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Book Reviews

Review of *A Cultural History of Chemistry*. Peter J. T. Morris and Alan Rocke, eds., Bloomsbury Academic: London, 2022

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When presented with a new multivolume series on the history of chemistry, one cannot help but compare it to J. R. Partington's masterful four-volume *A History of Chemistry*. The new six-volume *A Cultural History of Chemistry* reviewed here, however, is really a different beast and should not be viewed as a simple attempt to update Partington's previous series. As highlighted by series editors Peter Morris and Alan Rocke in the Series Preface that begins each volume, "This is not a conventional history of chemistry, but a first attempt at creating a cultural history of the science." As such, this series brings together 50 contributors in an effort to present the first detailed and authoritative survey of the impact of chemistry on society, as well as how society has influenced and impacted chemical practice and thought. Spanning from the earliest applications of the chemical arts in antiquity up through the present, this cultural history is split into six volumes, each covering a specific time period, with the structure of each volume consistent throughout the series. As such, each volume begins with an introduction, followed by the identical chapter titles: Theory and Concepts; Practice and Experiment; Sites and Technology; Culture and Knowledge; Society and Environment; Trade and Industry; Learning and Institutions; Art and Representation. As a result, this gives the reader the choice of focusing on a specific time period within a single volume, or following a chosen theme across history by reading the corresponding chapter in each of the six volumes. Each volume concludes with both a Bibliography and an Index, with all six volumes providing a combined 1728 pages of material. Separate reviews for each of the six volumes are given below, followed by some concluding remarks about the overall six-volume effort.

Volume 1: *A Cultural History of Chemistry in Antiquity*. Marco Beretta, ed. (review by S. C. Rasmussen)

The initial volume covers by far the largest timespan, tackling nearly 4000 years over the period from 3000 BCE to 600 CE. The challenge of this task is highlighted by editor Marco Beretta in the introduction, particularly considering the limited surviving written sources from this period of history. Beretta argues that it is this scarcity of literary sources, in comparison to the wealth of archaeological objects, that has led to the focus on the material background of the chemical arts in previous attempts to cover this period by authors such as Partington. Still, in addition to the many practical achievements evidenced during antiquity, Beretta gives a good overview of the literary genre available that can be used as a lens into this period of time. The following chapters are then collaborations between the four contributors of this volume, with each author covering one of the primary cultures of focus: Egypt by Sydney Aufrère; Mesopotamia by Cale Johnson; Greco-Roman by Matteo Martelli, with Beretta providing overarching conclusions. This uniform structure for each chapter thus provides additional consistency throughout the various subjects discussed. Chapter one attempts to make connections between mythology and chemical theory, particularly within the Egyptian civilization. While the natural philosophies of the Greeks and Romans were more independent of such mythological influences, they did incorporate ideas and concepts from the older civilizations. Chapter two then delves into the technical practices during this period, including the wealth of chemical species applied, with discussion of the names and symbols used to distinguish the reagents, species, and products involved. Chapter three goes on to analyze the state of laboratories and the technological advances found within antiquity. For those that have studied the history of chemical technology of this period, this chapter is perhaps the most traditional of those offered in the volume, and offers a good overview of technical workshops and their products. Chapter four then reflects on the influence of religion on chemical practices, with focus on connections between the gods of a given culture and various activities of the craftsman. Chapter five then discusses the impact of the growing chemical technology on the local environments, both in terms of overexploitation of resources and the effects of toxic byproducts released during various operations. For a topic so prevalent in the discussion of modern chemical practice, it was very eye-opening to see these relationships mapped onto practices in antiquity. Chapter six covers the processes of trade between neighboring societies as a result of progresses made in the production of goods via chemical processes. This of course included not only the products themselves, but minerals, ores, and other reagents needed for their production. Chapter seven then discusses the development of recipes and the production of recipe books, which served the dual purpose of transmitting knowledge to future generations, as well as providing better control to the access of this knowledge. The final chapter then discusses the relationship between various practices and their artistic representation, both visually and in words (poems, songs, etc.). As illustrated by the quick summary given above, this volume brings much that is new to the study of this period of chemistry, providing new context to consider when reflecting on the processes and technologies developed during antiquity. While it would have been nice to have included aspects of the Far East, Beretta makes good arguments for why this was not included in the current effort. Regardless, this volume is highly recommended for anyone with an interest in this earliest period of chemical practice.

