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Reviews

Styles of Knowing. A New History of Science from Ancient Times to the Present. By CHUNGLIN KWA. Pp. 376, illus., index. University of Pittsburgh Press: Pittsburgh. 2011. $27.95. ISBN: 978-0-8229-6151-2.

Originally published in Dutch, this fine book has now been adapted for anglophone audiences. It provides an engaging history of science founded on both cultural context and shifting philosophies of science. The framework for its approach was inspired by Alistair Crombie's three-volume *Styles of Scientific Thinking in the European Tradition* (1994), but it is not a mere summary of his work. Chunglin Kwa emphasises the role of both intellectual and wider cultures in the practice of science much more than did Crombie. Styles of knowing, he stresses, respond to social circumstances, a view shared widely by historians of science today.

Following Crombie's taxonomy, the author presents the history of Western science in terms of six styles of knowing. Broadly speaking, these styles extend beyond mere practices or methodologies: they include the philosophical underpinnings defining the criteria of good science, and cultural values concerning the means of achieving certainty. Yet they are not paradigms in the sense that Thomas Kuhn developed the notion, either. These distinct styles of science, it is argued, are independently configured and overlap only partially, based on approaches that may defy further justification. The modes do not succeed one another in a linear fashion, but instead form alliances in particular historical contexts. Science, then, becomes a constellation of styles, each with a distinct cultural trajectory. This perspective also avoids the need to construct a grand narrative encompassing all cultures: the book is explicitly an account of Western science, leaving Islamic, Chinese and Orthodox Christian experiences, for example, unexamined.

Chapters focus consecutively on the six approaches and end with a discussion of twentieth-century science. The first to be examined is the deductive style developed by the Greeks, founded on deriving new knowledge solely from established facts. Kwa traces this confident approach through the Christian era to the seventeenth century. Although evolving substantially during the late Middle Ages, it lost ground during the Renaissance to three other rising styles: the experimental, the hypothetical-analogical, and the taxonomic. Distinct forms of the experimental style are illustrated by the search for general insights (e.g. Galileo) and by searches for anomalies (e.g. Francis Bacon and Robert Boyle). The hypothetical style, by contrast, relied on identifying analogies between nature and technology, such as the notion of a clockwork universe. And the taxonomic style — arguably the least respected of the forms of knowledge — was based on organising and inter-comparing. Ironically, this book is itself an illustration of the strengths and weaknesses of this approach: creating order out of a chaos of detail but, as yet, unsupported by a theoretical justification.

Kwa explores the rise of evolutionary and statistical styles from the early nineteenth century. The statistical style became characteristic of not only physical sciences such as astronomy, but also biology and the newer social sciences. The discussion of both the experimental and statistical styles also draws on the work of Ian Hacking. But Kwa resists John Pickstone's more recent variant taxonomy — distinguishing natural history, analysis and experimentalism as distinct ways of knowing — as being less robust than Crombie's approach, which can readily accommodate it. More generally, the introductory and following chapters provide a useful signposting of historiographical markers, making connections between evolving ideas in sociology, art history and science and technology studies. The result is a well-grounded and interdisciplinary account that should appeal to both novices and more advanced students of the subject.

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One value of this approach for undergraduates (the original planned audience for the book) and other nonspecialist readers is its variety of "hooks" to catch their attention and pull them into the subject. This may be more compelling and easier than remembering a series of facts organised by other schema, such as expanding knowledge, refinement of methods, or other implicit indicators of progress. Modern readers will be able to recognise elements of the six styles in their own intellectual lives. In this respect, the book could be used to trigger classroom discussions or independent thought, comparing the ways in which individuals interact with the natural world and gain confidence in their personal convictions.

As Kwa notes, however, his approach leaves the development of engineering and technology largely unexamined. Rejecting the notion that technology is merely applied science, he suggests tentatively that technology may be an additional style characterised by its emphasis on visualisation. Just as drawings and diagrams linked conceptual to practical solutions, he suggests that computer simulations have increasingly done the same from the late twentieth century. Perhaps underlining this categorisation, the book includes no illustrations.

Overall, this is a refreshing account that will encourage reflection and discussion about styles of knowing through history, as well as their relevance in the present day. As a means of motivating interest in science, and its history and its cultural links, this book is highly recommended.

University of Glasgow SEAN JOHNSTON

How Modern Science Came into the World. By HENDRIK FLORIS COHEN. Pp. 832, illus., index. Amsterdam University Press: Amsterdam. 2012. €65. ISBN: 978-90-8964-239-4.

The author of this book has undertaken a comparative analysis of "nature-knowledge," starting with the Greeks and then moving on to the Islamic world and China. He then looks to Europe and what happened to his two versions of nature-knowledge when they arrived in Europe in the medieval period and later. These forays into other cultures are the barest of sketches, with very little cultural context provided. Nevertheless, Floris Cohen hopes to solve some riddles about the uniqueness of the Scientific Revolution, which occurred only in Europe in the sixteenth and seventeenth centuries. At the same time, he wants to shed new light on why it did not happen elsewhere.

The undertaking is tenuously wedded to a chimerical framework of "upswings and downswings" of scientific progress in various times and places outside Europe. Historians of science have long known that the Scientific Revolution occurred only in the West, and hence the only serious issue is what was unique about European cultural and institutional structures. Unfortunately, those dimensions of his analysis are exceptionally weak. The long-term story of the volume, however, focuses on what Cohen calls six scientific *transformations:* the realist-mathematical revolution of astronomy; the kinetic-corpuscular transformation of natural philosophy; the new emphasis on fact-finding through experiment, labelled the Baconian transformation; the geometrisation of corpuscular motion; a subsidiary experimental transformation, enigmatically called the "Bacon-brew"; and finally, the grand synthesis of Newton.

This volume of over eight hundred pages and nineteen chapters (plus an Epilogue) is so idiosyncratic and poorly constructed that it defies all expectations. At the end of each of the nineteen chapters, there is a section called "Notes on Sources Used," but because the author does not use footnotes to inform the reader on whose work his assertions are based, the early pages, especially, have the feeling of metahistory: it is clearly Cohen's unique interpretation of what he thinks happened in Greece, Islam, China, and elsewhere. For example, the first chapter falls under the heading of "Nature-knowledge in Traditional Society" that begins with the Greeks. Cohen sets up two archetypes of nature-knowledge, which he calls "Athenian" and "Alexandrian." But in the sketch of the underlying themes of Greek science and some of its main figures, there are no footnotes to assure the reader that what is presented is indeed based

on specialist knowledge of Greek science and philosophy. Only direct citations are footnoted. He attempts to use these two archetypes for comparison throughout the rest of the book.

