faculties in European universities, who obstinately clung to scholastic notions of Aristotelian logic and Galenic humoral medicine. Although Paracelsus advocated for new observations of nature, he couched many of his within a Christian-based cosmology that he combined with hermetic and alchemical convictions. Fundamental to his philosophy was the view that the universe was a chemical system controlled by correspondences, sympathies, and astral forces. These operations were also reflected in the physical body of man. Through this lens, the philosopher-physician incorporated a new elemental system developed to supplement the traditional Aristotelian matter theory, which was based on the four elements of fire, air, water, and earth. Paracelsus instituted a second structure of elementary matter based on a tripartite system of sulfur, mercury, and salt. As Debus has observed, by doing so, he "called into question the whole framework of

[1] Walter Pagel, "Paracelsus and the Neoplatonic and Gnostic Tradition," *Ambix* 8, Issue 3 (1960): 125.

ancient medicine and natural philosophy."[2] This contemplative and mystical worldview of Paracelsus was heavily influenced by the alchemical heritage drawn from contemporary philosophy of Renaissance Neoplatonism, which had come into vogue with the Florentine Platonists of the late fifteenth century.[3]

In the course of investigating the origin and rise of niter theories, it is important to develop an understanding of the historiographical orientation of scholars, as well as the social, economic, intellectual, and religious dimensions characteristic to the end of the Renaissance and the dawn of the Scientific Revolution. This revolutionary time period of the sixteenth and seventeenth centuries stands as a transformative era heralding the inauguration of a new approach to the natural world and man's place in it. Human understanding witnessed an intellectual and cultural transformation marked by experimental science as a new approach to truth and objectivity, which emerged as an alternative to the antiquated ideologies of Greek and medieval legacies. Bound up in tensions surrounding religious and social reform, this transition provided the scaffolding for the emergence of a new natural philosophy.

1.2 The Neoplatonic and Hermetic Traditions

The era surrounding Paracelsus' life was a tumultuous period in history characterized by the discovery of new continents and the expansion of population and trade, development of new material industry, and mounted attacks against standing institutions of government and religion. The Renaissance had shifted man's perspective to one of power and self-awareness concerning his place in the universe and his interaction with the world, thus establishing a more dynamic and intellectual relationship with nature and his environment.

The fifteenth century saw restored enthusiasm for the Platonic dialogs and the resurrection of Hellenistic philosophy that assimilated the doctrines of the mythical Hermes Trismegistos.[4] Revived interest in the Corpus Hermeticum (c. 1460) offered an

---

[2] Allen G. Debus, *The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries (*New York: Dover Publications, 1977), 78.
[3] Allen G. Debus, *The English Paracelsians* (New York: Franklin Watts, Inc., 1966), 18.
[4] Philosophers of the Renaissance immortalized Hermes Trismegistus as the alleged author of the *Hermetic Corpus*, a series of divinely inspired texts that heavily influenced sixteenth-century Christian thought and

alternative approach to seeking perennial truths and an understanding of the world. Framing their natural philosophy within the allegorical setting of the macrocosm and the microcosm, proponents of these hermetic philosophies argued that those who devoted their life to the study of nature would have the capacity to comprehend the being of man as a microcosm and acquire a more perfect and concrete knowledge of natural philosophy.[5] Concurrent endeavors to reconcile this Hermetic revival with Christian doctrine were also undertaken to "acquire support through philosophical and symbolical knowledge - a new type of Gnosis."[6] This gave rise to two schools of thought: (1) the belief in traditional medical practices informed by mathematics and the science of motion; and (2) a mystical and spagyrical cosmology inspired by strong religious overtones and a belief in chemical knowledge as the key to equally understanding man and nature.[7]

Although the writings of Paracelsus reflect these Renaissance thought trends, there are discernible divergences in his ideas that represent an appeal to both antiquity and his inherently anthropocentric worldview that embraced an experimental approach and advocated man's dominion over nature. Even though he was unable to completely eliminate every remnant of traditionalism from his reasoning, he nonetheless forcefully advocated for the abandonment of the static worldview of the ancients, emphasizing instead man's moral responsibility to comprehend the wonderful magnitude of Creation. Paracelsus believed in the agency of invisible forces that permeated the universe. "He was responding to current issues in his discussions of mining, metallurgy, medical herbs, syphilis, medical education, and the reform of apothecaries, as well as in his Bible commentaries and doctrinal writings on the Eucharist and the Trinity."[8] The intricacy of his writings stems in part from the mounting tension between religious and humanist contentions.

---

religious practices. In this way, he was also purported to be a contemporary of the biblical Moses. Hermetic teachings informed the practices of alchemy, astrology, and Renaissance occultism. Debus, *The Chemical Philosophy, 32; The English Paracelsians, 22.*

[5] Allen G. Debus, *Chemistry and Medical Debate: van Helmont to Boerhaave* (Canton, MA: Science History Publications, 2001), 4.

[6] Pagel, "Paracelsus and the Neoplatonic and Gnostic Tradition," 125.

[7] Debus, *Chemistry and Medical Debate,* 5.

[8] Nicholas Goodrick-Clarke, *Paracelsus. Essential Readings* (Berkeley, Calif., 1999), 4.

Pagel tells us, however, that the prevalence of Neoplatonic currencies in the Paracelsian Corpus should not come as a surprise, "for it was in Renaissance Neoplatonism that he could find the sources and traditions that led to the uncovering of the Occult and Invisible in Nature." Magic inherent to this tradition was closely bound to religious pursuits, with the aim of uncovering the virtues instilled in nature for the prosperity of man. It was through magic that man was able to unveil invisible influences inherent to natural objects, thereby forming a foundational platform for the practices of medicine, philosophy, and astronomy. Magic also served as a function by which a magus could summon celestial and natural forces, whether astral, vegetal, or mineral, so as to direct the energy of their virtues toward himself or other bodies. To seek and obtain this knowledge resulted in the attainment of divine understanding.[9] Such was the quest of these Renaissance natural magicians who accepted the responsibility of examining the wonders of God's creation in order to receive the gift of knowing their Creator.

It is this unorthodox, mystical worldview of Paracelsus that gives his philosophy a distinctive identity which deserves further examination in order to understand the approaches past historians have taken when discussing the development of his chemical philosophy, specifically in regards to implementing an ethereal salt principle, and the ways in which these theories impacted subsequent alchemical doctrines.

2. Concepts of the Macrocosm and Microcosm

2.1 Introduction

> Now the limbus is heavens and earth, the upper and lower sphere, the four elements, and whatever is within it [the world]. This is why he properly bears the name microcosmus, for he is the entire world. From this it follows that insofar as he indeed is this, the physician must know both spheres, [the ones] above and below, in their element and essence, their properties and nature. If he does know these, then he understands what ails the human being in his times of need. He who was made by God must know more than he who is raised up by man.[10]

[9] Pagel, "Paracelsus and the Neoplatonic and Gnostic Tradition," 157.
[10] Paracelsus, *Paracelsus (Theophrastus Bombastus von Hohenheim, 1493-1541): Essential Theoretical Writings,* ed. Andrew Weeks (Leiden: Brill, 2008), 649.

In these words, Paracelsus expressed his foundational view of the relations between the macrocosm and microcosm. The macro-microcosm theory was a prevailing philosophy throughout early modern Europe by which man was reflected as a smaller representation (microcosm) of the greater cosmos (macrocosm) in which "all forces of the universe are joined together."[11] Drawing on comparisons of man and nature found in the pre-Socratics and in Plato's *Timaeus* (his cosmological and cosmogonical dialog), Hermetic natural philosophers held the conviction that the heavens, earth, and all of Nature were interconnected through a continuous system linking the celestial and the sublunary domains. In this, all things in the great world, represented by the macrocosm, were also to be reflected in the manifestation of man as the microcosm.[12] The union of these two realms was facilitated by "firmamental coordination" among astral influences and correspondences that were frequently explained by way of sympathetic or antagonistic agencies.[13]

Following the Neoplatonic tradition, Paracelsus maintained that man is the lesser world, for all things in heaven and earth exist and are united with him. These powers were not embodied in the form of matter, but were expressed in the form of spirits or virtues:[14]

> Following the creation of all these things, the human being was fashioned out of them by the hand of God, after [God's own] formation. What does it mean when we say this? Nothing other than that you should understand that the human being is the small world, not in form and physical substance, but rather in all the forces and virtues, like the great world. From the [nature of the] human being there follows the noble name *microcosm*. What the name implies is that all the celestial courses, the terrestrial nature, the aqueous properties, [and the] aerial essences are found within him. In him is found the nature of all fruits of the earth and all ores, [the] nature of the waters, as well as all *constellationes*, and the four winds of the world. What upon the earth is there of which its nature and power are not found within the human being? That is how noble, how subtle, [and] how sensitive the limbus was out of which the human being has been fashioned—from which God created the human being after his own image. For every natural [thinker or human being] should contemplate how God who

[11] Walter Pagel, *Paracelsus. An Introduction to Philosophical Medicine in the Era of the Renaissance*, (Basel 1958, reprint 1982), 215, footnote 45.
[12] Allen G. Debus, *The Chemical Promise: Experiment and Mysticism in the Chemical Philosophy, 1550-1800 (*Sagamore Beach: Science History Publications, 2006), 24.
[13] Pagel, *Paracelsus,* 67. See pages 67-69 for further explanation of firmament influence and correspondence.
[14] Pagel, "Paracelsus and the Neoplatonic and Gnostic Tradition," 132-135.

created the human being after his own image, made him out of the noblest *compositum*, which will always lack for any equal.[15]

As the quoted passage above indicates, these virtues were made manifest by various means such as terrestrial, aqueous, and aerial functions – an important concept that underscored the chemical exchanges invoked by Paracelsus to explain the interaction between the macrocosm and microcosm which shall be elaborated on in a subsequent chapter. Due to man's perceived status in the hierarchy of nature, also known as the Great Chain of Being, he is therefore privileged and can receive direct knowledge of Nature owing to the connection uniting the faculties of his inner, constitutional being to the larger cosmos. To examine the human constitution with regard to this knowledge was to look beyond the superficial exterior of physical phenomena to the invisible order of the soul and to the miraculous powers of the Creator. Owing to the belief that an examination of the macrocosm would indubitably lead to an understanding of man, many physicians and alchemists took a profound interest in what Debus has branded the new 'chemical philosophy.'[16]

2.2 A System of Correspondences

This emphasis on cosmic virtues paralleled mystical notions of reason that sought to join the greater and lesser worlds through the understanding and manipulation of correspondences and sympathies between terrestrial objects and heavenly forces. In Paracelsus' elaborate system of natural philosophy and medicine, this comprehensive view of the cosmos was constructed around analogies rather than differences between various objects or phenomena.[17] Belief in the macrocosm-microcosm analogy created a direct connection between the celestial and sublunary worlds and fostered a view of creation as a divine chemical unfolding of nature. As we will see later on in this essay, this prompted Paracelsus to advocate for an explanation of nature through chemical analogies. It followed that chemical changes observed in the macrocosm should also be

[15] Paracelsus, *Essential Theoretical Writings,* 485.
[16] Debus, *The Chemical Promise,* 70. For a more thorough exposition on Debus' concept of the new 'chemical philosophy', see *The Chemical Philosophy* (1977) and *The Chemical Promise* (2006).
[17] Pagel, *Paracelsus,* 227.

mirrored in the smaller world of the microcosm.[18] Such occurrences manifested themselves as a sympathetic, or magnetic, attraction between the inner constitution of an object and a heavenly external force. The different outcomes, in terms of human character and fate were believed to be caused through this kind of exchange. Such a relationship stemmed from the conviction of an ultimate universal unity of all living organisms connected through a one world-soul.[19]

The acceptance of sympathetic unions was a well-instituted notion during this time period and played an integral role in other mediaeval and Gnostic ideas.[20] In keeping with this tradition, Paracelsus envisaged all life as consisting of two components: a material, elemental form and an invisible, astral form. Man, as a microcosm, similarly consisted of a rudimentary elemental body as well as an astral body (*corpus sidereum*) that informed him and was able to communicate with the divine constituents of the macrocosm, the concealed virtues or direct emanations of God in the natural world.[21]

Therefore, if man, as the pinnacle of God's creation, united in himself all the constituents of the world — minerals, flora, fauna, and celestial essences — he could acquire a more profound and total realization of nature beyond what ccould be perceived and comprehended by the rational mind. It is at this intimate level that man obtained true knowledge: "It is his 'astral body' that 'teaches man.'"[22]

By redistributing heavenly virtues as common endowments of all objects in nature, man could implement the ultimate goal of '*Magia Naturalis'*, which is to 'marry Heaven and Earth.'[23] In this way, Paracelsus illustrated how the fundamental tenets of medicine are based on cosmic sympathies between the physical body of man and divine influences. His belief in symbolical correspondences induced him to adopt an expanded empirical perspective of Nature, one that he incorporated into his conception of elementary matter, mainly characterized through his *tria prima.* This philosophical framework provided the underpinnings for Paracelsus' decision to add salt as a "prime"

[18] Debus, T*he French Paracelsians,* 11.
[19] Pagel, *Paracelsus,* 224.
[20] Pagel, *Paracelsus,* 37.
[21] Goodrick-Clarke, *Paracelsus. Essential Readings,* 24.
[22] Pagel, *Paracelsus,* 50.
[23] Ibid, 51.

material from which Nature structured countless forms and figures which will be expanded on below.

2.3 Paracelsus' Medical Theory: *Chemistry and the Microcosm*

Paracelsus advocated that the physician, as a *magnus* and receiver of divine revelation, should seek truth in his practices through the familiarity and working knowledge of virtues in all natural objects:[24]

> Medicine should be arrayed in its art and wisdom so that all who are learned in it might possess a marvelous aspect and incur amazement by the exaltation of this art. For who is it that is adorned by the heavens other than the doctor who recognizes them? Who is adorned by the earth but its philosophus? The occult powers of the earthly firmament are disclosed by the physician. To him alone the occult powers of nature are made manifest. All other scholars are [to be] informed about these matters by the physician. This is why philosophy encompasses all organs and parts [and] health as well as illness."[25]

Much of Paracelsus' medical thought was influenced by his respect for the Neoplatonist philosopher, Marsilio Ficino (1433 - 1499) who argued that "medicine without heavenly grace is ineffective and even harmful, [therefore] the physician must embrace astronomy as an essential part leading to that priestly charity which is exercised through medicine."[26] Ficino's concept of a priest-physician was founded on the belief that God endowed superior minds with the ability to recognize the divine connection between earthly elements and heavenly virtues so as to reveal knowledge required for the needs of man.[27] These medical practitioners, according to Paracelsus, were afforded provisional gifts from the Creator through the use of magic and the Kabbalah, which supplied them with the requisite knowledge needed in the performance of their duties.[28] This divine wisdom prompted natural magicians to marshal the powers of sympathetic spirits that originated in the heavens, but transcended the terrestrial realm as they became accessible to the lower elements of life.[29] Heinrich Cornelius Agrippa von Nettesheim

---

[24] Goodrick-Clarke, *Paracelsus. Essential Readings,* 25.
[25] Weeks, *Essential Theoretical Writings,* 129.
[26] Pagel, *Paracelsus,* 222.
[27] Ibid, 223.
[28] Charles Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time* (New Haven: Yale University Press, 2008), 162.
[29] Ibid, 148.

(1486 – 1535), from whom Paracelsus also drew inspiration, described this magic as the "location of sympathies in nature by exploiting the principle of attraction of like by like, or of bringing things together through their correspondences (*in attractu similium per similia et conveniendum per convenientia*)."[30]

The connection between the macrocosm and microcosm provided a central framework for Paracelsus' medical theory, which he supplemented with his revised conceptions of matter. Through this structure he developed a radically different approach to medicine. He broke from tradition and redefined the understanding of human physiology. One of his revolutionary notions was that some diseases were regarded as entities distinguished by specific changes and causes that originated outside the human body, rather than materializing from an internal humoral imbalance. Such an assertion was demonstrative of Paracelsus' opposition to Galenic ideas that employed the ancient qualities of hot and cold to classify illnesses as part of the human constitution: melancholic, choleric, sanguine, or phlegmatic. For Paracelsus, the essence of disease was to be compared to a perversion in an organism's form that corresponded to processes in nature. Hence, treatment and remedies were to be sought in the greater macrocosm of nature which were associated to the malady afflicting the microcosmic human body.[31]

This relationship suggests that a thorough study of nature will help discover the means by which to cure bodily afflictions. He supplemented this cosmological scheme with his concept of alchemical processes, notably utilizing chemical reactions to explain the processes of human physiology, particularly in regards to the preparation of medicinal remedies. If the greater universe operated on chemical principles, it followed that so too must the bodily functions of man. This led Paracelsus to visualize disease as a local reaction seated in a particular region within the body that could be defined in chemical terms.

While Paracelsus's new chemical medicine stood in stark contrast to the Galenic humoral theory, his pathology was still rationalized as a change in matter - particularly in relation to chemical elements, perceived not as substances, but as fundamental principles

[30] Ibid, 148.
[31] Goodrick-Clarke, *Paracelsus. Essential Readings,* 30.

that constituted the structure of both the macrocosm and microcosm.[32] Charles Webster, suggests that Paracelsus' endeavors to determine a unified approach to the aetiology of disease was a catalyst in his conception of his three-principle theory.[33] Paracelsus envisioned the three primary principles as exerting their influence throughout the celestial, cosmic domain, as well as inhabiting the terrestrial realm. He held the belief that since all chemicals were constructed from mercury, sulphur, and salt, any poison was reducible to these three. Equally, all medicines were comprised of these three principles. He therefore concluded that one must first identify the roots of a disease in order to reveal the source from which the physician might then be able to obtain a cure: "With that you have the human being whose body is nothing but a *sulphur*, a *mercurius*, a *sal*. In these three <things> stands its health, its illness, and everything that pertains thereto. And just as there are no more than three, so, too, all diseases are caused by the three, not by four *humores, qualitates,* or anything of the kind."[34] Thus, the three principles therefore became the determinant that accounted for the processes of human physiology, including rationalizations for disease and discernment for proper treatment.[35]

In particular, salt assumed a special importance in Paracelsus' pathology, as he regarded it to be the source for the process of disease development. He maintained that the accumulation of distinctive elements like salts were responsible for maladies such as gout and epilepsy, as opposed to an alleged upset of the equilibrium of the humors. He reasoned, thus, that the diversity of diseases corresponded to different variations of salts.[36]

Paracelsus also viewed salt as an active component in the terrestrial atmosphere which he and his followers believed served as a medium for spiritual influences to descend to the domain of man by way of astral emissions. Chemical influences were

---

[32] Goodrick-Clarke, *Paracelsus. Essential Readings,* 31.
[33] Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time*, 142. This is also demonstrated in Weeks' translation in which Paracelsus writes: "It is also well and proper to seek the anatomy of the *microcosmus*…whereby it is ascertained what blood is, of what sort of *sulphur, mercurius*, or salt; or what the heart is: what sort of *sulphur*, what sort of salt, and what sort of *mercurius*; and so on with the brain, and everything else in the entire body. This is the true anatomy: this is the basis upon which to proceed." Paracelsus, *Essential Theoretical Writings,* 373.
[34] Paracelsus, *Essential Theoretical Writings,* 323.
[35] Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time*, 136.
[36] Ibid, 142.

exchanged through this process and salt, in particular, was perceived as being transmuted by aerial sulphurs and niters that were correlated with the "breath of the Lord." Such ideas carried medicinal implications for later Paracelsians who actively opposed the practice of bloodletting arguing that it was detrimental to the patient to release the vital nitrous part of the air from the blood.[37]

2.4 Conclusion

This elaborate system of universal connection and astral parallels informed the spiritual dimension of the human constitution and the corporeal aspects of disease in Paracelsus' medical theory. With this understanding of the human body, he formed the basis for the notion of a chemically created universe founded on his elemental three-principal theory, and a key for visualizing bodily functions as chemical processes which could be corrected through the use of chemically prepared medicines. The impact of Paracelsus' holistic approach to the unity of divinity, nature, and man redirected the aim of Renaissance philosophers from the humoral medicine of the ancient Greeks that had dominated medical practice in the Western world up to that point, and aligned them towards the search for physical truth through chemistry.[38] Such a directional change in theory proved significant in the shift of modern philosophical thought and established the basis for the propagation of niter theories which in themselves would become integral to the explanations of future theoretical philosophies.

3. Vitalism

3.1 Introduction

The combination of mysticism and empiricism in the doctrine of Paracelsus produced sweeping effects in the intellectual development of the seventeenth-century medicine and science. "In all fundamental points of [Paracelsus'] doctrine," Debus has noted, "religious motives can be recognized: in his employment of analogy like that of macrocosm and microcosm, in his theory of sympathy and antipathy, in his rejection of

[37] Debus, *The English Paracelsians,* 32.
[38] Ibid, 41.

ancient humoralism in favour of his doctrine of seeds and created entities."[39] In order to better comprehend the writings of Paracelsus, we must understand the provisions of his religious ideology as these pertained to the source of life.

3.2. Vital Spirits

Growing from the Neoplatonic and Hermetic traditions of Renaissance culture, early modern philosophers imagined the universe to contain the presence of 'vital forces' or 'vital spirits' that contributed to the activity and motion of natural phenomena that characterized the distinction between organic and inorganic matter. Their source was attributed to a 'world soul' or *anima mundi,* usually credited to a divine origin. The belief that inorganic matter was governed by spiritual elements inbuilt to the inner most constitution of physical organisms became a subject of intense interest in the late sixteenth and seventeenth centuries. Invisible spirits or forces were thought to permeate the universe and sustain life in all things, both organic and inorganic. Practitioners of alchemy often adopted these vital explanations through their exploration of problems pertaining to an array of varying natural phenomena and disciplines such as mining and metallurgy, as well as pharmacy and medicine. From their perspective, the same vital principles that governed the innate functions of life were also present in the development and growth of matter. Through this vitalist cosmology the celestial and terrestrial worlds were joined as one living cosmos that subsumed both animate and inanimate organisms into a single whole of nature.[40]

Natural phenomena were thought to result from the influence of one or more intangible entities that maintained an ambiguous character, being neither fully physical nor fully immaterial. Spirits were variably referred to a "pneuma," "quintessence," or even air, breath, or wind. Incorporeal references also appealed to a universal "soul" or "mind".[41] Ficino, distinctly associated the cosmic vital spirit with an alchemical

---

[39] Walter Pagel, *Religion and Neoplatonism in Renaissance Medicine,* ed. Marianne Winder (London: Variorum Reprints, 1985), 120.
[40] Ku-ming Chang, "Alchemy as Studies of Life and Matter: Reconsidering the Place of Vitalism in Early Modern Chymistry," *Isis* 102, no.2 (June 2011): 323, 328.
[41] Arianna Borrelli, "The Weather-Glass and its Observers in the Early Seventeenth Century," in *Philosophies of Technology: Francis Bacon and his Contemporaries, vol. 1,* ed. by Claus Zittel et al. (Leiden: Brill, 2008), 95.

quintessence, which he presumed to be a physical substance that could be extracted through the art of distillation. Ficino's identification of these alchemical expressions for the "spirit of the world" (*spiritus mundi*) would eventually pave the way for alchemy as the means by which philosophers would seek to isolate the vital principle of the universe, a task eagerly pursued by ensuing alchemists.[42] As the first principle of all things, it was this vital principle that united chemistry and medicine, and guided the pursuits of the alchemists.' Their practical work often involved the extraction and manipulation of a hypothesized cosmic vital spirit, which they attempted to distill or condense by chemical means. By the seventeenth century, following in the influence of Paracelsus' works, these vitalistic approaches progressively identified this "spirit" with the form of salt, particularly an aerial niter or saltpeter.[43]

3.3 Paracelsus' Spiritual Forces and a Vital Salt Principle

Paracelsus readily adopted a vitalistic worldview like his predecessors believing that all living things depended on the constant provision of a life spirit. The conceptual framework of Neoplaontic thought served as the doctrinal basis of his ideas on the supremacy of the spirit and the exchange of vital forces in matter.[44] Paracelsus entire philosophy of nature was conceived as a theological creation in which vitalistic operations formed the foundational essence of life at the intersection of the macrocosm and microcosm. He visualized spirits as active agents responsible for the operative phenomena in nature as well as the human body, as he explained in his work *De Natura Rerum Libri Novem*:

> The life of things is none other than a spiritual essence, an invisible and impalpable thing, a spirit and a spiritual thing. On this account there is nothing corporeal, but has latent within itself a spirit and life, which, as just now said, is none other than a spiritual thing … For here we should know that God, at the beginning of the Creation of all things, created no body whatever without its own spirit, which spirit it contains after an occult manner within itself. For what is the body without the spirit? Absolutely nothing. So it is that the spirit holds concealed within itself the virtue and power of the thing, and not the body …[45]

---

[42] William R. Newman, "From Alchemy to 'Chymistry,'" in *The Cambridge History of Science*, vol. 3: Early Modern Science, ed. Katharine Park and Lorraine Daston (Cambridge, 2006), 500-01.
[43] Debus, *The Chemical Promise,* 70; Chang, "Alchemy as Studies of Life and Matter," 326, 329.
[44] Pagel, *Paracelsus,* 226.
[45] Paracelsus, quoted in Antonio Clericuzio, "The Internal Laboratory," 52.