Volume 2: *A Cultural History of Chemistry in the Middle Ages*. Charles Burnett and Sébastien Moureau, eds. (review by R. H. Crabtree)

Sébastien Moureau's introductory chapter sets out the geographic scope of volume 2 as the Islamic South, the Orthodox East and the Latin West over the period 400-1500 C.E. It also outlines the grave difficulties facing students of the period, such as widespread pseudepigraphy, shifting nomenclature, allegorical symbolism and coded language. Applications to medicine, dying and transmutation are discussed and linked to alchemical principles and classifications, such as the familiar four element theory. The operations chapter that follows highlights the difference between craft and alchemy: both sought useful products but the latter also sought theoretical understanding. Various types of distillation, calcination, dissolution, coagulation and sublimation are also covered along with the equipment needed for each. Difficulties arise in interpreting the texts because they embody unstated 'know-how' that is hard to reconstruct. The third chapter on laboratories contrasts the abundance of relevant images in Latin sources with their paucity from Arabic ones, and even where they do exist in the latter they are often allegorical. There is also a useful extended discussion of archaeological finds with diagrams and images. Another avenue for exploration of the topic, although still too rarely used, is experimental, by design of historical replications. As for laboratories,

domestic spaces seem to have been most common, but artists' depictions of them may owe more to invention than to reality. Archaeology indicates that abbeys may have housed workshops for preparation of inks for the scriptorium although this may have been a craft rather than a true alchemical tradition. Castles and noble urban dwellings have also provided similar evidence. Various specific tools, types of furnace and items of apparatus are listed or described, with the helpful addition of their Arabic and Latin names. Chapter 4 provides an interesting discussion of alchemy's relations with other natural philosophic efforts along with contemporary criticism of the practice. Already in Arabic mss., alchemy is not always listed among the sciences and its validity can be disputed. Because it had not existed in Aristotle's time, so not discussed by him, this had the effect of giving alchemy a secondary standing. Its relationship to the occult sciences of astrology and magic also hurt its standing, although many continued to hold the occult sciences as authentic. The close association of alchemy with medicine, especially in connection with Paracelsian doctrines and the analogy between an elixir curing people and the philosophers stone 'curing' metals is noted. The interconnection with religious ideas, so important in the period, is not neglected, as in the discussion of the quintessence and the special affinity of alchemy with Shiite Islam. In the Latin West, both detractors and supporters of alchemy are found among religious scholars, Roger Bacon being a notable adherent, Ramon Llull taking the opposite position. Mary the Jewess is identified as a rare female adept, remembered today in the French term 'bain Marie' for an aqueous heating bath. Chapter 5 discusses the place of alchemy and the alchemist in Society. For example, as a supposedly purely practical art without theoretical underpinning, Buridan thought it had no place in a monastery, but some monasteries did have alchemical connections. Numerous Arabic and European royal courts also encouraged alchemical efforts. A major concern was economic: currency minted with false alchemical gold would be equivalent to counterfeiting. The next chapter discusses medieval chemical technologies with case studies on metal and glass production, thus going beyond pure alchemy into trade and commercial concerns. Educational concerns follow next with a discussion of oral and manuscript transmission of the art, noting the problems posed by semantic fluidity of alchemical terms and the problems with later alchemists composing alchemical texts falsely attributed to well-known scholars, such as Llull, who in reality opposed the art. Perhaps the most original chapter is the final one on art, in which the images, often allegorical, found in the manuscripts are discussed and illustrated. In summary, this volume will be a valuable addition to institutional and personal scholarly libraries.

