BOOK REVIEWS

Promethean Ambitions: Alchemy and the Quest to Perfect Nature. William R. Newman, University of Chicago Press, Chicago, IL, 2004, 352 pp, 8 color plates, 20 halftones, Cloth, ISBN: 0-226-57712-0, $30.

Our understanding of alchemy and its influence continues to grow. In this significant book, Newman does not directly examine the theoretical content of alchemy but the attitudes towards claims made by alchemists that they were able to perfect and even outdo nature by artificial means. From the beginning of alchemical practice, critics of alchemy regarded such claims of transmutation as either impossible or morally objectionable. Alchemists, on the other hand, defended their art by claiming to work with the genuine substances of nature, and not, like the other arts, by only superficially manipulating the external characteristics of materials. In short, alchemists raised two questions: are we capable of duplicating or even outdoing nature, and *should* we try to outdo nature? In the light of current questions about genetic engineering and cloning, these two questions seem remarkably modern. But as Newman shows, these are old questions, dating in part to ancient Greek ideas about the distinction between the artificial and natural.

The idea that man could compete with and possibly outdo nature arose in ancient Greece and was most closely associated with the decorative arts. In the Greek classical ideal, the purpose of statuary, for example, could have two goals. The first was mimicry, the creation of as realistic a representation of a natural object as possible. The second was "perfective," an attempt to create something not actually found in nature, such as a composite sculpture of Helen of Troy more beautiful than any existing woman. As a human art, ancient alchemy followed closely this distinction between the real and artificial, and often alchemists claimed their craft to be a perfective art that went far beyond other human arts in its power. A frequent claim of early alchemical texts, including those recorded in the Leiden and Stockholm papyri, touts the ability of man to create products "no different from their natural exemplars" (p 25). But critics of alchemical claims appeared at the same time: they maintained the Leiden and Stockholm papyri also clearly described recipes for making substances that only "mimic" natural things, and that many of the claims contained in alchemical works were fraudulent.

Newman's second chapter is a reworking and enlargement of his classic 1986 *Isis* article on the alchemical debate in the Middle Ages. The central claim of alchemists was that their art was different from the other arts—alchemists suggested they had the power to do genuine conversions, accelerating nature's own processes to outdo nature. Such claims were met with skepticism from the outset. In the influential thirteenth-century manuscript titled *Sciant artifices,* the Arabic philosopher Avicenna gave a powerful two-fold argument against transmutation. Avicenna claimed that art, always weaker than nature, could never duplicate it, and that the genuine underlying causal properties of substances were unknowable and therefore immune to manipulation. For this reason, according to Avicenna, synthetic gold crafted in the laboratory would never actually be real gold. Given authority by a mistaken attribution to Aristotle, the *Sciant Artifices* provided the fundamental argument against the power of artificial production of natural substances and the primary point of attack for the defenders of alchemy. Some commentators, including Albertus Magnus and Thomas Aquinas, used Avicenna's argument to demonstrate that demons and witches were incapable of transmutatory acts. Another common criticism of alchemical claims was theological: humans could never imitate, and certainly could not exceed God's own creative power. A number of writers came to the defense of alchemy, among them Paul of Taranto, who made a distinction between the "perfective" arts (alchemy or medicine) that get at the essences of substances, and the "mimetic arts" (sculpture, for example) that manipulate only surface features.

This well developed dichotomy between the natural and the artificial had further ramifications in the visual arts, the subject of Chapter 3. Examining the attitudes of Renaissance artists Leonardo Da Vinci, Vanoccio Biringuccio, and Bernard Palissy towards alchemy, Newman notes that all three acknowledged the value of alchemical recipes for making pigments and materials useful to their crafts, yet all three rejected the central claim of transmutation. Da Vinci used the common argument that true transmutatory powers would usurp the power of God, while Biringuccio thought the claims of alchemists absurd because, were they true, alchemists would have acquired untold wealth. While denying alchemical claims to transmutation, Palissy appropriated those same alchemical motives to the process of petrifaction and the creation of his extraordinarily life-like ceramic pottery.

Perhaps the most bizarre subject (to modern readers at least) of *Promethean Ambitions* concerns medieval and renaissance notions on spontaneous generation and the creation of artificial life. In Chapter 4, Newman recounts the history of the idea of artificial generation from the (possibly) Greek legend of Salaman, the artificial child of King Harmanus who, according to legend, was "cooked" in a sealed vessel outside the womb. Later works in this tradition offer numerous explicit recipes for creating artificial life. *The Book of the Cow*, for example, describes the growth of a "rational animal" in the womb of a mutilated cow, and Jewish magical texts offer numerous recipes for creating a golem. But the most influential figure in the story of the homunculus was Paracelsus, who fully incorporated the major issues of the art/nature debate into the artificial production of life. Paracelsian conceptions of the homunculus took on eugenic overtones, as recipes for the homunculi commonly involved allowing male semen to mature without the female component. The growth process outside of the female womb would result in a more perfect being. The production of a homunculus was also important for theological reasons, in particular for explaining the incarnation of Christ in Mary's womb. Reaction to these Paracelsian claims followed the same pattern as in alchemy itself, as it was argued that man could never mimic, and certainly not improve on God's creative acts.