Pagel, who examined Paracelsus' vitalistic approach to nature, believed him to be above all a naturalist, who asserted that the works of nature constituted a visible reflection of God's hand in creation.[46] The effects of these vital spirits or forces permeated the universe, and it was man's responsibility to comprehend these invisible virtues given as direct emanations from God. Therefore, the efforts of the naturalist who investigated nature were deemed as a religious duty.[47] Naturalism to Paracelsus meant the observational and experimental study of divine evidence.[48]

The search for spiritual forces that determined the nature and form of matter was a salient aspect of Paracelsus' natural philosophy. Throughout his medical works, such as the exposition *De Natura hominis libri duo* (1575), Paracelsus often emphasized the role of the *Spiritus Vitae* or Spirit of Life which he posited as an omnipresent spiritual force that permeated the entirety of nature. He asserted that "the Spirit of Life is the spirit that moves in all parts of the body and in all of them is one and the same, it is the highest power of life from which all members live."[49] It was believed that this cosmic force interacted with a corresponding spirit present in the body of man, the "astral" body, which joined his physical being to his spiritual one. The notion of an astral body had Neoplatonic origins. Some Renaissance philosophers associated this abstraction of "spirit" with Aristotelian-Galenic medical spirits. These medical spirits were initially considered the agency by which the soul commanded the body.[50]

While these traditional conceptions of spirits, no doubt, informed the original thought of Paracelsus, the development of alchemical practices during this time turned his reasoning towards both a vitalistic and chemical explanation. Like his predecessors, Paracelsus sought the invisible virtue inside natural objects believing that the form and function of an organism was directed by a distinct, innate life force and not determined

---

[46] Pagel, *Paracelsus,* 53.
[47] Ibid, 54.
[48] Ibid, 56.
[49] Goodrick-Clarke, *Paracelsus. Essential Readings,* 27.
[50] Borrelli, "The Weather-Glass and its Observers in the Early Seventeenth Century," 97.
For a nuanced perspective of Paracelsus' distinction pertaining to the components of the natural universe and of the microcosm of man, especially in regards to the soul and astral (or sidereal) bodies, see Dane T. Daniel, "Invisible Wombs: Rethinking Paracelsus's Concept of Body and Matter." *Ambix,* Vol. 53, No. 2 (July 2006,):129–142.

merely by its physical chemical components. For him, chemical constitution acted as a crude covering that masked the cardinal, intrinsic essence of the vital spirit. The latter was the ultimate, underlying determinant that affected the composition of matter.[51] Nicholas Goodrick-Clarke has clarified this thought process: "Paracelsus generally 'spiritualized' matter, in claiming that such spiritual forces are the true elements and principles, while the Elements and chemical substances are only the crystallized deposits of such forces."[52] Hence the activity and form of matter were conditioned by the volatile or spiritual principles contained within natural bodies. Those principles chemically activated the otherwise inert material constitution of such bodies.[53]

Of prime importance in this context were the frequent references to a vital salt principle that was advanced not only as a life-giving substance that circulated throughout the human body, but also as a universal spirit with celestial origins that resided as an active component in the atmosphere conferring life to the world below. This essence was commonly described as a *sal nitrum* or niter (a term incorporating multiple different kinds of salts, although most often associated with saltpeter), a substance to which alchemists ascribed both mystical and chemical connotations.[54] The prevalence of this aerial niter theory can be traced back to the final decade of the sixteenth century in the printed tracts of Paracelsus' found in the Huser edition of his work (printed in ten volumes between 1589 – 1591). This identification is important from a historical standpoint because it helps establish a specific time period by which to pinpoint the intellectual source of the concept that will be expounded later in this analysis. Later descriptions of this aerial, vital salt can be found in the literature of notable Paracelsians who referred to it as the *Miraculum Mundi* or *Spiritus Universalis,* an entity whose virtues sustained the growth and subsistence of both celestial and terrestrial objects.[55]

3.4 Conclusion

[51] Goodrick-Clarke, *Paracelsus. Essential Readings,* 27.
[52] Ibid, 28.
[53] Ibid, 33; Pagel, "Paracelsus and the Neoplatonic and Gnostic Tradition." 132.
[54] Ibid, 46.
[55] Allen Debus, "The Paracelsian Aerial Niter," *Isis* 55, no. 1 (March 1964), 59. See also Antonio Clericuzio's "The Internal Laboratory" for examples of Paracelsian accounts of universal and vital spirits attributed to or referencing saline and niter aerial principles.

The iatrochemical and alchemical literature concerning vitalistic cosmologies that followed in the wake of Paracelsus contributed much to the reconstitution of medical theory and the restructuring of medicine in terms of the source and function of medical spirits. Such an approach led to the adoption of what has been termed (by Debus and others) "chemical philosophy." These views inspired many European physicians to discard the antiquated humoral doctrine of diseases and rely, instead, on the assumption that the development of life and the structure of matter were both guided by pervasive vital principles. This contributed to a general change of focus toward the extraction and manipulation of spirits through distillation for the construction of medicines. From a practical standpoint, the chemical analysis of blood was central.[56]

4. Alchemy and the Chemical Philosophers

4.1 Alchemy and the Early Modern Neoplatonic Tradition

The practice of alchemy underwent a transformation between the high Middle Ages through the end of the seventeenth century when it rose to respectable prominence in Europe. Increased interest in alchemical and hermetic texts during this time could be tied back to the *Corpus Hermeticum,* which played a part in the unification of a comprehensive alchemical cosmology with that of Renaissance Neoplatonism.[57] Its functional value grew as alchemists began to apply this reasoning to their pharmaceutical preparations and physiological explanations.[58] Historical analysis of alchemical literature validates the tenacious and unrelenting quest of its practitioners to elevate alchemy's status from its subservience to the physical sciences.[59]

European traditions that supported the practice of late medieval alchemy focused primarily on the particulars of metallic transmutation and agents of various potencies and abilities, unlike the alchemy of eastern Asian cultures where the objective of alchemy centered on the quest for immortality and the prolongation of life. Western practitioners

---

[56] Ibid, 51, 53-54.
[57] Debus, *The Chemical Promise,* 64. See also William Newman's explanation in "From Alchemy to 'Chymistry,'" 502.
[58] Ibid, 31.
[59] Debus, *The Chemical Promise,* 35. See Debus' other works, to include *The Chemical Philosophy*, as well as Bruce Moran's *Distilling Knowledge: Alchemy, Chemistry, and the Scientific Revolution* for further analysis on chemistry's role in the Scientific Revolution.

did not adopt this viewpoint until the Latin translation of Islamic texts became available in the eighth and ninth centuries.[60] Alchemy henceforth began to take on an increasing importance in the development of medicine and in the preparation of remedies as referenced in the works of alchemical authors such as Roger Bacon (1214 – 1294), Arnold of Villanova (1235 – 1311), and John of Rupesciassa (1300 – 1365) who stressed the art and knowledge of distilling crude substances to draw out the healing essences of nature.[61]

4.2 Paracelsus' Alchemy

A closer look at Paracelsus' own practice of alchemy is important for a greater understanding of how his philosophy was largely oriented towards a greater cosmological arrangement founded upon chemical processes that went beyond the traditional model of transmutation and simple preparations. His alchemical approach laid the foundation from which he was able to postulate his new matter theory that gave rise to his tripartite conception, and facilitated the inception of an ethereal salt and subsequent niter theories.

Growing up, Paracelsus had been influenced by traditional alchemical practices that had made their way into medical and industrial trades throughout central Europe by the thirteenth century. As the son of a physician, he was trained in alchemical and medicinal processes during his childhood, being able to identify healing herbs and minerals of the region. He had also been exposed to local mining and metallurgical techniques in his hometown that incorporated the methods of smelting and refining ores.[62] This acquaintance predisposed Paracelsus' perspective for a chemical worldview that would make way for a new understanding of the universe and man.[63]

By reason of the wisdom he procured through his personal exploration of nature and practice of medicine, Paracelsus openly condemned the Aristotelian-Galenic medical institution of the universities. He insisted that their form of scholastic natural philosophy and formal logic operated in ignorance of the Scriptures and of the understanding of

[60] Debus. *The English Paracelsians,* 23.
[61] Ibid.
[62] Ibid, 6.
[63] Ibid, 23.

Divine Nature.[64] Paracelsus argued that the enlightened man must seek knowledge via methods of observation and experimentalism which was realized through the practice of alchemy:

> If the physician is not practiced and experienced in this [art], which is the highest and greatest that there is, then his entire art is in vain. For nature is so subtle and sensitive in its [substances] that it does not lend itself to use without great art. For [nature] brings nothing to light that is complete as it stands. Rather, the human being must perfect [its substances]. This completion is called *alchimia.*[65]

In particular, Paracelsus' approach to alchemy sought to establish a new foundation of medicine inspired by his chemical interpretation of creation and his approach of combining spiritual forces to the chemical expression of natural phenomena.[66] Paracelsus advanced the belief that the ultimate goal of alchemy does not lie in the archaic notion of producing gold or silver, but to prepare what he termed the *arcana,* whose cardinal function was to establish relation with the stars, that it might be applied against disease in order to restore health and balance in the body.[67] The preparation of medicine, then, was not a fixed method, but must be varied according to disease.[68] In this way, man becomes an alchemist of nature. Pagel elaborated on Paracelsus' philosophy by clarifying that: "It is the celestial-spiritual-essences and forms which the physician and naturalist must study and try to extract, for they alone are productive of miraculous effects. These 'formal and spiritual principles' constitute the

---

[64] Paracelsus approached his work and studies as a religious duty believing that further knowledge of God could "be understood only through fresh and unprejudiced study in the field and in the laboratory, not through a rehash of ancient texts in academic disputations." Allen G. Debus, "Fire analysis and the elements in the sixteenth and the seventeenth centuries," *Annals of Science 23*, Issue 2 (1967): 127.

[65] Paracelsus, *Essential Theoretical Writings,* 211.

[66] Tied to the concept of *semina*, or invisible, spiritual seeds that functioned as the formative agents of all organic bodies, Paracelsus conceived these active forces as having a distinct influence on the internal activities and biological processes of terrestrial life. Although this theme stretches throughout his writings, they are best elaborated in his work the *Paragranum* in which he advances his vision of combining what he deems the four fundamental "pillars" of medicine: Astronomy, Philosophy, Alchemy, and Virtue. Paracelsus, *Essential Theoretical Writings,* 71. Weeks, *Essential Theoretical Writings,* 9, footnote 12.

[67] "It is not that one should be saying, 'Alchemy makes gold or it makes silver.' Here is the real purpose: to make arcana and to direct them against the diseases. This is the path [the physician] must follow: this is the foundation. For all these things stem from the intention of nature and from its proved certainty. Accordingly, nature and the human being are to be joined together, harmonized and assimilated with respect to health and disease. In this lies the path of healing and convalescence. All of this is brought about by alchemy without which these things would not happen." Paracelsus, *Essential Theoretical Writings,* 221. See also Sherlock, "The Chemical Work of Paracelsus," 36.

[68] Ibid, 38.

'universal balsamic medicine' in which all parts are homogeneous, most simple, pure and highly spiritual."[69] Thus, without alchemy, medicine would remain stagnant and primitive.

Analysis of Paracelsus' alchemical theories has been explored in the comprehensive works of historians Pagel, Debus, Sherlock, and Principe who flesh out the particular features and premises inherent to the physician's alchemical system and their distinction from the works of his medieval processors. For Paracelsus, the art of alchemy resided in the very being of Nature itself, both in the visible and invisible worlds, with God himself acting as the master Alchemist or Chymist. Divine Creation was thus considered primarily in terms of a chemical separation and seen as a "chemical unfolding of nature" from whence the Creator formed the ordered world out of primordial chaos by means of alchemical techniques such as extraction, purification, and distillation.[70] Debus specifies that a "fundamental notion which underlies the thought of Paracelsus is that of the unity of all things, the manifestation by the 'world-whole' of an organic, almost living interdependence of all the parts."[71] This all-encompassing system described "the cycle of rain through sea air, and land … [as] a great cosmic distillation. The formation of minerals underground, the growth of plants, the generation of life-forms, as well as the bodily functions of digestion, nutrition, respiration, and excretion" as chemical processes inherent to natural order.[72] Alchemy, thus, concerned the examination of the whole of the cosmos.

Pagel summarizes the object of Paracelsus' alchemy as a "study [that] should be based on the parallelism between macrocosm and microcosm, the manifestation of 'life' and organization in inorganic nature and the various possible transformations of the three fundament [Paracelsian] states of matter, the fluid (Mercury), the solid (Salt) and the combustible (Sulphur) which between them account for the multiplicity of objects."[73] Debus affirms that this is consistent with traditional thinking of sixteenth-century philosophy in that, "according to ancient cosmological schemes, a study of the four

---

[69] Pagel, "Paracelsus and the Neoplatonic and Gnostic Tradition," 138.
[70] Debus, *The Chemical Promise,* 76. See also Lawrence Principe's description of the chemical creation in *The Secrets of Alchemy (*Chicago: University of Chicago Press, 2013), 128.
[71] T. P. Sherlock, "The Chemical Work of Paracelsus." *Ambix* 3 (May 1948): 34.
[72] Lawrence M. Principe, *The Secrets of Alchemy* (Chicago: University of Chicago Press, 2013), 128.

elements does not mean chemistry as we know it but rather an investigation of the spheres of these elements and their place in the universe. The importance of the Paracelsian definition here is in uniting the alchemical with the cosmological meanings."[74]

4.3 Conclusion

The alchemy of Paracelsus and its incorporation of vital forces contributed much to the establishment of a new chemical philosophy and the restructuring of medicine. Such was the transformation of his methods, that future Paracelsians described this new form of medical practice as *chymiatria*, or iatrochemistry.[75] After the mid-sixteenth century, many European physicians began to discard the humoral doctrine of diseases and relied, instead, on spiritual principles and a chemical understanding of the human body. Their focus turned toward the extraction and manipulation of spirits through distillation for the construction of their medicines. Included among these chemical spirits was the association of a vital salt principle which was postulated not only as a life-giving substance that circulates throughout the inner nature of the human body, but also as a universal force with celestial origins that resided as an active component in the atmosphere and worked to confer life to the world below. Descriptions of this aerial, vital salt can be found discussed in the literature of notable Paracelsians who referred to it as the *Miraculum Mundi* or *Spiritus Universalis* whose virtues sustained the growth and subsistence of both objects in the sky as well as on earth.[76] This essence was commonly associated with *sal nitrum*, a substance that alchemists ascribed both mystical and chemical connotations to.[77] These Paracelsian contributions to the development of current chemical thought inspired substantial changes to the theory and practice of medicine and were widely diffused and reinterpreted by his followers, which helped to cement the notion of vital salts into the new Chemical Philosophy.

---

[73] Pagel, *Paracelsus,* 267.
[74] Debus. *The English Paracelsians,* 24.
[75] Newman, "From Alchemy to 'Chymistry,'" 504.
[76] Allen Debus, "The Paracelsian Aerial Niter," *Isis* 55, no. 1 (March 1964), 59. See also Antonio Clericuzio's "The Internal Laboratory" for examples of Paracelsian accounts of universal and vital spirits attributed to or referencing saline and niter aerial principles.
[77] Ibid, 46.

5. Paracelsus' Tria Prima and the Inclusion of Salt

5.1 Introduction

Prior to the published works of Paracelsus, alchemical authors of late antiquity commonly appealed to the prominent four elements of Aristotelian matter theory as well as the sulfur-mercury theory of metals to form the foundation of their philosophies used to describe nature and the microcosmic disposition of man. Reasoning from these early conceptions, alchemists advanced explanations of matter structure, physicians postulated the causes of disease, and philosophers extended theories of motion. Despite his decisive criticism of ancient thought, Paracelsus generally accepted these elemental arrangements as a fundamental tenant of his own cosmological ideology, but with notable modifications.

In an early summary of his philosophy, Paracelsus laid out his conception of the Aristotelian elemental virtues with regards to Creation and their status as the first products of the divine alchemical separation. He expressed his dissatisfaction with the interpretation of matter in traditional Aristotelian terms of elements and qualities. In his *Archidoxis* (1525), he arrived at the conviction that water, earth, air, and fire are not the last and irreducible components of matter, but composite bodies in themselves.[78] In the traditional view of the ancients, elements are corporeal and therefore limited. Throwing aside the long-established material essence as based in paired qualities (e.g. hot and dry, cold and wet), Paracelsus instead believed them to be unrefined resemblances of the true spiritual elements upon which more complex forms of matter were dependent[79]. The Aristotelian elements were therefore seen not as material constituents, but were visualized as categorical forms. Their purest forms function as "matrices" which generate natural objects and provide a place in which they dwell, as well as inherit their corresponding "signatures."[80] Andrew Weeks has noted that in his early seminal works, Paracelsus identified the need to "bridge the gap between crude experience of alchemical

[78] Pagel, *Paracelsus,* 82, 98.
[79] Debus, *The Chemical Philosophy,* 57, 78.
[80] Pagel, *Paracelsus,* 82.

forces on the one hand and his view of the animate, human, and divine meaning of medicine and alchemy on the other."[81]

5.2 The Addition of Salt

Paracelsus' solution was to introduce a second elemental structure that provided a better explanatory role of his spiritually active universe. Alternative to the four traditional elements, his surrogate theory consisted of three primary principles – salt, sulphur, and mercury – which Paracelsus visualized as the fundamental components and directing principles of matter.[82] As with the Aristotelian elements, these Paracelsian principles were not to be envisaged as the perceptible, tangible substances that we familiarly call by those names, but were regarded primarily as spiritual and metaphysical essences that had intrinsic, soul-like forces rather than visible, chemical components of a body.[83] In Paracelsian cosmology, the three primary elements were incomparable with those of Aristotelian physics. The elements operated merely as containers for the three principles, from which they extracted nourishment and substance, analogous to an embryo in the womb.[84] Thus, the three principles served as the fundamental building blocks of natural objects whose function and appearance were determined by the matrix (earth, water, air, fire) in which they were generated.[85] Substances, as well as diseases, thus differed according to the integration of the three principles in conjunction with their corresponding matrices.[86]

---

[81] Andrew Weeks, *Paracelsus: Speculative Theory and the Crisis of the Early Reformation* (Albany, N. Y., 1997), 108.
[82] Walter Pagel & Marianne Winder, "The Higher Elements and Prime Matter in Renaissance Naturalism and in Paracelsus," *Ambix* 21: 2-3 (July & November 1974), 106.
[83] Pagel, *Paracelsus,* 228.
[84] Massimo L Bianchi, "The visible and the invisible. From alchemy to paracelsus," in *Alchemy and chemistry in the 16th and 17th centuries*, ed. P. Rattansi and A. Clericuzio (Dordrecht: Kluwer Academic Publishers, 1994), 22.
[85] Pagel, *Paracelsus,* 130.
[86] Goodrick-Clarke, *Paracelsus. Essential Readings,* 30. Nicholas Goodrick-Clarke expounds on the elemental matrix of Paracelsus further: "In his theory of matter, Paracelsus had invoked the Elements as matrices in which *semina* could thrive and proceed towards specific forms. But there is a total sum of species (*Iliadus*) which can be generated by the principles (Sulphur, Salt, and Mercury) in any given matrix…But since man represents a microcosmic matrix, there is also an *Iliadas* of man…Paracelsus' pathology thus rehearses his dynamic theory of matter, whereby the three principles of constitution can direct conditions in the body in a manner comparable to their operation in an elemental matrix."

A vital aspect of the three-principle theory was its ability to illustrate and make sense of natural phenomena to every degree, with special emphasis on the parallel relationship between the two spheres of the macrocosm and microcosm. Extending this new matter theory to the whole of the cosmos, Paracelsus externalized the three principles to command their influence throughout the whole firmament as well possess the full range of properties needed to explain all chemical processes that occurred within the terrestrial realm.[87] "This unified conception of the cosmos was essential to Paracelsus, since his theory of disease, as well as his other theories, assumed active commerce between the firmament and humans or other living organisms … Neoplatonic cosmology and cosmogony entailed a more unified conception and continuous hierarchical gradation reaching down by a process of emanation from the cosmic mind, the point of contact with the Creator and source of celestial intelligences, eventually to the realms of nature and material existence. The entire system is linked by innumerable bonds of sympathy between higher and lower states of existence."[88] This arrangement was also known as the Great Chain of Being – a Neoplatonic concept to which Paracelsus ascribed that was expressed as a hierarchical organization of all matter and life beginning with the lowest existence of minerals and metals and advancing up to the divinity of God. Through this interpretation, he thus concluded that all universal matter consisted of the same principles that could be distilled and refined back into the primary substances of sulphur, mercury, and salt.[89]

Commonly referred to as the *tria prima*, the first detailed exposition of the Paracelsian doctrine of *Sal, Sulphur,* and *Mercurius* was featured prominently in first few chapters of *Opus Paramirum* (c. 1530). Paracelsus describes the three principles as hidden within natural objects being concealed underneath their actualization as a unitary

[87] Charles Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time* (New Haven: Yale University Press, 2008), 137, 143.
[88] Ibid, 142.
[89] "It should be noted that while all things are constituted in the three prime principles, they cannot be separated without the destruction of the simple matter itself; for in separation the virtue of Mercury, of Sulphur, of Salt, vanishes and goes back into the first matter, as may be seen outside the Microcosm, Mercury being transmuted into soot, Sulphur into oiliness, Salt into alkali, whence it is manifest that the first matter cannot pass into' the ultimate matter in the absence of a medium." Paracelsus, "Chirurgia Magna, Tract III., Lib. III," in *The Hermetic and Alchemical Writings VII,* 125.

whole.[90] To seek true knowledge, one must penetrate the surface of each substance in order to ascertain their constituent segments and thus make them accessible to sensory perception.[91] The three principles are almost universally employed in Paracelsus' writings from this date onwards and began to acquire ascendancy in medical and alchemical texts during his time in Basel (1526 – 1528).[92] Notable expositions of the *tria prima* in the Paracelsian corpus are featured in other works such as *Von den ersten drei Principiis, De Natura Rerum*, *De Generationibus...Elementorum*, and the *Meteorum*. *Von den natürlichen dingen* details one of Paracelsus' earliest universal applications of the three-principle theory.[93]

Under this new paradigm of chemical medicine, Paracelsus utilized his elevated three-principle theory in his pathology:

> There are three substances which confer its own special body on everything, that is to say, every body consists of three ingredients. The names of these are Sulphur, Mercury, and Salt. When these three are compounded, then they are called a body ; and nothing is added to, or coheres with, them save and except the vital principle. Thus, if you take any body in your hands, then you have invisibly three substances under one form. … Before all else these three substances and their properties in the great universe should be understood. Then the investigator will find the same or similar properties in man also : so that he now understands what he has in his hands, and of what he is making himself master.[94]

What we see here is not the application of simple chemical constituents, but rather the operation of innate prime agencies that informed structure, physicality, and function. Paracelsus viewed the fundamental composition of man as consisting of the *tria prima,* assembled in the material called *limbus*.[95] The presence of the three principles could be discerned through their assigned qualities, which were revealed through routine chemical processes such as the application of heat resulting in combustion or through the force of

---

[90] "The whole machinery of the universe is divided into two parts, a visible body and an invisible body. The visible and tangible is the body of the universe, consisting of three primals, Sulphur, Mercury, and Salt. This is the elemental body of the universe, and the elements themselves are that body. The body which is not tangible, but impalpable and invisible, is the sidereal heaven or firmament." Paracelsus, *The Hermetic and Alchemical Writings Vol II,* 284.
[91] Bianchi, "The visible and the invisible," 18.
[92] Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time,* 139.
[93] Ibid, 141.
[94] Paracelsus, *The Hermetic and Alchemical Writings of Aureolus Philippus Theophrastus Bombast, of Hohenheim, called Paracelsus the Great. Vol II.* ed Arthur Edward Waite (Berkeley, Calif: Shambhala, 1976), 99-100. Also annotated in Paracelsus, *Paracelsus. Essential Readings,* 31.

distillation. In general, "sulphur was considered to be the cause of combustibility, structure, and substance. Solidity and often color were due to salt, and the vaporous quality was always assigned to mercury."[96]

The *tria prima* invoked the enthusiasm of many chemists who drew a connection to the Trinity and, on a more functional level, to corresponding actions in their distillations displayed by the vapor, liquid, and solid phases.[97] Webster asserts that Paracelsus' "adoption of a theory of matter based on the three principles enabled him to articulate his theories in a credible manner, embodying reference to commonly understood chemical substances and employing descriptions of the disease process that would have seemed convincing to his intended readership."[98] The capacity of the three primary elements to abide in many physical forms as well as display a diverse range of physical properties appealed to those who adopted the *tria prima* as an explanatory model in their own experiments.

This tripartite division was not an arbitrary decision either. Paracelsus, inspired by theological concerns, contended that there was supremacy granted to the number three which was emulated in the essence of the Father, Son, and Holy Spirit. He elaborated on this in his work, *Meteorum*, where he claimed that all things in the cosmos are made "from three" by virtue of the threefold *fiat lux* by which God created the world as reflected in the Holy Trinity.[99] This model was also developed in one of his earlier theological treatises, De *Genealogia Christi,* which was dated by Kurt Goldammer to around 1530. Here the physician discusses the order of creation embodied in the image of the divine Creator, explicitly identified with the Trinity: "in this manner in three things all things have been created … namely, in salt, in sulphur, and in the liquid. In this three things all things stand, whether they are sensate or insensate … for in the same manner as God has spoken: 'we create the human being after our image.' So, too, you understand

---

[95] Weeks, "Introduction," in *Essential Theoretical Writings,* 16.
[96] Debus, *The Chemical Philosophy,* 80.
[97] Debus, *The Chemical Promise,* 8.
[98] Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time,* 144.
[99] William R. Newman, *Gehennical Fire: The Lives of George Starkey, an American Alchemist in the Scientific Revolution* (Chicago and London: University of Chicago Press, 2003), 107.
For a further explanation of the trinitarian aspect of the tria prima, see Pagel, *Paracelsus,* 104, footnote 271.

that in the same manner that the human being is created, so too, all creatures are created in the number of the Trinity, that is, in the number three."[100] From these passages we can conclude that Paracelsus extended the three primary principles beyond just the trinity of body, soul, and spirit, to that of the animal, mineral, and vegetable kingdom. In this he imparted a decidedly chemical description of nature alongside that of animate life, identifying mercury with the spirit, sulphur with the soul, and salt with the body.[101]

5.3 Legacy of the Sulphur-Mercury Theory

Debus, among other historians, has pointed out that sulphur and mercury were already commonly employed elements referenced in alchemical and Hellenistic texts on the origin of metals within the earth.[102] This theory purported that all metals were composed of different measures of a sophic sulphur and a sophic mercury, usually depicted as pneuma or spirits, which were volatile and granted color to some base metal.[103] What was original to Paracelsus' philosophy was his decision to add salt as the third principle asserting that all matter and organisms, not just metals and minerals, were composed from the three fundamental components of the *tria prima.*

Inherent to Paracelsus' refinement was the emphasis of salt, not meant as solid body of matter, but as an inborn principle which commanded material towards the solid state.[104] This newly embraced status of the primal substance was no longer confined to common salt, but elevated the element to cosmic dominance.[105] Throughout his writings, Paracelsus' reflections on his veritable alchemical and medicinal experiences were "captured by a wide range of salts, especially nitre (potassium nitrate), but also the

---

[100] Weeks, *Paracelsus: Speculative Theory and the Crisis of the Early Reformation*, 118. Also noted in Goodrick-Clarke, *Paracelsus. Essential Readings,* 316.
Andrew Weeks also notes this theological connection in one of Paracelsus' disputed late works, *De Imaginibus,* which further elucidated a tripartite parallel with reference to the human faculties: "das gemüt, der glaub und die imagination" are said to be both three and one ("es kompt eins aus dem andern") and are therefore comparable to "dem trinitato deo." Weeks, *Essential Theoretical Writings,* 300.
[101] Reijer Hooykaas, "Chemical Trichotomy Before Paracelsus?" in *Selected Studies in History of Science* (Coimbra: Por ordem da Universidade, 1983): 118; Weeks, *Paracelsus: Speculative Theory and the Crisis of the Early Reformation*, 115.
[102] Debus, *The English Paracelsians,* 27; Debus, *The Chemical Promise,* 28.
[103] Hooykaas, "Chemical Trichotomy Before Paracelsus?," 108.
[104] Pagel, *Paracelsus,* 88.
[105] Walter Pagel, *The Smiling Spleen: Paracelsianism in Storm and Stress.* (Basel: Karger, 1984), 7.

vitriols of copper, iron, and magnesium, as well as the diverse and biologically active salts generated by metals such as mercury, arsenic, antimony, and lead."[106]

Some historians, however, have questioned whether there were medieval precedents to the Paracelsian addition of salts and have contended that he was not the first to propose a three-component theory of matter. In the *Smiling Spleen*, Pagel gives examples of alchemical authors who exalted salt to the status of an operational force in nature. Among them were Arnold of Villanova (1240 – 1311) who described salt in his *Rosarium* as the 'occult secret of the wise and old', and Raymond Lull (1232 – 1316) who made salt the "'first' in that it enables sulphur and mercury to penetrate matter by virtue of its intrinsic soul-like fiery heat" and claimed that "Sal in rebus omnibus."[107] What is perplexing is that Pagel continues on in an attempt to provide evidence for this assertion, but does so by quoting scientists and philosophers who identify as Paracelsian yet unmistakably came after Paracelsus himself.[108]

