Extended Essay

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From Alchemy to Chemistry:

How far did the Scientific Revolution explain Alchemy's decline in Europe?

An Extended Essay in

History

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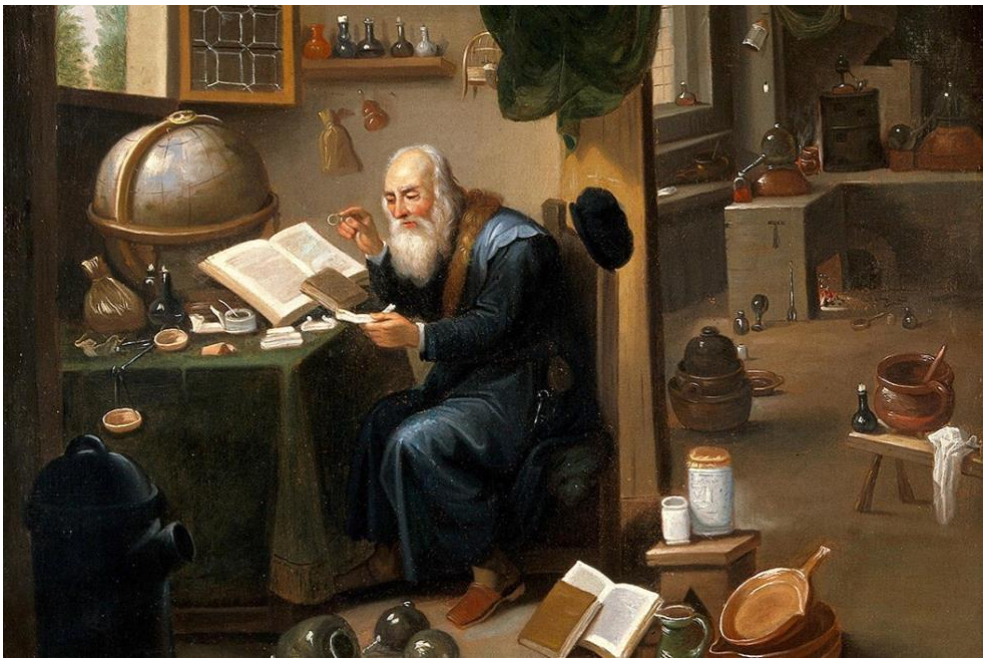

Figure 1 Follower of David Teniers the Younger, An alchemist in his laboratory, 1610-1690, Wellcome Collection.

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Introduction and Significance

In the British chemist Joseph Priestley's last book, published in 1796, he wrote: "There have been few, if any, revolutions in science so great, so sudden, and so general, as the prevalence of … the new system of chemistry, or that of the *Anti*phlogistons, over the doctrine of Stahl, which was … thought to have been the greatest discovery … in the science" (Conant 13). At this time, Priestley was almost alone in standing for the phlogiston theory – a theory he was so close to overthrowing if he had not misinterpreted the unrecognized gas as "phlogisticated nitrous air" (modern name: nitrous oxide) (35, 55). The alchemist Stahl (1660-1724) proposed this convincing phlogiston theory that states combustion is caused by an unperceivable fire-like element, phlogiston, "imprisoned" in combustible objects that can only be detected when it is "escaping" from the combustible objects (Muir 64-65). The theory was almost universally accepted by scholars then as it can be "scientifically" confirmed. However, the theory was eventually replaced by modern chemistry theory as we know it now: phlogiston did not cause the burning, but oxygen in the surroundings did (Conant 14; Muir 64).

Alchemy has a long history. The name "alchemy" was coined in sixth to seventh-century Europe. Previously, alchemy was named the sacred art, the divine science, the occult science, and the art of Hermes (Muir 12, 62). Having its origin in Egypt, Egyptian theology influenced alchemy heavily. After spreading to Europe, alchemists focused on studying natural phenomena (13). The Polish alchemist Michael Sendivogius accounted in his 17th-century book *The New Chemical Light*, "the sage sees heaven reflected in Nature as in a mirror, and he pursues this Art … for the love of the knowledge which it reveals" (13-14). In general, alchemical practices were tightly related to studying nature.