For the author, the Athenian mode of nature-knowledge is said to be a form of natural philosophy that stresses the need to find and use "first principles" to construct causal explanations of the totality of nature. In contrast, he poses the Alexandrian mode, which is said to be based on the application of mathematics to parts of the natural world. Whereas the former approach tends to be all-encompassing, the latter is generally piecemeal, as few domains of the natural world have been capable of mathematical treatment. The great exponents of this mode of analysis are Ptolemy and Euclid, who applied mathematics to the planetary spheres, optical rays, and musical intervals.

Regarding the Athenian mode of analysis, a reader will be surprised to find that there is no discussion (in this crucial first chapter) of Aristotle and the Aristotelian worldview. There is no mention of Aristotle's "natural books" (his *Physics*, *On the Heavens, Meteorology, Plants and Animals*, etc.), which, a millennium later, were directly embedded in the new European universities. Likewise, the lack of any reference to the logical and argumentative style of Aristotelian analysis and the deeply embedded idea that natural forces control the world is a grave omission. Not only was this heritage of separating nature from supernature (from the pre-Socratics through Plato and Aristotle) knowingly adopted by hundreds of generations of Europeans, it was just as obviously missing in the Islamic borrowing, as well as in the autochthonous scientific development of China.

Of course, the Greek mathematical tradition of Euclid and Ptolemy was a crucial component of natural philosophy that was transmitted to the Islamic world, yet Cohen forgets to mention that all Arab and European astronomers from that time until Copernicus assumed that the actual shape of the world was a question for natural *philosophers*, not mathematicians. Consequently, Cohen's later discussion of Copernicus's hypothesis flounders just as it presents that major innovation as a minor adaptation of the Alexandrian mode of analysis (pp. 105–13). Galileo and Kepler seem to get more credit than Copernicus, and the discussion of Galileo's advances is very unevenly presented, unhinged from chronology. It then takes fourteen chapters to get to Newton (chapter 19), which is a vast landscape of notes and commentary.

The most critical omission in this analysis is any emphasis on the fact that Aristotelian natural philosophy was not taught in the madrasas, and, throughout its history, the dominating intellectual figures of Islamic thought were opposed to the naturalistic causation that was so central to Greek thought. The absence of that kind of formal study in the Islamic world, as compared with Europe, goes a long way towards explaining the faltering of scientific progress in the Islamic world and its unceasing advance in Europe from the medieval period to the present. Cohen's fixation on upswings and downswings leads him to suggest that there was an upswing in scientific research under the Ottomans, yet even he has to admit that there was only ossification (p. 69) when in fact no advances occurred (sixteenth century to nineteenth century) comparable to the earlier period.

It is impossible to do justice to the extreme variety of topics, diversions and explorations that the book contains. There are illustrations, but few, if any, are fully incorporated into the text. They seem tacked on. Most unfortunately, the text is rambling and difficult to read. Students will not be helped by the disconcerting lack of narrative coherence. No chapter or section has a brief, concise summary or conclusion. Chapter V has a "summing up of some 'what-if' history" that rambles on for two and half pages, a thousand words or more. The text is littered with dozens of paragraphs written in a confusing style, with clause after clause piled on, obscuring the point of the sentence (see, for instance, p. 521). Few students or specialists in the history of science will be charmed by this style of writing. Given the many flaws of the volume, its textual inadequacies, factual uncertainties, excessive length, and lack of concision on any topic, I cannot recommend it.

Harvard University TOBY E. HUFF

Paracelsus. Die kleine Wundarznei. Zum ersten Mall vollständig in modernes Hochdeutsch übertragen und mit Anmerkungen versehen. Edited by Daniel Hornfisher. Pp. 112, illus., index. Frank-Daniel Schulten: Norderstedt. 2011. €19.90. ISBN: 978-3-932961-95-3.

Hornfisher's modern German version of *Die kleine Wundarznei* seems to be written for those already familiar with Paracelsus, yet the author makes it clear that the book is not for scholars. In the introduction, Hornfisher clearly states that the goal of the book is to bring Paracelsus's legacy into modern times by providing the reader with an easy-to-read interpretation of the original work. Although the introduction provides a good amount of information about the tract, it does not introduce the reader to Paracelsus. Indeed, I find no biographical information about the author also known as Theophrastus Bombastus von Hohenheim (ca. 1493–1520). I expected that, in order to make the reader aware of Paracelsus's legacy, the introduction would at least explain how this tract, called the "The Little Book of Wound Healing," fits into Paracelsus's gigantic oeuvre. Instead, the introduction explains that the text is a modern version of what was once the notes of various students who attended a lecture given by Paracelsus in Basel. Hornfisher goes on to explain how scholars have arrived at the understanding that the version that he uses for this translation (the one by Figulus) is the best version of the tract. As a Paracelsus scholar, I found this aspect of the introduction fascinating, but I am not the intended reader of this book.

Turning attention to the translation, I located (with some difficulty) the version of the tract that Hornfisher uses, so that I could compare his modern German with the original. The translation is laudable. At times, he has eliminated portions of the tract that were redundant or incomprehensible in the original. One of the greatest challenges in reading Paracelsus's work is his penchant for rambling, so I think that Hornfisher's decision to eliminate such meandering would make the work more accessible to a modern German reader.

After spending some time with this book, I am left wondering about the benefit of using this particular tract to help German-speakers get to know Paracelsus. This work is not part of the voluminous Sudhoff edition of Paracelsus's collected works. It is the Sudhoff collected works that people tend to think are most representative of Paracelsus's natural philosophy. Hornfisher remarks that *Die kleine Wundarznei* shows how Paracelsus dealt with a variety of injuries and gives a glimpse of how modern Paracelsus's ideas were. I agree with Hornfisher that elements of contemporary medical ideas are present in *Die kleine Wundarznei*, but I wonder how well the reader would be able to recognise the things that are ahead of their time without any context about the history of medicine. While the translation work is commendable, this book would have benefited from a more broad-reaching introduction that would guide the reader in learning about Paracelsus in the context of the history of medicine.