As becomes clear in Chapter 5, Newman has a larger historical point to make than simply recounting odd and bizarre medieval and renaissance ideas about transmutation and spontaneous generation. The rich and detailed medieval debate about the powers of alchemical arts and technology in general strongly influenced the attitudes of natural philosophers in the seventeenth century, in particular concerning the new approach to experiment. By a careful analysis of important works of Daniel Sennert, Francis Bacon, and Robert Boyle, Newman shows that formerly cryptic statements in their most famous works make more sense in light of the alchemical debates of previous centuries.

In the final chapter, Newman outlines the continuing influence of alchemical discussions about the powers of alchemy and chemistry as art. In Goethe's *Faust*, Part II, for example, the main character Wagner is occupied in making a homunculus to render sexual reproduction obsolete. One source of Darwin's ideas on transmutation of species, the eighteenth-century naturalist Joseph Kölreuter, used the explicit imagery of "transmutation" and the sulfur-mercury theory of alchemy to describe the results of his plant hybridization experiments. Mary Shelley's *Frankenstein* must be understood as being written within a long tradition of discussions about creating artificial life. In chemistry, the debate over whether Friedrich Wöhler made "natural" or "synthetic" urea in 1828 was a logical continuation of the artificial/natural distinction first laid out by the alchemists.

Newman draws numerous parallels between the medieval debates to our own current discussions about genetically modified foods, genetic therapies for disease, cloning, and stem cell research, pointing out that these debates are only the latest manifestation of long-standing ethical issues surrounding the proper use of technology. *Promethean Ambitions* is extraordinarily rich in detail and for that reason in places is not an easy read, as Newman draws on a large number of well-known and obscure texts. The chapters also seem long (Chapter 2 is 80 pages, for example), but *Promethean Ambitions* is an important and ambitious book that will reward the careful reader. *Peter J. Ramberg, Division of Science, Truman State University, Kirksville, MO 63501*

The Chemical Industry at the Millennium: Maturity, Restructuring, and Globalization. Peter Spitz, Ed., Chemical Heritage Press, Philadelphia, PA, 2003; 387+ xii pp, ISBN 0-941-90134-3, $45.

In the decades following World War II the U.S. chemical industry was especially significant both nationally and internationally. By contrast, the past few decades seem to have been especially uncertain times for the industry. The competitive landscape has been reshaped by both abrupt increases in feedstock prices and globalization. Pressure from the financial community has forced mergers and acquisitions that have eliminated famous company names, like Union Carbide, Allied Chemical, and American Cyanamid. A traditionally strong positive contribution to the national balance of trade has slipped into negative values. Some companies have changed their main focus to the life sciences and agriculture, hoping that a shift to specialty chemicals would insulate them from large swings of the business cycle, but these efforts do not seem to have been very successful. It is important to understand these developments, both for chemists as well as for the general public, and Peter H. Spitz, the principal author of this book, is well qualified to discuss these changes.

For some time, Spitz has been the managing director of a consulting company that specializes in the chemical industry, and his previous book, *Petrochemicals: The Rise of an Industry,* is a classic that reviewed developments in the industry from 1930 to about 1980. Spitz identifies three factors that were the dominant influences on the chemical industry over the past two decades: globalization and foreign competition, the increasing influence of the financial community on industry strategy, and increased governmental regulation. Spitz and an impressive roster of coauthors discuss the role that each of these factors has played.

International trade has always been important for most major chemical companies, but now the U.S. chemical industry is faced with a truly global market. Spitz notes that four national characteristics have traditionally made the U.S. Gulf Coast a major petrochemical exporting region: (1) availability of infrastructure, skilled labor force, and raw materials; (2) high demand for the products in the home country; (3) the presence of related supplier industries; and (4) a well managed and competitive local market. By the 1990s, oil and natural gas production had peaked in the Gulf Coast, and production increasingly shifted overseas. Many countries developed local chemical suppliers, either in combination with existing multinational corporations or as independent operations. Even though the United States continued to be an important market, more and more industrial production is shifting to Asia, Latin America, and the Middle East, attracted by cheaper feedstock and labor costs.