Of particular note is the contention that other alchemists, who long preceded Paracelsus, accepted arsenic as a third principle and that in this way the sulphur-mercury theory of the composition of metals was developed into a trichotomy.[109] However, Reijer Hooykaas warns against drawing this conclusion stating that in these cases, "we should be careful, because the number three in this case is wholly fortuitous. Some alchemist extend theses three to four or even more 'spirits.'"[110] Even Pagel acknowledged this diversion contending that "it is also true that the *Latin Geber* speaks of the *Tria Principia* of metals, namely Sulphur, *Argentum Vivum* and Arsenic – but in this Arsenic occupied no position similar to that of *Sal* in the Paracelsian scheme."[111]

This discussion would be incomplete without a brief mention of the fabled Benedictine monk, Basilius Valentinus, a consummate vitalist motivated by both religious and medical determinants who allegedly lived during the fifteenth century. He produced a number of advanced alchemical and medical writings said to have contributed

---

[106] Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time,* 138.
[107] Pagel, *The Smiling Spleen,* 41.
[108] Ibid, 37 - 42. What Pagel does agree on is that Paracelsus was the first to incorporate salt as a principle in a universal cosmic synthesis; see *Paracelsus*, 357.
[109] Hooykaas, "Chemical Trichotomy Before Paracelsus?," 105.
[110] Ibid, 112.
[111] Pagel, "Paracelsus and the Neoplatonic and Gnostic Tradition," 154.

to the preparation of many compounds and of their application to medicine, including the ubiquitous employment of salt. Former sixteenth- and seventeenth-century scientists and philosophers accused Paracelsus of plagiarizing the works of Valentine. More modern scholarship, however, has concluded that the opposite is seemingly true and that the spurious authorship of the works of Valentine can be attributed to a chemist and salt-works owner named Johann Thölde, who came much later in the historical record and misappropriated his teachings and thoughts from Paracelsus.[112]

Other historians, notably Hooykaas, assert that there were only two principles prior to Paracelsus, not three.[113] Debus agrees that Paracelsus was the first to implement a chemical triad and that those who seek a chemical trichotomy in the literature prior to Paracelsus are mistaken.[114] Addressing a Stoic interpretation of Aristotelian matter theory consisting of passive and active elements as well as the allusion to a chemical triad of sulphur, mercury, and arsenic, these historians dismiss other medieval philosophers such as Gerber, Albertus Magnus, and Roger Bacon as having promoted a doctrine of three elements as a precursor to the Paracelian *tria prima.*[115]

Where Paracelsus differed from these older elemental theories was in his extension of sulphur and mercury as applicable to all objects in nature, unlike medieval alchemists who limited this dyad's role to metals alone in formal scholastic interpretation.[116] Instead, he emphasized the chemical role of these substances. As Pagel suggested, "The old theory was 'static,' whereas that of Paracelsus is 'dynamic'" (i.e. the principles are agents and the elements merely patients/receptacles).[117] Pagel further explored how the implementation and use of the three principles contributed to the origins of modern chemistry. He explained how Paracelsus used known chemical reactions to describe physiological processes and that "his theory of the Three Principles

[112] Hooykaas, "Chemical Trichotomy Before Paracelsus?," 105; Debus, *The Chemical Philosophy,* 94. Hooykaas, Debus, and Moran have written in their research further details contending the dubious identity of Basil Valentine and how the facts point to Johann Thölde as the author/creator of this fictional character.
[113] Hooykaas, "Chemical Trichotomy Before Paracelsus?," 105-106.
[114] Debus, *The English Paracelsians,* 45.
[115] Hooykaas, "Chemical Trichotomy Before Paracelsus?," 114-115; Debus, *The English Paracelsians,* 45.
[116] Hooykaas, "Chemical Trichotomy Before Paracelsus?," 117-118.
[117] Pagel, *Paracelsus,* 270.

and his study of metals and minerals including attempts at inorganic analysis (as laid down in his "Archidoxis") constitute the basis of systematic chemistry."[118]

Much of this dynamic characterization was made possible by his juxtaposition of salt as the third entity in a triumvirate that was operative in all realms of the micro- and macrocosms. This addition was original, and indeed, necessary to his active cosmic synthesis. Salt was given an exalted position as a prime principle that makes action in nature possible and was ultimately regarded by Paracelsus as superior rather than equal to sulphur and mercury. As the active solidifying principle in matter, it directed the formation and shape of bodies empowering them to penetrate matter.[119] Paracelsus stated that:

> "this can be summed up by saying that without salt there would be nothing tangible present. For example, it is from the salt that the diamond and iron receive their hardness; lead and alabaster their softness, and so forth. Every congelation, [every] coagulation is from the salt. For this reason, there is one *sal* in bones and another in the blood, and yet another in flesh, and another still in the brain, etc. For just as there are many *sulphura*, there are also many *salia*."[120]

He added that, "salts exist in a peculiar and most excellent nature, with more abundant properties than appear in other substances."[121]

Paracelsus' work the *Herbarius* (c. 1525), which historians believe may well precede the *Opus Paramirum*, contains no mention of the three principles, but includes several sections devoted to the discussion and description of a *Sal* which is said to provide consistency to other compounds preventing the forces of separation and degeneration. As such, salt is described by Paracelsus as a balsam fundamental for the sustainment of human life and other living beings, as well as for the preservation of edible provisions. Webster concludes that: "these early comments, although not conclusive, suggest that at an early stage in his scientific writing Theophrastus was beginning to attach particular importance to salts, mercury, and sulphur."[122]

---

[118] Ibid, 272, footnote 225.
[119] Ibid, 357.
[120] Paracelsus, "Paramirum," in *Essential Theoretical Writings,* 413.
[121] Paracelsus, "The Archidoxies of Theophrastus Paracelsus" in *The Hermetic and Alchemical Writings Vol II,* 13.
[122] Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time,* 140.

5.4 Conclusion

The Paracelsian theory of matter, and its notable inclusion of salt, marked the beginning of many philosophers and physicians adopting an iatrochemical view of the world. The Neoplatonic cosmology of Paracelsus ushered in the practice of searching for physical truth and an understanding of the universe through chemistry. This was more thoroughly realized in the works of his followers. Although there was confusion over the relationship of the three principles to the traditional elements, iatrochemists freely utilized both cosmological frameworks as they deemed suitable. Even so, due to their growing inclination towards demonstrable chemical operations, they wrote recurrently of the *tria prima* whose existence seemed to be verified by their experiments.[123]

The acknowledgment of Paracelsus as the one who first introduced a distinct three-principle theory of matter, and notably elevated the primary status of salt, should be heeded by historians in the search for answers pertaining to the questions of how and why aerial niter theories emerged during this time period. The following analysis of documented writings, timelines and events will reveal the importance of placing these developments and circumstances in historical context so as to see the connection between activities and modes of thought influential to the evolution of niter theories.

[123] Debus, *The Chemical Philosophy,* 79, 81.

Chapter 2: Gunpowder Technology and Its Cultural and Political Influence

1. Introduction

Before delving into the attributes of the *sal nitrum* theories of Paracelsus and his followers, it is important to briefly assess the broader cultural environment of this time period. The prevalent and continuous state of conflict throughout the sixteenth and seventeenth centuries brought forth significant changes in the conduct of war.[124] Operating as a driving force of encouragement to both professionals and practitioners, these events resulted in newly learned skills as well as technical discoveries and innovations. These prevailing events also functioned as a powerful vehicle for cultural transfer throughout Europe facilitating the dissemination of new intellectual and social currents. Frequently, wars and battlefields served as an inception point for emerging fields of study and scientific disciplines of the early modern period.[125]

Central among these challenges was the growing adoption of gunpowder weaponry by governments and military organizations. During this time Europe saw a transformation of feeble states rise to become political powers accompanied by militaries employing advanced technologies that broke from traditional modes of warfare. The violent destruction wrought by the new weaponry would be felt for centuries to come as monarchs and military leaders pushed the boundaries of their influence and probed the possibilities of this new technology. Gunpowder use elevated the already overwhelming battlefield experience by occasioning shock, fear, and destruction on an unprecedented level. And it was saltpeter, as a catalytic agent, that provided gunpowder with this explosive, deadly force.

The pursuit of this nitrate and its utilization as the principal ingredient in gunpowder showcases the social and cultural response to the changing nature of warfare, and the transformation of national economics and visions of state security.[126] A closer

---

[124] In his work, *The Military Revolution* (Cambridge, 1996), 1, Geoffrey Parker references a study conducted by J.S. Levy in which he calculated that prevalence of war in Europe in the years between 1500 and 1700 were "the most warlike in terms of the proportion of years of war underway (95 per cent), the frequency of war (nearly one every three years), and the average yearly duration, extent, and magnitude of war."

[125] Kelly DeVries, "Sites of Military Science and Technology," in *The Cambridge History of Science*, ed. Katharine Park & Lorraine Daston (Cambridge: Cambridge University Press, 2006), 307, 319.

[126] David Cressy has conducted impressive research on the economics of saltpeter production and its perceived role in national security in his recently published works. See "Saltpetre, State Security and

look at this 'commodity of empire'[127] poses a salient issue for historical inquiry, as saltpeter not only provided the state with destructive power, it also quickly became a vital, strategic, and economic resource that was thrust into the social conscience and gradually pervaded common affairs. Its influence was observed not only in political and economic discourse, but also in the religious, moral, artistic, and psychological rhetoric of the era. Although salt and nitrates were familiar provisions in the experiments and practices of natural philosophers and physicians throughout the sixteenth and seventeenth centuries, this deep cultural connection afforded the growing prominence and stature of saltpeter playing an important role in providing a framework that prompted intellectual speculation of new scientific and philosophical endeavors.

2. Origins of Gunpowder and Its Introduction to the West

2.1 Origins of Gunpowder

Early forms of gunpowder or "black powder" (used to denote the difference between the early configurations of gunpowder and chemical mixtures developed towards the end of the eighteenth century) were recognized and documented in Europe as early as the twelfth century. Perspectives concerning the discovery of the explosive propellant are greatly varied, but the prevailing consensus is that methods of making gunpowder first originated in China around 1044, during the Northern Song Dynasty (960 – 1127 A.D). In an elusive search for an elixir of immortality, Chinese alchemists discovered the explosive power of mixing saltpeter, sulfur, and dried honey to create what they called "fire drug."[128] Saltpeter, in its natural condition, was commonly found throughout China (the Arabs called saltpeter "snow from China") and was incorporated into various alchemical operations.[129]

Vexation in Early Modern England*," Past and Present* Vol. 212 (2011) and *Saltpeter: The Mother of Gunpowder* (Oxford: Oxford University Press, 2013).

[127] Brenda Buchanan, "Saltpeter: A Commodity of Empire," in *Gunpowder, Explosives and the State: A Technological History*, ed. Brenda J. Buchanan (Aldershot, England: Ashgate Publishing Limited, 2006).

[128] Jack Kelly, *Gunpowder: Alchemy, Bombards, and Pyrotechnics: The History of the Explosive that Changed the World* (New York: Basic Books, 2004), 21.

2.2 Introduction of Gunpowder to the West

In the succeeding two centuries, black powder mixtures were transported via trade routes through merchants and envoys making their way across central Asia and the Middle East through North Africa, eventually reaching Europe. The earliest surviving formula for gunpowder in Western literature is documented in the writings of the English natural philosopher Roger Bacon, whose *Epistola de secretis operibus artis et naturae, et de nullitate magiae* (Letter on the Secret Workings of Art and Nature, and on the Vanity of Magic) registers a low nitrate recipe believed to have been written sometime between 1248 and 1267. Bacon provided further descriptive details, recalling his experience with the experimental substance in his later *Opus majus* (c.1267): "Certain inventions disturb the hearing to such a degree if they are set off suddenly at night with sufficient skill, neither city nor army can endure them. No clap of thunder can compare with such noises. Some of them strike such terror to the sight that the thunders and lightnings of the clouds disturb it considerably less."[130]

Research has uncovered similar early gunpowder recipes in manuscripts composed by German natural philosopher Albertus Magnus (c. 1193–1280) in his *De mirabilibus mundi* (Concerning the Wonders of the World) and notably in the Latin work *Liber ignium ad comburendos hostes* (Book of Fires for the Burning of Enemies, c. 1300), which was a collection of incendiary weapons and pyrotechnical substances attributed to Marcus Graecus that contained four formulae for gunpowder. Several formulas employed mysterious anagramic codes, detailing mixtures and measurements of a substance that would grant god-like powers of thunder and "flying fire."[131] Yet it is important to distinguish that the instructions for these early gunpowder mixtures show that the objective was to project the power of a fiery or incendiary substance to burn the enemy — not to shoot him with a projectile or ball.[132]

---

[129] Hans Delbrück, *The Dawn of Modern Warfare: History of the Art of War, Volume IV,* trans. Walter J. Renfroe, Jr. (Lincoln: University of Nebraska Press, 1990), 23-24; Bert S. Hall, *Weapons and Warfare in Renaissance Europe* (Baltimore: The Johns Hopkins University Press, 1997), 41.
[130] Kelly DeVries, "Gunpowder and Early Gunpowder Weapons," in *Gunpowder: The History of an International Technology*, ed. Brenda J. Buchanan (Bath: Bath University Press, 1996), 123-24; Hall, *Weapons and Warfare in Renaissance Europe*, 43.
[131] DeVries, "Gunpowder and Early Gunpowder Weapons," 124; "Sites of Military Science and Technology," 307-308.
[132] Delbrück, *The Dawn of Modern Warfare,* 24, 27.

2.3 Securing Gunpowder Ingredients

The mixture that was eventually deemed most effective as a propellant force emerged towards the end of the thirteenth century and was comprised of three ingredients: sulphur, charcoal, and saltpeter. Sulphur (sometimes called brimstone) was being routinely imported from the volcanic regions in southern Italy and parts of Sicily up though the middle of the eighteenth century. It could also be attained domestically in England near mineral springs or copper mines. Wood for charcoal was readily available as production had become well-established during the Middle Ages as a consumer need of the metalworking industry. The best charcoal was usually obtained from soft wood procured in the Wealden provinces of Surrey and Kent, as well as areas of Essex. English powder makers preferred the thin branches of light, soft timber like alder, willow, and black dogwood. As gunpowder making advanced, craftsmen began to recommend employing different types of wood depending on the type of weapon, such as "willow for heavy guns and hazel twigs for hand guns."[133]

These ancillary ingredients in gunpowder were quite easy to come by, but sources of saltpeter were sparse and had to be obtained at great expense. As a primary agent in rapid combustion, saltpeter was considered the most essential component of gunpowder in terms of quantity and function. This fine, crystalline mineral occurs naturally as a waste product of bacteria caused by the oxidation of nitrogenous matter and its interaction with alkalis or earthly soils, such as potash or lime. The putrefaction and decay of organic substances, such as manure, rotting plants, and even the flesh of dead animals, results in the generation of ammonia which, in turn, is oxidized by bacteria to produce nitrate. These nitrate compounds usually develop with other available metals such as calcium, sodium, or potassium. Calcium nitrates and sodium nitrates were potentially used in early mixtures of gunpowder, but due to several disadvantages they were typically converted to the more favored potassium nitrate (KNO_3), which was deemed more effective. Environments most suited for the generation of saltpeter are

[133] Cressy, *Saltpeter: The Mother of Gunpowder,* 129; Frank, *Harvey and the Oxford Physiologists,* 12; Wayne Cocroft, *Dangerous Energy: The Archaeology of Gunpowder and Military Explosives Manufacture (*Swondon: English Heritage, 2000), 2; Seymour H. Mauskopf, "Chemistry in the Arsenal: State Regulation and Scientific Methodology of Gunpowder in Eighteenth-Century England and France" in *The Heirs of*

situated in warmer countries, such as China and parts of South Asia, where conditions of high temperatures and humidity combined with rainy and dry seasons promote the rapid decomposition of material. Consequently, large deposits of natural nitrates were not commonly found in European climates.[134]

2.4 Mining for Saltpeter

Procurement and manufacture of saltpeter as a viable military resource posed a perplexing challenge to state and military officials who struggled to understand the elemental nature and properties of this ambiguous mineral. Unaware of the biological process of nitrification, "government advisers wondered whether saltpetre was a substance to be mined or grown."[135] In her research, Kelley Devris elaborates on a group of ambitious intellectuals, labeled "courtly engineers" by modern historians, who sought to profit from the growing proliferation of gunpowder weapons. The intellectualization of warfare and of the technology behind it, was undertaken as a subject of interest by both gentlemen amateurs and professional authorities who endeavored to attain credibility and professional standing through their published works and discussion of military arts. There were a number of engineers who attempted to gain patronage through proposed scientific and technological innovations intended to facilitate the mass cultivation and harvest of saltpeter; many of which embraced the new invention of the printing press to propagate their ideas.[136]

The first description of the mining of saltpeter in Western literature appears in a 1405 work on military technology called *Bellifortis* by Conrad Kyeser.[137] However, the most popular accounts of the first attempts to cultivate and manufacture saltpeter by means of nitre-beds or plantations can be found in three technical treatises published

---

Archimedes: Science and the Art of War through the Age of Enlightenment, edited by Brett D. Steele, Tamera Dorland (Cambridge, Mass: The MIT Press, 2005), 302.

[134] For more in depth information on the natural formation of saltpeter see: Jack Kelly, *Gunpowder: Alchemy, Bombards, and Pyrotechnics: The History of the Explosive that Changed the World*; Brenda J. Buchanan, "Saltpeter: A Commodity of Empire," 68-69; and James Frey, "The Indian Saltpeter Trade, the Military Revolution, and the Rise of Britain as a Global Superpower," *Historian* Vol. 71 Issue 3 (2009): 510-11.

[135] Cressy, "Saltpeter, State Security and Vexation," 75.

[136] DeVries, "Sites of Military Science and Technology," 317.

[137] A.R. Williams, "The Production of Saltpetre in the Middle Ages." *Ambix* Vol. 22, Part 2 (1975), 125.

during the sixteenth century. In 1540 Vannoccio Biringuccio (1480 – 1539)[138] published *De la pirotechnia*, a renowned work on metallurgy, minerals, mining, and combustible materials in which he devoted a chapter to the nature of saltpeter and how to extract it, as well as methods for making gunpowder.[139] Other scholars and professionals writing on the subject of saltpeter and gunpowder later heavily plagiarized his text. Among these was Georgius Agricola's (1494 – 1555) *De Re Metallica* (1556) which also provided detailed descriptions about the properties and characteristics of saltpeter as well as some of the earliest methods of procurement.[140] A treatise on ores and assaying describing "the right and most perfect way of the whole work of saltpeter" was written by Lazarus Ercker (1528 – 1594), a superintendent of the mines in Bohemia for Emperor Rudolph II. His work, published in 1574, describes where one can find earth abundant in saltpeter and how taking a sample of water and evaporating it in a copper dish can determine the saltpeter content.[141] It is to be noted that the authors of these treatises provide explanations that strictly entail the extraction of saltpeter only from natural sources and do not explain how to cultivate nitrous earth artificially.

2.5 Corning of Gunpowder

In addition to the issue of attainment and purification of these ingredients, there was the common problem of how to combine them in perfect proportions to produce the "best" powder. This usually meant the fastest burning and hence ballistically most powerful.[142] Gunpowder firearms evolved rapidly up until 1700, but the technology and manufacture of gunpowder itself remained relatively unchanged throughout the sixteenth and seventeenth centuries. The notable exception was the development of the advanced process of the corning of gunpowder.

---

[138] Vanoccio Biringuccio was a wealthy Italian metallurgist who resided in Siena. It is interesting to note that most of his wealth and status was achieved by his control of a monopoly in the manufacture of saltpeter. Bruce Moran, *Distilling Knowledge: Alchemy, Chemistry, and the Scientific Revolution*, (Cambridge: Harvard University Press, 2005), 39.
[139] Vannoccio Biringuccio, *The Pirotechnia of Vannoccio Biringuccio,* ed. Cyril Stanley Smith and Martha Teach Gnudi (Cambridge, Mass: The MIT Press, 1959), 405-416.
[140] Georgius Agricola, *De Re Metallica*, trans. Herbert Clark Hoover. (New York: Dover Publications, Inc., 1950), 560-565; see also Cressy, Saltpeter: *The Mother of Gunpowder,* 13-14.
[141] Partington, *A History of Greek Fire and Gunpowder*, 317; David Cressy. "Saltpeter, State Security and Vexation," 79.

This technical innovation came in response to the desire to improve the ballistic performance of existing powder as well as to make it more fit for logistical objectives and storage. Part of the problem lay at the heart of gunpowder itself. Saltpeter used during this period was not pure potassium nitrate. Most European deposits of nitrates contained other compounds that yielded a mixture of nitrates and other salts, in particular calcium and magnesium. Gunpowder containing calcium nitrate was excessively hygroscopic. This tendency to absorb water from the atmosphere quickly spoiled the gunpowder mixture which is why medieval gunners exerted great effort to "keeping their powder dry."[143] Early methods to alleviate this problem came in the form of baking the gunpowder into balls or large loaves called *Knollen* which reduced the exposure of air due to a smaller surface area, or by adding wood ashes rich in potassium carbonate in an effort to purify saltpeter through a form of ion-substitution.[144]

However, by improving the purity of the potassium nitrate in gunpowder to repeal dampness, the powder makers inadvertently created a more dangerous problem by making the refined powder more potent. The strength of the new powder created a critical situation for soldiers who faced the threat of their weapons exploding in their hands if the shot was loaded incorrectly – an incident that took the life of Scottish King James II. Powder makers set to work to develop a strategy that would moderate the strength of this corned powder. It was eventually discovered that the secret lay in the production method. Once powder makers determined and established control over the powder's grain size, shape, and surface texture, the more appropriately "shaped grains could be produced in sizes nearly optimal for the gun they were destined to serve, and with controlled-grained corning came the possibility of tailoring gunpowders to different classes of guns."[145] Manufacturing gunpowder grains with uniform size and smoother surfaces allowed for more control over the speed of combustion and made high nitrate powders safer to employ. Previously, military gunpowder came in only one grain size.

---

[142] Mauskopf, "Chemistry in the Arsenal," 294.
[143] Bert S. Hall, "The Corning of Gunpowder and the Development of Firearms in the Renaissance," in *Gunpowder: The History of an International Technology* (Claverton Down, Bath: Bath University Press, 1996), 91.
[144] Hall, "The Corning of Gunpowder," 89, 91-2; see also *Weapons and Warfare in Renaissance Europe*, 103.
[145] Hall, *Weapons and Warfare in Renaissance Europe*, 101.

A man by the name of William Congreve introduced the construction of two grain-sizes: "a small-grained powder for small arms and cannon priming, and a larger-grained powder for cannon."[146] The mixture proportion for military gunpowder was only established after many experiments over an extensive period of time. For a comparative analysis, the French produced six different powders with varying ratios of ingredients for different weaponry,[147] while the English set their proportions at roughly 75 parts saltpeter, 10 parts sulphur, and 15 parts charcoal, per 100 parts of gunpowder for all firearms and artillery, with the difference only lying in the size of the grains.[148]

Despite this considerable change in the preparation of gunpowder, it appeared to have had little effect on its production, transportation, storage, and availability. The relatively stagnant procurement and manufacture of this vital military resource seemed to be exacerbated by the perplexity surrounding the vitalizing qualities and "spirit" of its principal ingredient. The widespread adoption of gunpowder weapons in Elizabethan and early Stuart England, in conjunction with the English bias towards mixtures containing a high saltpeter content, became an impetus in an age of frequent war to secure a chemical understanding of saltpeter as well as to devise methods for its organic generation and harvesting.[149]

3. Rise of the Nation State and Gunpowder Wars

3.1 Introduction

Although the first appearance of firearms in the West remains a matter of continuing debate, documentary evidence provides accounts of their common acceptance and utilization by the early decades of the fourteenth century. From the first recorded employment of cannons in 1331 at the German siege of Cividale in Friuli, Italy, to the

---

[146] Mauskopf, "Chemistry in the Arsenal," 304.

[147] Partington, *A History of Greek Fire and Gunpowder*, 325. French gunpowder ratios of saltpeter, sulphur, and charcoal:

	Cannon	Musket	Pistol
Strong	100:25:25	100:18:20	100:12:15
Weak	100:20:24	100:15:18	100:10:18

[148] Partington, *A History of Greek Fire and Gunpowder*, 325. See also DeVries, "Sites of Military Science and Technology," 310 and Delbrück, *The Dawn of Modern Warfare,* 29.

[149] Hall, *Weapons and Warfare in Renaissance Europe*, 43; Cressy, *Saltpeter: The Mother of Gunpowder,* 3, 48-120.

campaign of Edward III in 1346 at the Battle of Crécy where hand held firearms were first utilized by both English and French armies, to the uprising revolts in the Papal States in the 1350s, gunpowder weapons gained public popularity and were recognized widely by European societies and governments.[150]

However, it was military engagements in the first quarter of the sixteenth century that confirmed gunpowder weapons would command the strategy and tactics of future battlefields.[151] By this time, descriptions of the powerful stench and efficiency of gunpowder on the battlefield began to saturate historical accounts and narratives told by returning soldiers. All sieges organized after the middle of the fifteenth century were conducted with an array of iron artillery cannons which easily felled stone walls and fortifications under the destructive force of incessant barrage as was the case with Monte San Giovanni as well as the once thought impregnable walls of Constantinople in 1453.[152] The harquebus, a muzzle-loaded weapon and forerunner of the rifle, also rose to prominence in 1503 at the Battle of Cerignola, one of the first battles to be won by hand held firearms. Naval guns also began to appear on the decks of ships imposing a formidable opponent in anti-ship warfare as well as in conducting bombardment of coastal fortifications. As England faced ever-growing complexities on the battlefield, reigning monarchies quickly learned "that no modern state could thrive without handguns and artillery."[153]

3.2. Nation States and Gunpowder Technology

The military origins of the early modern European state depended on the effective use of this new technology and the involvement of an authority with the means to acquire and sustain it on a commensurate scale.[154] The new mechanical weapons being deployed were very costly, and as such, they necessarily found their greatest admiration and utilization in the hands of royalty and government officials. The growing nature and

---

[150] Hall, *Weapons and Warfare in Renaissance Europe*, 43- 45.
[151] Richard A. Preston et al, *Men in Arms: A History of Warfare and its Interrelationships with Western Society* (New York: Frederick A. Praeger, 1956). 90.
[152] DeVries, "Gunpowder and Early Gunpowder Weapons," 121.
[153] Cressy, "Saltpeter, State Security and Vexation," 83.
[154] Peter Wilson, "European Warfare 1450-1815," in *War in the Early Modern World*, ed. Jeremy Black (London: Routledge, 2005), 180.

intensity of gunpowder conflicts fostered an expansion in the general scale of warfare, encouraging states to exercise more control in an effort to manage the new demands placed upon their infrastructure.[155] Henry VIII[156] and Elizabeth I, in efforts to become militarily self-sufficient, went to great lengths to develop and control the gunpowder industry with an emphasis on protecting domestic supplies of saltpeter.[157] Military historians have argued that: "it was the alliance of gunpowder with the other resources of the national state that was to produce the recognizable beginnings of modern warfare in the sixteenth century."[158]

Examples of this were played out during the Tudor and early Stuart governments, which showcased how the utilization and refinement of mobile cannons and individual firearms forged new methods and means of waging conventional wars. Military supply trains began to see an increase in the load of gunpowder as an essential asset, while commanders began to experiment with different techniques that incorporated firearms into traditional military tactics and formations. The Privy Council ordinance acknowledged that the longbow was no longer a suitable weapon and adopted the harquebus in 1595 as the primary weapon for the English militia. European armies began to re-organize their soldiers into massive formations, fashioning tactical units of up to 3,000 men that came to dominate battlefields. The primary role of cavalry as a shock unit declined rapidly and became instead an important means for reconnaissance. The Thirty

---

[155] Ibid, 177.