Washington University, St. Louis Amy Eisen Cislo

Magic, Memory and Natural Philosophy in the Sixteenth and Seventeenth Centuries. By Stephen Clucas. Pp. 332, illus., index. Ashgate: Farnham. 2011. £80. ISBN: 978-1-4094-1975-4.

For the past twenty years, Stephen Clucas has excavated the traditions underlying the ferment within Renaissance Europe's natural-philosophical, literary and polymathic communities. His impressive erudition and sensitivity to fine philosophical distinctions have enabled him to revitalise the study of linkages between the Scientific Revolution and the "occult sciences." Because much of this work has been published in collections of essays or journals not consistently consulted by an anglophone readership, its scope and significance have not been fully appreciated. The Variorum collection of twelve of his articles is thus a welcome presentation of his work to a broader audience.

The essays in the collection fall into four groups, preceded by a brief preface tracing the trajectory of Clucas's interests. The first cluster includes studies of the Elizabethan polymath John Dee. As Clucas notes, because Dee was both a prominent natural philosopher and a

practitioner of esoteric theological methods, he has served as a touchstone for modern scholars —notably Frances Yates and her acolytes — seeking the origins of modern science in the occult sciences of alchemy, astrology, and, above all, magic. This concern has often led scholars to describe Dee's enterprises as "magical" or "scientific" without investigating the broader contexts for particular aspects of his work. In Clucas's hands, by contrast, Dee emerges as an innovative figure whose eclectic philosophical practice absorbed dynamic philosophical movements into medieval "precatory" technologies that viewed prayer as a means to compel earthly change. These essays expertly reveal how Renaissance scholars previously associated with a unitary "Hermetic tradition" in fact reconfigured medieval practices of pious study to increasingly prioritise operative and active knowledge of the natural world.

This conviction that Renaissance thinkers who are often essentialised (or dismissed) as "occult" wielded an eclectic array of scholarly practices also characterises the second cluster of essays, on the production and reception of Giordano Bruno's mnemnotechnics. Clucas shows that Bruno's imagistic "art of memory" was not talismanic, as Yates would have it, but instead constituted a disciplined effort to harmonise psychological, ethical and philosophical reasoning with the structure of divine creation. Such spiritual exercises represent an iteration of a Catholic Reformation approach to knowledge, one which tested the bounds of the licit even while clearly deriving from accepted traditions. In the last of these essays, Clucas contrasts Bruno's and Galileo's use of the dialogue genre to reveal how this approach allowed them not only to propagate natural-philosophical beliefs, but also to interrogate the strengths of various styles of philosophical argumentation.

The third cluster, which will be of particular interest to readers of this journal, examines the manifestations of atomism and corpuscular theory in early modern England. Clucas, supported by his remarkable technical grasp of matter theory, argues that Gassendi's revival of atomism constituted one extremely potent version within a range of Renaissance "neo-atomist" revivals. Figures such as Walter Warner, in the circle surrounding the Earl of Northumberland in the late sixteenth century, shared Dee's eclecticism, and they adapted atomism to address problems within their own philosophical inquiries. Indeed, as Clucas shows, atomism was predominantly revived by neo-atomists such as Margaret Cavendish and Hobbes, who adopted this approach, rather than Gassendi's method of organising whole philosophical systems around atomism.

In the final group, Clucas reveals that the pansophic ambitions of the Hartlib circle inherited the concerns and methods explored in previous essays. Their pursuit of a "true logic" was, as he shows, guided equally by the pursuit of spiritual and intellectual reformation. Similarly, their sophisticated, if idealistic, methods of integrating knowledge sought to fuse an expansive range of traditions into a synthesis that they conceptualised as stimulating dramatic alteration — indeed, a perfection — of theological and practical knowledge.

This is rigorous, high-level scholarship, essential for anyone interested in the disciplinary contexts or intellectual traditions of early modern alchemy and chemistry. By placing his subjects within appropriate theological and philosophical milieu, Clucas offers a persuasive account of how the spiritual dimensions of disciplines such as alchemy contributed to the rise of the empirical natural philosophy. My only criticisms concern some of the decisions in the selection and ordering of the chapters, although I duly acknowledge the difficulty of such choices. The chapters are ordered chronologically according to subject, but as Clucas's interests have proceeded backwards in time, the book begins with his most recent scholarship and proceeds to his oldest; thus, the later chapters invoke problems that the earliest resolve. Appending a more formal conclusion — or a more analytical preface — might have revealed the perceived benefits of such an ordering. Lastly, I would have appreciated the inclusion of several of Clucas's literary essays. While each individual chapter is strong, there are aspects that are repeated between them, and the whole does not do service to the breadth of his interests. But these caveats aside, this is an excellent collection.

College of William and Mary, Williamsburg NICHOLAS POPPER

Secrets and Knowledge in Medicine and Science, 1500–1800. Edited by Elaine Leong and Alisha Rankin. Pp. 247, illus., index. Ashgate: Surrey and Burlington. 2011. £60. ISBN: 978-0-7546-6854-1 (hbk).