Spitz and his coauthors argue that stock prices and a greater focus on short-term performance rather than long-term objectives play an increasingly dominant role in the development of industrial policy. The pressure by Wall Street for quick profits has forced a focus on mergers and acquisitions at the expense of long-term research and development. Many companies have attempted to produce higher profit margins and greater growth by switching from commodity to specialty chemicals. This emphasis on short-term profits was accompanied by efforts to develop simplified matrices to predict future business performance. Despite suggestions that this was not appropriate for a highly integrated industry like chemicals, these models were used to justify financial pressure to restructure and merge companies and to favor specialty chemicals over commodity chemicals. It was predicted that these changes would produce higher profitability and greater growth, but in most cases these expectations have not been met. Other initiatives, such as cost cutting, layoffs, and early retirement, also appear to have been generally inadequate to improve the bottom line. Ironically, one of the authors points out that the recent period of lagging profits may simply have resulted from the underlying fact that commercial innovation occurs on a fifty-year cycle, and the most recent period of major product releases was 1940-1970.

Finally, Spitz argues that "…issues related to the environment and toxicity have in many respects had a greater effect on the industry than almost all the other traumatic events it had to face in the declining years of the twentieth century" (p 208). A succession of widely publicized chemical incidents has given the public a perception of the chemical industry that Spitz labels as dismal. In some cases, such as the Bhopal disaster or the contamination of the James River by Kepone, there has been some factual basis for this negative view; in other cases, such as the pesticide Alar, the justification for public outcry has been more arguable. During this period, a combination of governmental encouragement and changing industrial attitudes has produced more information sharing with local communities, massive investments in environmental controls, and elimination of many hazardous products from production processes.

The chemical industry has made intense efforts to improve how it is perceived by the public. In the 1980s, the chemical industry developed the Community Awareness and Emergency Response (CAER) and the Responsible Care initiatives to enhance health, safety, and environmental performance. These efforts have produced concrete improvements, which the industry can point to with pride, but these successes do not seem to have alleviated the public's apprehensions. Unfortunately, a single negative incident has more influence on public attitudes than a consistent history of improvements. Government regulations are surely burdensome to the chemical industry, but they may also provide the best way to prevent a few rogue companies from disrupting the efforts made by most of the industry to be responsible citizens.

Spitz closes with a cautiously optimistic evaluation of the future of the chemical industry. He predicts that many of the trends described above will continue to be important. Despite the recent period of relative inactivity, the industry will continue to be reshaped by restructuring and consolidation. Industrial efforts to re-establish public confidence will continue, with sustainable development and "Green Chemistry" as major themes in the process. One of the biggest challenges for the chemical industry will be to find ways to enhance economic growth rates now that it has become a mature industry; that is, one that grows no faster than the GNP. Spitz suggests that there may be another price spike for energy and feedstocks. He summarizes by saying that despite all the problems, we live in a society where the products of the chemical industry are essential. Thus, his conclusion might be described as guardedly optimistic.

Events since the publication of this book suggest that the three factors identified by Spitz et al. may sometimes be closely related to a fourth topic, namely, the weather. Hurricanes Katrina and Rita had a devastating impact on both the drilling platforms and the production facilities along the Gulf Coast. These hurricanes have affected the U.S. chemical industry in several ways. Natural gas is the preferred feedstock for much of the chemical production in this country, and prices of this critical raw material were already beginning to soar before the two hurricanes struck. It is not yet clear how much damage these storms did to either the drilling platforms or the refineries, [but it seems likely when the price of natural gas stabilizes, it will be at unusually high levels.] This may tend to further weaken the ability of U.S. chemical producers to compete in the global marketplace.

The hurricanes have also forced Congress to become aware of how much the petrochemical industry, as well as the drilling platforms that it depends upon, are concentrated in a relatively small and vulnerable geographic region. Congress is discussing the possibility of expanding the allowed offshore drilling areas and/or diminishing environmental regulations, but at this point, it is still unclear whether these efforts at deregulation will be successful. Regardless of what happens in this country, chemical exports to the European Union are threatened by a growing tendency in Europe to challenge the idea that the United States will define the limits of environmental regulation. Examples of more aggressive environmental policies already passed in Europe include new recycling requirements and RoHS (which restricts the use of toxic substances, like lead, within electrical and electronic equipment). In addition, a broad new regulatory framework, called REACH, Registration, Evaluation, and Authorization of Chemicals, is currently under discussion. REACH proposes to require toxicity testing for 30,000 widely used chemicals that were accepted without significant testing when the U.S. passed the Toxic Substances Control Act. Adjusting to these regulations may be a special challenge for American companies, which are already facing a more competitive global marketplace.