People from all social backgrounds could practice alchemy for different aims. Some people were interested in finding the Philosopher's Stone that converts metals into gold (this activity is later known as "chrysopoeia"), some were passionate about finding the super-medicine *aqua vitae* (later known as "iatrochemistry") that purifies bodies from diseases and achieve eternal life, some were attracted to the alchemical philosophies, while some do everything together (Moran 9).

Alchemy was embedded coherently in the societal and cultural systems, such as social institutions, religious beliefs, and philosophical ideas, so alchemy practices were recognized as a rational pursuit at the time (Moran 25). Therefore, once some alchemists claim they "successfully" produced the Philosophers' Stone or found the *aqua vitae*, people tended to believe in their successes – only if the procedures were not examined rigorously (30-31). Generally agreed by chemists and science historians, alchemy prevailed in Europe from the ninth century until the end of the eighteenth century, when modern chemistry started developing (62).

Meanwhile, the Scientific Revolution from the sixteenth to the eighteenth century was when new scientific ideas emerged and rejected previously well-recognized beliefs from ancient Greece up to the Middle Ages (Nnaji). The Scientific Revolution laid the foundation of many modern scientific advancements. Yet, the Scientific Revolution's impact on various sciences in the sixteenth to eighteenth centuries is defined differently in historiography. Some historians argue that the Scientific Revolution was primarily centered upon mathematics and physics progressions in the sixteenth to the seventeenth century.

The term "Chemical Revolution" is often explicitly used for the 18th-century modern chemistry's development, mainly referring to discovering oxygen, determining water's molecular composition, and Lavoisier's new chemical nomenclature (Conant 12). For instance, in science historian Herbert Butterfield's *The Origins of Modern Science*, he named a part of the Scientific Revolution "The Postponed Revolution in Chemistry" (Butterfield). His documentation led to the awareness that smaller revolutions made up the larger overall Scientific Revolution. In this essay, the Scientific Revolution refers to the entire period, not restricted to fields. So, after the Scientific Revolution, the place of chemistry as an independent discipline was established in European universities (Crosland).

Under the Scientific Revolution, alchemy gradually declined, and modern chemistry developed. However, a clear-cut line in the transition is hard to draw (Moran 99; Muir 64). The intertwined transition from alchemy to chemistry led to ambiguous naming, increasing the difficulty in historical studies. As elaborated in the contemporary historians of science Newman and Principe's influential paper, even during the late seventeenth century, the terms "alchemy",

"chymistry", and "chemistry" were used as synonyms, as well as "alchemists", "chymists", and "chemists" (Newman, *Alchemy vs. Chemistry*). In the eighteenth century, for the first time, "alchemical activities" were known to be restricted to gold-making only, known as "chrysopoeia", as gold-making was only a part of alchemical activities previously (Newman, *Secrets of Nature* 386). Also, not until the start of the eighteenth century were "alchemy" and "chemistry" used separately, mainly due to the anti-chrysopoeian Lemery's intentional efforts (Newman, *Alchemy vs. Chemistry*; Newman, *Promethean Ambitions* 13).

To keep things clear, "alchemy" will be used to refer to all alchemy and chemistry activities before the seventeenth century, "chymistry" will be used for all related activities in the seventeenth century, and "chemistry" will be used only for the chemistry events after the seventeenth century. Nonetheless, this is not to say after the 17th century, alchemy had no chemical traces, nor chemistry is entirely free of alchemical influences. The primary views in existing literature concerned with my research question can be generally categorized by the different ways of viewing the relationship between alchemy and modern chemistry. The traditional discontinuity view holds that alchemy and chemistry are different fields, with the Scientific Revolution leading to alchemy's decline and modern chemistry's rise. The more contemporary continuity view states that the Scientific Revolution contributed to this gradual "evolution" from alchemy to modern chemistry.

This essay mainly evaluates the different discontinuity and continuity views on traditional alchemy's decline in Europe from the intellectual and social aspects. While a clear boundary between alchemy and early modern chemistry is hard to argue, I propose that the Scientific Revolution did not entirely cause alchemy's decline. The Scientific Revolution contributed greatly to how people viewed alchemy negatively and changed how people interpreted their experimental results, leading to alchemy's decline. However, alchemy's skepticism, experimental-based approach, and constant re-evaluation in alchemical and chymical studies were a long practice.