[156] With an appreciation for the destructive force of gunpowder, Henry VIII set the precedence for succeeding English monarchs by devoting extensive resources and capital to the construction of garrisons, fortresses, and ships. With an ambitious taste for war, he waged battle on three separate occasions between 1512 – 1546 against the French and the Scottish. He readily employed gunpowder technology during his invasion of France in 1513 with a force that "carried 510 tons of gunpowder, and its siege guns consumed up to thirty-two tons a day. In 1540, he established the avant-garde Deal Castle capable of mounting 200 cannons followed in later years by a chain of other coastal forts. The assault on Boulogne in 1544 featured a siege train of 250 guns that bombarded the town with 100,000 rounds of heavy shot." Cressy, "Saltpeter, State Security and Vexation", 83.

[157] Richard Winship Stewart, *The English Ordnance Office 1585-1625: A Case Study in Bureaucracy* (Woodbridge: The Boydell Press, 1996), 6-7, 80.
One of these nuances was the organization of the English office of the ordnance which had been established in the early 1400s, but was subjected to an escalated role and level of activity becoming its own identity with a break from the master of the armory in 1485. Located in the Tower of London, the ordnance office was responsible for the purchase of English firearms during the rule of the Tudor and Stuart monarchs. As a safety measure, the more dangerous materials, including saltpeter, gunpowder, camphor, and other flammables, were guarded inside the Tower precincts.

[158] Preston, *Men In Arms,* 85.

Years' War (1618 – 1648) saw the establishment of the first permanent and modern army as well as an attempt in the standardization of gunpowder weapons, to include paper cartridges for all musketeers and the adoption of three standard sizes for cannons.[159] The beginnings of modern military drill were also introduced and were instrumental in executing more effective control of troops during battle as well as positively impacted the discipline and morale of the men. By the beginning of the 1700s, European governments had instituted organizational reforms and took an aggressive role in soliciting scientific societies to perform ballistic experiments that helped to illustrate and enhance the understanding of gunpowder propulsion. The effectiveness of gunpowder stocks rose rapidly in a few short decades and reached a climax during the Seven Years' War (1756 – 1763). As new technology and scientific applications outpaced developing military tactics, increased firepower after the 1740s caused horrific slaughter and major battles produced thousands and, at times, tens of thousands of casualties.[160]

So profound were the changes seen in political strategy as well as military tactics and technology in response to these idiosyncratic state of affairs, that a number of historians have referred to this period as a "military revolution." It is beyond the scope of this thesis to examine in depth or make assertions regarding the accuracy of these "revolutionary" claims. But it is worth briefly noting the validity and importance of this scholarly debate. Originally put forth by Michael Roberts in his inaugural lecture at Queen's University in 1955 and developed further in his published work, *The Military Revolution, 1560–1660,* Robert's idea maintained that transformation in the conduct of war between 1560 and 1660 as a result of the widespread use of gunpowder technology was central to the escalation of the scale and cost of warfare, which facilitated the monopolization of military force by the state as only governmental resources and wealth could cover the expense of the new weaponry and their logistical requirements.[161]

---

[159] Ibid., 92-99.

[160] Frey, "The Indian Saltpeter Trade," 546-47.
During the Seven Years War at the battle of Zorndorf in 1758, casualties of the defeated Russian Army numbered 21,000 soldiers – approximately 50 percent of their army. Fredrick the Great won a pyrrhic victory at the cost of 13,500 men, or 37.5 percent of his total force. Max Boot, *War Made New: Technology, Warfare, and the Course of History, 1500 to Today* (New York: Gotham Books, 2006), 87.

[161] Roberts presented his notion of a "Revolution in Military Affairs" during a 1955 inaugural lecture at Queen's University, Belfast in a paper titled "The Military Revolution: 1560-1660."

Roberts focused highly on the adoption of portable firearms as well as the reforms of high profile military leaders and their influence "on society at large through such indirect mechanisms as taxation (to support armies) and bureaucratic administration (to supply and direct them)."[162] Military historian, Geoffery Parker, extended the scope of this 'revolution' to encompass the period 1500 – 1800. He also deviated somewhat from Robert's claims arguing "the military revolution was not just one transformation within a long series of changes in the military art (albeit a critical one) but the total transformation of warfare marking the differences between the Middle Ages and the modern world."[163] Other scholars have promoted their own components of this idea to include the growth of standing armies, organization of administrative and financial accounts, rise of state bureaucracies, the development of the *trace italienne* fortifications, and projection of a global European military power. There are a handful of historians, such as Jermey Black, Kelly DeVries, Michael Duffy, and Bert Hall, who rebuff this label of 'revolutionary,' challenging the various perceived metrics of change and assertions of a technologically driven transformation of warfare. Even so, most contend that there was a generalized adjustment in the constitutional and societal nature of warfare that swept Europe throughout this time period either as the result of, or in reaction to, the acceptance and employment of gunpowder technology. Indeed, even "Hume, Macaulay, Carlyle, and Adam Smith all approved the notion that gunpowder was the agent of evolutionary changes that marked the end of the Middle Ages and the beginnings of modern history."[164]

3.3 Gunpowder Wars and National Security

As warring conflicts became more prevalent, historical records show frequent requests for sizable quantities of gunpowder to be delivered to military units or directly to

---

[162] Hall, *Weapons and Warfare in Renaissance Europe*, 202-203.
[163] Ibid, 203. Geoffery Parker, *The Military Revolution: Military Innovation and the Rise of the West, 1500-1800* (Cambridge: Cambridge University Press, 1996).
[164] Jones, *The Art of War in the Western World*, 2; J.R. Hale, "Gunpowder and the Renaissance: An Essay in the History of Ideas," in *From the Renaissance to the Counter-Reformation*, ed. Charles H. Carter (New York: Radom House, Inc, 1965), 113.
For a list of of works pertaining to discussions surrounding the Military Revolution thesis, see Clifford Rogers, *The Military Revolution Debate* (Boulder, CO: Westview Press, 1995) and Kelly DeVries, *A Cumulative Bibliography of Medieval Military History and Technology* (Leiden: E. J. Brill, 2002), 578–87.

a site of potential conflict. It was also noted that on many occasions, the ingredients to manufacture gunpowder were separately delivered and then mixed on site.[165] By the second quarter of the fourteenth century, English public records show progressively large amounts of gunpowder material being purchased for military consumption.[166] In fact, gunpowder became the single largest expense of the Ordnance Office budget with approximately £4,800 spent per year between 1593 – 1625 accounting for 37 percent of total ordnance expenditures.[167] In this unpredictable time of incessant war, the English government became concerned by the lack and shortage of gunpowder, and particularly its major ingredient, saltpeter. By 1636, reacting to the demands made by military leaders and the threat of potential conflict, King Charles I, "out of his princely care of the safety of his kingdoms," issued a proclamation demanding that all gunpowder "be seized [for] his Majesty's use."[168] Restrictions were placed on the trade and retail of gunpowder provisions by common merchants, and complete control of its manufacture was given to workers contracted by the government so "that there shall be always ready in his Majesty's magazines or store-houses, such competent proportions of good and serviceable gunpowder."[169]

As gunpowder supplies became exhausted at alarmingly rates, English monarchies, as well as other European states, quickly grasped that their military strength was subject to the procurement of saltpeter. In 1652, Parliament issued *An Act for making Salt-Petre* to ensure that England's citizens understood "how necessary it is, in this time of War, to have a constant and certain supply of Gunpowder for the supply of the Armies and Navies imployed (sic) for the defense and safety of this

---

[165] DeVries, "Gunpowder and Early Gunpowder Weapons," 126, 128. For example: 31 lbs of gunpowder was sent to the site of the siege of Saint-Sauveur-le-Vincomte between 1370-1375, Pierre Gilles sent weapons and 166 lbs of gunpowder to Harfleur in 1383 to deter a potential attack, in 1385 King Charles VI of France sent a supply of powder to Flanders suspecting an English attack, Charles V decreed in 1414 that a store of powder be gathered in anticipation of the oncoming attack of Henry V, Philip the Good was commissioned to deliver a shipment of gunpowder with bombards and other arms to the siege of Melun in 1420, and in 1465 Louis XI demanded that saltpeter and other artillery powders be readied so that he could campaign against the duke of Burgundy.

[166] Williams, "The Production of Saltpetre in the Middle Ages", 125.; Seymour H. Mauskopf, "Chemistry in the Arsenal," 294.

[167] Stewart, *The English Ordnance Office*, 88.

[168] *By the King: A Proclamation Prohibiting the Importation of Forraine Gun-powder, and that His Majesties Subjects may be constantly supplied out of His Majesty's Store-houses*, (London, 1636).

[169] Ibid.

Commonwealth."[170] Quickly depleting their reserves of gunpowder, the national security of the state lay vulnerable to conquest, and without the principle ingredient of saltpeter there could be no firepower munitions.[171] By 1689, King William III and Queen Mary II in the first year of their reign found it necessary to prohibit the exportation of saltpeter from the British isles with the declaration that "as Salt Petre is the Principal Material of Which Gunpowder is made, which is that kind of Ammunition wherein the strength of War conflicts" it was therefore "absolutely necessary for the Defense and Safety of this Realm."[172]

By the fifteenth century, the English gunpowder industry became heavily dependent on imported saltpeter from 'parts beyond the seas' to supplement its needs. Trade of such a vital resource was conditional to embargoes, interceptions, logistical adversity, and temperamental foreign pricing which, frequently, exasperated the intended recipient.[173] Ruling authorities and state officials therefore sought to supplement their saltpeter stores through the encouragement of domestic production methods, as well as by imposing their governmental authority at the behest of the crown to acquire sources of local saltpeter.

4. The State and Saltpeter

4.1 Manufacture and Production of Saltpeter

The earliest reference of the manufacture of saltpeter in England comes from a document dated 1490, commissioning a clerk of the ordnance, John Stok, "to provide houses, land, vessels, wood, coals, etc. for the manufacture of saltpeter for the King's ordnance."[174] Later, Henry VIII's appreciation for gunpowder munitions stimulated a national awareness of the element and he urged his subjects to locate and mine saltpeter. In 1515 he hired a gentlemen by the name of Hans Wolf "to go from shire to shire to find a place where there is stuff to make saltpeter of."[175] Appointed as one of the king's

[170] *An Act for making Salt-Petre* (London, 1652).
[171] Cressy, "Saltpeter, State Security and Vexation", 73.
[172] *By the King and Queen: A Proclamation to Prohibit the Exportation of Salt Petre* (London, 25 July 1689).
[173] Cressy. "Saltpeter, State Security and Vexation," 85.
[174] Williams, "The Production of Saltpetre in the Middle Ages," 126.
[175] Ibid.

powder makers at the Tower of London, Wolf was instructed to patrol the English countryside to determine "'where he and his laborers shall labor, dig, or break in any ground' to make saltpeter."[176] However, local skills and production level were assumed to have remained inadequate, for in 1561 a government effort was made to establish a more permanent saltpeter source in England. Queen Elizabeth granted two merchants, Phillip Cockeram and John Barnes, a license for ten years to produce saltpeter with a method obtained from a German foreigner by the name of Gerard Honrick who was granted £300 to explain to them the secret of saltpeter making. A copy of this agreement and Honrick's recipe for the production of artificial nitre-beds was printed in the State Papers (and was noted again in 1641).[177]

Despite these efforts, domestic knowledge of saltpeter production proved unsatisfactory in England throughout the fifteenth and sixteenth centuries and was not deemed a commercially viable industry. It was not until the middle of the sixteenth century that the special cultivation of "nitre-beds" or "saltpeter plantations," in which nitrates were artificially produced and harvested on a larger scale, are cited in historical sources.[178] Methods of producing saltpeter via these means were published in the works of Italian and German mineralogists, Biringuccio, Agricola, and Ercker. It is important to note that all three authors referenced the use of various manures in the process. However, they failed to mention the employment of adding urine to the soil —a procedure that was described in both Kyeser's and Honrick's recipes. A.R. Williams, whose research on the early production of saltpeter stands as a principal source of information on this subject, noted that this was a significant perception as it turns out that "piles of dung alone will not produce any saltpeter; the addition of urine is necessary as well."[179] Ercker's treatise discussed the extraction of "wall saltpeter" which hinted at the necessity of urine being present for the generation of the niter. In the Middle Ages, walls were constructed utilizing a cheap method of mixing earth and manure for building

[176] Buchanan, "Saltpeter: A Commodity of Empire," 70.
[177] Ibid. Also in Williams, "The Production of Saltpetre in the Middle Ages," 126. A reprinting of Honrick's recipe can also be found in Williams' article.
[178] DeVries, "Sites of Military Science and Technology," 311.
[179] Williams, "The Production of Saltpetre in the Middle Ages," 127. See Williams' work for a more analytical and chemically detailed overview of the production of saltpeter during the fifteenth and sixteenth centuries.

material which would harden as it dried. If one of these walls was utilized for the structure of a stable or latrine, it is natural that it would be exposed to urine, which would absorb and accumulate in the dried earth mixture over time creating conditions for a perfect niter-bed. People eventually came to realize that it was the elements present in these walls that produced saltpeter since it was observed that nitrates were not found typically on walls of stone or brick. But the walls that were made of cheaper material would constitute barns, stables, and outhouses and, being intermittently saturated with urine, would naturally form deposits of nitrous earth.[180] The addition of urine is significant as it is the source of the nitrate by means of furnishing urea that in turn hydrolyses to ammonia. The presence of the other two materials, manure and earth, is necessary as they provided the bacteria required to oxidize the ammonia to nitrate. Therefore it is not surprising that when studying Honrick's recipe we see ingredients such as lime which was responsible for the production of calcium carbonate, urine which served as the source of ammonium ions, dung which contributed some bacteria, and earth which allocated nitrifying bacteria and increased the available surface area.[181]

4.2 Saltpetremen

The Privy Council, who served as a body of advisors to England's monarchy, had received frequent offers from various entrepreneurs over the years proposing cheaper and easier methods of producing saltpeter, but no alternative had matched the efficiency of simply digging it naturally out of the ground. Consequently, the government set about collecting saltpeter in social and public dwellings under the auspices of national interests. The procurement of the organic material was entrusted to individuals called saltpetremen who, beginning in the 1550s, were responsible for seeking out deposits of nitrous-rich earth and delivering contracted amounts back to the Ordnance Office in London.[182] Licensed by the Crown, these saltpetremen would travel to an inhabited location and set up shop near an available source of water and firewood. With a central processing center established, teams of workmen would unleash themselves into towns and dwellings in

[180] Williams, "The Production of Saltpetre in the Middle Ages," 127-28.
[181] Ibid, 131.
[182] Cressy, *Saltpeter: The Mother of Gunpowder,* 76-87.

search of traces of saltpeter deposits. Testing the earth for saltpeter relied on a provincial technique of assaying the soil by placing a slight amount of dirt on the tip of the tongue to assess its bitterness. The more bitter the earth, the likelier it contained a high nitrate content conducive for finding saltpeter. The workmen would then claim the spot and set to work by digging up large openings of earth about six to eight feet in depth and loading it into containers for relocation to be processed at a central established point before being transferred to London.[183] These acts quickly roused resentment in the local people as farmers lost valuable manure that was meant to be used for fertilizer in their fields, and soap makers were deprived of wood for ashes that went instead to the refinement of the excavated earth.[184]

Saltpetremen had developed a dubious reputation (they often accepted bribes on behalf of the land owners whose fields and buildings they spared).[185] After completing their baneful task of gathering nitrogenous waste, the saltpetermen were obligated to refill the holes they had just dug with a replacement mixture of manure, dirt, and liquid waste so that in a period of another five to six years, the ground would yield another harvest of saltpeter. But the saltpetermen often snubbed this requirement leaving yawning holes of overturned earth and a trail of damaged structures and disturbed animals.[186] Their dismissal of property rights and lack of concern for those whose dwellings they invaded began to reach serious measures. Public records have documented such incidences as when a group of contracted saltpetermen defiled a parish church by pulling up benches and seats so that they could dig twenty cart loads of saltpeter from the earth leaving "the ground unlevelled so as the parishioners are not able to perform their duties of divine service [and] could not conveniently bury their dead."[187] In 1630, a report was filed in Gloucestershire condemning insidious acts committed by the saltpetermen and their digging "in all places without distinction, as in parlours, bed-

[183] Richard Winship Stewart, *The English Ordnance Office 1585-1625: A Case Study in Bureaucracy* (Woodbridge: The Boydell Press, 1996), 80-81; Cressy, *Saltpeter: The Mother of Gunpowder,* 76-87.
[184] Buchanan, "Saltpeter: A Commodity of Empire," 71; Cressy, *Saltpeter: The Mother of Gunpowder,* 102-104.
[185] Cressy, "Saltpeter, State Security and Vexation", 89.
[186] Stewart, *The English Ordnance Office,* 81.
[187] Public Records Office, SP 16/165/38; *Commons Debates*, 1628, ed. Johnson et al., ii, 41, 387 as referenced in Cressy, "Saltpeter, State Security and Vexation," 94.

chambers, threshing floors, malting houses and shops … [they] have digged in churches, hallowed chapels and churchyards, tearing men's bones and ashes out of their graves to make gunpowder of." Without regard to civility or privacy, they brought their work into the homes of English residents and placed "their tubs by bedsides of the old and impotent, sick and diseased, of women with their children sucking at their breasts, and even of women in childbed and of sick persons lying on the deathbeds."[188] Country residents and local farmers attempted to resist the worker's efforts to invade their lands and farms through such methods as invoking the death of the queen in 1603 as invalidating the patents that granted the saltpetermen permission to dig on their land, as well as going so far as to pave their barns and other areas used to house animals with boards, gravel, sand, and even brick so as to thwart the growth of saltpeter.[189]

Resentment and dislike for the saltpetermen reached a climax during the warring reign of Charles I as the demand for gunpowder grew. In 1626, he issued a proclamation to his subjects asking for help to procure the best quality saltpeter in the interest of the kingdom's "infinite security" and requested that all persons save the urine of their families and their animals to be collected by those in the business of powder making.[190] But as war loomed on the horizon, the government did not abate in their demand and dependency to procure gunpowder materials. Parliament issued an ordinance in 1644 (and again in 1652) for the "making of salt-peter within the kingdom of England and Dominion of Wales for the preservation and safety of the kingdom*"* in which they sanctioned state agents "to search and dig for saltpetre in all pigeon-houses, stables, and all other outhouses, yards, and places likely to afford that earth."[191] The justification for these intense measures was always correlated with several references to the "concerns

[188] Public Records Office, SP 16/165/38; Gloucestershire Archives, D7115/1, 38 as referenced in Cressy, "Saltpeter, State Security and Vexation," 95.
[189] Stewart, *The English Ordnance Office,* 83.
[190] *By the King: A proclamation for the Better Making of Saltpeter within this Kingdome*, (London, 2 Jan 1627); see also J.R. Partington. *A History of Greek Fire and Gunpowder*, 319. See also David Cressy. "Saltpeter, State Security and Vexation," 78.
[191] *An ordinance of the Lords and Commons assembled in Parliament for the making of salt-peter within the kingdom of England and Dominion of Wales for the preservation and safety of the kingdom,* (London, 5 Apr 1644); see also *An Act for making Salt-Petre* (London, 1652), 1929.

[of] the public safety."[192] Nonetheless, to assuage the complaints and protests against the saltpetremen and to establish a formal account of how the removal of saltpeter was to occur, Parliment established rules and parameters that the saltpetermen were to comply with to include beginning their work "from half an hour after Sun-rising in the morning, till an hour before Sun-setting" and "[to repair] any damage which shall be done by them."[193] The saltpetermen remained under the public's critical eye as they continued this intrusive method throughout England until the 1660s.

5. Science, Society, and Gunpowder

5.1 Introduction

The cultural and intellectual fervor of the Renaissance began to reach its peak in the fifteenth century. Renewed interest in classical antiquity, in concert with the humanist reform, stimulated philosophical dissension concerning authoritative sources and man's potential for acquiring knowledge. Theories incorporating gunpowder weapons were no exception to this and played an important role in many social and scholarly discussions as:

> "the success of the new weapon was a key argument for those who felt that man could discover things unknown to the ancients, and that his intelligence should not be directed only to the rediscovery of ancient wisdom but to advancing, increment by increment, on what he could find out for himself about the physical world."[194]

Emerging developments in war became matters of public discussion that pervaded both the imagination as well as the practical affairs of society. This awareness was greatly accelerated by the advancement of the printing press and the publication of text and images that ensured that this appreciation evolved well beyond those places where wars were actually fought. Gunpowder had thus become, not only a pivotal component in warfare, but also an agent in the intellectual and sociopolitical revolutions of the time.

5.2 The Influence of Gunpowder on European Culture and Society

---

[192] *An ordinance of the Lords and Commons assembled in Parliament for the making of salt-peter* (London 1644).
[193] Ibid.
[194] Hale, "Gunpowder and the Renaissance," 128.

British historian and acclaimed scholar of the Renaissance, J.R. Hale, explored this cultural dichotomy surrounding the emerging views of gunpowder in society. His research helps paint a colorful depiction of how this technological transition was fundamentally reshaping social behavior. Those that supported firearms maintained that they were necessary for the state and essential for the defense of one's country. Guns provided a guarantee of order, protected an individual and his household, and, importantly, also safeguarded merchants allowing trade to flourish. Hale has noted that the strongest argument in defense of gunpowder weapons was that man was not created with fangs and claws akin to animals, but God had provided him with the intellect to invent weapons to arm himself against the perils of nature and his enemies. This argument was defended by both secular and religious writers alike including English explorer, Sir Walter Raleigh, who declared that the strength of man, "with art and wisdom, [may] strive to excel our enemies in those points wherein man is excellent over other creatures." Rev. J. Davenport echoed this sentiment in a sermon to the Artillery Company of London affirming that man "can take… from within the bowels of the earth, what may serve for his use and benefit."[195] As gunpowder weapons became a representation of war itself, we see in the metaphors of Renaissance drama the gun replacing the sword as a symbol of virility. "In this device," Hale argued, "the projectile symbolized not the horror of war but a praiseworthy moral quality, energy held in check until the critical moment, vigor tempered by a wise restraint."[196]

Nonetheless, there were also many detractors who detested the introduction of the new weapon. Such views were centered on the belief that gunpowder and firearms were pernicious instruments of the devil; they were held in chivalrous contempt as the weapons of cowards who caused great suffering. Martin Luther and Sebastian Münster, decried harquebuses and cannon as creations of the devil. Even Biringuccio, who became well-known for his technical work on metallurgy and military arts, declared that "a great and incomparable speculation is whether the discovery of compounding the powder used for guns came to its first inventor from the demons or by chance."[197] This

[195] Hale, "Gunpowder and the Renaissance," 117-118.
[196] Ibid, 132-133.
[197] Ibid, 119.

correlation became commonplace in society and was realized in dramatic effect though vivid illustrations and animated narratives. As early as 1489, the title page of a Basel edition of Saint Augustine's *De Civitate Dei (City of God)* included an illustration that depicted two walled cities: one wall was protected by heavenly angels, the other by a cohort of devils, one of which was armed with a gun. A most prominent example of this devilish identification in English literature can be found in book six of Milton's *Paradise Lost*, as the angel Raphael relates to Adam how Satan developed an "instrument to plague the Sons of men" by showing them how to make gunpowder.[198]

Despite these negative associations, firearms and cannons became a source of fascination for many Europeans, and opposition to them was in part subdued as they became increasingly popular. These cultural processes were stimulated through both direct and indirect influences, affected in part by the dynamic cultural and intellectual transformation of the Renaissance, along with the burgeoning power and political pursuits of early modern European states. The technical achievement of gunpowder weapons and the grandeur of their strength and power eventually became a source of both national and professional pride. With respect to national and civic politics, the cannon became recognized as a symbol of status and distinction during the course of the Renaissance.[199]

5.3 Science and Gunpowder Technology in Early Modern Europe

Captivated by this cultural attraction, philosophers and practitioners of the sciences during this period equally sought to resolve concerns of both national and social importance. Many conducted original investigations in order to advance the procurement and manufacture of military resources through the application of their own observations and experiments. In the process of carrying out these intellectual endeavors, DeVries points out, "They not only used traditional chemical and metallurgical terminology and philosophy in their discussions but also added lengthy discussions of tactics, drilling,

[198] Milton, Paradise Lost, VI, Lines 469-557 as annotated in Debus, "The Poet's Nitre," 250-51; Hale, "Gunpowder and the Renaissance," 118-120; and Delbrück, *The Dawn of Modern Warfare,* 31.
[199] Hale, "Gunpowder and the Renaissance," 130-131.

training, and gunfire employing mathematics and geometry."[200] The growing scientific enthusiasm of pre-Enlightenment societies contributed to embracing gunpowder weapons for the properties they exhibited relevant to ballistics and the laws of motion, and what the new technology unveiled about metallurgy and the chemistry of explosives. In his famous work, *Novum Organum*, Francis Bacon was so awed by the capabilities of gunpowder that he recommended it as an industry for study and declared that, in conjunction with the printing press and the magnet, gunpowder had "changed the appearance and state of the whole world" and that "no empire, no sect, no star seems to have exerted greater power and influence on human affairs than these mechanical discoveries."[201]

Attainment of saltpeter and an understanding of its essential volatile properties in gunpowder necessarily became a focus of scientific concern. The scholarship of historians Robert Frank and David Cressy depict the interest of individuals of scientific renown who, by the mid-1600's, had turned their attention to the perplexing nature of saltpeter and the needs of the state. This preoccupation was particularly cultivated by associates of the Hartlib Circle who expended a great deal of innovative resourcefulness in their endeavors to find ways of "generating" saltpeter for gunpowder in order to supply the short reserve of the Commonwealth.[202] The physician, Benjamin Worsley (1618 – 1673), who was granted a patent for a new way of extracting saltpeter from dung in 1646, devised a saltpeter enterprise in which he conceptualized "a system of workhouses for the poor … where all their 'easing' of excrement and urine could be collected and processed." Thus the masses would become "both producers and processors in a centralized urine economy" helping to save the state money as well as ensure its own self-reliance.[203]

Contemporaries of Worsley, Robert Boyle (1627 – 1691) and Samuel Hartlib (1600 – 1662), also ruminated on strategies for the artificial production of large quantities

---

[200] DeVries, "Sites of Military Science and Technology," 319.
[201] Sir Francis Bacon, *Novum Organum,* ed. Joseph Devey, M.A. (New York: P.F. Collier, 1902), 105; Hale, "Gunpowder and the Renaissance," 129.
[202] Robert G. Frank, *Harvey and the Oxford Physiologists: Scientific Ideas and Social Interaction (*Berkeley: University of California Press, 1981), 121.
[203] Frank, *Harvey and the Oxford Physiologists,* 121.

of commercial saltpeter in order to furnish the state with munitions. This in part was due to the fact that Boyle greatly resented the aggressive and impertinent digging of "those undermining two-legged moles we call saltpetermen" who targeted his pigeon house at his family estate in Stalbridge, Dorset and whom he had to bribe in order that they would spare digging up his cellar and stables.[204] However, Boyle's interest in saltpeter also extended to the laboratory. As saltpeter became more frequently used as a reagent in laboratory experiments, he believed that the properties exhibited by niter could help exemplify the scientific utility of the corpuscular philosophy. This he eventually outlined in a series of five tracts which he published in 1661 under the title *Certain physiological essays*. In a particular tract entitled, "A Physico-Chymical Essay, Containing an Experiment with some Considerations touching the differing Parts and Reintegration of Salt-Petre," Boyle depicted a framework in which he explained the properties of saltpeter using atoms and corpuscles and stressed its philosophical nature as a subject that "may well deserve our serious enquiries."[205]

Boyle's practical application of saltpeter and ideas of nitro-sulphureous particles were later expounded on by other seventeenth-century partisans seeking to confirm a system of chemical elements. Although Boyle himself was dismissive of the Paracelisan principles, other philosophers readily adopted both the functional utilization and philosophical characteristics of niter to advance their views. "Thus did practical process for 'generating' niter, real and illusory, merge imperceptibly into the assumption of an aerial nitrous substance."[206] As we shall see in the next chapter, it was saltpeter's practical application in gunpowder as well as its philosophical nature that helped the substance become a central component in multiple theories of emerging scientific disciplines.