By the end of the century, despite the introduction of various new strategic theories, the chemical industry is still failing to deliver the sustained growth rates desired by the financial community. Unless some new family of widely used products goes into production in the near future, it seems unlikely that the financial community will change this attitude. Development of nanomaterials could help boost chemical profits and make the sector more attractive, and large amounts of research time and money are being invested to bring this possibility to fruition. Aside from the long-recognized danger of putting all the eggs in one basket, there is a real danger that the enthusiasm to move as rapidly as possible may not allow enough time to examine the potential environmental problems associated with this development. As the resistance to genetically modified foods suggests, public suspicion that problems may exist can be almost as detrimental to broad acceptance of a new product as an actual environmental disaster.

This book is recommended for a broad range of readers, including historians of science, investors, and industrial chemists. It may, however, be most useful to academic chemists. Most students who major in chemistry will ultimately be employed by the chemical industry, and so planning the future direction for chemistry departments requires an understanding of what is happening in the industry as well as what is likely to happen in the future. These authors have done us all a service by providing a compact and accessible evaluation of the chemical industry at a crucial time in its development. *Harry E. Pence, Dept. of Chemistry and Biochemistry, SUNY Oneonta, Oneonta, NY, 13820, pencehe@oneonta.edu.*

François Blanchet, Tome I: L'Étudiant et le Savant. Stéphane Castonguay and Camille Limoges. VLB ÉDITEUR, Montréal, Québec, 2004, 396 pp, paper, ISBN 2-89005-884-0, $29.95.

François Blanchet (1776-1830) was the first person born in Canada to write a scientific work, and the present book is the first part of a two-volume biography in French. Blanchet's claim to scientific fame was a short book that he published in 1800 entitled *Recherches sur la médecine, ou l'application de la chimie à la médecine*. This biographical volume covers the first 25 years of Blanchet's life and includes the complete text of his short book; the last third of the volume is devoted to extensive notes and references. While the subject might not appear to hold much of chemical historical interest, Blanchet's early life ties in with the history of medicine in North America, with the close connection between medicine and chemistry at that time, and with how quickly the new chemistry of Lavoisier was introduced into North America.

Blanchet was one of six children of a farmer near Montmagny, Québec. His early schooling is unknown, but from 1790-1794 he was enrolled in the Séminaire du Québec. After leaving the Séminaire a year early, he took the unusual step of deciding to pursue a medical career and apprenticed himself by contract to Dr. James Fisher (British) in Québec City during the period 1795-1799. While with Fisher, he learned English and became interested in science. He must have read widely at this time, including Lavoisier's *Traité Élémentaire de Chimie* (publ. 1789). Fisher and a colleague, Dr. John Nooth, thought enough of Blanchet to urge him to attend the School of Medicine at Columbia College in New York, the oldest in America. Blanchet was financially able to do this only because he had sold his share of his deceased father's estate to a brother. He spent two years at Columbia, where he came under the influence of Drs. Samuel Mitchill and David Hosack. Mitchill played the principal role in the early introduction of Lavoisier's chemical system into the United States, and Blanchet was an eager disciple. [By this time phlogiston was dead in North America even though Priestley was living in Pennsylvania.] In fact, although this twenty-three year-old medical student did not do any experimental chemistry himself, he had the youthful audacity to write and self-publish a book (246 small pages) whose purpose was to apply the new chemistry to suggest a new system of medicine based on oxygen and Lavoisier's caloric. The book was written in French, apparently because Blanchet was intent on making a name for himself in Québec, and most copies sold in Québec.

After his sojourn in New York, Blanchet returned to Québec in 1801 where he practiced medicine and entered politics. The second volume of the biography will be concerned with this later part of his life.

Blanchet's book strikes the present-day reader as a curiosity. The word *recherches* in the title really refers to Blanchet's thoughts and observations rather than to experiments. In places the book reads like a manifesto with many assertions, some plausible at that time, some not. Blanchet rejected all traces of vitalism; the body was a machine and everything in it was chemical: "To give life, I only ask for an organized machine, some oxygen and some caloric." Such a view separated him from most of his medical contemporaries. At a time when the nature of bacteria, viruses, and biochemistry was as yet unknown and organic chemistry was barely in its infancy, Blanchet explained all medical conditions and problems (*e.g.* sleep, fevers, inflammations, diarrhea, plague, etc.) as the result of imbalances between oxygen and caloric (regarded as a material substance). In his mind there is not much room for doubt. Oxygen is responsible for all decomposition/decrepitude in the body. Sleep results from an accumulation of caloric in the body during the day. Gout is caused by an excess of oxygen. In times of famine, plague is caused by oxygen and caloric attacking the muscles for lack of fatty material on which to act. Blanchet also included his thoughts on some nonmedical natural phenomena such as the nature of light. He rejected Newton's views and insisted that light is contained in and comes directly from the viewed object. Comet tails were the result of the combination of oxygen with combustible substances from the comet. There is even a rather poetic view of death as a chemical process involving oxygen combining first with the carbon and hydrogen of the body and then with the body's nitrogen and muscles: "Death is the tribute which we render to the universal reservoir of the elements of nature, toward which our existence has indebted us." All in all, the speculations in Blanchet's opus provide a colorful picture of an early but premature attempt to understand biological processes in terms of Lavoisier's chemistry.