The history of chemistry still needs historical studies. As alchemy's importance to the origin of early modern sciences is generally conceded by contemporary literature, more careful examinations of alchemy's specific contributions should be done. Especially concerning alchemy's diverse and complex subject matter, balanced and rigorous studies will elucidate

preconceptions of alchemy. Investigating this topic at the crossing of history and science also allows better acknowledgment of the connection between scientific developments and the philosophical, sociological, and historiographical movements over time and appreciation for future scientific developments (McEvoy).

Methodology

After the Scientific Revolution, a sensitive boundary defining the physical subjects and the spiritual subjects was developed. Alchemy was grouped along the lines of metaphysics, entrenching with occult, magic, and superstition. The prioritized objectivity and rationality rejected traditional alchemy (Moran 10; Newman, *Alchemy vs. Chemistry*). Additionally, early eighteenth-century writers' (such as Lemery, Geoffroy, and Fontenelle) focused extensively on exposing alchemists' gold-making lies, which impactfully portrayed this field as a fraud and an occult. This influential occult view caused scholars at the time, early chemical historians, and even some modern historians to possess a negative attitude toward alchemy and characterized chemistry and alchemy as two distinct fields (Newman, *Secrets of Nature* 386). Also evident in references from the nineteenth-century beginning, alchemical mentioning was strongly linked with occult practices, such as witchcraft and magic (387). These occult fields were disregarded.

In the nineteenth century, an occult revival happened, where occult topics, such as magic and witchcraft, were re-embraced instead of condemned. Consequently, alchemy received attention again, but often only on the occult aspects (Newman, *Secrets of Nature* 387). The "spiritual alchemy" view shifted people's negative perception of alchemy by redirecting people's attention away from alchemy's fraudulent gold-making impression to the connection between alchemy and personal spiritual growth (388-389). For instance, the journey of finding the Philosopher's Stone is also a preparation for the alchemist's spirit (Moran 67). The nineteenth to twentieth-century chemists and physicists Frederick Soddy and Ernest Rutherford, who studied radioactive elements, once considered their scientific findings parallel to metal transmutation in alchemy (Morrisson 4). Noteworthy authors' efforts, such as Franz Anton Mesmer, Julius Evola, and Titus Burckhardt, laid the foundation and supported the "spiritual alchemy" view to flourish and extend into the twentieth century.

Then, alchemy's spiritual interpretations attracted many philosophers and psychologists, incentivizing them to study earlier alchemists' works and incorporate alchemical beliefs into their work (Nummedal, *Alchemy in Europe and the Middle East – The Scientific Revolution And Beyond*). For example, psychologist Carl Gustav Jung (1875-1961) interpreted the symbolisms in alchemy as a projection of internal developmental psychological stages (Calian). Jung also noted that if the rise of chemistry made the principles of alchemy erroneous, the spiritual aspects of alchemy would "not disappear" (Jung 37). While Jung's research based on his alchemy and psychology connection is now criticized for a lack of evidential support, the modern historian Mircea Eliade's *The Forge and the Crucible: The Origins and Structures of Alchemy* takes the perspective in studying alchemy like a religious study instead of a proto-science only (Calian; Eliade). Nonetheless, Eliade's work is also commented on by William R. Principe and Lawrence M. Newman as "directly influenced by late nineteenth-century occultism" as alchemy before nineteenth-century occultism did not contain enough spiritual aspects to place the field entirely along with other religious studies (Newman, *Secrets of Nature* 30).

While twentieth-century psychologists diverged alchemy away from physical chemistry, many early 20th-century historians studying alchemy also had a dismissive attitude towards traditional alchemy. The dismissive attitude was possibly due to eighteenth-century writers' efforts in characterizing alchemy as fraudulent gold-making. Finding alchemy unscientific, E. J. Dijksterhuis and A. Rupert Hall remarked alchemy is a "pathology of thought" and an "obstacle to the development of rational chemistry" (Dijksterhuis; Newman, *What Have We Learned from the Recent Historiography of Alchemy*; Rupert Hall). A notable historian representing this view is E. J. Holmyard. He argued that alchemy's entire system was singlehandedly destroyed by the 17th-century chymist Robert Boyle, and the development of modern chemistry was blocked by alchemy (Coyne). He named the less scientific practices as alchemy, the science-like practices before the Scientific Revolution chemistry, and the practices afterward the Revolution as modern chemistry.