---

[204] Cressy, *Saltpeter: The Mother of Gunpowder,* 129; Frank, *Harvey and the Oxford Physiologists,* 121.
[205] Cressy, *Saltpeter: The Mother of Gunpowder,* 10; Frank, *Harvey and the Oxford Physiologists,* 121-122.
[206] Frank, *Harvey and the Oxford Physiologists,* 122. For a more in-depth description of Boyle's interest and experiments with niter, to include how his studies were utilized by subsequent authors, see Frank, *Harvey and the Oxford Physiologists,*117-139, and Debus, *The Chemical Philosophy*, 473-491.

Chapter 3: Paracelsus, Gunpowder, and the Origins of a Universal Salt

1. Introduction

Living and traveling in an era marked by the dramatic shift in the conduct of war spurred by the rapid adoption of firearms and gunpowder weapons, Paracelsus was well aware of the importance accorded to saltpeter as the key ingredient in gunpowder. The attention paid to and the resources demanded by ruling governments to institute military action incorporating this new technology no doubt drove saltpeter to the forefront of awareness of alchemists and philosophers. Although certain properties of saltpeter had already been known for some time – such as its effectiveness in preserving meat and its potency as a fertilizer – growing military need was the catalyst that drove it to an exalted status in alchemy. This maturing interest in salt and niter compounds can be traced through numerous commentaries and alchemical works written between the warring years of European turmoil throughout the sixteenth and seventeenth centuries that demonstrated the developing changes in thought among iatrochemists.

What was the unifying thread behind the propagation of these niter theories? Unlike the references to saltpeter that were discussed in the previous chapter, these new progressive salt theories were not to be found in medieval texts. They were embraced in the early modern system of alchemical theory, "as a result of its increasing vitalism."[207] Paracelsus' decision to add salt as a fundamental principle in his three-principle theory was a reflection of this trend towards the acceptance of a vitalistic universe and the influence brought on by the power of gunpowder technology.

Paracelsus was certainly not the first to acknowledge salt as an ingredient necessary for life. However, the origins of a philosophical *sal nitrum* theory with universal application ultimately lie in the Paracelsian corpus which expounded the vivifying and remarkable powers of salt as a vital, animate force and not simply as a mineral compound. Pagel summarizes Paracelsus' reverence for salt by explaining that:

> "he saw its significance in its 'forces' – he treated of '*Salz und seinen Kraften'*. Essential for man it corrects the digestive 'cooking'. Still more importantly it is a 'balsam', albeit of 'earthly' nature. As such it is active everywhere, in blood, in vegetation, in metal, stone, fungus, wood. No chemical reaction can dispense with it,

[207] Newman, *Gehennical Fire,* 87.

> as is evident 'through the alkali which are all salts and are produced by all things'. More actively spirit of salt is a powerful chemical agent of 'heroic' – corrosive – energy….At a higher level it assumes the dignity of a 'tinging spirit of life' comparable to an 'invisible celestial fire and air' that is enclosed in the body. It has in itself 'life' that is a spirit which can be distilled away leaving a 'dead earth' *(tot erdrich*) behind."[208]

This chapter is an attempt to unify the historical material of the preceding two chapters by bridging the studies of Neoplatonic alchemical tradition and the evolving European cultural and military transformation centered on early gunpowder technology. The intent of this juxtaposition is to show how these influential variables shaped the beliefs, perceptions, and intellectual thought of Paracelsus in the formative period of his early travels and studies, which led him to develop his elaborate system of universal connection founded on a particular synthesis of vitalistic ontologies resulting in the notion of a universal *sal* principle as a source of life and energy. Thus, building upon the insightful scholarship of other historians of science, in particular the efforts of Debus, Guerlac, Waite, and Pagel, we can trace the influences of Paracelsus' distinct interest in a philosophical salt and establish the conceptual premises of its origin. In doing so, we can identify a starting point for *sal nitrum* theories within early modern natural history and medicine.

2. Paracelsus and Salt Reconsidered

2.1 Paracelsus' Travels and Experience in the Army

Following the early education of his childhood provided by his father, as well as tutelage under several religious leaders to include four bishops and one abbot, Paracelsus decided to try his hand in the greater world so that he might gather the kind of knowledge that only comes from experience. From the early age of fourteen he became a "vagrant journeyman-scholar" throughout Europe, parts of the Middle East, and some areas of near East Asia.[209] Travel became essential to Paracelsus' professional practice. He insisted

[208] Pagel, *The Smiling Spleen,* 38.
[209] Pagel, *Paracelsus,* 8, 10, 13-14. See also Stoddart, *The Life of Paracelsus Theophrastus Von Hohenheim 1493-1541*, 61-80 for her detailed research and account of Paracelsus' travels as well as Arthur Edward Waite, *Lives of Alchemystical Philosophers, Based on Materials Collected in 1815 (*London: George Redway, York Street, Covent Garden, 1888), 139.

that: "A doctor must be a traveller because he must inquire of the world. Experiment is not sufficient. Experience must verify what can be accepted or note accepted. Knowledge is experience.[210] Visiting several European universities, Paracelsus was assumed to have obtained his bachelor's degree in Vienna, between 1509 – 1511, and possibly obtained an M.D. degree at the University of Ferrara in Italy between 1513 and 1516.[211]

After the year 1516, his wonderings led him to England where he received news about the recent outbreak of war in the Netherlands. In an effort to expand his own academic proficiency, Paracelsus seized upon the opportunity and made his way to Scandinavia where he took up a post with the Dutch army as a military surgeon. Although information pertaining to his service under Christian II, King of Denmark between 1518 and 1521 is limited and even contentious, he was believed to have been sent to Stockholm where he administered cures and treatments to both Danish and Swedish wounded soldiers.[212] During this time, he also explored the mines of Sweden in order to study the conditions and environment to which miners were subjected, which he later captured in his work *Diseases of Miners*. Paracelsus also explored the earthly contents of the mines, identifying iron, copper, lead, alum, sulphur, silver, gold, and of special significance, zinc.[213]

Following his time in Scandinavia, Paracelsus made his way to Italy where he took up employment as a military surgeon in the Venetian army under the authority of Emperor Charles V beginning in 1522. As mentioned in the previous chapter, the campaigns of Italy were marked by a distinct transformation in military organization and tactics and these engagements were defined as one of the central conflicts of the sixteenth century due to the exceptional appreciation of gunpowder weaponry during this period. There is speculation that Paracelsus was present at the battle of La Bicocca in 1522,

---

[210] Anna M. Stoddart, *The Life of Paracelsus Theophrastus Von Hohenheim 1493-1541* (London, John Murray, 1911), 63.
[211] Pagel, *Paracelsus,*10; Phillip Ball, *The Devil's Doctor: Paracelsus and the World of Renaissance Magic and Science* (New York: Farrar, Straus, and Giroux, 2006), 69-71. As Webster points out, this is speculation based on hints provided by Paracelsus. Little of this is certain and is debated among historians.
[212] Pagel, *Paracelsus,* 13-14; Stoddart, *The Life of Paracelsus Theophrastus Von Hohenheim,* 67-68; Ball, *The Devil's Doctor*, 71-74.
[213] Stoddart, *The Life of Paracelsus Theophrastus Von Hohenheim,* 68.

which was one of the first conflicts to be won by harquebus fire from entrenchments.[214] Through first-hand experience, these substantial changes and their consequences surely made an impression on the young Paracelsus and his philosophies and practices as a physician. In his most famous work published during his lifetime, *Die grossen Wundarzney* (1536) or *The Great Surgery*, he recounted his narrow escape on the last boat out of Rhodes following its siege by the Turks under Suleiman II who claimed it for the Ottoman Empire.[215] He also recounts his observations of various wounds and aliments of the soldiers who fought in these battles as well as annotated his thoughts and reflections on gunpowder and its effects (more on this below).

Historians generally place Paracelsus' practice as an army surgeon and involvement in military campaigns between the years 1517 to 1524 spanning the continent throughout Holland, Scandinavia, Prussia, Tartary, and other countries under Venetian influence.[216] This experience is notable in our consideration of his interest in developing the concept of a vital salt as it was most likely one of the primary catalysts leading him to consider the particular properties of saltpeter in both his medicinal and philosophical theories after noting the formidable and powerful effects of gunpowder firearms and explosives. Indeed, it was from this point forward following his military exploits that Paracelsus became known for his unconventional cures and began to develop his critique of common practices of traditional medicine. Upon his return to Germany in 1526, he took up a university professorship in Basel where he lectured on physics, medicine, and surgery. "There, in his lectures, he professed internal medicine, denounced the antiquated systems of Galen and other authorities, and began his instruction by burning the works of these masters in a brass pan with sulphur and niter. He created innumerable enemies by his arrogance and his innovations, but the value of his mineral medicines was proved by the cures which he performed."[217]

---

[214] Preston et al, *Men in Arms,* 90.
[215] Debus, *The English Paracelsians,* 15; Stoddart, *The Life of Paracelsus Theophrastus Von Hohenheim,* 71.
[216] Pagel, *Paracelsus,* 14; Debus, *The English Paracelsians,* 15.
[217] Waite, Arthur Edward, ed, "Preface to the English Translation," in *The Hermetic and Alchemical Writings of Aureolus Philippus Theophrastus Bombast, of Hohenheim, called Paracelsus the Great* Vol I (Berkeley, Calif: Shambhala, 1976), xiii.

2.2 Ancient Concepts of a Vital Air

The affirmation that there were vital life-sustaining properties in the air was a common notion among Renaissance philosophers and had become a subject for further exploration in the early modern reformation of science and medicine. It was self-evident that all terrestrial beings required air to live, and this conception was captured in the ancient notion of *pneuma*.[218] Air was thought to be the medium through which the heavens transmitted animate virtues that contributed to generation, growth, and nutriment.[219] Exemplified through the image of a *spiritus vitae*, this notion professed nature as a whole that included healing powers which were the same powers that enlivened the body.[220] It should come as no surprise that Paracelsus confirmed these ancient views of a vital air and to recall that his search for invisible spirits regulating the actions and characteristics of visible bodies was a cornerstone of his natural philosophy.[221]

The importance of the *spiritus vitae,* or spirit of life, was frequently addressed in works such as *De Natura hominis libri duo* or *Two Books on the Nature of Man* in which Paracelsus describes this spiritual force as an omnipresent entity in the vital collective whole of nature. The *spiritus vitae* could be found throughout the stars and within heavenly influences "like an invisible celestial vapour." This was in direct opposition to the Galenists who believed that the organs of the human body were regulated by various and distinct corporeal spirits. Instead, Paracelsus maintained that "the Spirit of Life is the spirit that moves in all parts of the body and in all of them is one and the same, it is the highest power of life from which all members live."[222]

We may conclude, then, that a spirited air was, according to Paracelsus, necessary for combustion and respiration. Moreover, he maintained that these vital properties were generated from a starry emanation or a heavenly fire that he contrasted with common

---

[218] Allen G. Debus, "The Paracelsian Aerial Niter," *Isis* 55, no. 1 (March 1964): 44.
[219] Ibid, 50.
[220] Weeks, *Paracelsus: Speculative Theory and the Crisis of the Early Reformation*, 109.
[221] Debus, "The Paracelsian Aerial Niter," 44.
[222] Peter J. Forshaw, "Morbo spirituali medicina spiritualis convenit": Paracelsus, Madness, and Spirits," in *Aisthetics of the Spirits: Spirits in Early Modern Science, Religion, Literature and Music*, ed. Steffen Schneider (Göttingen: V&R Press, 2015), 291-292.

terrestrial fire.[223] Debus stresses that this reference to stars is a salient point as Paracelsus believed these cosmic figures to be predominantly sulphureous while others were principally nitrous in composition. These astral emanations were universal agents of influence on mankind and represented a dominant channel between the macrocosm and microcosm. All motion, activity, and form in the both the upper and lower atmosphere were held to depend upon these airy, volatile principles or a heavenly fire, the essential ingredient being a vital Sulphur which, in time, Paracelsus came to refer to as aerial niter or saltpeter.[224]

Unlike its corresponding earthly salt, Pagel explains that in the Paracelsian corpus, a fiery spirit varyingly indicated as "saltpeter," "aerial niter," or "nitrous salt," received "its life-giving virtue, its *natura vivificans*, from the spirit of the world. It comes to us through the air. Originally, however, it derives from a nitrous exhalation of the earth, a terrestrial salt, that joins the universal spirit equally through the air."[225] That Paracelsus believed this salt to be spiritual in nature and vital to life cannot be doubted as he, himself, stated that: "the Life of man is nothing other than an astral Balsam or a Balsamic impression, a heavenly and invisible fire, an included air and a tinging spirit of salt."[226]

As was common with other substances in alchemy, the term niter came to encompass a wide variety of other salts besides potassium nitrate and was described as a substance possessing both mystical and chemical connotations.[227] His belief in the universal capacity and application of niter substances was due to the: "many virtues [that are] hid in the use of salt … Virtues peculiar to salt are found in no other substance."[228] However, among these nitrous compounds, it was saltpeter most of all that Paracelsus specified as having significant, mystical overtones. In *De meteoris*, Paracelsus gave the names spirit of salt and saltpeter to the same substance.[229] This of course was primarily

---

[223] Allen G. Debus, "The Aerial Niter in the Sixteenth and Early Seventeenth Centuries," *Actes du Dixième Congrès International d'Histoire des Sciences,* Vol. II (Paris, 1964): 835.
[224] Debus, *The Chemical Philosophy,* 57, 78; also in "The Paracelsian Aerial Niter," 45.
[225] Pagel, *The Smiling Spleen,* 39.
[226] Paracelsus, *De natura rerumnin* op. cit., vol. 1, p. 889. as cited in Debus, "The Paracelsian Aerial Niter," 45.
[227] Debus, "The Paracelsian Aerial Niter," 46.
[228] Paracelsus, *The Hermetic and Alchemical Writings Vol I,* 261-262.
[229] Debus, "The Paracelsian Aerial Niter," 47, footnote 21.

due to saltpeter's role as an explosive agent in gunpowder which set it apart from other salts, for when used in this capacity, saltpeter "acquires another spirit, a different nature and condition."[230]

Before exploring further the transition of saltpeter from a physical element to a philosophical explanatory scheme (or cosmology), I believe it is necessary to determine at what point during his studies Paracelsus sanctioned salt as a supreme universal agent and the third fundamental principle in the *tria prima.* In addressing this question, it will help put into context a timeframe of historical circumstances in order to establish a conceptual understanding of salt philosophies and the origins in the belief of an aerial niter and its correlation with the rise in gunpowder weaponry. It is my intent to also challenge some specific assumptions and conclusions drawn by a number of modern historians with regard to Paracelsus' first claim to niter theories and his conception and employment of a vital salt spirit.

2.3 Paracelsus' Archidoxis and First Mention of the "Three Principles"

In his pioneering essay, *Archidoxis of Magic,* Paracelsus examined the mysteries of nature and the natural magic of divine creation. This composition was a principal work that is believed to be the first summary of his early preoccupation with alchemical and natural-philosophical ideologies. Sherlock asserted, "from a chemical point of view the most important single work of Paracelsus is the *Archidoxis*."[231] His iconoclastic vision as written in this work cultivated the beginnings of a decidedly chemical approach to the descriptions of metals, planets, astrology, alchemy, and the use of chemically made cures.

It is in the *Archidoxis* that we see Paracelsus' first rejection of the traditional interpretation of the four Aristotialan elements and his effort to put forth a modified understanding of their role in nature.[232] Historians of science who have written on the subject of Paracelsus' distinction between his three chosen principles and the traditional

[230] Paracelsus, *The Hermetic and Alchemical Writings Vol I,* 263.
[231] Sherlock, "The Chemical Work of Paracelsus," 43. Andrew Weeks noted that even though Sudhoff classified the *Archidoxis Magicae* as spurious, he argued that the document displays magical images and conforms extensively to Paracelsus' authentic work. Weeks, *Essential Theoretical Writings,* 884.
[232] Pagel, *Paracelsus,* 98.

four elements, claim that although he explored an alternative analysis of the time-honored Aristotelian system, the mention of his three-principle theory did not surface until his later works. This belief is held by both supporters and critics of Paracelsus alike, including scholars such as Newman, Sherlock, Daniels, and even Debus and Pagel.[233] For example, Sherlock, in his exposition of Paracelsus' influence on the science of chemistry, declared that "throughout the *Archidoxis* the generally received teaching concerning the four elements is taken for granted, and there is no mention of the Paracelsian doctrine of the three principles."[234] Pagel likewise assertd "the *Archidoxis* treats of the elements of the ancients and finds no place for the three principles, sulphur, salt, mercury, which appear, however, in the other treatises side by side with the ancient elements."[235]

Despite this common belief in the absence of the three principles in the *Archidoxis*, a closer examination of Paracelsus' composition reveals that the philosopher-physician in fact *did* articulate a distinct, albeit brief, mention of his doctrine of *Sal, Sulphur,* and *Mercurius* in his theoretical work.[236] Furthermore, he lays claim to the affirmation that he is the first to propose this specific three-principle theory. The first occurrence of the three principles referenced as the fundamental components of all matter is found in Chapter III under the subheading, "*The Preparation of the* Sal circulatum, OR, *Circulated Salt,"* where Paracelsus described the relationship between water and the three principles:

> In our other books we have sufficiently shewn and made clear that the true element is water, or the sea, as if the true mother of all metals**,** *and from its primal essence it received the sperm of the three principles, of which none before me has made any mention, only they built up their principles from sulphur and mercury, neglecting all mention of the third principle, that is to say, of salt which lies in the sea.* But, having been taught by experience, I have in my other books touched upon the fact that the

[233] For further examples of other historians' research and publications that claim there was no mention of the three principles in *Archidoxis*, see the following: Daniel, "Invisible Wombs," 132; Debus, *The Chemical Philosophy,* 57-58, footnote 139; Newman, "From Alchemy to 'Chymistry,'" 505; Andrew Weeks, ed. *Essential Theoretical Writings,* 300, footnote e.
[234] Sherlock, "The Chemical Work of Paracelsus," 45.
[235] Pagel, *Paracelsus,* 86.
[236] This specific work of Paracelsus has been translated into English from the Geneva folio Latin edition (1658) by A. W. Waite and J. H. Oxen into two volumes. It is from these two translations that I quote.

first entity or quintessence of the element of water is the centre of metals and minerals.[237]

This essential feature in the writing of Paracelsus, it appears up to this point, has gone unnoticed by scholars in their dialogue of Paracelsian matter theory.[238] How this detail has been overlooked remains a mystery as the following examples will demonstrate that Paracelsus distinctly identifies salt, sulphur, and mercury as the three prime elements in the *Archidoxis* and cites all three under a singular identification referring to them collectively as the "three principles" and "three essences." The awareness of the above passage and the following quotations are important for establishing a historical timeframe and contemplating situational circumstances that influenced Paracelsus to consider the addition of salt as the third prime in his tripartite theory of matter.

---

[237] Emphasis *mine*. Paracelsus, "The Tenth Book of the Archidoxis," in *His Archidoxis: Comprised In Ten Books: Disclosing the Genuine Way of Making Quintessences, Arcanums, Magisteries, Elixirs, &c: Together with His Books of Renovation & Restauration, of the Tincture of the Philsophers, of the Manual of the Philosophical Medicinal Stone, of the Virtues of the Members, of the Three Principles, and Finally His Seven Books of the Degrees and Compositions, of Receipts and Natural Things, trans.* J. H. Oxon (London,1660), 146 and *The Hermetic and Alchemical Writings VII,* 87.
Paulo A Porto is the closest scholar whom I have come across that references this section in the *Archidoxis*. However, he only speaks of Paracelsus' "circulated salt" and does not mention his three-principle theory. See Paulo Alves Porto, "Summus atque felicissimus salium": The Medical Relevance of the Liquor alkahest," *Bulletin of the History of Medicine,* Volume 76, Number 1 (Spring 2002): 12.

[238] A subtle, yet ongoing, debate among historians of science who focus on the chemical heritage of the Renaissance and the Scientific Revolution is over the origins of an aerial niter theory and which historical figure is most influential for its development and propagation. The crux of this historical contention lies in the various interpretive perspectives of an authoritative metaphysical niter. As such, in trying to trace the source of these ideas, other historians have assigned credit for the development and circulation of more definitive niter theories to those philosophers and alchemists labeled as Paracelsus' followers. The presumptions imbedded in these claims all assume a Paracelsian influence, yet they clearly do not substantiate an in depth familiarity of the Paracelsian corpus and therefore fall short of acknowledging the level of detail that an original universal salt principle theory was developed and utilized by Paracelsus to account for natural phenomena at every level in the cosmos.

My intent here is not to digress into a comparative analysis of these scholars' works, but to inject into this discourse the preceding evidence examining the hitherto unaccounted commentary in the *Archidoxis* of Paracelsus' self-proclamation as the *first* to present salt as a third principle of matter which he did based on his "experience," and the innate properties and virtues he thus ascribed to salt substances. I submit that a renewed evaluation of the relationship between the origin of niter theories and their popularization among natural philosophers of the late sixteenth and seventeenth centuries, to include their correlation to the observational effects of gunpowder, would benefit from closer scrutiny of the manuscript variants of Paracelsus' seminal works the *Archidoxis* and *Grossen Wundarznei.* This assessment should also include the consideration of his Basel lectures and how they were received and re-circulated by his students. A comparative analysis of these texts placed in their historical context of early sixteenth-century Modern Europe is necessary for developing a deeper comprehension of the initial formation of the chymical architecture of Paracelsus and his universal salt principle.

2.4 The Universal Agency of Salt

With regard to the above quotation, it is in the *Archidoxis* that we see the beginnings of salt as a cosmic agent in Paracelsus' writings, circumscribed within the sphere of alchemical vitalism and medicinal practice, that would come to form the cornerstone of niter theories and salt chymistry in various disciplines of natural philosophy. The theological as well as the medicinal and nature-oriented commentary of the *Archidoxis* confirmed that these niter or salt essences were rooted in nature for the benefit of life endowed by the Creator. It appears, however, that Paracelsus' insistence on the spiritualization of salt began to form well before he articulated a three-principle theory in the *Archidoxis*. As Webster has noted, in the physician's earlier works such as the *Herbarius*, dated around 1525, he devoted whole sections to this vital element, "which is described as a balsam necessary for the life of humans and other living beings, as well as for the preservation of food materials. In its dissolved form, in body fluids, salt actively supported life; in its precipitated form it strengthened the tissues of plants and animals. As an indication of its importance, Paracelsus argues, God provided reserves of salt in abundance."[239]

Similarly, the elevated status of salt is echoed in the early pages of the *Archidoxis*. Paracelsus referenced both the physical and spiritual versatility of niter substances claiming, "salts exist in a peculiar and most excellent nature, with more abundant properties than appear in other substances."[240] Preceding his statements concerning the three prime principles, he penned a section titled, "*Of the* Elixir *of* Salt; *by the Virtues of which, the Body is Conserved",* where he explained that:

> There is no lesse power and virtue in *Salt,* then in *Balsame,* whereof we have spoken; and that for this reason, because *Flesh* is preserved by *Salt* from putrefaction for many dayes, years, and a long time. And that, sundry wayes, and by one way more then by another. By the same *Basis* and *Rule* will it be possible to Conserve and Preserve the body; Not that we advise the Use of *Salt* in such a manner as tis used in dead *flesh* but tis necessary to make thence-from the *Elixir* of *Salt,* which doth materially penetrate the Spirit of Life, so, that it lives by the Salt, even as salted Flesh; for this *Elixir* is so subtile, that it may be compared to the Spirit of Life.[241]

[239] Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time,* 140.
[240] Paracelsus, "The Second and Third Book of the Archidoxis," in *Archidoxis*, 19. Also stated in Paracelsus, *The Hermetic and Alchemical Writings Vol II,* 13.
[241] Paracelsus, "The Eighth Book of the Archidoxis," in *Archidoxis,* 120.

It is clear that Paracelsus sees salt far beyond just its physical form. Some have claimed that he drew his inspiration from biblical readings. But this assumption is merely a misplaced appeal to his steadfast religious beliefs. Although salt does figure as an instrument of metaphorical imagery in the Bible, its character is attributed only to its common form as a mineral substance precious for its culinary and purification qualities, as a unit of ceremonial offering, or its economic value (i.e. uses only in physical form). An illustration of salt embodying any spiritual or mystical properties is notably absent.[242]

Mention of the "three principles" or "three essences" also arise in various occurrences throughout the second volume of the *Archidoxis.* Here salt is referenced more as a fundamental constituent of nature along with sulphur and mercury. Through these explanations, the alchemist-philosopher is emboldened in his attempts to establish the superiority of his three-principle system with regard to their function and relationship to all created matter. These spheres of application apply to metals, celestial bodies, medicinal cures, and treatments of men:

> Moreover this as so may be accompted of as a kind of Restauration when a metall is naturally made out of Salt, Sulphur and Mercury: This perfection being accomplisht, are brought into a perfect metal, this metal may again easily return into its three first Principles, so that is Salt, sulphur and Mercury may again be made apparent, as they were at the first Generation thereof, insomuch that the metalline Essence may wholly passe away, and it be no more a metal. Thus may it also happen, *viz.* that the matter of the three Principles may return into a metal.[243]

> Every Generated or begotten thing, and every thing produced from its Elements, is assigned to three; *viz* to *Salt, Sulphur,* and *Mercury:* out of these three is a Conjunction made, which Constituteth one body and united Essence. As to what

[242] Paracelsus was an astute scholar and interpreter of Christian Biblical teachings which greatly influenced his philosophy towards nature and his medical practice (for further literature on Paracelsus' religious convictions and inspiration, see Dane Daniel's works *Paracelsus' "Astronomia Magna": Bible-Based Science and the Religious Roots of the Scientific Revolution* and "Invisible Wombs; Rethinking Paracelsus's Concept of Body and Matter.") Although it is most likely Paracelsus referenced the works of William Tyndale and his English translations of biblical texts from Hebrew and Greek, an examination of the King James Bible that followed shortly after these translations reveals over 50 verses that directly mention salt. However, as stated, all of these references allude to the physical state of the mineral and do not refer or allude to any spiritual properties.