Volume 3: *A Cultural History of Chemistry in the Early Modern Age*. Bruce T. Moran, ed. (review by A. Greenberg)

The third volume traverses the sixteenth and seventeenth centuries. Paracelsus, born in 1493, revolutionized the medical paradigm; in 1597, Libavius published the first chemistry textbook; in 1697 Stahl published the phlogiston theory of combustion. The Introduction, by volume editor Bruce T. Moran, outlines historical and technical upheavals during the Renaissance. The cabinet of medicines enriched by discovery of New World plants and animals; Luther and the Protestant Reformation; Dutch East India Company and economic growth of Europe; Becher, chemist, and commercial advisor to the Holy Roman Emperor. Chapter One (Theory and Concepts…), by Lawrence M. Principe, seemingly "squares the circle" by accessibly contextualizing the four chemical theories of this era: Aristotle's hylomorphism: "forms" imposed upon "prime matter"; four elements; mercury and sulfur; and a "quasi-particulate conception of the structure of matter". To add to complexity, Principe describes variations and overlaps of these theories. William Newman and Principe reintroduced the archaic term "Chymistry" to remove the artificial barrier between serious alchemy and chemistry. Practice and Experiment… by Joel A. Klein emphasizes the development of chymistry as a practice and theory of analysis and synthesis. Beginning with pseudo-Geber, continuing with the sixteenth-century works of Agricola and Brunschwig, technologies of assaying and distillation became widely available to artisans and adepts. Indeed, Paracelsus considered the human body as a process of spagyria, a disassembly and reassembly of the tria prima (mercury, sulfur, salt). Sennert chemically separated gold-silver alloy, precipitating a silver salt and then recovering the pure metal. The gravimetric work of van Helmont began to make analysis quantitative. Laboratories and Technology…, by Donna Bilak, beautifully describes and illustrates the laboratory technology of the mid-seventeenth century with woodcuts of apparatus from LeFèvre's Compendious Body of Chemistry (1662) and a painting by David Teniers the Younger. But the foibles, failures and road to poverty of gold makers are illustrated by Bruegel painting engraved by Galle, and allegorical secrets illustrated in Atalanta fugiens (1618), by the musical alchemist Maier, in which a washerwoman launders philosophical matter to remove impurities.

Culture and Science…, by Andrew Sparling, describes the communication of chymical information by peripatetic chymists, including Paracelsus and Kunckel, a century later. During this period books and pamphlets found avid readership. Boyle described, in print, witnessing transmutations and Newton was an avid reader of the Harvard-trained alchemist Starkey. Chemistry and Environment…, by William Eamon, is a very ambitious, wide-ranging chapter emphasizing the role of distillation, from purely commercial to charitable, pigments, mining, domains of women, the exponentially-increasing role of books including books of secrets, chemical imagery, warfare, the environment among topics. Trade and Industry…, by Tilmann Taape, returns to the economies of distillation, including woodcuts of apparatus from the fifteenth and sixteenth centuries. Plat's Jewell House of Art and Nature (1594) is cited for the clarity of presentation of works culled from many sources. In Learning and Institutions…, Margaret D. Garber offers examples of the roles of European noble courts and universities, in fostering theory and practice. Physicians played an important role as liaisons between the courts and universities such as those in Prague, Jena, Wittenberg, and Leiden as well as in France and England. Arts and Representation…, by Elisabeth Berry Drago, employs a woodcut, an engraving and eleven paintings (in black and white), as well as excerpts of poems in order to illustrate the chymical mysteries, glories, foibles, and frauds, as imagined by the artists of the period. This third volume, although replete with names, theories, processes and historical perspective, is a must for any institutional collection as well as for individual libraries of those interested in a truly interdisciplinary approach to the history of chemistry.

Volume 4: *A Cultural History of Chemistry in the Eighteenth Century*. Matthew Eddy and Ursula Klein, eds. (review by A. Greenberg)

