BOOK REVIEWS

A History of Chemistry. Bernadette Bensaude-Vincent and Isabelle Stengers, translated by Deborah van Dam, Harvard University Press, Cambridge, MA, 1996, 305 pp. Originally published as *Histoire de la chemie*, Editions La Découverte, 1993.

From the 1960s to the early 1990s anyone wanting a recent history of chemistry had essentially two choices: Aaron J. Ihde's one-volume treatment or the multi-volume work by J.R. Partington. Both were intended to be comprehensive surveys, both organized along the lines of a chronological narrative, and both written by chemists. Since 1990, however, there has been an embarrassment of riches with the appearance of a dozen general and specialized histories of chemistry.

In this burgeoning list *A History of Chemistry* offers something fundamentally different; it is an alternative, as well as a direct challenge, to traditional histories of chemistry. Written by a professional historian of science (Bensaude-Vincent) and a professional philosopher of science (Stengers), this text provides a counterpoint to the notion of a seamless narrative of chemistry. Consisting of five individual "snapshots" of chemistry, it offers many fascinating vignettes, written in a lucid, readable style—a tribute to both the skills of the translator and the original French text produced by the authors.

Bensaude-Vincent and Stengers approach their subject on the basis of assumptions that many chemists may not hold. Unlike those chemists whose histories often served as "manifestoes for their science [and] described a chemistry that was sure of its identity—and of its successes as well," these authors are not at all sure of that identity. In fact, they adopt the "quest for the identity of chemistry" as their guiding principle for this narrative. The central question "What is chemistry?" leads them to pose additional questions:

> What if, instead of digging out the hidden past of a well-defined science whose identity is not in question, we envisage this science as the product of a history? What if, instead of saying that chemistry has a history, which one can choose to study or ignore, we propose that it is a history in progress?

According to the authors, a history based on the answers to these questions "would less resemble the triumphal march of a science that is sure of itself than a long chain of events shaping a science that is haunted by questions of its nature." But despite their claims that the "place of chemistry in the hierarchy of the sciences was always a matter of debate" and that chemistry has been continually obliged to renegotiate its relationship with the other sciences, Bensaude-Vincent and Stengers do not show chemistry to be unique in this regard. Nevertheless, working from the assumption that "there is no eternal essence of chemistry, no transcendent object that is unveiled over the course of the centuries," the authors free themselves to look for "chemistry's successive identities" over a long global history. These they organize into the five chapters, each of which "presents a different face of chemistry [and] delineates its identity at a given time."

The first of these five snapshots provides a glimpse at some of chemistry's origins in alchemy and in the 17th-century revival of certain Ancient Greek ideas about matter. The second and third chapters are surveys of 18th- and 19th-century chemistry, respectively. In Chapter 4 the authors meander through several areas of in-

dustry associated with chemistry, and in the final chapter they offer samples of chemistry from the 20th century. There is also a short epilogue. In all these chapters the authors "paint broad historical pictures" from which, they argue, "it is possible to understand all the industrial and intellectual adventures that at various periods have shaped chemistry's successive identities . . ." We believe that the shortcomings of this approach outweigh its advantages.

In the opening chapter, "Origins," Bensaude-Vincent and Stengers find ideas in Greek thought from Thales to Aristotle

> that obsessed and still obsess chemistry—principles, elements, atoms, the problem of differentiation, the relationship between the one and the many, generation interpreted as an ephemeral transgression of a static order or as a result of perpetual conflict.

A list of ideas that have infused chemical thinking for more than 2000 years suggests their longevity even if they do not represent a continuous tradition. It is true that Dalton's atoms were not identical to those of Democritus and Leucippus, but the choice of the term "atom" in the early 1800s was not arbitrary.

This opening chapter also covers the link from alchemy to chemistry. Just as the authors "find the description of procedures . . . that create a practical continuity between alchemy and chemistry," they also find a theoretical continuity, largely on the basis of Paracelsus, who is termed "the best known of the sixteenth-century chemists." The authors cite other transitional figures—van Helmont, Glauber, and Becher—as participants in an "indecisive struggle between rival doctrines," the outcome of which was not at all clear at the time. But the authors do not make it clear either how that struggle proceeded or what events and issues determined its outcome.

Broad strokes are also problematic in the third chapter, "A Science of Professors." Bensaude-Vincent and Stengers describe Paris as "the center of European chemistry" in 1800, but they give little indication that the center ever moved during the 19th century. This chapter presents an interesting overview primarily of French chemistry, though Kekulé, Mendeleev, and Faraday do flit across a few of its pages. The cameo role of Faraday is typical. His contributions to electrochemistry are listed as a chemical interpretation of the battery, the introduction of the terms "anode" and "cathode," and the laws of electrolysis. The authors sketch out Faraday's electrochemistry in little over half a page, less than the space they devote later in the chapter to Dumas' rejection in 1836 of Avogadro's hypothesis and of atomic theory in general.