The present volume could be useful to those interested in the early development of chemistry and medicine in North America. The extensive notes and references in the last third of the book are particularly valuable. An English translation of the volume seems unlikely. *Edgar W. Warnhoff, University of Western Ontario*.

Lebenslinien: Eine Selbstbiographie. W. Ostwald, K. Hansel, Ed., Verlag der Sächsischen Akademie der Wissenschaften zu Leipzig and S. Hirzel Verlag GmbH, Stuttgart, 2003, xii + 626 pp, ISBN 3-7776-1276-6, € 140.

Given the well-known tendency among American and British historians of science to emphasize the social, political, and religious consequences of science rather than its internal conceptual and experimental content, it comes as something of a surprise that the Latvian-German physical chemist, Wilhelm Ostwald (1853-1932), has attracted so little attention from this audience. Certainly few other late 19th-century and early 20th-century chemists so closely approximate the ideal of a Renaissance Man than did Ostwald, for in addition to his Nobel-Prize winning work in physical chemistry, he was a tireless leader and organizer of scientific journals and societies, an active atheist and proponent of Haeckel's monism, a promoter of the universal language movement, a relatively decent philosopher and historian of science, one of the leaders of the energetics movement in Germany and one who very early recognized the role of energy and pollution in human history, the originator of one of the major systems of color classification, and an author of books on the theory of oil painting, as well as a relatively talented painter himself. Yet the only full book-length biography of Ostwald I am aware of is the 1969 Russian biography by Rodnyj and Solowjew, which, though available in German translation since 1977 (N. I. Rodnyj, J. I. Solowjew, *Wilhelm Ostwald*, Teubner, Leipzig, 1977), has never been translated into English.

Central to the writing of any future biography of Ostwald is his own three-volume autobiography, *Lebenslinien*, originally published by Klasing & Co. GmbH of Berlin between 1926 and 1927, and now made available once more in a single-volume, corrected reprint sponsored by the Saxony Academy of Science of Leipzig. In contrast to the original edition, with its blue matte covers and 5.5 x 8.5-inch format, the reprint is in an 8 x 12-inch double-column journal format and is officially volume 61 of the Academy's transactions. It comes with a new forward and introduction, explanatory footnotes by the editor, Karl Hansel, and a photographic appendix which contains many items not found in the original edition.

It goes without saying that the editor and Academy of Science are to be congratulated in making this important document once more accessible to historians of chemistry. It is an indispensable source of information on the life, thought, and times of this important chemist, and will hopefully plant the seeds that will eventually lead to a full book-length, English-language, biography of this fascinating man. *William B. Jensen, Department*

Dyes Made in America 1915-1980: The Calco Chemical Company, American Cyanamid and the Raritan River. Anthony S. Travis, Sidney M. Edelstein Center, Hexagon Press, Jerusalem, 2004, xiv + 582 pp; ISBN 965-555-149-0, £ 60. Distributed by Jeremy Mills Publishing Limited.

"The plant is so vast, it uses 20 million gallons of river water daily, burns 700 tons of coal a day.... Its tools range in size and ease of dexterity from a small delicate laboratory scale to a crane with a 100-foot long boom.... Its employees produce one patentable idea a week, a profusion of products as diverse as a resin to protect silk and a pharmaceutical to aid ulcer victims.... This CHEMICAL CITY has ... a power house supplying enough electricity to serve a community of 30,000 families ... [and] was one of two locations in the State at one time to have the new electron microscope. ... It produces the most beta naphthol of any source in the U.S. It operates one of the largest biological waste treatment plants in the world." (pp 29-30).

In quoting this passage from a 1965 publication of American Cyanamid's Organic Chemicals Division, Tony Travis has laid down the scale and scope of history of the Calco Chemical Company. This is the history of the production site at Bound Brook, New Jersey, of an early dye-making enterprise that became a major and diversified corporate division, and of management strategies and their impacts on R&D. At the same time, it is a history of the rise and fall of the American dyestuffs industry, and an exemplary study in environmental history. To my knowledge, it is the first work dealing with the history of chemical industry that combines these several strands in a single volume. With this book, a well-researched and documented study becomes available that draws on and explains the interplay of R&D, production, management, and pollution and regulation, all presented within the history of a single chemical plant.