According to its cover, this fourth volume in the series covers the period from 1700 to 1815. Emerging as a modern science, chemistry achieves respect in cultural and academic circles and contributes to material wealth as laboratory and workplace skills improve agriculture, pharmacy, medicine, manufacture, and the fine arts. The Introduction, by the editors, describes the institutionalization of chemistry in eighteenth-century Europe in the context of the Enlightenment. A major school of thought attributes the chemical revolution largely to Lavoisier and his contemporaries. Another school conceives Lavoisier's breakthroughs in a wider context that developed gradually throughout the eighteenth century. Chapter One (Theory and Concepts…), by Ursula Klein, navigates readers through the complexities of the earliest chemical theories which maintained their hold into the eighteenth century: Greek atomists, Aristotelian philosophers, and Paracelsians. Stahl is a crucial link blending mechanical-corpuscular theories with theories based upon four principles comprising matter, transforming Becher's seventeenth century theory into phlogiston-explaining combustion and calx formation as one. Stahl linked his chemistry with affinity tables. The concept of the chemical element was critical and Macquer (1753) was an important pioneer anticipating Lavoisier's definition of a chemical element. Even so, Lavoisier conceived of gaseous oxygen containing the element oxygen with the imponderable element caloric, the latter released as heat when oxygen combined with, say, mercury. In Chapter Two (Practice and Experiment…), Victor D. Boantza defines eighteenth-century terms of chemical operations, most still familiar but some obscure (e.g., collature, filtration through a hair sieve) and illustrates apparatus from the 1757 edition of Lemery's Cours de chymie. Plants were exploited using "wet chemistry", e.g., solvent extraction, and more often by "dry chemistry", e.g., distillation, to produce medicines. Mineral chemistry led to Geoffroy's affinity table (1718), devoid of theory but the first ordering of chemical (and some physical) properties. Pneumatic chemistry, pioneered by Hales, Brownrigg, Cavendish and Priestley "set the table" for Lavoisier. Chapter Three (Laboratories and Technology…), by Marco Beretta, makes the important point that even university laboratories started with close ties to artisans, businesses and industries. Pharmacies had the greatest initial impact on laboratory techniques. A plate from the 1763 Encyclopédie depicts a mid-eighteenth-century laboratory. Beretta emphasizes Macquer's impact on theory and experiment including his 1766 Dictionnaire. The remainder of this chapter is devoted to pneumatic chemistry including illustration of Lavoisier's complex gasometer. Beretta describes Scheele's contributions, surprisingly little mentioned elsewhere in this volume. Chapter Four (Culture and Science…) by Bernadette Bensaude-Vincent describes the increasing fascination of professionals and the lay public with chemical demonstrations (no longer "the mere province of 'sooty empirics'") and lectures by Shaw, G.-F. Rouelle, and Cullen. Venel's essay and the illustrations in the Encyclopédie further popularized chemistry. At Edinburgh, Cullen's successor Black trained a generation of chemistry professors including those at the best American universities. The concluding section examines chemistry-inspired philosophies. In exploring Chemistry and Daily

Life, Matthew Daniel Eddy (Society and Environment…) takes an amazingly inclusive approach describing Patronage, Sociability, Consumerism, Politics, The Environment and Ecology. Particularly illuminating was the discussion of the interplay between chemistry and consumerism in European attempts to uncover the secrets of Chinese porcelain. Pott's unsuccessful attempts to crack the Meissen Company's formulation of porcelain led to the first widely-recognized chemical classifications of the earths. Chapter Six (Trade and Industry…) by Leslie Tomory begins with the mechanization of textile production during the industrial revolution, increasing the demand for innovation in and production of chemicals for bleaching, dying and fixing dyes to fabrics (salts termed mordants). In the section on metallurgy, we learn that Europe was initially dependent and eventually inspired by Indian technology as a source of high-quality zinc for making brass. A section on domestic goods is followed by one on chemical industries including gunpowder buoyed by Lavoisier's encyclopedic research on saltpeter. John C. Powers (Learning and Institutions…) describes the evolution of didactic chemistry from artisan chemists in the early eighteenth century toward university professors, noting that in 1720 there only six chemistry professorships in German universities that increased to twenty-eight in 1780. Apprenticeships were common in the early eighteenth century, but the quality of training was highly variable, and the increasing sophistication of chemical science demanded sounder didactics including theory. There were public lectures, for example G.-F. Rouelle, at the Jardin du Roi, that were often open free to the public and private instruction for those who could afford it. Boerhaave, at Leiden, presented a fairly modest course for university students but a more comprehensive course for paying customers. Throughout the eighteenth century, textbooks evolved from purely practical to incorporate theory, culminating in Lavoisier's 1789 Traité. Art and Representation…, by John R.R. Christie, illustrates the growing fascination among growing urbane middle and upper classes, depicting fascination with the science as well as opportunities for satire from such as Gillray. Perhaps the apex in chemical artwork is the very large, much-analyzed portrait by David of the Lavoisiers in the Metropolitan Museum of Art. Among literary representations, considerable emphasis is placed on the radical English poet Anna Letitia Barbauld, who remained Priestley's correspondent well beyond his emigration to America following the 1791 "Priestley riots" in Birmingham. As Christie comments: "Priestley's appearances in Barbauld's poetry received gentler and more positive handling than from the carricaturists of the 1790s."