Chapter 5, "Dismembering a Territory," returns to this antiatomism as still significant as late as the beginning of the 20th century.

In 1910 many specialists in inorganic chemistry still thought that the atomic and molecular hypothesis was only a fiction and criticized the way those unobservable entities were presented as if they really existed.

> . . . But if the atom provoked skepticism from inorganic chemists, it was the target of much more radical questioning from two renowned physical chemists, Pierre Duhem and Wilhelm Ostwald.

As committed positivists, these "two renowned physical chemists" hardly represent mainstream views in turn-of-the-century chemistry. Duhem, a professor of theoretical physics, rejected the scientific validity of any kind of model of matter; and Ostwald, one of the last chemists to oppose atomic theory, had retreated so far into energetics that he seemed to deny the existence of matter as commonly understood by other scientists at that time. It is certainly true that many chemists throughout the 19th century were skeptical of the Daltonian atom, and French scientists were among the most vigorous antiatomists. But even those who doubted the physical existence of atoms usually found the concept useful in explaining chemical phenomena, and many chemists did not regard atoms only as "fictions whose pretension to reality was by definition temporary and relative to their ability to organize the facts." In this, as in other instances, Bensaude-Vincent and Stengers do not do justice to a very complicated story.

The authors make many other claims that call for greater discussion than they provide—chemistry is the "daughter of speculative alchemy" (p 209); chemistry is now little more than "a service science, subordinated to physics, and in the service of biology and industry," apparently with no identity of its own (p 253); and "today 'purity' appears to be the prerogative of physics" rather than chemistry (p 256).

In addition to statements that are open to debate, this book contains statements that are mistaken in fact—Volta's "'pile' . . . generated electricity, as a Leyden jar does" (p 108); and "Wollaston . . . preferred to determine all these equivalent weights in relationship to the basic unit O = 100" (p 117). There are also statements whose meaning is not readily apparent to us—"it is always useless to rewrite history" (p 231); chemical equi-

librium is "the state in which the rates and affinities are simultaneously zero [and] is no longer a privileged state, but only the state to which irreversible processes lead" (p 249); and "if the activity in chemistry becomes more abstract, it also tends to escape subordination to physical law" (p 261).

The potpourri of topics in Chapter 5 does not provide a representative picture of 20th-century chemistry. Instead, the authors select topics that tend to be allied with physics and thus support their view that "chemistry may seem to be a kind of applied physics" (p 245). For example, they include some discussion of the work of Ilya Prigogine in connection with nonequilibrium systems and dissipative structures, which are an important, but minor aspect of contemporary chemistry. Neither the general list of references nor footnotes cite any publications of Prigogine, not even *Order Out of Chaos* (1984), which he co-authored with Isabelle Stengers. There are other omissions and numerous errors in the references as well.

All told, these are not qualities that recommend *A History of Chemistry* as a text for undergraduate courses in the history of science or for "a wider nonprofessional public," as one blurb on the dust jacket suggests. This text raises philosophically complex issues about the nature of historiography: the aims, methodologies, and the agendas and biases of chemists, as well as those of historians, who write histories of chemistry. These are not issues for the neophyte or the generalist.

Bensaude-Vincent and Stengers clearly intend their history of chemistry to be provocative, and it is, but it is most appropriate for readers who are already familiar with the subject. These individuals can certainly profit from this particular history whether they are sympathetic to a postmodernist reading of history or not. This book raises fundamental and disquieting questions, which challenge chemists with a historical bent to re-examine their views and attitudes about the history of their own science. Chemistry shouldn't ever be the same. *Richard E. Rice and Joanne A. Charbonneau, General Education Program, James Madison University, Harrisonburg, VA 22807.*

The Making of the Chemist: The Social History of Chemistry in Europe, 1789–1914. David Knight and Helge Kragh, Ed., Cambridge University Press, Cambridge, 1998. xxi + 353 pp. $80.

One of the most notable characteristics of science during the nineteenth century is the increasing trend towards professionalization, characterized by the intensive training of students to make a living in a specific scientific discipline. In this regard chemistry was no exception, and understanding how and why this process of professionalization took place is one of the more intriguing questions in the history of chemistry. Early in the nineteenth century, there were essentially no "professional" chemists, and those who practiced what we call chemistry were dedicated amateurs or employed in medical or pharmaceutical schools. By mid-century, students were no longer trained in chemistry for individual trades, but as "chemists," and that training became remarkably uniform. "Professional" chemists were everywhere: occupying chairs of chemistry in university philosophical factories, in industry, in agriculture. The process by which this took place is no less important than the intellectual development of chemical theory.