Anyone familiar with the large corpus of early modern "books of secrets" knows how rich and, at the same time, frustrating these sources can be for historians. As William Eamon, to whom we owe a seminal study of this genre, notes in his contribution to this volume: "On the face of it, books of secrets are the most transparent of documents . . . Yet . . . early modern books of secrets are by no means transparent. In fact, they present the serious reader with many puzzles about why they were written, for whom, and how they were read" (p. 46). This volume, edited by Elaine Leong and Alisha Rankin, takes up some of these basic questions. As the editors rightly note in their introduction, books of secrets — which often bear some traits of how-to manuals and recipe books — epitomise a knowledge economy in which "secrets held the key to unlocking the mysteries of nature, curing disease, maintaining good health, making practical every day substances, and even creating wondrous tricks" (p. 3). However, coming up with precise definitions remains an elusive task for the historian: although we know which sorts of objects and knowledge were often labelled as secrets in this particular period, it still remains difficult to answer the question as to what exactly constituted a secret (p. 7). The situation is further complicated by the fact that early modern people often employed a variety of different terms when they referred to what we today simply call a "secret." In Latin, for instance, aside from *secretum*, there are at least three other terms: *arcanum*, *occultum*, and *mysterium*. A closer look at such terminological differences remains a desideratum. In general, however, the volume deserves credit for adopting a broad view of scientific and medical secrecy, and for studying this phenomenon in various national contexts. A number of chapters deal with the dialectics of secrecy and openness in early modern England (A. Mukherjee, M. Hunter, and M. DiMeo), while others focus on case studies from Germanic lands (T. Nummedal), Spain (M. Cabré), Italy (T. Storey and S. Cavallo), and France (L. W. Smith). Introductory chapters that primarily address methodological and historiographical issues complement these contributions. Pamela H. Smith surveys the interconnections between secrecy and craft knowledge in the early modern period, arguing not only that books of secrets often recorded ingredients and operations but "that they also attempted to convey the secret of embodied cognition" (p. 66). William Eamon, whose own studies helped to reassess the important role that books of secrets played in the early modern knowledge economy, synthesises arguments he made in his previous work and reasserts that, in the case of early modern authors such as Girolamo Ruscelli, we can observe the "discovery that publishing secrets was ethically superior to concealing them from the unworthy" (p. 45). In light of more recent research by other scholars, Eamon admits that realising practices of scientific "openness" turned out to be much more problematic and difficult than simply condemning secrecy. This qualification is important and well in line with some of the other chapters in this volume — such as in Michelle diMeo's study of the Hartlib Circle — which underscore how secrecy was still "sometimes promoted and required within [the] larger environment of openness" (p. 107). Eamon also points to a number of desiderata in this field of inquiry, and outlines the historiographical obstacles that, until a few decades ago, hampered in-depth research on books of secrets — a genre that, according to the traditional narrative, had been obliterated by the rise of "open science": "With the progress of the sciences and physical change, books of secrets . . . can no longer show any reason for existence," wrote no other than John Ferguson (1837–1916), the chemist and historian who compiled the first (and still relevant) bibliography on this topic.

The focus of the volume lies, as its title suggests, on one particular aspect of early modern secrecy, namely the role of secrets in medicine and science. The collection makes a welcome and differentiated contribution to this field of research. Complemented by future studies on related aspects — such as political secrecy — this work can help us attain a better understanding of what the German sociologist Niklas Luhmann once called the "cosmological status" of secrecy in the early modern period.

Harvard University Daniel Jütte

James Watt, Chemist: Understanding the Origins of the Steam Age. By David Philip Miller. Pp. x + 242, illus. index. Pickering & Chatto: London. 2009. £60. ISBN: 978-1-85196-974-6.

The thesis that forms the basis of Miller's book is simple: the traditional characterisation of James Watt as an engineer needs to be challenged to determine whether he might be better understood as a chemist. To some readers of this book, this must seem to be another contentious reappraisal by a disputatious academic. Although Watt had no formal education as a chemist (for that, he almost certainly would have had to study medicine), it would be wrong to describe him as a *chimiste manqué*, as he spent significant amounts of his working life conducting chemistry experiments. Many of these he recounted in correspondence to his close friend Joseph Black, holder of the chair of medicine and chemistry at Edinburgh University. Black took Watt's chemistry seriously, and he made carefully considered comments on Watt's reports and ideas in his replies. Miller's claims for Watt being a chemist are closely argued and well supported in this excellent treatise.

Watt's early reputation was defined by two well-known visual images. The massive statue of 1825 by Francis Chantrey, purchased by public subscription for Westminster Abbey (from where it was disgracefully expelled in 1960), shows Watt with a scroll on his lap. Lord Brougham interpreted this as an attribute of a philosopher (that is, a physical scientist), and the inscription on the base, devised by him, describes Watt as having "Early exercised in philosophic research." John Eckford Lauder's historicist painting of 1855, *James Watt and the Steam Engine: Dawn of the 19th Century*, shows the youthful Watt contemplating the famous model of a Newcomen engine, which he was required to repair in his capacity as mathematical instrument maker to Glasgow University. His right hand holds a pair of dividers, about to inscribe a sheet of drawing paper. Is not this the archetypical portrayal of the engineer of genius? Miller asks us to look closer, particularly at a kettle bubbling away on a stove. This could be interpreted as the power source, but equally it can serve as a reference to Watt's experiments undertaken to calculate the latent heat of steam. He described his revised findings to Black in a report and letter of 8 March 1781 (Black had developed the concept of latent heat when he taught chemistry at Glasgow in the 1750s). At the time, heat was considered to be a chemical topic, an element, even. Watt believed steam to be a compound substance of water and heat.

Gradually, in the nineteenth century, Watt's reputation would morph from that of philosopher into what Miller terms a "philosophical engineer." This status of engineer was promoted in subtle ways by Watt himself, who was unwilling to be known as a mere mechanician. After his death in 1819, Watt quickly became a legendary figure, and some wanted to think that his heat experiments formed an early basis for the new science of thermodynamics. This was sometimes implied by those delivering the annual Watt Anniversary Address, James Joule's being the first to be given, in 1865. Henry Dyer, giving the 1889 address, connected Sadi Carnot's work with the steam engine improvements of Watt. Miller provides a detailed discussion concerning Watt's steam indicator, possibly created as early as 1785, an instrument that produced traces on paper, and that was visually remarkably similar to Emil Clapeyron's 1834 diagram of the cycle of a heat engine, and this further promoted the myth. Much more recently, some science historians, Donald Cardwell and Keith Laidler among them, continued to claim Watt's ideas as inspiring the development of thermodynamics. This Miller rejects, his final chapter of the book bearing the uncompromising title "Why Watt was not a Proto-Thermodynamicist." That in itself does not make Watt a chemist, but there are clear indications that he wanted to be one, working within the sphere of influence of Joseph Black and William Irvine in Glasgow, and of Joseph Priestley and James Keir in Birmingham. His letters reveal that he was often trying to think in a chemical kind of way, that he had a deep curiosity and enthusiasm for the subject, that he was happy conducting experiments, and that he was anxious to pass on chemical intelligence he came across. It may be because he was so good at putting steam engines together that we now find it difficult to categorise him in other ways. Watt comprehended his engines in chemical terms.