Volume 5: *A Cultural History of Chemistry in the Nineteenth Century.* (Edited by Peter J. Ramberg, ed. (review by R. H. Crabtree)

The introduction to Volume 5 notes the high points of a century, the 'long' 19th, that may mark the high point for chemistry as a whole. This takes us from debates on atomism to the puzzling phenomenon of radioactivity. Whether Dalton's atoms were real, as he thought, or merely useful concepts, remained a continuing debate throughout. The middle of the century saw both Mendeleev's Periodic Table and the rise of organic chemistry and the dyestuff industry dependent on it. By the end of the century, professionalisation of the field was far advanced with universities creating laboratories for teaching and research, especially in Germany where the chemical industry also flourished, for example in dye production. A theory chapter follows that traces the development of the ideas of atoms, equivalents and formulas and argues that Berzelius and Davy were the most influential figures of the early period. The finding that Liebig's silver fulminate and Wöhler's silver cyanate had the same chemical composition led Berzelius to coin the term isomerism and explain this result in terms of a differing atomic arrangement. The rise of physical chemistry in the same period is discussed, including such figures as Gibbs, foreshadowing the rise of the US as a scientific power in the next century. Ostwald, denying physical atoms, used thermodynamics as a replacement scaffold for discussion of the experimental facts. Spectroscopy came into being with an early application of elemental analysis of the solar atmosphere by comparison of the solar spectrum with laboratory standards. Chapter two charts the development of experimental practice, including analysis, lab equipment, the representation of molecules, a section that includes an image of Kekulé's own molecular models. The next chapter contrasts the relative simplicity of the chemical laboratory in 1800, often in a private space, with the vastly more complicated situation by the end of the century when labs were almost always institutional and used not just for research but also for teaching, Germany taking the lead. Oxford resisted adding experimental sciences to its curriculum perhaps because most of its graduates took up clerical appointments. Chemistry, it was also felt, did not fit with the intellectual activities of the University. Activity also spread to the Americas: by the end of the period, Harvard had a Chemistry Department with 14 teaching staff and more than 300 students engaged either in undergraduate or graduate studies, thus approaching closely to the modern pattern. The next chapter more directly justifies the cultural history

orientation of the whole work by looking at the influence of chemistry on the wider world. Jane Marcet's 'Conversations on Chemistry' popularized chemistry in 16 British editions from 1805 to 1853; public lectures, such as ones by Tyndall, Frankland and Faraday, were very well attended, including by Marcet herself. Faraday published his 'Chemical History of a Candle' in 1861, a work that, remarkably, is said to have never been out of print since. Applications to agriculture were the topic of several books in the period intended to encourage scientific farming, such as Liebig's 'Agricultural Chemistry'. Anaethesia in medicine also depended on chemistry, for example Queen Victoria much appreciated being given chloroform in her last two confinements. Advances in forensic medicine included the celebrated Marsh Test for arsenic and Orfila's test for blood stains. Religious influences were still evident--Prout, for example, pointed to Dalton's Laws as examples of divine wisdom. Mary Shelley's celebrated novel, 'Frankenstein', published as early as 1818, includes references to then-current popular science. The rise of photography from the 1840s relied on chemistry for development of the images and of course the dye industry led to much brighter clothing becoming available. The next chapter continues the theme of the influence of chemistry on society with a discussion of the numerous ways in which this was felt. For example, how the supply of clean water, and pure food and drugs was assisted by analytical chemistry. As for industry, we are told that chemists were only employed in significant numbers after 1870, because prior industrial practice differed little from traditional craft procedures. Chemical industry was strongly represented in the trade fairs that followed the Great Exhibition of 1851. Explosive manufacture was perfected in the same period, an advance that was to have a big impact in both peace and war. Thanks to the the foundation of women's colleges, such as Girton at Cambridge in 1869 and Vassar in 1865, women made significant contributions to research late in the century, but were sadly still excluded from many professional bodies. Chapter 6 covers chemical industry, with a close look at pharmaceuticals and fertilizers. The next chapter covers learning and institutions, with special attention to popularization and the role of chemical societies and their journals. The final chapter takes the 'mad scientist' as its theme, not a particularly appealing one to this reviewer. As a general point, a common problem with edited volumes is evident here: some material is duplicated in different chapters but otherwise this work provides a view of chemical history from an original viewpoint and will be a valuable addition to institutional and personal scholarly libraries.