The roots of Calco were in a burlap manufacturing firm, its brand name Cott-A-Lap providing the first three letters of the company's name. In 1915, when World War I made imports of German dyes difficult (and soon impossible), the board decided to take on production of dyestuff intermediates at a site in northern New Jersey, some 20 miles from the Atlantic coast line and adjacent to the Raritan River. The new enterprise, the Calco Chemical Company, followed, and sometimes set, trends in the American organic chemical industry. After adding numerous dyestuffs and pigments to its portfolio, Calco in 1927 opened one of the first U.S. industrial research departments. In 1929, American Cyanamid acquired Calco, which became effectively the organic chemicals division of this industrial giant. The division, America's largest producer of sulfa "wonder" drugs, took up manufacture of amino plastics, which first brought colored plastic items into U.S. households. At the same time, its personnel led the introduction of physical methods into chemical analysis and set standards for instrumental color matching. During World War II, the Calco division contributed substantially to the efforts of the Allied forces, with intermediates for explosives and the processing of rubber, as well as melamine laminates for protection of maps, and drugs to heal the wounded. After 1945 the division maintained an innovative pace in dyestuffs, polymers, and agrochemicals. The conversion of discontinuous, "batch" manufacturing into continuous production processes received considerable emphasis. In addition, what from the early 1950s was formally known as the Organic Chemicals Division collaborated closely with American Cyanamid's biological unit, Lederle Laboratories. From the late 1960s, however, increasing competition, management failures, and lack of innovation contributed to a crisis, which in 1980-82 led to the end of most chemical production at the Bound Brook site. This happened as American Cyanamid increasingly moved into the life sciences, which had been made possible by the tremendous research experience accumulated at its now near-defunct Organic Chemicals Division.

As early as the beginning of the 1930s, Calco made efforts to deal with its pollution of both the Raritan River and of the atmosphere. This followed constant public pressure and, increasingly, state involvement that was considerably intensified in the 1960s and 1970s. While American Cyanamid took measures to avoid heavy capital investment in waste treatment and became engaged in litigation with state agencies, it did, when forced to do so, apply state-of-the-art technologies for environmental protection, and contributed substantially with R&D to their evolution. The third, activated carbon, stage of its wastewater treatment facilities opened in 1977, only a few years before the production site closed shop.

Travis tells these stories in two parts, the first one dealing with the organizational and R&D history, the second with environmental issues. Nevertheless, they are shown to be closely interrelated and connected by two very useful summary chapters at the end of each part. Also in many other ways, *Dyes Made in America* is two books in one. Travis gives documentation of sources high priority, sometimes quoting extensively from reports, letters, and interviews. This adds a feeling of immediacy to a story that does not lack detail in presenting facts. Furthermore, the wide choice of sources (and historical actors) leads to a balanced view. In other words, the author gives the reader not only the opportunity to arrive at his or her own reasoned judgment, but even exerts a subtle push in this direction. However, Travis does not hesitate to present his own analysis on, among other issues, the reasons for decline, the changes in character of chemical production, and, especially, environmental aspects.

The author notes that this book is the third in a trilogy. With his *Rainbow Makers*, Travis tracked the origins of the synthetic dyestuffs industry in Western Europe in terms of a macro-history. The second book, written in collaboration with this reviewer, was a biographical study of Heinrich Caro, research director at BASF, the largest German chemical enterprise at the end of the 19th century. Now, with Calco, Travis presents the micro-history of one company's production site. His work on the rise and decline of the dyestuffs industry—once the pinnacle of high technology, a provider of life-style goods and life-saving treatments, prior to becoming an industry in economic crisis, and a major threat to the environment—has come full circle. As he does in his other works, in *Dyes Made in America* Travis weaves knowledgeable explanations of chemical processes together with insightful analyses of structural history into a form that makes complex history understandable and accessible. *Carsten Reinhardt, University of Regensburg*.

The Elements of Murder. John Emsley, Oxford University Press, Oxford & New York, 2005; xiii + 421 pp, ISBN 0-19-280599-1, $30.

The Elements of Murder describes uses and abuses—including homicidal abuses—of five toxic elements. Its protagonists are mercury, arsenic, antimony, lead, and thallium. The book is not really about the history of chemistry; however, it contains much interesting material about chemistry in history, and for that reason it may well capture the interest of readers of the *Bulletin*.