In opposition to the traditional view, the more contemporary continuity view focuses on the intimate correlation between alchemy and chemistry. These scholars, mostly from the 1950s onwards, reconsidered the traditional dichotomous view and believed that aspects of alchemy contributed to modern chemistry (Clements). Furthermore, as historians Newman and Principe

pointed out in their influential paper "Alchemy vs. Chemistry: The Etymological Origins of a Historiographic Mistake", published in the late 20th century, alchemy and chemistry had a very blurry, if none at all, borderline before the mid-eighteenth century etymologically (Newman, *Alchemy vs. Chemistry*). This paper harshly challenged the assumptions of previous historians with a traditional view of alchemy, such as the work of Marie Hall, who argued that the existence of "chemistry" and "alchemy" as two words naturally implied a distinction between the disciplines (Marie Hall). Newman and Principe's paper also noted the lack of clarity in previous works. Newman's study had a particular focus on Robert Boyle. Other impactful historians supporting this continuity view include Bruce T. Moran, who justified the two disciplines' connection through the works of Robert Boyle and Isaac Newton and argued more moderately that certain aspects of alchemy became more like chemistry during the Scientific Revolution. The historian Ferdinando Abbri suggested a more nuanced relationship between the two disciplines (Abbri; Moran).

Despite the increasing awareness of alchemy's non-mystical sides in recent literature, the context in which the alchemists worked inevitably differed from the later chemists. Since many of the alchemists' theories were built upon ancient ideologies and unrealistic pursuits, some historians, such as George Sarton, attempted to portray the practical alchemists as analogous to chemists is far-fetched (Sarton). We need to remember the Historian's Fallacies, as David Fischer defined, in this context that modern chemistry theories were absent in the minds of most alchemists and chymists (Fischer). Therefore, giving false scientific understanding to alchemists should be avoided.

This essay approaches the research question by evaluating how existing literature interprets traditional alchemy's transition into chemistry under the Scientific Revolution. The following section first considers the evolutionary nature of chymists' works throughout history and then examines the social aspects from the Scientific Revolution that contributed to alchemy's decline.

Alchemy's Intellectual Aspects

New theories and interpretations were often raised throughout alchemy's history, renewing the discipline. In ancient Greece, the philosopher Aristotle conceptualized that everything

comprises four elements, earth, fire, air, and water, each with distinct "qualities". Then the later Middle Ages, Arabic writers, under the influence of Aristotelian thinking, proposed that the two dominant elements in metals are sulfur and mercury, in which gold and silver were the purest metals due to their high "sulfur" and "mercury" concentration, respectively (Moran 25-26). However, these major changes in beliefs were regarded as advances within the broader field of alchemy instead of posing a revolution. Therefore, the re-evaluation in alchemy is constant throughout its development and did not lead to a separation within the field, like alchemy and chemistry.

Yet, historians who support the alchemy and chemistry discontinuous view often set their frameworks based on the view that the rise of science caused alchemy's decline – especially during the Scientific Revolution (Clements). As the historian Tara Nummedal outlined in her book, many notions raised by chymists in the seventeenth century opposed traditional alchemy. Out of these notions that seemed to separate alchemy and chemistry, experimental chemistry and atomic theory developments most fundamentally challenged many alchemical assumptions, contributing to the decline (Nummedal, *Words and Works in the History of Alchemy* 330-337).

Despite ideological challenges, many chymists, such as Robert Boyle (1626–1691), tried to adapt alchemical beliefs to improve alchemy so alchemical theories fit the phenomena. He is often known as one of the "Fathers of Chemistry" for Boyle's gas law and the corpuscular theory of matter. His works undermined the ancient Greeks' four-elements view and led to the development of atomic theory (Greenberg 14, 142). The corpuscular theory of matter states that the external world is formed by small corpuscles (particles) in motion and exemplifies his mechanical philosophy, which also rejected the "growing towards perfection" and matter transmutation views in traditional alchemy (Eaton). Nonetheless, this seemingly new theory extended a long-lasting alchemical belief: the corpuscularian tradition from the medieval alchemy writer Geber (Moran 146; Newman *Experimental Corpuscular Theory*, 294-300). The direct connection was further exhibited in Boyle's work's wording. In his unpublished *Essay the […] Of the Atomicall Philosophy*, which records his proposition of the corpuscular theory, he "borrowed heavily, and without acknowledgment, from the works of Daniel Sennert", a prior alchemy writer who embraced the corpuscular theory (Coyne; Newman *Atoms and Alchemy*, 160; The Robert

Boyle Project). He even used "two [identical] examples … in the same order and without any break" as Daniel Senner's writing (Newman *Atoms and Alchemy,* 160). After all, Boyle believed matter transmutation was possible and worked toward this target for decades (Nummedal, *Alchemy in Europe and the Middle East – The Scientific Revolution And Beyond*).