The Making of the Chemist, the result of a European Science Foundation program on the Evolution of Chemistry, provides a first step towards understanding how and why chemistry emerged as a profession during the nineteenth century. The authors consist of both professional historians of science and chemists. The volume, containing a preface by Knight and an afterword by Kraghe, is divided into three groups of European countries. The most space, understandably, is given to the "Big Three:" France (2 articles), Germany (2 articles), and Britain (3 articles). The remainder covers the "second tier" countries (Italy, Russia, Spain, Belgium, Ireland, Sweden) and finally those in the "periphery" (Denmark/Norway, Portugal, Greece, Lithuania, and Poland). Although nearly all the articles are valuable insofar as they recount the emergence of chemistry in the neglected "peripheral" countries, the strongest

contributions are those by Ernst Homburg on the many contexts of the emergence of the German chemical profession in the first half of the nineteenth century, Nathan Brooks on the emergence of academic chemical profession in Russia, and Kostas Govraglu on the cultural and intellectual issues facing natural philosophers and chemists in nineteenth century Greece. Colin Russell's chapter on chemistry in Sweden seems curiously out of place in the context of the volume, as it merely recounts the discoveries made by Swedish chemists and neglects the issues of professionalization altogether. The two most glaring omissions among European countries are the Netherlands and Switzerland, and it is not obvious why they were not included.

Despite the wide range of countries covered, there are remarkable similarities in the professionalization of chemists during the nineteenth century. There was everywhere a tension between practical and academic chemistry, and chemistry as a science emerged only slowly from medicine and pharmacy. Training of chemists took place at both the universities and the technical institutes, and there was always a tension between them as to what that training entailed. A common theme is the tendency of nearly all countries by mid-century to emulate the model of the teaching laboratory at the German universities begun by Friedrich Stromeyer at Göttingen and made spectacularly successful by Justus von Liebig in Gießen. Also clear is that, although Germany lagged behind France (where, Crosland reminds us, in the early century chemistry was second only to mathematics in prestige) and Britain in the training and practice of chemistry, within the space of 50-60 years, it surpassed both of these countries to become the undisputed leader in the practice of chemistry and in chemical education.

The issues involved in understanding the process of professionalization are extraordinarily complex, involving broad cultural, intellectual, and political issues that are unique to each country. This volume offers an excellent overview of the issues historians must face when confronting the problem of characterizing the nature of professionalization in chemistry specifically and the sciences in general during the nineteenth century.
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The Aspiring Adept: Robert Boyle and His Alchemical Quest. Lawrence M. Principe, Princeton University Press, Princeton, NJ, 1998, xiv + 222 pp. Cloth, $45.

Over twenty years ago, B. J. T. Dobbs argued in *The Foundations of Newton's Alchemy* that Isaac Newton was deeply involved in alchemical practice. In doing so, Dobbs brought to light a major aspect of Newton's life (he wrote over a million words on alchemy, far more than he wrote in physics) that previous biographers had considered "embarrassing" and attempted to explain away. In *Aspiring Adept*, Principe draws on extensive, previously unexamined archival sources to reveal that Robert Boyle, long considered to be the "Father of Modern Chemistry," was as thoroughly involved in alchemy as his younger colleague Newton. The resulting book is of remarkable significance for our understanding of Boyle's place in seventeenth-century science and within the history of chemistry.

Alchemy as an historical human activity has all too often been relegated to pseudoscience and treated as an irrational enterprise undertaken by "unenlightened" people in a "pre-scientific" age. For this reason Newton and Boyle have long been considered to have been "above" the practice of alchemy. According to Principe, this unfortunate consequence has its roots in two historiographic mistakes: 1) the tendency to regard Boyle and Newton as "modern scientists" and therefore read their work as "precursors" to our own ideas about nature, and 2) a general lack of understanding of (admittedly extremely difficult) alchemical theory and practice, specifically the tendency to lump "alchemy" into a single monolithic philosophy of nature. One of Principe's most valuable contributions in this book is to initiate a recasting of "alchemy" into several different activities, and to illustrate the subtlety of the relationships between alchemy and religion. In order to avoid confusion over the meaning of the terms "alchemy" and "chemistry," which shifted enormously in their meanings both during and after the seventeenth century, he reintroduces the archaic term "chymistry," to mean the sum total of chemistry/alchemy in the seventeenth century, and re-

vives the Greek term "chrysopoeia" for that specific area of chymistry concerned with transmutation, and "spagyria" to refer to the drawing out of essential principles for later recombination and purification.