John Emsley, longtime Science Writer in Residence at Cambridge University, is a prolific and popular writer about chemistry in everyday life. *Molecules at an Exhibition* (1998) and his most recent previous book, *Vanity, Vitality, and Virility: The Science behind the Products You Love to Buy* (2004), are fine examples of the genre. He has also written in a more explicitly historical vein in *The 13th Element: The Sordid Tale of Murder, Fire, and Phosphorus* (2000), published in the UK as *The Shocking History of Phosphorus: A Biography of the Devil's Element*. And he has demonstrated a facility for marshalling information about the elements both in the form of a data compendium (*The Elements*) and in a more discursive combination of data and interesting facts (*Nature's Building Blocks: An A-Z Guide to the Elements*, 2001).

Echoes of all of these forms and of these earlier books can be seen in *The Elements of Murder*. Writing about the various hazards of phosphorus led Emsley to investigate other dangerous elements, and *The Elements of Murder* was the result. What he tells us about these elements includes basic information that might be found in a compendium—abundances, typical sources, and common uses. These everyday uses are what put the elements into contact with people, where they could cause harm. Emsley also highlights the uncommon use of the elements mentioned in the title: as means to commit murder.

After an introductory chapter on toxic elements in alchemy, each of the five protagonist elements appears for several successive chapters. Each element is introduced through background information such as environmental abundances and sources, typical concentrations in humans, harmful concentrations, sites in the body where the element tends to accumulate, and the like. The narrative then turns to ways in which human beings might encounter these elements or their compounds, whether in medicines or pigments or through occupational exposure. Each element's section concludes with rather detailed descriptions of murders committed by means of that element. The book's final chapter treats 12 other poisonous elements in a summary fashion. More than 30 pages of supplementary material round out the book, including a glossary that defines some technical terms and acronyms, a bibliography that points to sources of additional information, and an index.

The book is well organized, as the previous paragraph suggests, but it is not arranged historically. It is, however, easy to find material of historical interest in two broad categories. One such area is the history of chemical technologies: an overview of how the protagonist elements and their compounds were used. The other area comprises specific cases of how the elements harmed or killed particular people in history.

Several of the featured elements were employed in medicines, perhaps surprisingly, in view of their toxicity. For instance, a great many medicines contained mercury in forms ranging from the inorganic mercury compounds used by Paracelsus to treat syphilis to the ethyl mercury compound thimerosal used as a vaccine preservative. Pigments were another common application of several of these elements. The arsenic-based compound orpiment (As_2S_3) was popular among artists as a golden-yellow pigment until it was displaced by the lead-based chrome yellow (lead (II) chromate, $PbCrO_4$). Another lead compound, tetraethyllead, was used as an anti-knock additive in gasoline recently enough so that gasoline pumps still read "unleaded." Lead (II) acetate was used much longer ago as quite a different kind of additive; it was the "sugar of lead" used by ancient Greeks and Romans to sweeten wine. *The Elements of Murder* is filled with information of this sort on the great variety of uses of its featured elements, past and present.

In my opinion, the exploits of notorious poisoners are the least interesting part of the book. The many 19th-century cases of rogues poisoning a series of spouses and lovers ran together in my mind. The fault is not with the author, whose writing here is clear and meticulous as throughout the book. The fault, rather, is with the repetitive monotony of the subject, perhaps a reflection of the banality of evil.

The poisonings I found much more interesting were ones that involved famous victims rather than infamous perpetrators. British Kings Charles II and George III, composers Beethoven and Mozart, Isaac Newton, and Napoleon Bonaparte are among the celebrated figures who may have been harmed by encounters with the book's featured elements. Poison and murder have long been suspected by some in Napoleon's death. It is difficult to say whether poison was the cause of his death; however, Emsley carefully reviews the evidence as well as possible mechanisms for exposure to more than one toxic element. When Napoleon became ill in the spring of 1821, his doctors treated him with tartar emetic (potassium antimony tartrate) and later with calomel (Hg_2Cl_2). Posthumous analysis of his hair showed high levels of arsenic, which may have been inhaled in the form of trimethylarsine. Emsley describes how many humbler 19th-century Europeans were poisoned in this way by their wallpaper: microorganisms that grew in damp rooms converted arsenic from the pigment Scheele's green ($CuHAsO_3$) to the volatile trimethylarsine.

Emsley's account of arsenic poisoning by wallpaper-damaging microbes represents the best of *The Elements of Murder*, by which I mean most of the nonmurderous parts. It is an exposition of one of the myriad fascinating and complex interactions between people and chemicals that makes chemistry so interesting—whether from the past or the present. *Carmen Giunta, Le Moyne College, Syracuse, NY 13214-1399.*

Elegant Solutions: Ten Beautiful Experiments in Chemistry. Philip Ball, Royal Society of Chemistry, London, 2005, viii + 212pp, ISBN 0-374-22979-1, £19.95.