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A Vision of Modern Science. John Tyndall and the Role of the Scientist in Victorian Culture. By URSULA DEYOUNG. Pp. 280, illus., index. Palgrave Macmillan: Basingstoke. 2011. £52. ISBN: 978-0-23011053-3.

Unlike his friend Thomas Huxley, Tyndall was no patriarch: his marriage was childless, he had no students, and although his widow survived into my lifetime she did not commission a *Life and Letters*. One of the best known men of science in Britain from the 1850s until his death in 1893, he was soon almost forgotten; only recently has his pioneer work on greenhouse gases been recognised. Ursula DeYoung's book begins with a biographical sketch, and this is followed by essays on Tyndall's science, philosophy, theology, views on education, and posthumous reputation. As the successor to Davy and Faraday at the Royal Institution, like them he gave elite London audiences enthralling public lectures enlivened with beautiful, painstakingly planned and executed experiments: succeeding generations can recover only pale evocations of these, published in his *Fragments of Science*, or *Heat as a Mode of Motion*. His disdain for the churches, notably in his presidential address to the British Association for the Advancement of Science (BAAS) in Belfast in 1874, created a furore that is now hard for Europeans, at any rate, to appreciate. In this book, we learn about his love for original research, but learn little about his own; and the verdict of posterity is not seriously challenged, that while he was important in his own day, he was in the second rank as a discoverer. But just as Nelson's navy depended upon its second and third rates as well as its hundred-gun first rates, so it is with science: and Tyndall is an excellent historical subject.

He was from Ireland, and his origins, like Davy's and Faraday's, were Protestant and humble; he became a surveyor, and then a teacher, and then, with his friend Edward Frankland, he went to Marburg in 1848 to work with Bunsen. Turning to magnetism, he attracted Faraday's attention on his return, becoming his colleague, eventual successor, and biographer. A daredevil climber (his ice-axe is preserved in Zermatt), he loved the Alps, studied glaciers and meteorology, and became a pantheist, admiring Emerson, Carlyle, and Goethe. His love of words and determination to be clear but not to oversimplify made him not only a great lecturer, but also a proponent of scientific education generally, for working men, for his Royal Institution and BAAS audiences, and for middle-class schoolboys and undergraduates, who were then almost all trained in classics. Current theory, even in Davy's *Consolations* (1830), was that science should follow such a "liberal education," which was common to all mandarins; Tyndall brought from his German experience a great admiration for research universities and the opportunities there to study science as a part of *Bildung*, inculcating modesty and honesty. With Huxley and others in the notorious X-club, he sought to break the stranglehold of the clergy in education. A believer in nature's laws, he could not countenance miracles or intercessory prayer, but had a place for personal religion in the subjective realm of emotion and poetry.

By the end of his life, Tyndall was overtaken by the modernity he had fostered. A new and less eloquent generation, specialists trained in universities, were self-consciously "scientists," seeing the "public" in a different light, and unenthusiastic about popularising. It hardly seemed possible to communicate their physics to outsiders without gross simplification. Tyndall's successors were Rayleigh and J. J. Thomson, both directors of the Cavendish Laboratory in Cambridge, who did their research elsewhere: their physics involved more mathematics, less wonder, a focus on university teaching, and teamwork. The ladder whereby self-educated enthusiasts like Davy, Faraday and Tyndall could rise to the top of British science had gone; and the Royal Institution lost its way. Scientists had achieved prominence, and formed a quasi-church scientific, with its own dogma, inculcated in science teaching; but a consequence was the rise of "two cultures." Tyndall's pantheistic rhetoric, membership of the Metaphysical Society, love of poetry and philosophy, emphasis upon imagination and urge to communicate his love and understanding of science without caricaturing it seemed curious and dated. But for historians, as a representative of his generation in at the birth of professional science in Britain, he is exemplary; and this account very useful.

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Reazioni tricolori. Aspetti della chimica italiana nell'età del Risorgimento. By Ciardi Marco. Pp. 208. Franco Angeli: Milano. 2010. €24. ISBN: 978-88568-1765-2.

Just one adjective is needed to describe the contribution this volume makes to historical–scientific literature: "necessary." The work of Marco Ciardi, professor of history of science at the University of Bologna, is, of course, one of the many possible answers to the requests created by the exceptional number of anniversaries that have fallen in the year 2011. Not only has 2011 been the International Year of Chemistry (UNESCO and IUPAC), but it is also the bicentenary of the so-called Avogadro's hypothesis. While this, along with the 150-year anniversary of the unification of Italy, can be considered an Italian anniversary, it also has worldwide significance.

In Ciardi's hands, we are able to follow the separate biographies of each chemist, but also to see how many times their paths cross during the Risorgimento. The index allows the reader two approaches to reading. One can follow a specific interest in a chemist, as in the chapter on Stanislao Cannizzaro (pp. 126–73). Likewise, one finds chapters with a wider scope, such as in the chapter "La chimica e gli uomini di lettere", where one learns of the scientific skills of Giacomo Leopardi, no doubt more famous as a poet (pp. 75–82).

Ciardi demonstrates how the history of science of the Risorgimento (ca. 1820–1870) was equally important to the process of unification. Many of its leading personalities were involved both in Risorgimento issues and scientific disputes. From the correspondence between chemists and documents regarding the "Riunioni degli scienziati italiani" (1839–1847), one can appreciate the extent to which the scientific community felt unified prior to actual political union. The spread of ideas regarding political union was abetted by the efforts of Italian scholars to override territorial division and conflict. In spite of many important advances made through the work of Lazzaro Spallanzani, Alessandro Volta and Amedeo Avogadro in the eighteenth century, research went on in an ad hoc, piecemeal way. During the Restoration, chemistry earned a negative reputation because of its association with the revolutionary leaders of the "Jacobin ideology." As Ciardi argues, citing specific episodes, the study of chemistry was often boycotted in university contexts.

Both the specialist reader and the general reader who wishes to skip chemical details or philosophical digressions will understand that those who we quickly label "patriots" were often scientists whose work led to difficult civic and political choices. As in the case of Silvio Pellico and the controversy surrounding the question of how to "illuminate" towns, political concerns invariably coloured scientific issues.