Principe begins with a thorough examination of historical portrayals of Boyle, beginning with the collection of his papers in the seventeenth century. Very soon after Boyle's death in 1691, Boyle's alchemical works were ignored and forgotten in the creation of his collected works, in the attempt to cast him as a "rational" thinker like Newton, in opposition to alchemy, which even by the early eighteenth century had come to be viewed as "irrational" and suspect. Ever since, Boyle has been stripped of much of his seventeenth-century identity and cast impossibly as a "man ahead of his time" who eschewed "mystical" alchemy for the mechanical philosophy. By the mid-twentieth century, this view of Boyle as a "modern" scientist continued in the work of Marie Boas Hall, arguably the most influential Boyle scholar of the mid-twentieth century, who treated Boyle as a prelude to Lavoisier. In an insightful metaphor given by Principe, the resulting conception of Boyle was not of "a seventeenth century natural philosopher, but ... [of] a chemical John the Baptist."

Beginning his study of Boyle proper, Principe turns first to an analysis of the *Sceptical Chemist*, one of the most famous and difficult books in the history of chemistry. The fame of the *Sceptical Chemist* has previously rested solely on the very short passage, quoted in endless histories of chemistry, in which Boyle denounces the definition of chemical elements. While it has long been known that this passage did not in fact deny the existence of elements, the book as a whole has escaped the scrutiny of historians. Principe provides the first thorough historical analysis of the argument of, and audience for, the *Sceptical Chemist* and argues that Boyle directed it not toward "alchemists" per se, but toward a specific group of chymists: the Paracelsian chymists and systematizers who attempted to create entire chymical systems on the basis of only a few observations. It was decisively not a rejection of alchemy. Concurrent with Principe's analysis is the recognition that chymists as a group belonged to many different schools; it is impossible to categorize them together.

The next three chapters are devoted to showing that Boyle, in addition to not rejecting alchemy, actively embraced it, writing treatises with alchemical motifs, corresponding actively with practicing alchemists, and practicing alchemy itself. Chapter three introduces the *Dialogue on Transmutation,* a fragmentary unpublished document, set as a Galilean-type dialogue between two groups of chymists discussing the existence of the philosophers stone. As the *Dialogue* proceeds, Boyle leaves no doubt that the group of chymists defending the philosopher's stone is correct. The *Dialogue* is a major work, offering crucial insight into the kind of alchemical pursuits that interested Boyle. Chapter four looks at the role of "transmutational histories," or accounts of transmutations by various alchemical adepti (some traveling from town to town) that became famous throughout Europe. It seems clear that Boyle directly witnessed such transmutations several times and actively pursued, and would pay for, alchemical knowledge from the adepti that came to his attention. In chapter five, Principe demonstrates that Boyle himself attempted to uncover the secrets of the adepti, both in his intensive study of the metaphorical and secretive texts of chrysopoeic alchemy, and by his own laboratory experiments. Significantly, Boyle's own chrysopoeic and spagyric manuscripts were written in a system of often simple codes that he did not use in other contexts. In order to show Boyle's intense interest in experimental chrysopoeia, Principe traces Boyle's forty-year quest, documented in both archival and printed sources, for the philosophical mercury needed for preparing the philosopher's stone.

In the last chapter, Principe suggests three motivations for Boyle's intense interest in alchemy. The first is what we would call scientific—chymistry's value for furthering the practice of natural philosophy. As the philosopher's stone also offered the promise of a "universal medicine," Boyle found medical reasons for pursuing alchemy. The most startling motivation Principe uncovers, however, is the role of the philosopher's stone as an intermediary between the corporeal and spiritual worlds. If made, Boyle believed that the stone would attract angels. While at first this would sound fantastic and unbelievable, this belief in fact ties together Boyle's twin interests in the mutually antagonistic realms of corpuscular philosophy and Christian theology. As a devoted Christian, Boyle felt compelled to refute the atheistic implications of the mechanical philosophy and to understand how the incorporeal world of the angels could interact and intervene with the physical world.