[243] Paracelsus, "A Book of Renovation and Restauration, By Theophrastus a Philosopher and Phisician of Germany called Paracelsus the Great," in *Archidoxis,* 2.

> appertains here to the Body, that is not spoken of, but the Internality onely of the body.[244]
>
> Besides, whatsoever is of *Sulphur, Mercury,* and *Salt,* fall within the compass of both *Natures, viz. hot* and *cold,* by reason of the three Principles.[245]

It appears that Paracelsus intended to explicate his complete theory of sulphur, mercury, and salt early on in his manuscripts. However, as Sherlock acutely pointed out, "in each book of the *Archidoxis* there is a steady deterioration in quality as it proceeds, and that each book is of less value as a whole than the one which preceded it."[246] This observation regrettably applies to the physician's exposition of his theory of matter. For instance, we find an unfinished section in Chapter III of the fifth book of the second volume with the description " *Of the three first Essences, out of which a thing Generated is composed."*[247] Despite the lack of any detailed content, the conclusion can be drawn that Paracelsus had given serious thought and consideration to his three-principle theory by the time he sat down to write the compositions that were assembled into the *Archidoxis*.

2.5 Establishing a Timeline for the Writings of the Archdidoxis

Of particular importance for this analysis, is the establishment of the time period in which Paracelsus developed and wrote down these natural-philosophical ideologies. Weeks has addressed this chronology in the footnotes of his translation of Paracelsus' writings noting that while most of the physician's theories were recorded after his time in Basel, there are some manuscripts whose dates are unclear, but are thematically precursory to Paracelsus' published works after 1530. Among these writings we can include the books that became the *Archidoxis* and his tracts on natural spring waters.[248]

---

[244] Paracelsus, "Theophrastus of Hohenheim, of the Virtues of the Members: The Fifth Book. Of the four Elements how they are defended.," in *Archidoxis,* 79-80.
[245] Paracelsus, "The First Booke of the Degrees and Compositions of Receipts and Natural Things," in *Archidoxis,* 107.
[246] Sherlock, "The Chemical Work of Paracelsus," 57.
[247] Paracelsus, "Theophrastus of Hohenheim, of the Virtues of the Members: The Fifth Book. Of the four Elements how they are defended," in *Archidoxis,* 79.
[248] Weeks, *Essential Theoretical Writings,* 78, footnote a. Weeks also presented his argument that Paracelsus' alchemical and natural philosophical works such as *Archidoxis* were pre-Basel in the publication Udo Benzenhöfer, "Zur Archidoxis-Schrift des P.," in *Nova Acta Paracelsica* N.F. 19 (2005):

Sudoff has designated the origin of the *Archidoxis* writings to the period around 1525 – 1526.[249] Despite an official publication date of 1569, historians believe that many of Paracelsus' lectures delivered to his students during his academic professorship in Basel encompassed many of his ideas and theories contained in the books of the *Archidoxis*.[250] Ideas, we can assume, such as his three-principle theory of matter.

Historians agree that the first detailed exposition (and the first mention) of the three-principle theory was featured in the *Opus paramirum,* written roughly around 1529/30 and published in 1531.[251] As illustrated by the examples above, the three principles were clearly referenced in the *Archidoxis* which has been dated several years before the *Paramirum*, but could well offer the evidence for scholars to reconsider these dates and chronological order of the output of Paracelsus' writings. Early on in the second volume of the *Archidoxis* under a section entitled, "The Manual or, a Treatise of the Philosophical, Medecinal Stone," Paracelsus reiterated his conception that both man and metals consisted of sulphur, mercury, and salt and asserted that his readers should already be familiar with this idea as he had heretofore laid out this notion in his *Paramirum*:

> But we have afore told how man hath his original of *Sulphur, Mercury,* and *Salt,* even as Metals have; this therefore being sufficiently declared in the book, *PARAMIRUM,* 'tis needless to repeat it here wherefore I shall only shew you, how the aforesaid *Stone of the Philosophers* may be known, and in some measure prepared: Know therefore of a Certainty, that there's nothing so small, out of which any thing is to be made, that can stand without Form.[252]

This reading provides evidence for the possibility that Paracelsus outlined his doctrine of the three principles either during, or perhaps well before, he composed his chemical ideas in the *Archidoxis*. Despite the publication date of the *Opus Paramirum*, there are some who have acknowledged that the tract along with the *Paragranum* (1529 – 1530) presupposes Paracelsus' interest in practical and theoretical alchemy suggesting that the physical and chemical versatility of the three principles originated and captured

---

105-124; cf. Benzenhöfer, Studien zum Frühwerk des Paracelsus im Bereich Medizin und Naturkunde [Münster: Klemm & Oelschläger, 2005], 205f. Weeks, *Essential Theoretical Writings,* 7, footnote 9.
[249] Sherlock, "The Chemical Work of Paracelsus," 43.
[250] Stoddart, *The Life of Paracelsus Theophrastus Von Hohenheim,* 104.
[251] Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time,* 139; Pagel, *Paracelsus,* 24-25.
[252] Paracelsus, "The Manuel of the Stone of the Philosophers," in *Archidoxis,* 45.

his mind well before his time in Basel.[253] As we recall from our historical survey of Paracelsus' early travels, this would indicate that he conceived many of his revolutionary and pivotal ideas and had begun to write alchemical manuscripts while working as an army surgeon during the military campaigns of the early sixteenth century.

2.6 Conclusion

It seems likely that Paracelsus' early travels and experience as an army surgeon left a deep impression on the young physician and profoundly influenced his subsequent medical practice and thinking. It is also reasonable to assume that a prominent factor responsible for this impact was the developing frequency of gunpowder weapons and their shocking yet awe-inspiring effects, which he had experienced first hand during his military service. The acceleration in demand for saltpeter affected not only the economic priorities of early modern Europe, but also influenced the experimental interests of philosophers. The correlation between an emerging spiritual or aerial niter and the art and technical considerations of gunpowder is suggested by evidence concerning the evolution of Paracelsus' thinking about salt and the element's interaction with matter in the early stages of his career. This correlation is consistent with specific teachings and text devoted to salt and niter substances in his early works which will be expounded on in the following section.

3. Saltpeter and the "Gunpowder Theory"

3.1 Introduction

Paracelsus' choice of salt as his third principle is a reflection of the shifting intellectual and industrial landscape that gave shape to a knowledge of nature and the body in the early modern world. The variety of processes that niters or salts were incorporated into focused on their medicinal applications and extended to their agricultural value as a potent fertilizer and association with mineral acids as volatile "spirits." But distinct among these nitrous substances was saltpeter, or potassium nitrate.[254] Like all alchemists, Paracelsus sought mystical as well as chemical properties

[253] Webster, *Paracelsus: Medicine, Magic, and Mission at the End of Time,* 139; Pagel, *Paracelsus,* 24-25.
[254] Newman, "From Alchemy to 'Chymistry,'" 505.

for the substances he described and he oftentimes referred to saltpeter or *sal nitrum* as the *Miraculum Mundi* and the universal solvent. Saltpeter was thought to abide in everything, including the elements: "It is for this reason that it may be called the *Materia Universalis* since no one can live without the elements."[255]

But why would Paracelsus decide on an obscure substance found in the vilest conditions to be the preeminent entity responsible for prolonged life, spirit, and motion throughout all of nature? Though acknowledged as essential, salt had historically up to this point maintained a subservient status to that of other elements. A plausible explanation can be found in an analysis of Paracelsus' dialogue concerning saltpeter and its perceived applications in both nature and alchemical operations. As has been shown, Paracelsus' early travels and service as an army surgeon exposed him to the political, economic, and scientific aspects that surrounded the heightened procurement and usage of saltpeter during this period. And it is for this reason that, as a result of technological progress and the ascendance of gunpowder weaponry during the first quarter of the sixteenth century, the correlated explosive effects of this phenomena found in nature as well as the human body were incredibly influential on the physician's developing philosophical thought process.

The following section is an assessment of the gunpowder theory as it relates to Paracelsus' conceptual understanding and application of saltpeter in his alchemical and hermetic picture of man and the universe. We shall see that he used his explanations of chemical phenomena to illustrate a philosophy of cosmic correspondence that drew parallels to observations of gunpowder explosives and its combustible properties. With the intent to further build upon the discussion of previous scholars, my aim is to add further information drawn from the philosopher's writings that demonstrate the correlation of gunpowder's pervasive influence on Paracelsus' development of niter theories.

3.2 The "Gunpowder Theory" of Saltpeter

[255] Debus, "The Paracelsian Aerial Niter," 59.

According to Henry Gurlac in his 1954 essay, "The Poet's Nitre," it was the explosive property of saltpeter, realized through the technology of gunpowder that was identified as the responsible cause and reactive agent that fueled natural fires and subterranean movements. Paracelsus' elevation of saltpeter spiritualized its corporeal nature endowing the element with a kind of vitalism that came to dominate explanations of fiery, convulsive, and volatile phenomena found throughout nature and in the human body.

That Paracelsus juxtaposed his three prime principles with the nature and power found in this new technology is clear in his writings. The three are discussed with regard to their corresponding number to the ingredients in gunpowder and are assigned as active agencies throughout both the macrocosm and microcosm and illustrated through analogies of volatile, meteoric phenomena such as lightening, thunder, and earthquakes. These comparisons embodied theological and anthropological overtones that Paracelsus developed in his work *De Meteoris* in a chapter titled "De fulgure" which attested to the association of the *tria prima* as the ingredients of gunpowder and underscored the force and power of thunder as an allusion to Christ's second coming.[256]

The following excerpts drawn from the Paracelsian corpus are usually omitted or quoted in smaller fragments by historians when discussing Paracelsus' notion of saltpeter. However, when read and taken in context more thoroughly, these passages clearly elucidate saltpeter's essential role in gunpowder as the catalyst that drove Paracelsus to deduce its mystical properties and posit it as a fundamental force of nature:

> There is also another kind of salt which is called nitre. It is composed naturally of the natural salt of animals' bodies, and the salt of nutriment in those bodies combined. One salt having thus been formed from two, the superfluity is decocted into urine, and, falling on the earth, is again decocted in due course. The two constituents are more and more closely united, so that from them results one single and perfect salt through the chemical separation brought about by artificial decoction from its earth. It shews itself very clearly in the form of cones or of clods, provided it be thoroughly separated from the superfluous nutrimental Salt not yet digested by the animal decoction when it is driven off into the urine. *In Alchemy its use is very frequent. It would be idle to recount how great was the violence which a first experiment demonstrated therein with disastrous result, when it was compounded with sulphur and formed into blasting powder, whence it has been deservedly called terrestrial*

[256] Weeks, *Essential Theoretical Writings,* 478, 874.

> *lightning*. In the same way, from the salt of the liquor of the earth, which is an universal natural balsam, by which all things are built up in their special combinations, returning at length from this by resolution into the earth again — there is produced, as was stated above, a single salt, which afterwards percolating through the pores of the earth is coagulated in the form of cones of ice adhering to the rocks, from which circumstance it changed its name of Nitre into Saltpetre.[257]

This connection to gunpowder is further illustrated with reference to the production and harvesting of saltpeter in environments where urine-saturated earth is present:

> Besides the conditions of salt already mentioned, one other property remains. It is this. In whatever place the urine of men or animals is deposited there salt nitre is afterward produced. The urine being collected and prepared so as to form another salt, is called salt nitre. Now, salt nitre is salt formed from the natural corporeal salt and the salt of food. If these two are joined in man they expel from him what is superfluous by means of the urine, which is nothing else than natural, corporal, and nutrimental salt meeting with other humours. Now, if the urine be excreted into nitre, and stand for some time, then the spirit of salt meeting together in its operation, prepares one salt of out two, and that, indeed, of a peculiar kind…*No salt in the universe is like this one. Alchemy found it lying hid in nitre, reduced it to the form of a coagulated salt, and then evolved the latent virtue from it, only for purposes of Alchemy and the manual art. They tried to distil sulphur and salt nitre together, but this could not be accomplished on account of the violent chemical action produced. Having accomplished this afterwards by the addition of carbon, the Alchemists discovered gunpowder, and gradually so augmented this by new inventions that now it breaks through walls like a thunder-bolt. Hence it is with good reason called terrestrial lightning. By means of this salt many of the arcana in Alchemy are brought about which need not be described here…The nature of man is indeed wonderful, since, from the body of man or brute, simply from its excrements, and by an internal motion, such a generation is contrived that when it proceeds from living beings it is so violent against life that nothing more destructive can be imagined. It destroys man's life with such swiftness that no defence is sufficiently strong against it.* But these matters must be referred to metaphysical science in the Paramirum.[258]

These passages clearly demonstrate that Paracelsus formulated his ideas of saltpeter as a result of the profound influence and importance bestowed to gunpowder during this period, not only through meteorological analogies, but also through the process of the production of saltpeter via the harvesting of excrement and urination of human and animals. It is important to recognize his emphasis on the relationship of

[257] Emphasis *mine*. Paracelsus, *The Hermetic and Alchemical Writings Vol I,* 100-101.
[258] Emphasis *mine*. Ibid, 262-63.

saltpeter and urine as it provides evidence of the economic and social forces prevalent during the early sixteenth century. The source of obtaining saltpeter was clearly linked to the primary point of supply of securing it for military need. As saltpeter is not found in great quantities naturally in the European climate, it is reasonable to assume the pressure to meet the war demands for gunpowder drove saltpeter to the forefront focus of not only commercial and government interests, but also to that of philosophers and scientists. As Cressy has noted in his analysis of the political and philosophical aspects of saltpeter during this period, "the protean elusiveness of the substance made it a puzzle worth pursuing."[259]

The origin and generation of saltpeter remained an ambiguous issue well through the eighteenth century. This is reflected in the historic accounts of alchemists and researchers attempting to discern the mysteries of the nitrification of earth.[260] To Paracelsus, the theoretical understanding of the complexities of saltpeter were grounded in the practices of mining the substance for gunpowder. He observed that "nitre is excrement and the dead body of esile (sic) and nutrimental matter. And this dead body is that out of which putrefaction grows … Nitre forms in the pens and stables where cattle make water. For the earth whereon they make water is afterwards cooked and the salt nitre obtained from it. For all urine is salt."[261] Because of its unique nature, which encompassed attributes of the animal, vegetable, and mineral kingdoms, Paracelsus characterized saltpeter as a universal salt and, "an essential spirit and excrement of all salts, possessing a hermaphroditic nature."[262]

3.3 The Influence of Salt in Meteorological Theories

As discussed in Chapter 1, Paracelsus and his followers saw the universe as an interconnected chain of influence and they sought to interpret this united order in terms of vitalistic and chemical explanations. On the macrocosmic level they spoke of a world where every substance exhibits a reflection and an analogy of others in the various

---

[259] Cressy, *Saltpeter: The Mother of Gunpowder (*Oxford University Press, 2013), 15.
[260] Ibid.
[261] Paracelsus, "*De Tartaro* Lib. I., Tract III., *annotations"* in c. 2.; and "*Fragmenta Medica*, *De Tararo Nitreo" in The Hermetic and Alchemical Writings Vol I,* 100, footnote.
[262] Paracelsus, "*De Pestilitate,* Tract I" in *The Hermetic and Alchemical Writings Vol I,* 100, footnote.

domains of nature. Every plant, mineral, organism, or element found on earth had a parallel counterpart embodied in the higher firmament. Massimo Luigi Bianchi illustrates this thought process, explaining that:

> "since an exact isomorphism of structures connects worldly beings and phenomena which are distant one from another, it follows that the knowledge of what is concealed and impossible to grasp directly may be obtained from its more perspicuous and evident cosmic analogues, that the invisible may therefore be read in the visible, the internal in the external, and the distant in the near. Thus the phenomena of the external world become the model of which to base an understanding of the more enigmatic phenomena that occur in man."[263]

Because Paracelsus believed a study of the macrocosm would necessarily lead to an understanding of man, recognition of these cosmic links was of special interest to the physician. As he expounded in the *Paragranum*, it is only when one has knowledge of the origin of thunder, wind, and storms is he able to describe colic and *torsiones*; only by comprehending the generation of lightning, hail, and thunderbolts can one discern the complexity of urine, gallstones, gravel, and all the tartarous diseases.[264] Since the chemistry of the heavenly sphere makes visible what is concealed in the earthly domain, the answer lies in explaining meteorology.

During the Renaissance, the fount of meteorological theories stemmed predominantly from Aristotelian doctrine which, over time, was adjusted to meet the evolving naturalistic understanding of the world through developing philosophical and cultural changes. Many of these beliefs were incorporated by other thinkers and philosophers who adopted and transfigured their own theories pertaining to atmospheric phenomena such as wind, rain, exhalations, lightning, and earthquakes. The world of Paracelsus was no less animate than that of Aristotle and he frequently painted the sublunary region of Earth as a distillation flask interpreted in terms of chemical explanations to account for a wide variety of observations.[265]

While meteorological reasoning is found throughout Paracelsus' writings, the most inclusive and comprehensive treatment of his thoughts covering common weather phenomena as well as the trinitarian nature of the *tria prima* are found in his extensive

[263] Bianchi, "The visible and the invisible," 29.
[264] Ibid, 29.
[265] Debus, *The Chemical Promise,* 70.

treatises *De Meteoris* and the *Opusculum de Meteoris.*[266] Discussion of the *tria prima* was imperative for Paracelsus as he projected the three primary elements responsible for much of the activity of meteorological occurrences:

> These three principles are all of an igneous nature till they arrive at their operation, that is, at their ultimate matter. Sulphur is a fire which burns; salt nitre burns also; and it is in like manner with mercury. Now, fire cocks wind, and in the generation of winds the stars are vials and cucurbites, containing in themselves meteoric sulphur, mercury, and salt, which operate in these phials by means of our ethereal Vulcan. From these ethereal operations ethereal works are produced, such as the winds.[267]

Weeks has noted that Paracelsus took great pride in determining the nature of thunder and lightning.[268] His claims recorded in his Basel lectures as well as in *Grossen Wundarznei* illustrate this point as well as provide further evidence for the influential connection to gunpowder in his philosophies. Paracelsus viewed the *tria prima* as having an integral role in meteoritic phenomena and he compared the three prime essences to the ingredients of gunpowder hypothesizing them as the cause of "fulgur [the lightning flash]."[269] Saltpeter's explosive quality was also highlighted in the *Elf Traktat* which compares its presence in gunpowder ("das der alchimist bombardam heißt") to the effects of thunder.[270] Much reference was made to the generation of storms, earthquakes, and thunderstorms through analogies of artillery and gunpowder munitions in which Paracelsus posited meteorological and geophysical aspects of the paroxysm or forceful tremors as powerful events produced by "niter" and "sulphur in mercurio."[271] Just as heavenly and terrestrial forces assemble substances to create an explosion, so to must the alchemist employ the same materials. This dual perspective of corresponding explosive power in the microcosm and macrocosm is exemplified by Paracelsus in his work *De Colica*:

> Whatsoever man does the planets do also, but in an alchemistic sense and process. Accordingly, as the Alchemist seeks saltpetre in nitre, mercury in dung, sulphur in fire, so he also seeks the firmament, which is invisible Vulcan. When he has collected these substances and has united them, detonation follows, of that kind which in

---

[266] Paracelsus, *Essential Theoretical Writings,* 606.
[267] Paracelsus, *The Hermetic and Alchemical Writings Vol I,* 218.
[268] Weeks, *Essential Theoretical Writings,* 874.
[269] Ibid, 316.
[270] Ibid, 838.
[271] Paracelsus, *Essential Theoretical Writings,* 462, footnote c.

> heaven is called a thunderbolt, but the Alchemist terms it *Bombard*. For he has the power of producing thunder, as in magic, which is the philosophy of Alchemy.[272]

As Guerlac has pointed out however, "it was no great step to assume that the 'material causes' of lightning, thunder and earthquakes were in fact identical with, or very similar to, the materials that went into gunpowder."[273] Paracelsus was certainly not the first to do so. Others before him, like Roger Bacon, also alluded to explosive mixtures that resulted in the same familiar, yet terrifying effects produced in the clouds or beneath the surface of the earth. But what distinguished Paracelsus' philosophies from those before him was his treatment of saltpeter beyond its perceived external effects in nature. Paracelsus was the first to identify a spiritual and mystical component to saltpeter that posited an active agency that permeated the cosmos and was essential in dictating its interaction with other worldly phenomena. And it was these mystical properties that he incorporated into his vision of a vitalistic conception of nature directed by divine correspondences between the heavens and earth.

However, it wasn't just the explosive effects of saltpeter that led Paracelsus to suppose the mineral as the *Materia Universalis*. He also drew on its generative and fertilizing properties to provide an explanation of dynamic geocosmic phenomena. This was especially true in his application of niter to a system that enriched the growth of all living organisms. A chapter on salt in *Von den natürlichen Dingen* portrays the elements of the *tria prima* both as "prima condita" and as the recipients of "nutriment" from "all gewechs der erden."[274] Paracelsus and his followers viewed the universal salt as an active component in the atmosphere and believed it served as a medium for spiritual forces to descend to the domain of man by way of astral emissions. Notably, it was believed that elemental water, which contained a magnetic *sal nitrum* drawn from the earth, was pulled into the atmosphere and there received the vital power of the heavenly air. The water, now infused with the "power of life from the air" along with the *sal nitrum* of the earth, would be restored back to terra firma in the embodiment of dew or

[272] Paracelsus, "*De Colica*, s. v. *Paralysis*," in *The Hermetic and Alchemical Writings Vol I,* 42.
[273] Henry Guerlac, "The Poets' Nitre," *Isis* 45, no. 3 (September 1954): 246-247.
[274] Paracelsus, *Essential Theoretical Writings,* 316.

rain, whereupon the niter became joined to the fatness of the earth.[275] The niter would then fertilize the soil, which would result in the growth of vegetation and give color to plants. Upon entering the earth through its pores, this volatile salt when united with a terrestrial counterpart, would assume the form of the philosophers' mercury, which was the starting point for production of the great elixir.[276]

Paracelsus also extended this fertilizing property of niter to explain the formation of snow and hail in the upper atmosphere. If saltpeter was determined as the cause of thunder and lightning, it was easy to conjure that it resided in the air and imparted certain imagined properties into other meteoric phenomena. By way of astral emissions, this aerial niter percolated through the heavens enriching rain, snow, and dew that then fell to earth increasing the fertility of the soil.[277] Hail, likewise, was impregnated with this aerial salt, but in a manner that Paracelsus likened to thunder.[278] He distinguished these stones in their origin and material as different from those stones found in rivers, mountains, and streams.[279] Being generated outside the external world, "the spirits of the

---

[275] Newman, *Gehennical Fire,* 216-217.
[276] Ibid, 211.
[277] Guerlac, "The Poets' Nitre," 248.
[278] "It is the case that [the element of] fire is in its salt spirit, [causing] in that same element its own *congelatio*. This is why there are four *astra*, four fires, in other words a fourfold fire spirit or salt spirit, which in this case permits a generation and comes into play; and that in the process its *astrum* is involved that congeals it. This happens in the same way as it happens in the heavens when a stone, or [more precisely] a hailstone [or] thunderstone issues forth as a stone, or just as it draws its material, so you should know how to recognize this generation and understand it. This is not the stone of the rivers, the mountains, or the streams, or anything of that kind, but rather the stone of the *tonitrus* [thunder]. Precisely that is the generation with which I am dealing here. For it is the same in the *microcosmus* as in the heavens." Paracelsus, *Essential Theoretical Writings,* 607.

Paracelsus goes on to explain, "In this instance it happens to be the case that a thunder arises from the salt, and there is nothing but salt in the *prima materia*. And the spirit of the salt congeals itself. If this happens in a violent way, the salt is responsible for the fact that in the sulphur nothing can be united. This salt passes into stone; [and] the sulphur into fire, which means into its flash. The sulphur burns up in the air between the heavens and the earth. However, the salt turns into a stone and falls as such down to earth. It is the case that the *primae materiae* in the human beings are all spirits, and all stars, and the time of these matches up with their course." Paracelsus, *Essential Theoretical Writings,* 609.

[279] "It is necessary, first of all, to describe these particular *generationes* of the external world. You should be aware that these stones are drawn from the elements in [the form of] their lapidary waters; and yet they are not stone but rather a dew form which rises up from one element into another. That other element is the *ultima materia* of that element. Accordingly, the *primae materiae* of these stones end in the heavens. That is to say that the silent world has within itself the generation of these strange things. Now in philosophy it is an invisible thing; however, it becomes visible in the *ultima materia*. When it comes about that the spirits of the heavens are born from this salt in order to rule the heavens, they encounter the generation which is

heavens are born from this salt in order to rule the heavens" and consequently they must come from the same *materia.*[280] In the *Grossen Wundarznei*, Paracelsus provided an illustration of this harmonious system as it oscillated between the macro- and microcosm:

> The matter of thunder and lightning is a Saltpeter-Sulphur of the Firmament. In the same way that Sulphur and Salniter grow out of the earth and therefore become ordered together in one mass and substance, the heavenly materials behave. As an example: as Water grows in the heavens and then falls on the earth, so may also Fire grow in it. And as snow grows in the Heavens, so may also Salniter and other things grow out of the fire. Therefore from such things we should understand that the heavenly lightning is of a heavenly composition made out of the same materials as spring out of the earth and which through the stars are ordered in such a behaviour and way.[281]

3.4 Salt in the Microcosm and Body of Man

As a physician, however, Paracelsus was even more so concerned with explaining how the active agency of salt altered and affected the microcosm of the human body. We can conclude that, from a physiological perspective, Paracelsus did not regard salt as just an inert combustible, but deemed an excellence in its energy and life force that was "comparable to an 'invisible celestial fire and air' that is enclosed in the body."[282] This he did by also correlating meteorological activities to the circumstances that afflicted the health and disposition of man. We find in his lecture notes that Paracelsus was teaching the importance of saltpeter transmitted through celestial and terrestrial forces as early as his time in Basel through the comparison of its generation from urine to that of tartarus

---

the same as the *materia*. The spirit, [or] time, is that which congeals them; and in this congelation other things also participate and result, as the *Meteorica* establishes. In the conjunction of the united elements of this kind, the stone grows in the heavens so that it can subsequently fall to and strike the earth, [an occurrence] happening so frequently that no one takes any note or is very aware of it. In connection with this, you should be aware that in the body these [same] *astra* and elements are found, not differently than they are in the heavens." Paracelsus, *Essential Theoretical Writings,* 607, 609.