Ciardi makes extensive use of letters. This makes for interesting reading, giving us a sense of the intellectual activity of these scholars, who are equally at home discussing the industrial applications of a chemical discovery and its political value. Science scholars were drawn to difficult — indeed dramatic — choices, as in the case of Fabrizio Mossotti, who left Europe for political reasons (pp. 132–40), or that of Giovanni Plana, who decided to take up arms. "We must be patient," he wrote in 1847, "our country needs us as heroes."

If this volume is ideal for general readers looking for something different from the standard textbooks on the unification, it is also, as Ciardi hopes in his conclusion, a useful starting work for historians of science.

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Science in the Context of Application. Edited by Martin Carrier and Alfred Nordmann. Pp. 492, illus., index. Springer: Dordrecht. 2010. €99.95. ISBN: 978-90-481-9050-8.

This is a weighty book in its ambition, in its size (492 pages), in the number and prestige of the authors, in the standing of the editors, and in the quality of thought that the articles convey. Its heft may be physically off-putting to the casual reader, but this volume deserves careful reading by all those interested in modern science. Historians of chemistry will find only one

article (by Carsten Reinhardt) deliberately coming out of their discipline. On the other hand, it addresses the scale and complexity, inherent in such forms as industrial research, with which historians of chemistry have long grappled, it must be said often in lonely isolation. Thus, the book concentrates on three areas — information technology (including the problems of making silicon chips), biotechnology, and nanotechnology — each of which is closely related to chemistry.

The editors are distinguished German philosophers who have brought together predominantly German, but also Dutch, French and American, philosophers, sociologists of science and historians of science and of technology to discuss the messiness of the postmodern world expressed in such terms as mode 2 and Forman's "post-modernity." The authors are indeed diverse. They include such established founders of modern science studies as Arie Rip and Peter Weingart, who have been grappling with the problems of the social studies of science since the 1970s, and younger scholars. A variety of approaches is not surprising; more remarkable is the agreement on the singularity of the subject. Rip points out that, historically, those studying science have either black-boxed the epistemic business of science or, alternatively, whether as philosophers or ethnologists of science, have been so concerned with the protected space of science that they have not been adequately concerned with the nature of that protection. This book deals with a science that is problematic both at the microlevel and at what Rip calls the mesolevel of scientific institutions and communities.

From the beginning, Carrier, as an editor, points out the tension between a model of science in which the primary motivation for problem selection is the structure of existing knowledge and the unfettered curiosity of the individual scientist, and a world in which science is shaped by technical opportunity, professional and institutional pressures, and public and political concerns. The book therefore looks at science from six directions: philosophy and epistemology; the role of instruments; institutions; economic, political and public relations of science; the freedom of research and its inverse; and historical transformations in what the editors call science, values, and society. Naturally, the authors have drawn from their own, albeit relevant, larger research projects to contribute to these issues. The result is a variety of language. A few intersubject reference points nonetheless stand out. Vannevar Bush, for all the known complexity of the context of *Science the Endless Frontier*, is an icon symbolising fundamental science. Against the purity of the vision that he represented are the complex experiences of modern interdisciplinary laboratories. De Vries, for instance describes transformation of the Philips Natuurkundig Laboratorium. This began the 1950s as a fundamental laboratory that was expected to pump out discoveries to be exploited by the Product Divisions (but often, as in the case of the famous Stirling engine research, were not), and by the 1990s was having to generate most funds from research contracted by internal customers.

As the studies of nanotechnology, biotechnology and information technology stack up, the editors' question becomes more acute: is there something special about the recent postmodern mode 2 technoscientific era? The book therefore naturally concludes with a crescendo of three papers that address this issue directly. Schliemann, for instance, summarises the variety of proposed reasons for suggesting a break. He finds them generally unsatisfying, but emphasises one possible justification for suggesting a real change: the changing nature of public debate about science. However, this is hardly fleshed out. Similarly, Nordmann discusses the category of "technoscience," and raises the question of whether its very notion requires the sense that an era of "science" as a thing in itself has passed. The authors can hardly be blamed for not being authoritative. Instead, they round out a debate that should be considered conveniently presented rather than resolved.

So are there any fundamental criticisms? Yes, for the publisher. This book costs almost €100, yet copyediting could have been considerably better. There are simple typographic errors such as missing spaces between words, bibliographies are not always perfectly alphabetically arranged, and surviving Germanisms, such as a reference to a *Glasperlenspiel* in reference to Horrobin's 2003 evocation of a "glass bead game" (English original). The authors' English, generally a second language, is excellent but not perfect: tenses are occasionally confused, and

words not chosen ideally. These trivial but annoying errors detract from the authority of a book that should be read, not as a collection of separate chapters, but as a serious and coherent volume to be read and discussed from beginning to end.

The Science Museum ROBERT BUD

The Evolution of Drug Discovery. From Traditional Medicines to Modern Drugs. By ENRIQUE RAVIÑA. Pp. xxxii + 496, illus., index. Wiley-VCH Verlag: Weinheim. 2011. £50. ISBN: 978-3-527-32669-3.

Enrique Raviña is professor of pharmaceutical chemistry at the University of Santiago de Compostela in Spain, and, as he explains in the introduction to this book, was led to write this history of drug discovery because he noticed that the addition of some historical context concerning the pharmaceutical products that he was presenting increased the students' attention when he taught his courses. Thus, his primary goal was to teach the chemistry of medicinal products to future pharmacists, and the history of their discovery was subordinated to this aim. The resulting book, now translated into English, is a compendium of the major drugs in use in modern pharmacy (and some, like heroin or Salvarsan, that are no longer in use in this context), with a short history of who discovered them and how. Although, inspired by Paul Ehrlich's dictum "Geist, Geld, Geduld und Gluck" (intelligence, money, patience and luck) (p. 462), the author's take-home message is the serendipitous nature of the enterprise, the book is nevertheless structured around the evolution of drug discovery. The master narrative takes us from the dim and distant past of the cumulative empirical success of parts and extracts of plants in ancient civilisations all the way up to today's targeted drug design based on detailed knowledge of the structure of receptors on target cells. Nevertheless, once we arrive at the twentieth century (halfway through chapter 2), the ordering of the sections is transformed from chronological into a mix based on the provenance of the products, similar chemical structures, and the use of drugs in different types of disease. Thus, the presentation of a succession of active principles (Raviña does not have very much to say about vaccines, sera, and antibodies, which are not produced as pure chemicals) is globally oriented around groups of chemicals, often variations on a central structural theme that lends them a similar physiological function. In fact, the book's structure returns relatively quickly to that of a classic course in pharmaceutical chemistry. This impression is reinforced by the numerous chemical equations illustrating the structural relationships between classes of drugs such as the prostaglandins (pp. 235–37) and the anthracyclines (pp. 291–92).