Having thoroughly reconstructed Boyle as a devoted alchemist intensely interested in the chrysopoeic arts, Principe motivates us to rethink his place in seventeenth-century science. If he is not the "Father of Modern Chemistry," why is Boyle important? Rightly, Principe does not discard the importance of Boyle by denying entirely his influence on later generations, but

attributes the apparent conflict between Boyle as a modern and Boyle the alchemist as a previous deficiency of historians to see that a chymist in the seventeenth century possessed aspects of both. Further, because Boyle's corpuscularianism was likely itself derived from the alchemical tradition, we must consider the development of chymistry in the seventeenth century more evolutionary than revolutionary.

There are three appendices containing previously unpublished alchemical works of Boyle. The first and largest appendix is the extant Latin text of the *Dialogue on Transmutation*, reconstructed by Principe from twenty-three existing archival fragments, with an English translation on facing pages. Appendix Two contains other accounts of transmutations obtained by Boyle through interviews and prefaces to Boyle's other chrysopoeic works whose full texts have not survived. The third appendix contains a dialogue on the conversation with angels aided by the philosopher's stone.

In the end, we should not be too surprised that Boyle was interested in alchemy. After all, Boyle was a man of the seventeenth century, a period in which alchemical practice flourished before it disappeared in the eighteenth century. Because nearly all major natural philosophers in the seventeenth century England—Newton, Locke, Dee, Ashmole, Starkey, among others—were intensely involved in alchemy, we should be more surprised to find that Boyle was *not* involved in alchemical pursuits. *Aspiring Adept* is a rich work that should change the way we present Boyle in a history of chemistry course. For those interested in the history of alchemy, the relationships between "chemistry" and "alchemy," the emergence of the former from the latter, or the place of Boyle in the Scientific Revolution, it is required reading. *Peter J. Ramberg, Max-Planck Institute for the History of Science, Wilhelmstraße 44, D-10117 Berlin, Germany.*

Women in Chemistry: Their Changing Roles from Alchemical Times to the Mid-Twentieth Century. Marelene and Geoffrey Rayner-Canham, American Chemical Society and the Chemical Heritage Foundation, Washington, DC, 1998. xiv + 284 pp. Hardcover (Typeset), $34.95.

Readers are invariably surprised, on encountering a book about the history of women in science, by the number of women who have made significant contributions to mathematics, chemistry, physics, and the biological sciences. After reading about these women's accomplishments, however, the reader is often disappointed by the paucity of information available on both their personal and professional lives. A new book that attempts to fill this void was recently published by the American Chemical Society and the Chemical Heritage Foundation. Written by a wife and husband team, the Rayner-Canhams' latest book, *Women in Chemistry: Their Changing Roles from Alchemical Times to the Mid-Twentieth Century*, containing 207 pages of text and 45 pages of references and notes, introduces the reader to more than 100 female chemists and physicists by name, as well as a few whose names have been lost. Although the authors do an excellent job of presenting a broad spectrum of women chemists, they, too, admit at the end of the book, "It is unfortunate that we have so little record of the feelings of these individuals." In spite of this admission, the authors have made a significant contribution to the histories of women in chemistry. They have introduced us to many important women chemists and piqued our interest in learning even more about their personal and professional lives, as well as about how they interacted with their contemporaries as scientists.

The Rayner-Canhams are on the faculty of Sir Wilfred Grenfell College, Newfoundland, Canada, where Marelene is a Laboratory Instructor in Physics and Geoffrey is a Professor of Chemistry. They previously collaborated on *A Devotion to Their Science: Pioneer Women of Radioactivity*, a compilation of the lives and work of 23 women researchers who made contributions to the new fields of radiochemistry and nuclear physics in the early part of the twentieth century. Their

extensive research into the history of women in science uniquely equips them to tackle a book of this scope.

They begin the book with women who developed methods for extraction and distillation of plant compounds in Mesopotamia around 1200 BC and end with women of the 20th century who did their significant work before 1950. Although many of these women are linked to important scientific discoveries, in most cases only bits and pieces of their individual experiences have been preserved to help us understand and appreciate both their struggles and their contributions.

The authors' stated perspective in presenting their material was to "provide the context required by science historians," rather than simply to recount the biographies of individual female chemists. This is certainly a useful approach, especially considering the major influence that society, as well as cultural and historical events, exerts on the practice of science. The historical context is divided, as the book progresses, into three major subdisciplines of chemistry in which women were particularly active in the 20th century: crystallography, radioactivity, and biochemistry. A chapter on women's contributions to industrial chemistry, analytical chemistry, and chemical education, and as historians of chemistry is followed by a final chapter that draws some general observations and conclusions about women chemists in the 20th century.