Volume 6: A Cultural History of Chemistry in the Modern Age. Peter J.T. Morris, ed. (review by R. H. Crabtree)

The final volume has the formidable challenge of covering the period from 1914 to the present. Some of the themes include the rise of mechanism and of computational chemistry in explaining the course of reactions and of X-ray diffraction and of the common spectroscopic techniques for determining structures. The development of oral contraceptives influenced cultural behavior and demography and the rise of chemical engineering and green chemistry had a direct influence on industrial practice. Links with biology and physics were formed with the rise of molecular biology and chemical physics and links with industry came from natural products, polymers, silicones, solid state chemistry and catalysis. Isotope dating gave human development an absolute timescale and even determined the age of the Earth. Some of the themes of prior volumes are taken up again here, such as professionalization and internationalization. Adverse trends are also noted in the closure of some UK chemistry departments, and the possibility that the field might be largely absorbed by neighboring disciplines.

The major theoretical advance of the early period, the understanding of bonding and reactivity, led to mechanistic thinking that in turn fed into structure and synthesis with such advances as the hemoglobin structure and the Coenzyme B12 synthesis. Late in the period, nanoscience came to the fore with such novelties as Bucky Ball and carbon nanotubes. Research, education and policy form the core of chapter two, with emphasis on numerous advances, many of which affected the wider world. The next chapter examines the evolution of the laboratory over the period. A radical shift that started in the 1950s involved the introduction of major electronic instrumentation on a grand scale that displaced prior practices such as organic structure determination by chemical means. The advent of these costly machines greatly increased the costs of research but enhanced its output. Mass spectroscopy, gas chromatography and NMR spectroscopy are discussed in detail and the importance of timely books is illustrated by Roberts' 'Nuclear Magnetic Resonance' of 1959 that made NMR sufficiently understandable so the general bench chemist could use it. One point that could have had greater emphasis in this series as a whole is the importance of textbooks as both influencers of the field as well as providing evidence of its evolution over time. Chapter four shows how chemistry's earlier good public reputation was put in question in the 1970s by rising attention to such negative outcomes as industrial pollution and the

undesired side-effects of pesticides and drugs; items later added to the list include halocarbon refrigerants and perfluorinated 'forever chemicals'. Chapter 5 continues the same theme with the international regulation of pollution, climate change and efforts to ban chemical weapons, and introduces a new one with the rise of women in the field. Chapter 6 traces the rise of the chemical industry with special reference to its globalization and internationalization during the century. Beginning with Japan in the 1950s and more recently with China, the rise of East Asia as a scientific center is documented but the 1990s are considered to bring in an era of global science, facilitated by the new methods of communication across the globe. The final chapter on art and representation continues the theme of the 'mad scientist', mentioned in the last volume, as well as tracing the representation of scientists in general literature such as children's comics. In summary, this volume does a fine job of selecting telling aspects of the century's development in the field and providing a useful bibliography for further study.

SUMMARY OF THE REVIEWERS

In conclusion, we collectively believe that the cultural history covered in the six volumes presented above provides a fresh view of the history of chemistry, with analysis and discussion that surpasses the frequent presentation of notable individuals, chemical processes, and discoveries. By considering the full impact and interplay of society with chemical practice, a much more complete representation is achieved. As such, this series marks a valuable addition to the study and knowledge of the history of chemistry.