Although the book offers a clear and comprehensive introduction to drugs and their discovery, it does not go very far beyond that, as, behind most of the episodes recounted by Raviña, there lie rich, complex histories that he simply does not have the space to explore in the context of such a comprehensive project. Furthermore, the book is resolutely a history of individual chemists and biologists, with the pharmaceutical companies and other actors in the history of pharmacy being reduced to their role as employers of these great men (only a few women feature in this history). In the end, this is a history of drug discovery written by and for chemical pharmacologists rather than historians of science. Sometimes, this approach leaves obvious gaps, such as the unexplained lapse of time between Fleming's initial observation of the antibiotic potential of penicillin and the commercial development of the drug some fifteen years later. Nevertheless, having said this, and while it is unlikely that many of you will have the occasion to read the book from cover to cover, it is undoubtedly a useful resource for a historically oriented introduction to any particular drug or class of drugs. In this respect, it is similar to Walter Sneader's now classic work (*Drug Discovery: A History*, 2005), although more readily accessible. Indeed, the numerous photographs of scientists, packaging and other objects provide some visual relief from an otherwise very dense presentation.

University of Lyon I JONATHAN SIMON

Atombilder. Ikonografie des Atoms in Wissenschaft und Öffentlichkeit des 20. Jahrhunderts. Edited by Charlotte Bigg and Jochen Henning. Pp. 214, illus., index. Wallstein: Münich. 2009. €29.90. ISBN: 978-3-8353-0564-9.

This volume, the title of which would translate into English as "Atomic Images: Iconology of the Atom in Science and the Public in the Twentieth Century," and which goes back to a temporary exhibition "Atombilder" in the Deutsches Museum in Munich in 2007 curated by the editors, is disappointing in several respects. First, it contains hardly any new and original work. Some of the twenty-five small pieces are only short one-page or two-page notes attached to pictures that seem to be taken from the earlier exhibition, and of the remaining brief chapters, about half are addressed to a general audience and half to the specialist historian of science. Almost everything is recycled from earlier, frequently English, publications or is a summary of the work of others. Among the few original contributions, premature sketches of PhD or other projects prevail.

Second, despite the promise in the introduction of a multitude of perspectives on atomic images, the book provides quite a narrow and boring history of a physics point of view. Again and again, we read about the well-known problems of picturing atoms that arose from the move from the early semiclassical atomic models of Bohr and Sommerfeld (a local hero) to the quantum mechanics of Schrödinger and Heisenberg (another local hero). The rest of the volume deals with ways of documenting and commemorating the testing and deployment of atomic bombs, as well as issues around nuclear power plants. Both parts are enriched by museological reflections, among which Christian Sichau's piece on the history of atomic models in the Deutsches Museum and Helmuth Trischler's insightful chapter on the post-war history of the Hiroshima bomber *Enola Gay* in US aircraft museums clearly stand out. The only other chapter that I found worth reading was James Elkins's phenomenological analysis of the so-called rapatronic photographs of the first milliseconds of the atomic bomb tests, although this is at least his third version.

Historians of chemistry will be particularly disappointed by the total absence of any chemical aspect of atomic images — although two physicists, Michael Eckert and Christian Sichau, both obviously with surprise, independently observe that atomic models belonged to the chemistry department of the Deutsches Museum for most of the twentieth century. It seems like an irony (or a misplacement or an excuse?) that the only historian of chemistry among the authors, Michael Gordin, points out, in his chapter on nineteenth-century Mendeleev, that his periodic system of chemical elements was not meant to represent atoms.

The only historian of biology, Soraya de Chadarevian, appears to have earned her inclusion in this volume by a weird interpretation of the 1958 World Exhibition in Brussels: the structuring of the Science Pavilion according to the four categories "atom," "crystal," "molecule" and "living cell" presented, in her view, "physics and biology as one common enterprise that served to investigate the fundamental structures of the material and organic world" (p. 95).

As a result of the narrow focus, general historical theses about atomic images easily turn into plain nonsense, such as when the physicist and self-declared expert in the "history of matter theory" Christoph Lüthy argues that "for four centuries the components of matter have always been represented as small spheres" (p. 20).

It is questionable whether the volume would have passed peer review and would have been printed without the financial support of the Federal Government of Germany through its "Ministry of Education and Research," which was originally founded in the 1950s for the single purpose of promoting and funding nuclear energy research and development.

Berlin Joachim Schummer

Vom tragbaren Labor zum Chemiebaukasten. Zur Geschichte des Chemieexperimentierkastens unter besonderer Berücksichtigung des deutschsprachigen Raums. By Florian Karl Öxler, illus., index. Wissenschaftliche Verlagsgesellschaft: Stuttgart. 2010. €33. ISBN: 978-3-8047-2829-5.

Quiz any chemist whose youth was spent between the years 1920 and 1960, and the chances are that they were first attracted to the subject by the gift of a chemistry set. In my own case, following the discovery that toy soldiers could be melted on a gas stove and that weird things happened to mercury from a broken clinical thermometer, I graduated to having fun with an *All Chemist* chemistry set imported from Germany (as I now learn from this study). Like Oliver Sacks in *Dr Tungsten* (2001), I recall purchasing additional chemicals from my local pharmacy of Parris & Greening in Hove (the former West Brighton Dispensary founded in 1875), or by post from A. N. Beck's in London. No questions were ever asked. Although instructions accompanying nineteenth-century and twentieth-century kits were issued with warnings about dangers, Öxler has found only one case (in 1922) in which a fatality led to legal action against the seller of a chemical set. (A toddler swallowed nickel sulphate crystals from her brother's set.) Nevertheless, obsessive fears of risks and prosecutions (highlighted in today's European Union REACH legislation) mean that twenty-first-century sets have become harmless, unexciting toys with little or no pedagogic value.