Based on this historical-context approach, the first chapter offers a brief overview of women chemists prior to the Scientific Revolution (pre-eighteenth century). These women are collectively referred to as alchemists, although they made discoveries of lasting scientific importance to which their names are still attached. Among them is Maria Hebraea, who lived and worked in Alexandria during the early centuries AD. Her name is immortalized by her invention of the heating and distilling apparatus called the *balneum Mariae*, or water bath—the French *bain Marie* and the German *Marienbad*—which had a glass component so that reactions could be observed without interruption. The names of a number of Chinese female alchemists have also survived, as have those of highly educated abbesses who left written accounts of their scientific contributions made during the Dark Ages. The writings of several European women who had a passion for chemistry (or alchemy) during the 16th and 17th centuries provide a tantalizing glimpse into the frustration that these women felt as formal university programs were established for men only in France and England. The notable exception was in Italy, where women had some access to universities at the beginning of the 18th century. Queen Elizabeth I reinstated the complete ban on women at universities and issued the order that academic celibacy be continued in Britain, an order that was observed at Oxford and Cambridge Universities until 1882.

Women chemists in the 18th and 19th centuries are divided into two groups, chemist-assistants of the French salons and independent researchers. A biographical sketch of Marie Anne Paulze-Lavoisier (1735-1820) is one of the most satisfying in the entire book. It covers the many-faceted life of this remarkable woman, who actively participated in the controversial scientific and political events of her time, assisting her famous husband Lavoisier until he was decapitated during the French Revolution. Several of her contemporaries are also mentioned, but there is no discussion of their influence on each other, although they were almost certainly acquainted. Is the record silent on this point? The reader would like to know. Among the independent researchers who made noteworthy contributions was Elizabeth Fulhame (late 1700s), who is credited with the first recorded experiments on photochemical imaging, the first proposal of a two-step chemical reaction, and the first published concept of a catalytic process. She was elected a corresponding member of the Chemical Society of Philadelphia, and her discoveries were acknowledged by leading chemists in both the U.S. and Europe. At about the same time, Jane Marcet (1769-1858) wrote her popular book for young ladies, entitled *Conversations on Chemistry*, which went through 18 editions in Britain and 23 impressions in the U.S. Other important members of this group of "amateur chemists" were Helen Abbott Michael and Agnes Pockels, whose name is still associated with important results of her well-documented experiments, carried out in her kitchen, which contributed to the origins of surface science.

As the 20th century began, access to higher education became the key for women's participation in chemistry. Pioneers who opened the doors for women included Ellen Swallow Richards (1842-1911) at Massachusetts Institute of Technology and Rachel Lloyd (1839-1900), who received her Ph.D. in Zurich, Switzerland, and returned to the U.S. to make her mark as a professor and researcher at the University of Nebraska. Laura Linton (1853-1915) followed a well-traveled path from chemistry teaching and research into a career in medicine at age 47. Although there is no further mention of women who made the transition from chemistry into medicine, more examples are no doubt available and would have made interesting reading.

The discussion of women in crystallography gives well deserved credit to W.H. Bragg, W. L. Bragg, and J. D. Bernal for the mentoring support that they provided women scientists. Biographical sketches of Kathleen Lonsdale (1903-1971), Nobel Prize winner Dorothy Hodgkin (1910-1994), and Rosalind Franklin (1920-1958) provide an overview of both exciting developments in crystallography and the important historical changes taking place at British universities during the first half of the 20th century. Two particularly appealing photographs of Hodgkin and Franklin as young women are excellent additions to the text. A number of other female crystallographers are briefly mentioned. Completing this chapter should motivate the reader to undertake a search for more information about these fascinating and important female crystallographers; additional information is easy to find and well worth the effort.

The account of women in radioactivity is dominated by Marie Sklodowska Curie (1967-1934) and her daughter Irene Joliot-Curie (1897-1956), who both won the Nobel Prize in Chemistry for their contributions to this burgeoning field of research. Their life stories are already familiar to many readers, but some of their colleagues have long gone unnoticed. More insight into the lives of Norwegian chemist Ellen Gleditsch (1879-1968) and Viennese chemist Stefanie Horovitz (1887-1940), who was a victim of the Nazi purges, would help balance the record. Several women who were physicists, rather than chemists, are also included in this chapter, probably because of the interdisciplinary nature of nuclear science.

Some of the most interesting material in the book concerns women in biochemistry whose lives and careers have been similar to those of women currently working in the chemical professions. The founder of modern biochemistry and the primary mentor for women in this field was F. Gowland Hopkins of Cambridge University. His counterpart in the U.S. was Lafayette Mendel at Yale University; he trained 124 PhDs, 48 of whom were women. Icie Macy Hoobler (1892-1984) was one of Mendel's most famous female students, and her list of important accomplishments includes being the first woman to chair a local section (Detroit) and the first woman to chair a division (Division of Biological Chemistry) of the American Chemical Society. Two other women in this category are Nobel laureates: Gertrude Elion (1918-1999), who rose to prominence at Burroughs Wellcome, and Gerty Radnitz Cori (1896-1957), who finally was made a full professor at Washington University in St. Louis after she and her husband were awarded the Nobel Prize in 1947.