What are the Ten Most Beautiful Chemical Experiments? This is a question that can excite both chemists and historians. In his latest book, Philip Ball readily admits that lists such as this are bound to be contentious. Even the definitions of 'beautiful' and 'experiment' are fraught with controversy. Ball invites, even revels, in the heated debate that such endeavors generate; and his book provides an excellent starting point for such discussions. For Ball, both art and science are blended in the traditions of chemistry, and this blend leads to his notions of what constitutes both 'beauty' and 'experiment.' All the beautiful experiments selected for this book were "shaped by human attributions: invention, elegance, perseverance, imagination, ingenuity." The historical trip through all ten beautiful experiments covers several centuries and makes for an engrossing book.

Ball begins *Elegant Solutions* with Francis Bacon and experimentation. To be beautiful, experiments should be more than "perfectly and elegantly designed to yield an insight about the way the world works." For Ball and Bacon, experimentation should also be about art or *techne*; it should be about the craft of making things, both the objects of nature and novel things conceived by people. Chemistry, its values, and its ability to create and characterize new things do indeed need more emphasis in popular and scholarly writing on science and technology. Ball likens chemistry to engineering: "beauty need not lie in the conception or execution, but in the product." Though 'elegant' is the first word of his title, Ball wants beauty in experiment to be about more than elegance or simplicity. Elegance and simplicity are just two of the elements of Ball's conception of beauty. His ten chapters are each subtitled so as to pair 'beauty' with one of these elements: quantification, detail, patience, elegance, smallness, simplicity, imagination, simplemindedness, economy, and design. These may not be every reader's choices, but Ball's reasoning is sound and his aesthetic examples do cover a profound range of what makes experiments beautiful. His focus on the aesthetics of chemistry is refreshing.

Ball presents not an in-depth exegesis for each of his chosen experiments, but a clear explanation of its scientific content and import, situated in a broad historical and cultural context. In the end, his book is as much about people—mostly chemists—as it is about experiments, and rightly so. His experimental protagonists range from the seventeenth-century Flemish physician, Jan Baptista van Helmont, to the Curies, to Pasteur, to a number of twentieth-century chemists, including Stanley Miller, Neil Bartlett, and Leo Paquette. Experiments for Ball are not necessarily singular processes, but can comprise a series of investigations conducted over time, such as the twelve-year collaborative synthesis of Vitamin B_{12} by Woodward and Eschenmoser or the Curies' "ravishing" "years-long experiment" to isolate radium. While most of the book deals with the twentieth-century, an early chapter on Henry Cavendish and the constitution of water is a fine example of how Ball treats experiment. In this fourteen-page essay, Ball brings to life a major episode in pneumatic chemistry and the emergence of modern elements from the realm of phlogiston. He does this gracefully—complete with the politics, patronage, and personalities of science in the late eighteenth and early nineteenth centuries—telling how water came to be not an element but a compound constituted from inflammable air (hydrogen) and dephlogisticated air (oxygen). Not all Ball's experiments have withstood the tests of time with regard to being right, but they all illustrate his aesthetic of experiment and the transcendence of beauty.

Ball is the author of other popularizations of chemical science, such as *Designing the Molecular World* and *Stories of the Invisible: A Guided Tour of Molecules*. Commendably, Ball continues to write about chemistry for a general, educated audience, something that is too seldom done today. Ball has always tried to ensure that his books can be understood without scientific training and laments two failings in much of recent history and philosophy of science: the neglect of chemical history and the failure of contemporary authors to treat the aesthetics of chemistry. I highly recommend Ball's book, which makes much of chemistry—including such concepts as bonding, chirality, and fission—accessible to the nonchemist. Though many readers of the *Bulletin* will be familiar with it contents, it is well written and thought provoking. We can always learn more about what constitutes an experiment—the essential unit of chemical knowledge—and what role experiments played in the history and development of chemical science.

In spite of the book's inherently episodic structure, Ball ties his tales together with grace, yielding a coherent narrative. I have just two quibbles with the book. First are its two "Divertissements." While they are very brief and somewhat interesting, these interrupt the flow of the chapters and contribute little to the book's major themes. Second and more troubling is the lack of scholarly apparatus for references and sources. Although the book contains a modest bibliography, this is not explicitly linked to the text through notes, a bibliographic essay, or any other mechanism. Even direct quotations lack footnotes or page numbers to identify sources. Ball has clearly read widely in chemistry and history, and one wishes for more of a bibliographic apparatus to guide the interested reader to the relevant literature. *Leo B. Slater, Stetten Fellow, Office of NIH History.*