[280] Paracelsus, *Essential Theoretical Writings,* 607.

[281] Paracelsus, "Von den Naturlichen Dingen in the Opera" (1616), vol. 1, p. 1037, in *Grossen Wundarznei in the Chirurgische Bücher und Schrifften*, ed. J. Huser (Strassburg, 1618), p. 85 as cited in Debus, "The Paracelsian Aerial Niter," 46.

[282] Pagel, *The Smiling Spleen,* 38.

illness.[283] In his later work, *Von den Natürlichen Dingen,* he examines the medicinal application and art of processing "salz niter und saltpeter."[284]

By invoking the agency of saltpeter embodied in the *tria prima* and through analogies of the observed effects of gunpowder, the philosopher physician was able to illustrate the macrocosmic-microcosmic correspondence between cosmic forces and the nature of the human body through a familiarity of meteorological phenomena such as thunder and lightening (der Straal).[285] In his work, *Chirurgische Bücher,* Paracelsus explained: "It is through starry emanations that our atmosphere obtains this aerial intro and sulphur. In the upper air these occasionally react in the form of an aerial explosion seen and heard to man as thunder and lightning. But in the lower atmosphere these same emanations enter the body through respiration where they react in burning disorders or diseases."[286]

This aerial effluvia could also be understood as the responsible cause for other human maladies that resembled explosive or trembling macrocosmic phenomenon. Pathologies such as strokes, convulsions, spasms, or paroxysms bore a strong resemblance to the characteristics of earthquakes, thunderstorms, and volcanos were thought to be the result of violent reactions of nitrous and sulfurous particles in the blood, analogous to exploding gunpowder.[287] Other afflictions embodied the nitrous, fertilizing capacity of saltpeter in the form of hail from which at "some precise moment suddenly within some human being a stone of this kind can be born."[288] Paracelsus also drew upon semblances of saltpeter's volatile function in gunpowder to express diseases distinguished by hot and burning qualities. For example, in the chapter titled *Bertheonae* found in the *Chirurgische Bücher* he proclaimed that some fistulas and ulcers are caused solely by sal niter.[289]

---

[283] "et sicut ex urina foris der büchsenmeister seut saltpeter, ita in corpore quoque fit, ideo cum sal urinae venit ad renes, henkt es sich an sicut tartarus in vase." Paracelsus, *Essential Theoretical Writings,* 838, footnote a.
[284] Weeks, *Essential Theoretical Writings,* 838, footnote a.
[285] Ibid, 478.
[286] Paracelsus, *Chirurgische Bücher*, ed. J. Huser (Strassburg, 1618), 85, 354 as cited in Debus, "The Aerial Niter in the Sixteenth and Early Seventeenth Centuries," 836.
[287] Weeks, *Essential Theoretical Writings,* 112; also annotated in Pagel, *The Smiling Spleen,* 29.
[288] Weeks, *Essential Theoretical Writings,* 607, 609.
[289] Debus, *The Chemical Philosophy,* 108.

Indeed, to Paracelsus this sal nitric principle was an omnipotent presence that served as a source of heat, motion, and life force in the human body. Debus has expounded on this particular nuance within the Paracelsian philosophy showing that not only did he perceive an aerial sal nitric source culpable for burning bodily disorders, but that it was also requisite as a nutriment for muscular action and, on a larger scale, the Sal nitric life of man. In his teachings, Paracelsus insisted that "it is particularly important to speak of the air ... for in the air is the power of all life" … "the other life which we call S. S. nitri."[290] He proposed that through the act of breathing, the body extracted from the air a nitro-aerial spirit that then combined with sulfurous compounds in the body to cause a combustion, thereby generating motion and muscular action.

3.5 Conclusion

Paracelsus was thus able to account for the agency of salt on a universal scale by recourse to the production and employment of gunpowder. It was the science of gunpowder that validated itself, more than any other process, to the metaphysical justification of his tripartite theory of matter and the dynamic characterization of a vital aerial niter. The particular properties that characterized the nature of saltpeter confirmed the curious substance as an unrealized qualitative power and a promising key to a new chemical philosophy of nature.

By the beginning of the seventeenth century, niter and saline components were considered staple elements to be found in the experimental arsenal of many European academics and intellectuals. It had become customary to reference the vital air, or more precisely, the *flamma vitalis,* as a fundamental precept of the Paracelsian tradition[291]. The wide range of attempted explanations of natural phenomena that incorporated a nitrous compound attest to its profound influence on the investigation of various scientific undertakings, including its function as a component in cooling mixtures and medicinal remedies, as well as in liquid dissolving agents of metals.[292] Niter's utility was not only incorporated into theories and interpretations of atmospheric and earthly

[290] Debus, "The Paracelsian Aerial Niter," 48.
[291] Ibid, 51.

phenomena, but also in that of human physiological processes, eventually finding its way to the forefront in the debate surrounding the process of respiration and combustion. With such perceived agency to sustain all things in both the organic and inorganic worlds, a leading number of natural philosophers and iatrochemists during the course of the next century and a half undertook concentrated efforts to isolate this life essential ethereal salt.[293]

4. The Impact of Paracelsian Salt Philosophies and His Followers

4.1 Introduction

As wars and military campaigns continued to dominate the European continent throughout the sixteenth and seventeenth centuries, the theory of an aerial niter, and its capacity to explain various meteorological phenomena received considerable scientific support among those who followed Paracelsus and his teachings. It thus significantly influenced ideas and philosophies pertaining to the explanation of natural phenomena.[294] By the beginning of the seventeenth century, niter and saline components were considered staple elements to be found included in the experimental arsenal of Europe's academics and intellectuals. It had become customary to reference the transcendent agency of salt in natural processes as a fundamental dictum of the Paracelsian tradition. This exalted nobility spurred the interest of devout Paracelsians to seek out and attempt to isolate a primordial niter or "universal salt" from which all things draw their ultimate origin.[295] Martin Ruland's *Lexicon* of 1612 encapsulates this alchemical conviction: "He who knows the salt and its solution possesses the secret of the wise of old. Hence let salt be the foundation of everything and disregard everything else."[296]

Although we have reason to believe that the exposition of Paracelsus' chymical teachings, and consequently his philosophies of salt and niter, were introduced through his interactions with patients as well as through lectures given during his time in Basel throughout the 1520s, it wasn't until the publication and circulation of his works by

---

[292] Zbigniew Szydlo, "The Alchemy of Michael Sendivogius: His Central Nitre Theory," *Ambix* 40, part 3 (November 1993): 130.
[293] Debus, *The Chemical Promise,* 70.
[294] Guerlac, "The Poets' Nitre," 254.
[295] Newman, *Gehennical Fire,* 211.

German followers such as Adam von Bodenstein, Michael Toxites, and Gerhard Dorn in the 1560s and 1570s that his theories began to substantially penetrate academic and intellectual circles. In the 1590s, physician Johann Huser (1545 – 1604), published his prodigious ten-volume compilation of Paracelsus' works entitled *Bücher und Schrifften* (Books and Writings) which firmly embedded Paracelsian ideas in seventeenth-century philosophy.[297] Though acknowledged as essential, salt had historically up to this point maintained a subservient status to that of other substances. However, Paracelsus' universal *sal nitrum* principle constituted an elaborate and multifaceted engagement of nature and comprised a philosophical perspective situated upon a new chymical interpretation of the universe.

Niter was identified by these philosophical practitioners as "celestial, ethereal, aerial, which they extract from dew, air, or niter, or even from the excrements of animals" and was employed congruently in both chemical and physiological explanations.[298] "For them this was the familiar universal salt of the alchemists."[299] In addition to its identification as the primary ingredient in gunpowder, the particular properties that characterized niter were instrumental in its new function as an important theoretical element and cosmological principle. With its perceived agency to sustain all things in both the organic and inorganic worlds, the adoption of a metaphysical salt principle was carried over into experimental operations performed in sixteenth and seventeenth century chymical laboratories. "Saltpeter was, in both warfare and in chemistry, the only commonly available source of energy and 'heat.'"[300] Thus, it could be stated that this exploitation of niter emerged from both practical as well as a theoretical motivations.[301]

4.2 The Legacy of Paracelsian Salt Philosophies: The Implementation of Salt Spirits and an Aerial Niter

---

[296] Pagel, *The Smiling Spleen,* 42.
[297] Newman, "From Alchemy to 'Chymistry,'" 506.
[298] Newman, *Gehennical Fire,* 211.
[299] Debus, *The Chemical Promise,* 33.
[300] Robert G. Frank, *Harvey and the Oxford Physiologists: Scientific Ideas and Social Interaction (*Berkeley: University of California Press, 1981), 118.
[301] Ibid, 122.

The extraordinary influence of these niter theories and the coherence and explanatory power they provided for a new understanding of the universe had a profound impact on a number of leading natural philosophers and iatrochemists during the sixteenth and seventeenth centuries. This influence lasted well into the mid-eighteenth century. Historians of science in recent decades have produced a body of literature examining the practices of noteworthy scientific explorations that led to insights about nature and promoted a process of discovery through the adoption and application of a nitro-sulphureous principle. Early proponents of this endeavor in the half-century following the death of Paracelsus included Athanasius Kircher, Biringuccio, Jerome Cardanin, Bernhardus Varenius, and Gerhard Dorn, all of whom identified salt's spiritual nature and attributed the noise and activity of thunder, lightning, earthquakes, and volcanic eruptions to the explosion of a mixture of sulphurous and nitrous vapors analogous to that of gunpowder.[302] Debus attributed the first thorough and influential application of the Paracelcian nitro-sulphureous principle to Joseph Duchesne (1544 – 1609) who, in 1603, published the tract *De Priscorum Philosophorum verae medicinae material.* In this work he contested the long-held assumptions of Galenic medicine, and like Paracelsus, he regarded Creation as a divine chemical separation and felt compelled to demonstrate the existence of the three Paracelsian principles in all of nature.[303] He emphasized the notion of saltpeter as a life giving substance bestowed upon earth through macrocosmic divine distillation in the form of heavenly dew essential for the growth and generation of both vegetable and animal life.[304] Although he condemned its use in the manufacture of gunpowder, he exalted its pervading and dynamic power in nature:

> "I meane to speake of Niter, which men commonly cal Salt-Peeter. I let passe the detestable and pernicious use thereof, invented for the destruction of men: and yet I must confesse that it deserveth great admiration, in that it sheweth forth so great, and

[302] Guerlac, "The Poets' Nitre," 250. In his research, Henry Guerlac shows that in their works published shortly after the death of Paracelsus, these early philosophers developed meteorological and geocosmic philosophies referencing saltpeter and gunpowder weapons. In his *Pirotechnia* (I540), Biringuccio assumed that the noise of gunpowder was generated from the same conditions necessary for the production of thunder and lightning. Jerome Cardanin applied similar logic in his work *De Subtilitate* (1550) in which he explained earthquakes as a chemical reaction of inflammable materials beneath the earth's surface consisting of sulphur, nitre and bitumen. Of these substances, he remarked, "nitre, the "Master-ingredient" of gunpowder is the most powerful."
[303] Debus, "The Paracelsian Aerial Niter," 52.
[304] Ibid, 54.

> incredible effects, when as we being in these lower parts, it representeth thundrings and lightenings, as if they were in the aire aloft."[305]

Frank credits Daniel Sennert (1572 – 1637) with the earliest systematic attempt to incorporate an aerial nitrous explanation for atmospheric phenomena. In his *Epitome naturalis scientiae* (1618) and later in *Hypomnemata physica* (1636), Sennert described both lightning and thunder as consisting:

> "of a tenuous and fiery nitro-sulphureous spirit, differing only in the arrangement and quantity of the particles of sulfur and niter … Just as the 'antipathy' of sulphur and niter accountant for the explosion of gunpowder, so thunder and lightning resulted from the union of sulphureous, nitraous and aqueous vapors dispersed into the 'minutest atoms' and raise aloft from the Earth to join furious battle on high."[306]

A contemporary of Sennert's, Pierre Gassendi (1592 – 1655) also discussed the process of how an aerial niter was principally responsible for the freezing, cold effects in the upper atmosphere. This change in temperature "is produced by 'frigorific' corpuscles of a nitrous nature, which in winter produce snow and in the summer, hailstones."[307]

Other comprehensive theories were put forth by Bacon who regarded saltpeter as "the Spirit of the Earth," and discussed its fertilizing properties and remarkable effect on the growth of plant life in his work the *Sylva sylvarum* (1623). He also considered the mechanism of saltpeter in gunpowder, stating that it comprised "a notable crude and windy spirit," and that this vital spirit is related to a similar reaction between the air and flame that reacts in the body to produce muscular motion.[308] Robert Fludd (1574 – 1637) and Johann Rudolf Glauber (1604 – 1670) both invoked a philosophical salt that operated as the aerial spirit of life and the latent soul intrinsic to all physical generation. Glauber singled out saltpeter calling it the *Miraculum Mundi* and the universal solvent (known as the alkahest). In his voluminous *Opera chymica* (1658), he asserted that saltpeter may be found in all things. He theorized on a cosmological series of actions in which an aerial

[305] Ibid, 52-53.
[306] Frank, *Harvey and the Oxford Physiologists*, 119-120.
[307] Guerlac, "The Poets' Nitre," 251-252.
[308] Debus, "The Paracelsian Aerial Niter," 57; *The Chemical Philosophy,* 494.

sal niter was emanated from the stars and was transported though atmospheric channels to infuse moisture into the terrestrial realm in the form of rain, snow, and dew.[309]

More recently Zbigniew Szydlo, Wlodzimierz Hubicki, and William Newman have explored the influence of Michael Sendivogius' 'Central Nitre Theory' and its reinforcement of the prominence conferred to saltpeter in the seventeenth century. Sendivogious' elaborate universal theory, which he laid out in his *Novum lumen chemicum* in 1604, posited a universal *sal nitrum* that contained the principle of life realized through the distillation-like geochemical processes of earth and the generations of metals and minerals.[310] A product of the celestial sun that interacted with the central sun of the earth, niter was shown to be a versatile, ubiquitous element that combined easily with other substances and had the power to give and sustain life to living bodies through the air. Sendivogius asserted that once one was able to fix nitrous air, it would be able to penetrate any substance to include gold. From this Central Salt, man could construct the universal solvent, which would in turn allow for the multiplication of gold, or in other words, metallic transmutation (chrysopoeia).[311] Newman argues that this

---

[309] Debus, "The Paracelsian Aerial Niter," 59.

[310] Newman, *Gehennical Fire,* 87-89.

Szydlo quotes Sendivogius: "Therefore when there is raine made, it receives from the aire that power of life, and joins it with the salt-nitre of the earth (because the salt-nitre of the earth is like calcined Tartar, drawing to it self by reason of its drynesse the aire, which in it is resovled into water: such attractive power hath the salt nitre of the earth, which also was aire, and is joined to the fatnesse of the earth) and by how much the more abundantly the beams of the Sun beat upon it, the greater quantity of salt-nitre is made, and by consequence the greater plenty of Corn grows, and is increased, and this is done daily." Zbigniew Szydlo, "The Alchemy of Michael Sendivogius: His Central Nitre Theory," *Ambix* 40, part 3 (November 1993): 136.

[311] Paulo Alves Porto Porto, "Michael Sendivogius on Nitre and the Preparation of the Philosophers' Stone," *Ambix* 48, part 1 (March 2001): 11. Zbigniew Szydlo, "The Alchemy of Michael Sendivogius: His Central Nitre Theory," *Ambix* 40, part 3 (November 1993): 140-42.

The theory of a central salt and nitrous aerial substance can be seen echoed in the experiments and works of other seventeenth-century philosophers and scientists to include Cornelis Drebbel (1572 – 1633) who arguably launched the first navigable submarine in 1624 in which he devised a mysterious method of producing air for his travelers. A quote from an early work of Drebbel states that he was aware that 'saltpeter broken up by the power of the fire and thus changed into the nature of the air' indicates that he was aware that heating saltpeter, or potassium nitrate, results in its conversion to oxygen gas and potassium nitrite. This method of creating oxygen from saltpeter to supply his vessel with clean air has led some to claim that that Drebbel was actually the true discoverer of oxygen. Szydlo, "The Influence of the Central Nitre Theory of MichaelSendivogius," 81-82. See also Dr. Gerrit Tierie, *Cornelis Drebbel (1572-1633)* (Amsterdam: H. J. Paris, 1932), 70.

belief influenced many alchemists of the seventeenth century who sought the source of the philosophers' stone in a philosophical saltpeter.[312]

We also see the concept of a philosophical niter applied to the changing views of early modern medical practice and the decline of Galenic theory. Medical practitioners who subscribed to Paracelsian ideals frequently adopted the idea of a vital salt principle – which they believed existed as a nitrous substance in the air that was absorbed by the body. In the century following the death of Paracelsus, many European physicians began to discard the antiquated humoral doctrine of diseases and relied, instead, on spirits to describe the workings of the human body. Their vision of nature embraced, not a mechanistic conception, but a spiritual and biological view of man. This vitalistic ideology was evocative of the Paracelsian belief that nature was a revelation of God and that mankind was imbued with a spiritual essence governed by biological and chemical agents. The highly esteemed Danish Paracelsian, Peter Severinus (1542 – 1602), incorporated the notion that fevers and burning diseases were the consequence of a disruption of "nitroso-sulphureous" particles in the body.[313] The Rosicrucian physician and alchemist, Robert Fludd (1574 – 1637), advanced a universal theory of circular motion that accentuated the importance of a nitrous aerial entity and its ability to impart the spirit of life through arterial blood, which circulated throughout the body. Fludd's concept was adopted by George Ent (1604 – 1689) who later described in his *Apologia pro circulatione sanguis* (1641) how niter from the air is absorbed and used by blood.[314] The highly regarded Flemish physician, Jean Baptista Van Helmont (1580 – 1644), who is mostly remembered for his early theories of gas and digestion, reimagined the vital spirit as an alkaline salt-like substance with both physical and transcendental properties.[315] For Van Helmont, his abstraction of the spiritual life force was bound up

[312] Newman, "From Alchemy to 'Chymistry,'" 514.
[313] Petrus Severinus, *Idea medicinae philosophicae* (1571): 99, 133, 164 as quoted in Debus, "The Paracelsian Aerial Nitre," 49.
[314] Debus, "The Paracelsian Aerial Niter," 55.
[315] There is no doubt that Van Helmont correlates this vital spirit to a saline principle: "The vital Spirit therefore, *Is Arterial Blood resolved by the force of the Ferment and Motion of the Heart, into a salt Air being vitally enlightened*...[hence] The vital Spirit therefore is plainly Salt; therefore Balsamical, and a Preserver from Corruption." Jean Baptiste Van Helmont, *Oriatrike or Physick Refined. The common Errors therein Refuted, And the whole Art Reformed & Rectified: Being A New Rise and Progress of*

with concept of niter and the explosive nature of gunpowder.[316] Even though Van Helmont acknowledged the role played by all three ingredients (salt, sulfur, and charcoal) in the make up of gunpowder, he associated salt with a vital, life-giving spirit that he characterized as: "the *Archeus* [which] is in it self, a Gas, of the nature of a *Balsamick Salt."*[317] This view led Van Helmont to emphasize salt's agency and assimilate it into several of his other dominant chemical theories.[318]

By the mid-seventeenth century there were several established customs of nitrous aerial substances, and these theories found their way to the forefront of the scientific experiments and discussions of many members of the Hartlib Circle, and eventually the early founders of the Royal Society. Guerlac credits Sir Thomas Browne (1605 – 1682) with producing the first complete description of gunpowder theory in English. In his *Pseudodoxia Epidemica* he discussed not only the phenomena of thunder and lightning, but also elaborated on the source of earthquakes which he claimed were not understood by the ancients due to their lack of understanding of the properties of gunpowder.[319] Another Fellow of the Royal Society, Thomas Henshaw (1618 – 1700), acknowledged saltpeter as "this darling of nature (the very basis and generation of nutriment)" and its

---

Phylosohy and Medicine, for the Destruction of Diseases and Prolongation of Life., trans. John Chandler (London: Lodowick Hoyd, 1664), 110.

[316] "For Gun-powder doth the most neerly express the History of *Gas:* For it consisteth of Salt-peter … of Sulphur, and a Coal, because they being joyned, if they are enflamed, there is not a Vessel in nature, which being close shut up, doth not burst by reason of the *Gas,"* Van Helmont, *Oriatrike*, 107.

[317] Van Helmont, *Oriatrike*, 110.

[318] Like the *archeus*, Van Helmont considered the other governing authority in the body, the *alkahest,* to be a spiritual saline substance and one that was set above all other salts as he proclaimed, "I Will prove first, that the liquour Alkahest, [is] the first being of Salts." In particular, Van Helmont discussed the concept of his *alkahest* as being correlated to the Paracelsian notion of a "circulated salt" which historians of science have granted he used interchangeably throughout his writings. See Van Helmont, *Oriatrike*, 524 and footnote 42.

To illustrate: "His Liquor Alkahest is more eminent, being an immortal, unchangeable, and loosening or solving Water, and his circulated Salt, which reduceth every tangible Body into the Liquor of its concrete or composed Body." Van Helmont, *Oriatrike*, 805.

[319] "From the like cause may also proceed subterraneous Thunders and Earthquakes, when sulphureous and nitrous veins being fired, upon rarefaction do force their way through bodies that resist them. Where if the kindled matter be plentiful, and the Mine close and firm about it, subversion of Hills and Towns doth sometimes follow: If scanty, weak, and the Earth hollow or porous, there only ensueth some faint concussion or tremulous and quaking Motion. Surely, a main reason why the Ancients were so imperfect in the doctrine of Meteors, was their ignorance of Gunpowder and Fire-works, which best discover the causes of many thereof." *Pseudodoxia Epidemica,* Bk.II, ch. V in *The Works of Sir Thomas Browne,* ed. Charles Sayle (London, 1904), I, 272-273 as quoted in Guerlac, "The Poets' Nitre," 252.

use in gunpowder "the most fatal instrument of death that ever mankind was trusted."[320] Interestingly, in his "The History of the Making of Salt-Peter" he suggested, like Glauber, that the salt could be derived from animal parts:

> "for all abound with such a volatile salt fixed" and he was convinced that "the salt which is found in vegetables and animals, is but the niter which is so universally diffused through all elements…And that the reason why animals that feed on vegetables are obliged by nature…is because animals are fuller of that salt than vegetables."[321]

Niter was not only used to explain various meteorological and earthly phenomena, but also received considerable scientific support in the study of air and the processes of combustion and respiration. Frank's study of the Oxford group of physiologists, which included Thomas Willis, Robert Boyle, Robert Hooke, and John Mayow, showed that in their search for a life-sustaining agent, many of these learned men evoked a combustible nitrous agent akin to the energy of saltpeter in gunpowder. Thomas Willis (1621 – 1675) developed his corpuscular-chemical theory of muscle contraction, which became a central concept in his theories of the nervous system, by envisioning the union of "animal spirits from the nerve fibers, and saline-sulphurous particles from the arterial blood."[322] Under adequate stimulation from the nervous system, this substance would fragment and explode like gunpowder, which thereby invigorated the muscle causing it to contract. This 'gunpowder physiology' provided Willis with a means to explain a variety of pathological states including spasms, convulsions, paroxysms, and fits, all of which he attributed to explosive activity of nitrous and sulfurous particles in the blood.[323] Robert Boyle's chemical research between 1654 – 1656 on the properties and composition of niter also prompted his curiosity in the constitution of air. Boyle formulated his own ideas of a Paracelsian "vital principle" or "aerial niter" against the context of corpuscular philosophy and the concept of an aerial *pabulum nitrosum* which was said to provide vital energy to the blood.[324] Boyle's contemporary, Robert Hooke (1635 – 1703), advanced

---

[320] Thomas Henshaw, "The History of the Making of Salt-Peter," in Thomas Sprat*, The History of the Royal Society of London, For the Improving of Natural Knowledge* (London: 1722), 274.
[321] Henshaw, "The History of the Making of Salt-Peter," 275.
[322] Frank, *Harvey and the Oxford Physiologists,* 222.
[323] Ibid.
[324] Ibid, 117. From these observations, Boyle determined that air was a vital component of respiration and perhaps contained "a little vital Quintessence," but beyond that he resisted drawing any further conclusions.

an aerial saltpeter as a key component in his theory of combustion and spoke more frequently of a 'nitrous air' following the period after 1682.[325] Other notable scientific theories put forth by members of the Royal Society incorporating an aerial salt included John Locke, Kenelm Digby, Malachia Thruston, Richard Lower, and even Isaac Newton who incorporated sulphur-niter theories into his teachings as well as his popular work *Opticks,* in which he provided a summary of meteorological phenomena as well as an explanation of physiological process of respiration.[326]

Perhaps the most thorough physical and physiological explanation involving the vital properties of saltpeter belonged to John Mayow (1640 – 1679) — a student of both Willis and Boyle. In his 1674 publication, *Tractatus quinque medico-physici,* Mayow's opening paragraph distinctly identified niter as the "universal salt" and argued that this salt existed as a component of the air around us.[327] Through his experimental work, Mayow concluded that an active constituent in the air called "igneo-aerial particles" served as a type of aerial food necessary to fuel the internal sulphureous matter of the

---

Douglas McKie, "Fire and the Flamma Vitalis: Boyle, Hooke and Mayow," *In Science Medicine and History: Essays on the Evolution of Scientific Thought and Medical Practice*, ed. E Ashworth Underwood (London: Oxford University Press, 1953), 470-71.

[325] Debus, *The Chemical Philosophy*, 493-494. It is inferred that Hooke's interest in combustion stemmed from his acquaintance and interaction with Boyle. In the publication of his *Micrographica* (1665), we are presented with a comprehensive idea of Hooke's theory of combustion. Found under Observation XVI, 'Of Charcoal, *or burnt* Vegetables,' Hooke details an experiment in which he observed a piece of wood heated inside a closed vessel to produce charcoal, and how admitted air affected it. Hooke argued that air could only act as a solvent of sulphureous bodies if they were heated sufficiently and that this action of dissolution generates heat identified as fire, so consequently fire cannot be an element. It is of important note that Hooke identifies "that the dissolution of sulphureous bodies is made by a substance inherent, and mixt with the Air, that is like, if not the very same, with that which is fixt in Salt-peter, which by multitudes of Experiments that may be made with Salt-peter, will, I think, most evidently be demonstrated." Robert Hooke, *Micrographia,* (Reprint, New York: Dutton, 1964), 103-04.

[326] "…sulphureous Steams abound in the Bowels of the Earth and ferment with Minerals, and sometimes take Fire with a sudden Coruscation and Explosion; and if pent up in subterraneous Caverns, burst the Caverns with a great shaking of the Earth…the Vapor generated by the Explosion, expiring through the Pores of the Earth, feels hot and suffocates, and makes Tempests and Hurricanes, and sometimes causes the Land to slide, or the sea to boil…Also some sulphureous Steams, at all times when the Earth is dry, ascending into the Air, ferment there with nitrous Acids, and sometimes taking fire cause Lightning and Thunder, and fiery Meteors. For the Air abounds with acid Vapours fit to promote Fermentations, as appears by the rusting of Iron and Copper in it, the kindling of Fire by blowing, and the beating of the Heart by means of Respiration." Sir Isaac Newton, *Opticks or A Treatise of the Reflections, Refractions, Inflectinos & Colours of Light*, 4th ed. London 1730 (New York: Dover Publications, Inc., 1952), 379-80. See also Guerlac, "The Poets' Nitre," 255.