Therefore, Boyle's recognition as a scientist was rather like a hybrid product formed by the alchemical beliefs and the emerging scientific beliefs, reflecting the gradual transition from alchemy to modern chemistry. His works drew inspiration from previous alchemists heavily regarding knowledge, aims, and methods. As his method was analogous to the Scientific method and his quantified observations findings aligned with the gradually forming thoughts from the Scientific Revolution, his contributions were amplified. Future chemists continued to research him, focusing on the scientific aspects instead of the alchemical intentions and contributing to the depiction of "rise of science" and alchemy's decline (Greenberg 14).

While some chymists' findings were motivated by alchemical beliefs, such as Robert Boyle, many chymists who delved into the field were out of curiosity, like Antoine Lavoisier. Antoine Lavoisier studied chymistry almost a century later than Robert Boyle (Greenberg 614). He was introduced to and became interested in the phlogiston theory in a lecture while pursuing his law degree (American Chemical Society International Historic Chemical Landmarks). His contribution to chemistry and importance to alchemy's decline is seen in his crucial discovery of oxygen that overthrew the phlogiston theory (Conant 57). He also wrote the *Traite Elementaire de Chimie*, which systematically put forth the newest chemical findings, ultimately marking the phlogiston theory's end (Conant 58).

The findings of Robert Boyle and Antoine Lavoisier both relied on their employed quantitative experimental method, which echoed ideas from the Scientific Revolution. For example, Lavoisier used balance to measure the different weights of substances before and after combustion. Although Antoine Lavoisier's approaches led him to explain combustion more accurately, previous chymists also used the balance. A prior chymist, Libavius, published a book detailing quantitative methods used in building various laboratory apparatus, using a balance to measure weights, and determining alloys quantitatively (Moran 8). Even though some might object

that Lavoisier did not necessarily read Libavius' work, many chymists employed similar methods to reach other conclusions. Thus, the quantitative and empirical approach is not the most underlying factor that caused alchemical ideologies to decline.

In summary, the Scientific Revolution's contributions to alchemy's decline in challenging previous alchemical or chymical ideas and promoting more scientific experimental approaches were not as fundamental and impactful.

Social Aspects of Alchemy's Decline

The Scientific Revolution also had major societal influences, changing how people think and how science activities were organized on a societal level. Antoine Lavoisier utilized alchemical theories as a foundation for his studies and a precise empirical method similar to Robert Boyle. However, an important distinction between Robert Boyle and Antoine Lavoisier was how they interpreted their results. Notably, Antoine Lavoisier was born when alchemy's influence had started declining due to the fraudulent portrayal, so he and many later chymists possessed a more objective explanation of the observed phenomenon (Conant). Lavoisier's interpretations were not derived from the phlogiston theory, leading him to expose the faulty phlogiston theory and contribute to alchemy's decline.

Such a shift in perspective further stimulated the development of chemistry, displaying revolutionary characteristics. As Muir summarized, "The change from alchemy to chemistry is an admirable example of the change from a theory formed by looking inwards, and then projected on to external facts, to a theory formed by studying facts, and then thinking about them" (63-64). "Looking inwards" refers to how alchemists proposed theories from their own inspiration. "Projected on to external facts" means to how physical phenomena were interpreted with the assumption that their proposed theories were correct. In contrast, chemical theories were formed based on the physical phenomena first, then interpreting the results to see what the reality implies.

In addition to individual chymists' contribution to developing modern chemistry, societal changes also factored in alchemy's decline. In contrast to alchemists' previously secretive attitude

during the Middle Ages, increasing chymists called for openness in their field of study, facilitating the transition. For instance, Francis Bacon (1561–1626) “condemned alchemists' tendency toward secrecy” while promoting collaboration and openness in studying natural knowledge. However, when the historian John Henry Bridges claims Roger Bacon’s work is “not alchemy at all” for he sees a “clear … survey, of chemical science as an intermediate link between Aristotelian physics and the science of living bodies”, Bridges ignored the absence of chemical ideas in Bacon’s mind, where his beliefs still centered upon testifying alchemy’s unrealistic assumptions (Bridges 74-77; Moran 23-24). Alchemy was an important source of scientific knowledge to him (Nummedal *Alchemy in Europe and the Middle East – The Scientific Revolution And Beyond*). Bacon represented many chymists at the time, reflecting how secrecy was not a defining aspect of alchemy. The open attitude during the Scientific Revolution helped foster further studies.