Florian Öxler's rich study traces the modern chemistry set back to the portable laboratory (actually a portable furnace with "add-ons" that permitted distillation) advertised by Johannes Becher in his *Laboratorium Portatile* (1689), which, incidentally, first recommended the wearing of a laboratory coat. Becher's device was adopted and expanded by Peter Shaw and Francis Hauksbee in the 1730s during the first wave of popular peripatetic lecturing in England. In the same century, the expansion of mining and pharmacy led to the assembly of boxed sets of apparatus and chemicals for mineralogists and pharmacists. One of the most elaborate of these (not mentioned by Öxler) is the huge case of chemicals and equipment made for the Grand Duke of Tuscany (now in the Museo Galileo in Florence). Enthusiastic propagators of such chests included the mineralogist Johann Göttling, who hit upon adding an accompanying manual of experiments that could be performed by juveniles. Such kits became common in Great Britain in the nineteenth century, marketed by the growing number of philosophical instrument traders, such as Friedrich Accum, John J. Griffin, and William E. Statham. All this is a fairly familiar story to historians of chemistry, but is systematically presented by Öxler in its cultural and economic contexts. Most original, however, is his fine account of the Swiss school science teacher Wilhelm Fröhlich (1892–1969), whose quest for cheap, adaptable apparatus led him to the manufacture of Kosmos chemical kits in the 1920s. These were initially intended as equipment for schools that lacked laboratories, and were wonderfully ingenious in their construction; in 1932, he targeted younger children with his *All Chemist* kits. By then, there were many other competitors, such as Cheminova (Frankfurt) and Trix (Nürnberg), whose originators were either school supply companies (like Fröhlich's Kosmos) or toy manufacturers.

Öxler's informative and abundantly illustrated volume includes instructive lists of the apparatus and chemicals contained in some forty-two sets covering the period from Becher (1689) to the Strasbourg firm Joustra's Chemie 2000. These will be of great interest to historians of chemistry and science education, as well as to the increasing number of collectors of historic sets. While the emphasis of Öxler's study is on German-speaking manufacturers and distributors (including the former DDR), he carefully sets these entrepreneurs in a wider European and American context of commercial, cultural, pedagogic and chemical practice. The dissertation format of regimented summaries of secondary literature and analysis will be advantageous to readers whose knowledge of German is limited. Öxler's impressive dissertation was deservedly awarded the Bettina Haupt Prize for the best study in history of chemistry by a young German historian in 2011, and is to be warmly recommended.

University of Leicester William H. Brock

Lab Coats in Hollywood. Science, Scientists, and Cinema. By David A. Kirby, illus., index. MIT Press: Cambridge. 2011. £19.95. ISBN: 978-0-262-01478-6.

Although its title may be slightly confusing, *Lab Coats in Hollywood* is a substantial contribution to the growing bibliography on the always complex relationship between fiction film and science. But in this case, the author, David A. Kirby, lecturer in science communication studies at the Centre for History of Science, Technology, and Medicine at the University of Manchester, has set aside some of the general perspectives usually addressed, to instead focus his work on an aspect that is virtually unexamined to date: the role of science advisors in the heart of the Hollywood film industry.

Although it is certainly not a new phenomenon, interaction between science advisors and the film industry seems to have increased considerably in recent decades, and, in fact, with just a few relevant exceptions, Kirby analyses primarily productions from the 1990s and 2000s. The premises upon which his study is based are clear and solid. On the one hand, "a focus on scientific literacy through cinema," he warns, "is severely misguided" (p. 117), and in this regard his book explores, with great perspicacity, different aspects of the film-maker–science advisor relationship, other than concern with mere verisimilitude. What is really at play, maintains Kirby, is more like a kind of tension between plausibility and spectacle that science advisors must help smooth out, using terms that are described by some authors (Stephen Prince) as "perceptually realistic" (p. 28). In reality, film-makers and scientists do not have the same agenda, and it would be naïve to think that the only, or even the true, objective for both is "to render all the scientific depictions factual" (p. 38) in the films made. That is why, as Kirby very lucidly states, "much of this book is devoted to discussing *what* advice filmmakers want from their science experts and analyzing *how* filmmakers act upon this advice" (p. 42).

For members of the scientific community, fiction films serve (as much or more so than specialised documentaries) as "virtual witnessing technologies and communicative vehicles" (p. 35) that are able to reinforce a certain image of science that, in their opinion, is not always accurate or favourable but often appears in the mass media and, particularly, in film and television. The contribution of science advisors to big Hollywood productions doubtless seeks to minimise the number and extent of errors, help prevent future disasters, or reach any other specific objective, but, above all, science advisors consider film a powerful "promotional tool for the scientific community." So, in general, they do not hesitate to take part in projects that are inevitably conflictive, inasmuch as film producers and directors do not necessarily have the same concerns as scientists do, and, in fact, film professionals often take paths different from, and incompatible with, the paths that scientific rigour would indicate. But for Hollywood, as Kirby points out, the (often much-publicised) participation of science advisors gives its products a helpful "stamp of approval" (p. 224) that enables the desired synergy to appear despite it all and at the same time counters the superficial binary oppositions so often arising on this topic.

Kirby bolsters his arguments and discussions with first-hand information about the contribution of science advisors to films such as *Jurassic Park*, *Deep Impact*, and *Contact*, among many others. In doing so, he weaves a rich and detailed tapestry that shows, with clarity, the different types of advisory and consultation services that the film industry may require of scientists for each film, and, inversely, how the scientists respond in each case to the powerful demands for spectacle, without renouncing (or, at least, not *in principle*) a degree of plausibility compatible with the image of themselves that they want to convey to the public. Far from being a simple question of "accuracy," underlines Kirby, what takes place in this interaction, this *collaboration*, is a genuine struggle to shape "public perceptions of science" without questioning the demands of the box-office in any way. Some of the theoretical observations made by Kirby are doubtful or at least in need of additional nuance, for example his categorical statement that "contemporary filmmaking practices now emphasize realism" (p. 223), but, taken as a whole, it is entirely fitting to praise the sophistication of his analysis and salute *Lab Coats in Hollywood* as an important contribution to this field of study.

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