Inclusion of more information about the Garvan medalists of the American Chemical Society, from the list of 34 winners between 1937 and 1976 as listed in the appendix, would have been of great interest to many readers. In particular it would have been appropriate to include Dr. Marjorie Vold, who served on the faculty of the University of Southern California and represents the small, but important, number of women chemists who were professors at major universities. There is one brief reference to women's contributions to cosmetics chemistry in the biography of Florence E. Wall (1893-1988). Formulation of cosmetics is a recognized extension of chemistry and one in which women have made major contributions, including those of the famous and successful African-American entrepreneur, Madame C. J. Walker (1867-1919). Although not a trained chemist, she deserves recognition for her original formulations of products in this industry.

A history of women in chemistry would not be complete without acknowledging the contribution to the chemical education of women made by Emma Perry Carr (1880-1972), who was personally responsible for establishing at Mount Holyoke College an undergraduate chemistry department which was the equal of any in the country. One of the most memorable quotes in this entire book is that of a mourner at Carr's memorial service who remarked, "It was a resistant person who could fail to share her enthusiasm whether for science, for politics, for her family, for pi electrons, for baseball, or for the circus." Many of the women who are pursuing chemistry today can look back with appreciation to Emma Carr, who instilled that enthusiasm for chemistry and life in general into her young students. As this book closes with a review of the decades from 1900 to 1950, the picture is far from rosy. After two world wars had opened doors to entry-level positions for women in government, industry, and academe, many found the doors closed just as surely as an apparent new world order loomed into view. The promise of equal participation for women in chemistry was still a chimera, and the second half of the 20th century has continued to present many of the same challenges for women chemists. One of the values of reading this book lies in the reader's realizing that women can and have made outstanding contributions to chemistry in spite of the barriers that still exist to their full participation in a discipline in which gender distinctions certainly should have no place.

This is a book that should be read and retained for ready reference by anyone interested in the history of women in chemistry. It contains a wealth of well organized information and provides excellent suggestions for further exploration of the subject. It would be especially appropriate for use in a course on the history of chemistry. *Mary F. Singleton, 597 Gerard Court, Pleasanton, CA 94566.*

Fritz Haber: Chemiker, Nobelpreisträger, Deutscher, Jude. D. Stoltzenberg, Wiley-VCH Verlag GmbH, Weinheim, 1994. xiv + 645 pp. Hardcover, DM 98.

This thoroughly researched, detailed biography of the Nobel Prize winner Fritz Haber, coming 65 years after his death, is a rich source of information, not only about Haber's life and scientific activities but also about the climate of chemistry in Germany before and after World War I. It is a welcome resource and quite in contrast to the only brief biography in English [M. Goran, *The Story of Fritz Haber*, University of Oklahoma Press, Norman, 1967, 176 pp, octavo], in which, according to Stoltzenberg, much of the anecdotal material, derived from friends and relatives of Haber, is of questionable validity. A novel about Haber by H. H. Wille, *Der Janus-Kopf*, Buch Club 65, Berlin, was published in 1970.

Fritz Haber

The author, Dietrich Stoltzenberg, born in 1926, was trained as chemist at Karlsruhe under Criegee and spent his career in German chemical industry. He is the son of Hugo Stoltzenberg, chemist and manufacturer, who was in close communication with Haber in the early 1920s, after WW I, in connection with disposal of chemical warfare materials and the building of manufacturing plants in Spain and the Soviet Union, as well as in Germany. The relationship with Haber ended abruptly in 1925, when, in a confrontation between IG Farben and Hugo, Haber withdrew his support of Hugo in favor of the industrial giant. In spite of this, the author seems to present a highly objective picture of Haber, even in instances where he was at odds with Hugo Stoltzenberg.

The author has taken advantage of rich sources for this biography. A major resource is the archival material at the Max-Planck-Gesellschaft, Berlin-Dahlem, consisting of the papers (*Nachlaß*) of J. Jaenicke, together with many other materials he collected over a 20-year period, in anticipation of the preparation of an authoritative biography, which he never realized. Many other archival sources are cited, including private papers of Hugo Stoltzenberg and his wife, now in the possession of the author Dietrich; others in Germany, including some from the former DDR; documents from Israel, Cal/Berkeley (Emil Fischer *Nachlaß*), and Cal Tech.; and the autobiography of Charlotte Nathan Haber, Haber's second wife. The author notes that records of the WWI chemical warfare program were either destroyed or may be in archives of the former Soviet Union. Stoltzenberg spent eight years researching the myriad documents for the biography.