[327] Szydlo, "The Influence of the Central Nitre Theory of Michael Sendivogius," 86; John Mayow, *Medico Physical Works: A Translation of Tractatus Quinque Medico-Physici,* trans. A. C. B. and L. D. (Edinburgh: Alembic Club, 1907), 1.

body and that these nitro-aerial spirits passed into the blood through respiration.[328] These spirits were not only responsible for fermentation in the blood, but also for the performance of motion throughout the body: "in violent movements the nitro-aerial particles are separated from the mass of the blood to set up the contraction of the muscles and are used up, so that there is need of more frequent respiration by which the blood may repair its losses, and have restored to it anew nitro-aerial particles for carrying on the function of motion."[329] Some historians have argued that the influence of Mayow's niter-based philosophy in the late seventeenth and early eighteenth century provided a necessary foundation for intellectuals such as Priestly, Scheele, and Lavoisier to formulate their chemical theories of oxygen and bring about the demise of the theory of phlogiston.[330]

4.3 Conclusion

By the end of the seventeenth century, the literature and widespread awareness of an aerial niter principle was common knowledge in the scientific community. Ensuing Paracelsians claimed inspiration from him, but it does not follow that Paracelsus' philosophical saltpeter was identical to that of later scientific movements. Most philosophers in this period sought to interpret variations of Paracelsus' epistemic claims within the provisions of their own systems, and many saw the rationality of their own views as philosophically superior. Claims of indebtedness attributed to associates of the

---

[328] Mayow, *Tractatus Quinque,* 13. "With regard then to the aerial part of nitrous spirit, we maintain that it is nothing else than the igno-aerial particles which are quite necessary for the production of any flame."

Later in his work, Mayow provided a more comprehensive summary of how respiration supports the process of fermentation in the body to sustain life: "…the same nitro-aerial particles when introduced more profusely into the mass of the blood by the action of the lungs, and mixed in their minutest parts with its saline-sulphureous particles, brought to a state of active vigour, produce a very marked fermentation such as is requisite for animal life…Indeed I attempted to show above that nearly all fermentations of natural things result from the motion of nitro-aerial particles, and in fact I have no doubt at all that the effervescence of the blood is due to the same cause: accordingly when respiration is arrested, the effervescence of the blood immediately ceases and animal life is extinguished." *Tractatus Quinque,* 102.

[329] Ibid, 244.

[330] Partington enumerates the works and theories of over thirty other authors in the seventeenth and eighteenth centuries that cite Mayow's concept of an aerial niter and his philosophies concerning combustion and respiration, especially as it applied to the growing understanding of human physiology. J. R. Partington,"Some Early Appraisals of the Work of John Mayow." *Isis* 50, no. 3 (September 1959): 211-226.

later Paracelsian tradition are broad and general in character, and do not in themselves necessarily point to any particular way of reconstructing his thought. However, as Frank has pointed out, the properties of saltpeter were such that they could be adapted to the explanations of men who employed them. In this way "the notion of an aerial niter was a double edged sword. It did not dictate its own use, but was rather dependent upon physiological assumptions with which it was approached …. In the short run, the known properties of niter only seemed to compound their problem."[331]

Drawing on their alchemical heritage and convictions, Paracelsian thinkers heavily reshaped his theory of a nitrous aerial substance in a process of both active and creative reinterpretation to help enrich and expand the theoretical and empirical approaches towards the investigation of nature. This practical application of niter was assimilated into the research of major figures of the Scientific Revolution and contributed to the departure from the incongruent beliefs of classical ideologies. Appeals to an aerial niter by these philosophical practitioners, however, almost always echoed references of and included allusions to the instrumentality of saltpeter as the source of energy that enabled the powerful and volatile effects of gunpowder weapons. It is this connection to its original cultural and technological source that serves as a compelling point of philosophical inquiry. A reflection on the reasoning inherent to the adoption and employment of an aerial niter principle not only demonstrates knowledge translation or transfer from one domain to another, but also helps illuminate undervalued patterns and elements inherent to the conception of scientific progress and discovering truths about the unobservable world.

[331] Frank, *Harvey and the Oxford Physiologists,* 120.

Concluding Remarks and Reflections on the Influence and Impact of Aerial Niter Theories on the Philosophy of Technology

1. Situating the Philosophy of Technology and Aerial Niter Theories

Examining the chemical tradition that had informed the idea of an aerial nitrous substance, and the cultural environment that allowed these theories to flourish, is indicative of some of the ways in which these factors influenced subsequent – and continue to influence present – historical scholarship. The contributions of the Paracelsian philosophy were central to the important matrix of developing attitudes and theories in the seventeenth and eighteenth centuries that helped create new knowledge and practices relating to nature. These practices provided a nexus for an approach that fostered a constellation of evolving methods and ideas linking man and the universe in a cosmic economy of chemical and spiritual conversion. What is challenging in this historical narrative is the demonstration of the link that joined these progressive views and findings with the philosophical process that gave rise to new ways of thinking about the invisible structure of material reality. Paracelsus' decision to incorporate salt into his doctrine of the *tria prima* and his influential iatrochemical conception of the world not only represented a transformation in the conception and practice of science and medicine, but also functioned as an important element within the theoretical conception of the early modern worldview. Paracelsus' work is valuable in that it occupied a transitional position, one that offered an epistemic template for the development of a new comprehension of nature.

My intent in the preceding chapters has been to illuminate two main points. First, that Paracelsus was the first to develop and propose an ethereal salt principle — a theory not only realized through physical and chemical effects, but one that also possessed ontological and metaphysical utility. Second, that salt, or more specifically saltpeter, would not have taken on this metaphysical identity without the importance and growing popularity, as well as the economic and political significance, accorded to gunpowder weapons beginning in the Renaissance. Important to the development of these aerial niter theories was the intellectual environment of the time which allowed a metaphysical salt concept to flourish due to Neoplatonic influence and ideas of natural correspondence.

Alchemy and the perceived natural magic of divine creation both embodied and explained these processes, often constituting the language in which these vital ideas were discussed. This examination of the parallel rise of gunpowder weapons and the utilization of their principle source of power showcases the reciprocity between early modern science and emergent technologies. The perceived transition of saltpeter from the primary component in a technological instrument to a conceptual manifestation of the fundamental structure of reality reflects a unique epistemological transfer of concepts from craft knowledge to that of metaphysical and philosophical beliefs.

Though seemingly prosaic from a historical perspective, the development of this eternal salt archetype had significant conceptual repercussions that, when reflected on, provide a starting point for the emergence of new theorizations of agency and organization. Aerial niter theories provided more than just practical explanations for the material constitution of the earth and the operations of the human body — they were transposed to a theoretical plane transcending the physical, chemical, and biological realms. Instituting these niter particles as a cornerstone in a cosmological system of natural philosophy shaped the framework for conceiving an impression of natural order not only in the temporal sense, but also the metaphysical. This "knowledge," however, was only realized through the development and application of a specific technology — in this case, gunpowder technology. What makes this circumstance even more unique is that this technology was not built with the intent of understanding any particular feature of the universe. Here we are presented with the origin of a theoretical and metaphysical concept derived from a technology whose base principal intent did not necessarily infer an obvious correlation or mental association to an ordering principle of the cosmos.

What the development and application of aerial niter theories suggest is something important about the epistemological nature of science and technological progress. We are accustomed to thinking, and it is principally true, that most scientific theories begin with a metaphysical or philosophical conception (starting point of hypothesis) that is then translated into experiments. These often include developing the requisite technology needed to empirically realize and confirm the abstract theorization. However, this was not the case in the instance of gunpowder weapons and the evolution

of an aerial niter principle. In this case, we have a historical example of technology as the *origin* for supposed metaphysical knowledge that was then used to describe the fundamental structure and principles of nature. The advancement of this universal salt principle was unprecedented in that it was applied in a plurality of multifarious uses that intersected, and substantially impacted, a variety of early modern scientific disciplines and theories.[332]

Thus, while the technology of gunpowder realized and furthered a form of both tacit and physical knowledge, it inadvertently also inspired philosophical and metaphysical comprehension. I argue that this translation or transfer of cross-domain knowledge is an exceptional historical example, and that the implementation of niter theories reflects a non-typical conception of epistemic development than is normally observed between technology and philosophy.

The ascent of aerial niter theories and this notion of *lorem scientia metaphysicae* – or metaphysical knowledge inspired by technology – serves as a paragon for contemporary inquiry into philosophical contemplations on technology and its metaphysical groundings and relationship to nature. Does this historical example help prove Koyre's notion that technology involves its own form of knowledge? Do aerial niter theories play into the philosophies of Friedrich Dessauer (1881 – 1963) and Martin Heidegger (1889 – 1976), demonstrating that the nature of technology is a sense of Being that gives us access to eternal forms and, as such, is the nexus for understanding reality and of existence? Is technology capable of divulging something essential about the ontology of the universe? Did gunpowder technology embody, in the Heideggarian sense, the concept of *Enframing* that revealed to mankind some latent force of nature, thereby disclosing a previous unknown truth? Can we view technology as a force of nature imbued with power capable of defining the human experience?

This essay clearly does not aim to derive a grand unifying theory for determining and employing a philosophical framework for technology. Rather, it is an attempt to draw awareness to this historical occurrence in order to inspire a reconsideration of how historians and philosophers should think about the employment of these aerial niter

[332] Even though abstract conceptions like an aerial niter are flawed, often deeply so, they nevertheless

concepts. Specifically, how do we understand the significance of a physical element becoming a conceptual and intellectual reflection of the fundamental structure of reality? What are the implications of thinking about technology and our understanding of nature this way? Historical narratives of this sort provide a perspective on how a variety of new explanations were conceived by their originators, as well as offer an alternative way of understanding the multifaceted transformation that influenced these early modern philosophers' beliefs about causality, agency, and creation. Such an exchange contributes to developing discussions and emerging questions of whether technology can give rise to philosophical constructs and ideas about the structure of reality and truth in nature.[333]

2. Conclusion

The life and works of Paracelsus encompassed a philosophically rich and intellectually tumultuous period, one saturated with the aging ideals of the Renaissance giving way to an age of revolution and discovery. Paracelsus' work constituted an elaborate and multifaceted engagement with nature and brought up philosophical perspectives that wielded a prominent impact in a number of scientific and medical disciplines throughout the early modern era. Although his system was built on a chemically revised Neoplatonic cosmology, Paracelsus brought forth both new and provocative concepts that were vigorously expounded on in the work of his followers, which notably included his three principle constitution of the *tria prima* together with his emphasis on a "philosophical" or spiritual salt.

Historians of science and philosophy have assessed the contributions of these Paracelsian ideals from seemingly contrasting perspectives. Some have viewed the acceptance of the three principles as crucial to the development of early modern science, whereas others have argued for the dispensability of his alchemical-based system. With regard to his implementation of a fundamental or spiritual salt principle, the influence and

---

provide an intellectual launching pad for exploration and the discovery of future truths.

[333] Of note, authors and editors in the recent publication *Philosophy of Technology and Engineering Sciences* (2009) make a distinguished effort to address many of these abstract and philosophical issues with the intent to clarify and advance further research into the growing discipline of the philosophy of technology.

protraction of aerial niter theories have received literary and academic acknowledgement, though I contend that their causes and philosophical ramifications have not been fully understood. I have tried to unpack the distinctive features that contributed to the origins of these niter theories by devoting attention to Europe's intellectual and alchemical heritage, as well as the cultural and political influences that played into Paracelsus' personal experiences. I argue that this intellectual influence was distinctly shaped by the ubiquity of war and the adoption of gunpowder technology that both captivated the cultural conscious and played a profoundly important role in framing the politics, economics, and culture of the sixteenth and seventeenth centuries. Contrary to the traditional historical narrative, I have shown that this reassessment of Paracelsus' works confirms that he was the first to record a spiritual and philosophical salt principle as early as 1525 which he penned in his writings that were later published as the *Archdioxis,* and that the impetus for positing a theoretical salt agency was due to his experience and familiarity with gunpowder and gunpowder weapons.

The origins of aerial niter principles and the consequences of their exportation into both scientific and philosophical theories illustrates the extent to which gunpowder technology, as a form of empirical authenticity, introduced a shift in the perspective of epistemological and natural philosophical understanding. It is a remarkable example of technological knowledge and mechanical art that went on to influence the construction of an entire cosmology. Such a unique circumstance deserves further investigation as a possible means of discovering other nuanced parallels to aide in our comprehension of the intellectual and cultural history of the early modern period, as well as garner deeper insights into our understanding of themes and patterns in the history and philosophy of science more generally.

Bibliography

Primary Sources:

Agricola, Georgius, *De Re Metallica*, trans. Herbert Clark Hoover. New York: Dover Publications, Inc., 1950.

An Act for making Salt-Petre. London, 1653. Early English Books Online (158:E.1061[88]). University of Minnesota. 4 Feb. 2012.

An ordinance of the Lords and Commons assembled in Parliament for the making of salt-peter within the kingdom of England and Dominion of Wales for the preservation and safety of the kingdom. London, 1644.

Bacon, Sir Francis. *Novum Organum.* Edited by Joseph Devey, M.A. New York: P.F. Collier, 1902.

Biringuccio, Vannoccio. *The Pirotechnia of Vannoccio Biringiccio*. Edited by Cyril Stanley Smith and Martha Teach Gnudi. Cambridge, MA: MIT Press, 1959.

By the King. A Proclamation for the better making of Saltpeter within this Kingdome. London, 1626.

By the King: A Proclamation Prohibiting the Importation of Forraine Gun-powder, and that His Majesties Subjects may be constantly supplied out of His Majesty's Store-houses. London, 1636.

By the King and Queen. A Proclamation to prohibit the exportation of Salt Petre. London, 1689.

Henshaw, Thomas. "The History of the Making of Salt-Peter." In *The History of the Royal Society of London, For the Improving of Natural Knowledge*, edited by Thomas Sprat, 260-276. London, 1667.

Hooke, Robert. *Micrographia.* Reprint, New York: Dutton, 1964.

Mayow, John. *Medico Physical Works: Being A Translation of Tractatus Quinque Medico-Physici.* Translated by A. C. B. and L. D. Edinburgh: Alembic Club, 1907.

Newton, Sir Isaac. *Opticks or A Treatise of the Reflections, Refractions, Inflectinos & Colours of Light*, 4th ed. London 1730. New York: Dover Publications, Inc., 1952.

Paracelsus. *His Archidoxis: Comprised In Ten Books: Disclosing the Genuine Way of Making Quintessences, Arcanums, Magisteries, Elixirs, &c: Together with His Books of Renovation & Restauration, of the Tincture of the Philsophers, of the Manual of the*

Philosophical Medicinal Stone, of the Virtues of the Members, of the Three Principles, and Finally His Seven Books of the Degrees and Compositions, of Receipts and Natural Things. Translated by J. H. Oxon. London, 1660.

_____. *Paracelsus: Essential Readings*. Edited by Nicholas Goodrick-Clarke. Berkeley: North Atlantic Books, 1999.

_____. *Paracelsus (Theophrastus Bombastus von Hohenheim, 1493-1541): Essential Theoretical Writings.* Edited by Andrew Weeks. Leiden: Brill, 2008.

_____. *The Hermetic and Alchemical Writings of Aureolus Philippus Theophrastus Bombast, of Hohenheim, called Paracelsus the Great. Vol I.* Edited by Arthur Edward Waite. Berkeley, Calif: Shambhala, 1976.

_____. *The Hermetic and Alchemical Writings of Aureolus Philippus Theophrastus Bombast, of Hohenheim, called Paracelsus the Great. Vol II.* Edited by Arthur Edward Waite. Berkeley, Calif: Shambhala, 1976.

Van Helmont, Jean Baptiste. *Oriatrike or Physick Refined. The common Errors therein Refuted, And the whole Art Reformed & Rectified: Being A New Rise and Progress of Phylosohy and Medicine, for the Destruction of Diseases and Prolongation of Life*., trans. John Chandler. London: Lodowick Hoyd, 1664.

Secondary Sources:

Ball, Phillip. *The Devil's Doctor: Paracelsus and the World of Renaissance Magic and Science.* New York: Farrar, Straus, and Giroux, 2006.

Banchetti-Robino, Marina Paola. "Ontological Tensions in 16th and 17th Century Chemistry: Between Mechanism and Vitalism." *Foundations of Chemistry* 13 (2011): 173-186.

Bianchi, Massimo L. "The visible and the invisible. From alchemy to paracelsus." In *Alchemy and chemistry in the 16th and 17th centuries*, ed. P. Rattansi and A. Clericuzio, 17–50. Dordrecht: Kluwer Academic Publishers, 1994.

Boot, Max. *War Made New: Technology, Warfare, and the Course of History, 1500 to Today*. New York: Gotham Books, 2006.

Borrelli, Arianna. "The Weather-Glass and its Observers in the Early Seventeenth Century." In *Philosophies of Technology: Francis Bacon and his Contemporaries, vol. 1,* edited by Claus Zittel, Gisela Engel, Romano Nanni, and Nicole C. Karafyllis, 67-130. Leiden: Brill, 2008.

Buchanan, Brenda J. "Saltpetre: A Commodity of Empire." In *Gunpowder, Explosives, and the State*, edited by Brenda J. Buchanan, 67-90. Aldershot, England: Ashgate Publishing Limited, 2006.

Chang, Ku-ming. "Alchemy as Studies of Life and Matter: Reconsidering the Place of Vitalism in Early Modern Chymistry." *Isis* 102, no.2 (June 2011): 322-329.

Clericuzio, Antonio. "The Internal Laboratory. The Chemical Reinterpretation of Medical Spirits in England (1650-1680)." *In Alchemy and Chemistry in the 16th and 17th Centuries*, edited by Piyo Rattansi and Antonio Clericuzio, 51-83. Dordrecht: Kluwer Academic Publishers, 1994.

Cocroft, Wayne. *Dangerous Energy: The Archaeology of Gunpowder and Military Explosives Manufacture.* Swondon: English Heritage, 2000.

Cressy, David. "Saltpetre, State Security and Vexation in Early Modern England." *Past and Present* 212 (2011): 73-111.

_____. *Saltpeter: The Mother of Gunpowder.* Oxford: Oxford University Press, 2013.

Daniel, Dane T. "Invisible Wombs: Rethinking Paracelsus's Concept of Body and Matter." *Ambix,* Vol. 53, No. 2 (July 2006,):129–142.

Debus, Allen G. *Chemistry and Medical Debate: van Helmont to Boerhaave*. Canton, MA: Science History Publications, 2001.

_____. "Fire analysis and the elements in the sixteenth and the seventeenth centuries." *Annals of Science 23*, Issue 2 (1967): 127-147.

_____. "The Aerial Niter in the Sixteenth and Early Seventeenth Centuries." *Actes du Dixième Congrès International d'Histoire des Sciences, Vol. II* (Paris, 1964): 835-839.

_____. *The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries.* New York: Dover Publications, 1977.

_____. *The Chemical Promise: Experiment and Mysticism in the Chemical Philosophy, 1550-1800.* Sagamore Beach: Science History Publications, 2006.

_____. *The English Paracelsians.* New York: Franklin Watts, Inc., 1966.

_____. T*he French Paracelsians: The Chemical Challenge to Medical and Scientific Tradition in Early Modern France*. Cambridge: Cambridge University Press, 1991.

_____. "The Paracelsian Aerial Niter." *Isis* 55, no. 1 (March 1964): 43-61.

Delbrück, Hans. *The Dawn of Modern Warfare: History of the Art of War, Volume IV*. Translated by Walter J. Renfroe, Jr. Lincoln: University of Nebraska Press, 1990.

DeVries, Kelly. "Gunpowder and Early Gunpowder Weapons." In *Gunpowder: The History of an International Technology*, edited by Brenda J. Buchanan, 121-135. Bath: Bath University Press, 1996.

_____. "Sites of Military Science and Technology." In *The Cambridge History of Science*, edited by Katharine Park & Lorraine Daston, 306-319. Cambridge: Cambridge University Press, 2006.

Forshaw, Peter J. "Morbo spirituali medicina spiritualis convenit": Paracelsus, Madness, and Spirits." In *Aisthetics of the Spirits: Spirits in Early Modern Science, Religion, Literature and Music*, edited by Steffen Schneider, 287-306. Göttingen: V&R Press, 2015.

Frank, Robert G. *Harvey and the Oxford Physiologists: Scientific Ideas and Social Interaction.* Berkeley: University of California Press, 1981.

Frey, James W. "The Indian Saltpeter Trade, the Military Revolution, and the Rise of Britain as a Global Superpower." *The Historian* 71 (2009): 507-554.

Goodrick-Clarke, Nicholas. *Paracelsus: Essential Readings*. Berkeley: North Atlantic Books, 1999.

Guerlac, Henry. "The Poets' Nitre." *Isis* 45, no. 3 (September 1954): 243-255.

Hale, J.R. "Gunpowder and the Renaissance: An Essay in the History of Ideas." In *From the Renaissance to the Counter-Reformation*. Edited by Charles H. Carter, 389-420. New York: Radom House, Inc, 1965.

Hall, Bert S. "The Corning of Gunpowder and the Development of Firearms in the Renaissance." In *Gunpowder: The History of an International Technology*. Claverton Down, Bath: Bath University Press, 1996.

_____. *Weapons and Warfare in Renaissance Europe: Gunpowder, Technology, and Tactics.* Baltimore: The John Hopkins University Press, 1997.

Hooykaas, Reijer. "Chemical Trichotomy Before Paracelsus?" in *Selected Studies in History of Science* (Coimbra: Por ordem da Universidade, 1983): 105-119.

Jones, Archer. *The Art of War in the Western World.* Urbana: University of Illinois Press, 2001.

Kelly, Jack. *Gunpowder: Alchemy, Bombards, and Pyrotechnics: The History of the Explosive That Changed the World*. New York: Basic Books, 2004.

Mauskopf, Seymour H. "Chemistry in the Arsenal: State Regulation and Scientific Methodology of Gunpowder in Eighteenth-Century England and France," in *The Heirs of Archimedes*, edited by Brett D. Steele and Tamera Dorland, 293-230. Cambridge, MA: The MIT Press, 2005.

McKie, Douglas. "Fire and the Flamma Vitalis: Boyle, Hooke and Mayow." *In Science Medicine and History: Essays on the Evolution of Scientific Thought and Medical Practice*, ed. E Ashworth Underwood. London: Oxford University Press, 1953.

Moran, Bruce. *Distilling Knowledge: Alchemy, Chemistry, and the Scientific Revolution*. Cambridge: Harvard University Press, 2005.

Newman, William R. and Lawrence M. Principe. *Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chymistry*. Chicago: University of Chicago Press, 2002.

_____. "From Alchemy to 'Chymistry.'" in *The Cambridge History of Science*, vol. 3: Early Modern Science, edited by Katharine Park and Lorraine Daston, 497–517. Cambridge, 2006.

_____. William R. *Gehennical Fire: The Lives of George Starkey, an American Alchemist in the Scientific Revolution.* Chicago and London: University of Chicago Press, 2003.

Pagel, Walter. "Paracelsus and the Neoplatonic and Gnostic Tradition." *Ambix* 8, issue 3 (1960): 125-166.

_____. *Paracelsus. An Introduction to Philosophical Medicine in the Era of the Renaissance*. Basel, 1958; reprint 1982.

_____. *Religion and Neoplatonism in Renaissance Medicine.* Edited by Marianne Winder. London: Variorum Reprints, 1985.

_____. *The Smiling Spleen: Paracelsianism in Storm and Stress.* Basel: Karger, 1984.

Pagel, Walter & Marianne Winder. "The Higher Elements and Prime Matter in Renaissance Naturalism and in Paracelsus." *Ambix* 21: 2-3 (July & November 1974), 93-127.

Parker, Geoffery. *The Military Revolution: Military Innovation and the Rise of the West, 1500-1800.* Cambridge: Cambridge University Press, 1996.

Partington, J. R. *A History of Greek Fire and Gunpowder.* Cambridge: W. Heffer& Sons, LTD, 1960.

_____. "Some Early Appraisals of the Work of John Mayow." *Isis* 50, no. 3 (September 1959): 211-226.

Porto, Paulo Alves. "Michael Sendivogius on Nitre and the Preparation of the Philosophers' Stone." *Ambix* 48, part 1 (March 2001): 1-16.

_____. "Summus atque felicissimus salium": The Medical Relevance of the Liquor alkahest." *Bulletin of the History of Medicine,* Volume 76, Number 1 (Spring 200): 1-29.

Preston, Richard A., Sydney F. Wise, and Herman O. Werner. *Men in Arms: A History of Warfare and its Interrelationships with Western Society*. New York: Frederick A. Praeger, 1956.

Principe, Lawrence M. *The Secrets of Alchemy.* Chicago: University of Chicago Press, 2013.

Sherlock, T. P. "The Chemical Work of Paracelsus." *Ambix* 3 (May 1948): 33-63.

Stewart, Richard Winship. *The English Ordnance Office 1585-1625: A Case Study in Bureaucracy.* Woodbridge: The Boydell Press, 1996.

Stoddart, Anna M. *The Life of Paracelsus Theophrastus Von Hohenheim 1493-1541.* London, John Murray, 1911.

Szydlo, Zbigniew. "The Alchemy of Michael Sendivogius: His Central Nitre Theory." *Ambix* 40, part 3 (November 1993): 129-146.

_____. "The Influence of the Central Nitre Theory of Michael Sendivogius on the Chemical Philosophy of the Seventeenth Century." *Ambix* 43, part 2 (July 1996): 80-96.

Tierie, Dr. Gerrit. *Cornelis Drebbel (1572-1633)*. Amsterdam: H. J. Paris, 1932.

Waite, Arthur Edward. *Lives of Alchemystical Philosophers, Based on Materials Collected in 1815.* London: George Redway, York Street, Covent Garden, 1888.

Waite, Arthur Edward, ed. *The Hermetic and Alchemical Writings of Aureolus Philippus Theophrastus Bombast, of Hohenheim, called Paracelsus the Great. Vol II.* Berkeley, Calif: Shambhala, 1976.

Webster, Charles. *Paracelsus: Medicine, Magic, and Mission at the End of Time.* New Haven: Yale University Press, 2008.

Weeks, Andrew, ed. *Paracelsus (Theophrastus Bombastus von Hohenheim, 1493-1541): Essential Theoretical Writings*. Leiden: Brill, 2008.

_____. *Paracelsus: Speculative Theory and the Crisis of the Early Reformation*. Albany, N. Y., 1997.

Williams, A.R. "The Production of Saltpetre in the Middle Ages." *Ambix* Vol. 22, Part 2. (1975).

Wilson, Peter. "European Warfare 1450-1815." In *War in the Early Modern World*, edited by Jeremy Black, 177-206. London: Routledge, 2005.