The push for openness in alchemical studies was part of the attempt to institutionalize the field during the Scientific Revolution, which caused the discipline to be more scientific. The chymist Libavius believed “academic chemistry … was really public alchemy” (Moran 111). As alchemy was deemed a fraud and aligned with other occult fields, alchemy needed to be more scientific to be accepted in universities. Libavius realized a reformation to chymistry was needed to construct a more logical method to successfully push for acceptance of chymistry into university curriculums, like logic and math did to other sciences (106). This push for publicity indicates the field’s re-evaluation inspired by the Scientific Revolution, showing how the Scientific Revolution contributed to alchemy’s transition. After many chymists’ successive work, chymistry was gradually institutionalized as a university department at the end of the seventeenth century and the beginning of the eighteenth century in Europe (Abbri).

Consequently, chymical ideas, with chemical and alchemical aspects, were spread in universities. For example, Professor Samuel Williams, who taught at Harvard College between 1780-1788, wrote in his lecture notes that the "greatest diminution of air by Phlogiston is about one-fourth of its first quantity and air which is diminished to its utmost by any one process cannot be any further diminished by another" (Conant 15-16). This account describes the mathematical relationship between the diminution in air volume during combustion. The mathematical relationship and the seemingly righteous experimental observation’s interpretation could sound

convincing despite the faulty phlogiston theory it supported. So, the institutionalization publicized chymical ideas, promoted communication between scholars, and indirectly led to the later modern chemistry theories.

Along with other scientists' efforts during the Scientific Revolution, specialized scientific institutions were established. Establishing scientific institutions further incentivized cross-discipline influence on alchemy's decline. Particularly, the scientific academy Royal Society in the United Kingdom united many great scientists. The Royal Society was formed after a precursor group centered around Robert Boyle and other natural scientists in the early seventeenth century focusing on experiments, later approved by King Charles II, and expanded to include more and more scientists from all fields (Webster). Within this group, while many members practiced alchemy, such as Isaac Newton and Robert Boyle, chemistry was gradually prioritized over alchemy for its social significance, promoting chemistry progress (Alchemy In High Places).

Consequently, science became more organized in society, unlike alchemy before the seventeenth century (Conant 48). The Scientific Revolution's societal impacts made chymists interpret their findings more scientifically, and the push for institutionalization required chymistry to separate itself from the alchemical aspects.

Evaluation

Considering the traditional and more contemporary views, with support from primary and secondary sources, offer analysis of historical figures and the social landscape during alchemy's decline. Some historians' perspectives are skewed by historical texts that portrayed alchemy as a fraud and the rising modern chemistry as a discipline created by specific figures under the Scientific Revolution. The more nuanced and detailed contemporary view remedies alchemy's absence in the narration of the transition. However, I concede that this essay's accuracy and comprehensiveness are indeed affected by the time gap between me, the cited historians, and the chymists. Also, while I tried to minimize personal bias, my personal background as a chemistry student and interest in alchemy may still influence my impartiality when evaluating the sources.

To conclude, one crucial disparity that caused the opposing views is the two subjects' categorization. The Scientific Revolution contributed to people's negative perception of traditional alchemy as a fraud, causing the dichotomous view on alchemy's decline and rise of chemistry. The Scientific Revolution also fastened chemistry's establishment because promoting the scientific method and scholarly communication in institutes allowed discoveries closer to truth. Regardless, treating alchemy's decline completely because of the Scientific Revolution neglects alchemy's essential presence throughout the Revolution. Alchemy laid the conceptual foundation for many chymists, such as Robert Boyle, and incentivized many individuals to enter the field. After the Scientific Revolution, chemistry became similar to traditional alchemy but without the speculative mystical references. Therefore, while alchemy is now more integrated into the occults and magics nowadays, alchemy's skepticism transcends beyond the Scientific Revolution, regardless of the discipline's numerous names.

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