The language of the text is eminently readable for a non-German who has the fundamental grasp of the language. Sentence structure is straightforward, and the text is practically error-free. This reviewer noted only

two typographical errors (pp 32, 286) and one (p 124) for the date (1891, not 1899) of Haber's completion of the doctorate. The book is generously illustrated with 93 photographs, mainly of family members and collaborators, some from the author's own collection. The index for such a long book seems thin, with only a little over 300 entries. "Chlor" but not "Brom" is included, even though both are in the text; and some entries are confusing; the chemical firm Bayer, for example, is found under "Farbenfabriken Bayer"

The book is divided into fourteen chapters, some relatively short describing Haber's forebears, his youth, education, and private family life. Lengthy chapters are devoted to coverage of his Karlsruhe days, where he developed the fixation of nitration; his time before and after WW I as director of the Institute for Physical Chemistry and Electrochemistry at the Kaiser-Wilhelm Institute in Berlin; his key role in chemical warfare in WW I; and the awarding of the Nobel Prize in 1918. The author concludes with the purging of Jewish scientists from Haber's institute and elsewhere in Germany, his resignation in October, 1933, and his death from heart disease in January, 1934.

Stoltzenberg has produced a rich documentary of Haber and his era, but he has also succeeded in painting a vivid picture of the man. The reader learns that Haber, the child of "relaxed Jews," was eventually baptized as a Christian. He was ever the loyal German and only secondarily a Jew. His early love of classics, poetry, and drama was gradually superimposed by a fascination with science. He set up a chemistry laboratory in his room. When his father forbade it, his uncle allowed him space in the uncle's quarters. As a university student he was fascinated with concepts of a deity, consciousness, idealism, realism, and logic. He expressed impatience with the pedantic teaching he experienced briefly in Heidelberg under Bunsen, then 76 years old. Haber respected his colleagues throughout his life and maintained warm camaraderie with his students through regularly planned colloquia and social events. Willstätter was his life-long, closest friend. He corresponded familiarly with Einstein for a certain period of time before WW I. Always a prolific correspondent, he sometimes composed poetry to suit the occasion. Much of the correspondence is reproduced in the text. Yet Haber was not a particularly devoted family man. He excluded his first wife, Clara Immerwahr, Ph.D. (Abegg), from being involved in his research or teaching at Karlsruhe; after her suicide, he remarried but divorced Charlotte Nathan after ten years. His oldest child, the son of Clara, committed suicide in 1946.

Haber was an imaginative researcher and excellent administrator, politically very skilled, and intensely devoted to his profession. Among Haber's scientific contributions, the author describes in detail his ammonia synthesis from nitrogen, the development of electrochemistry, and luminescence. His dedication to his country is verified through his all-out effort to develop war gases, meticulously documented in Chapter 7. It also demonstrated his management skills, for he involved many scientists from the K-W Institute, some of whom served as guinea pigs, working at testing sites, designing gas masks, etc. Among them: Hahn, Geiger, Franck, Wieland, Friedländer, and Freundlich. Every one of the K-W chemical institutes was devoted fully to the war effort, except the Hahn/Meitner radium research program. Even Warburg's Biological Institute was taken over. Yet as the war proceeded, he also headed an extensive research program for the use of poison gases in pest control; he simultaneously turned his attention to the manufacture of nitrate fertilizers from ammonia, working closely with Emil Fischer. He was very adept at collaborating with German chemical industries in all these endeavors. Haber became consumed by his chemical warfare responsibilities, to the neglect of his family and friends and any earlier research interests. In the period after WWI, Haber was open to new ideas such as the quantum theory and directed research programs accordingly. Yet he could be scientifically naïve, giving support to projects on extracting gold from seawater and transforming mercury into gold. Later he absolved himself of any identity with the latter.

Stoltzenberg has accomplished what Jaenicke aspired to do at the highest possible scholarly level. More than just a carefully documented biography, this account provides insight into the scientific, social, and political events in Germany in the first quarter of the 20th century. Historians in widely diverse disciplines will recognize it as an invaluable document. An abbreviated edition in English will be published by the Chemical Heritage Foundation in 2000. *Paul R. Jones, Department of Chemistry, University of Michigan, Ann Arbor, MI 48109-1005.*