BOOK REVIEWS

Rediscovery of the Elements. James I. and Virginia R. Marshall. JMC Services, Denton TX. DVD, Web Page Format, accessible by web browsers and current programs on PC and Macintosh, 2010, ISBN 978-0-615-30793-0. jmarshall@jennymarshall.com $60.00 ($50.00 for nonprofit organizations {schools}, $40.00 at workshops.)

Before the launching of this review it needs to be stated that DVDs are not viewable unless your computer is equipped with a DVD reader. I own a 2002 Microsoft Word XP computer, but it failed. I learned that I needed a piece of hardware, a DVD reader. It can be installed inside the computer or attached externally. The former is cheaper, in fact quite inexpensive, unless you have to pay for the installation. Fortunately, a friend did this for me.

The first printing of *Rediscovery* is in process as I write, to be available in time for the BCCE (Biennial Conference of Chemical Education), which will be held in August, 2010 in Denton, TX, the authors' home campus. I am looking at a preliminary version, but I hold a complete list of the few significant changes and some corrections.

Clicking anywhere on the cover picture propels us to the opening statement and table of contents. During the last eleven years the authors personally visited every site where a chemical element was discovered. And opening any of the links reveals the extraordinary achievement this DVD represents, based on prodigious labors.

Here you can find mini-biographies of scientists, detailed geographic routes to each of the element discovery sites, cities connected to discoveries, maps (354 of them) and photos (6,500 from a base of 25,000), a time line of discoveries, 33 background articles published by the authors in *The Hexagon*, and finally a link to "Tables and Text Files," a compilation probably containing more information than all the rest of the DVD. I will discuss this later, except for one file in it: "Background and Scope." Here the authors point out that the whole project of visiting the sources, mines, quarries, museums, laboratories connected with each element, only became possible very recently. Four recent developments opened the door: first, the fall of the Iron Curtain allowing easy access to Eastern Europe including Russia; second, the universality of email and internet communication; third, digital cameras; and fourth, GPS navigation.

Being something of an historian, I tend to skim lists of names, and I was surprised to discover Liebig among the 217 names for whom the authors supply thumbnail biographies and explanatory background pictures. What did Liebig have to do with the elements? Well, I learned he had a sample of bromine before Balard had identified the element. However, Liebig had thought it was iodine chloride and labeled it as such. After Balard made his announcement, Liebig moved the bottle to his cupboard of "Mistakes." So I had to look up bromine in the list of elements, as well as Balard and Liebig among the scientists.

Do you want to know where bromine was discovered? Join Jim and Jenny Marshall as they travel to bromine's place of discovery. And thanks to the magic of clickable DVDs, you can catch the travelers and they will show you. Look up bromine in the list of elements and you learn that it was identified as an element at the school of pharmacy in Montpellier, France by Balard, who treated local brines with chlorine. Under bromine you also learn of bromine's crustal abundance, and you see a rare solid mineral that contains silver bromide. The formula of the ancient Phoenicians' Royal Purple (dibromoindigo) is given, as well as a picture of a murex seashell from which the dye was extracted. Under the Liebig biography you are asked to go to Montpellier. Why? You view numerous views of the city and of the school of pharmacy, but one panel is marked LIEBIG and tells of the latter's misidentification of the element—in French.

Shown a map of Montpellier, you can find a map directing you also to every other location where an element was discovered. And at those locations you will find photographs taken by the Marshalls showing the major sites, buildings, science-related institutions, and the ores and rocks where the element is most often found.

Those 217 names do not include duplications. You will find Andrada both under A and under D because his fuller last name was de Andrada, but he is not counted twice.

The elements are listed alphabetically for easy location, but where it says "next element" you might fear that you will be taken to the next element alphabetically. The authors, however, know their chemistry and they know what chemists and chemistry teachers are looking for. The next element refers to the one coming next in the periodic table, the one with one extra proton in the nucleus, the one with the next higher atomic number.

In preparation for their Magnum Opus the Marshalls published 33 articles in *The Hexagon*, the journal of Alpha Chi Sigma. You are linked to these and can read them whenever you want to, because they are part of the DVD. They include one mysterious title *Phosphoro de Bologna*, which makes you guess it is about phosphorus but you are mistaken. It is about phosphorescent substances such as barium and calcium sulfide. This and the other *Hexagon* articles contain detailed references to the primary or secondary literature, Lavoisier's treatise, and Partington—also to Oliver Sacks, who discusses phosphorescent materials on pages 226-7 of his memoir *Uncle Tungsten*. (Sacks made a special trip to Denton, TX to visit the authors and see their collection of elements and ores. In New York, Sacks has his own collection of elements, each sample in its proper place in an elaborate periodic table.) Three *Hexagon* articles focus on vanadium because it was first discovered by del Rio in Mexico. The information and samples were brought by von Humboldt to Europe, where it was not believed because of typical Eurocentric prejudices; it was then rediscovered in Swedish ores, and Wöhler gave convincing proof that the Swedish and Mexican elements were the same. This leads to a general discussion of Wöhler's life and work, including his artificial creation of urea in 1828 for which the original publication is given in *Ann. Phys. Chem.*

Another link takes you to biographical information about the authors. There you learn that James Marshall obtained his doctorate in organic chemistry at Ohio State University and ever since has taught and done research at the University of North Texas, while Virginia (Jenny) is a computer expert and has taught the subject in schools and to yearbook staffs. She is responsible for much of the helpful computer wizardry in this DVD that makes it such a pleasure to use.

On their opening page the authors announce that this DVD was designed for students, teachers, and interested laymen. However, historians of chemistry and of the chemical elements should not, because of this disclaimer, pass it by. There is much here that may be helpful: the maps, the new photographs, and the links that may take the scholar to new sources and new locations.

You may find some typographical or substantive errors. Having been an editor (mostly part-time) for over two decades, I know that no matter how hard one tries, an error-free document is practically impossible. And authors greatly appreciate learning of errors and problems because corrections can be made for a new printing, even for a DVD, long before a new edition is contemplated.

Focusing now on the link entitled "Tables and Text Files," it contains seven sections of which the first is "Acknowledgments," five and a half pages, single spaced, of 194 individuals who were "direct contributors" to the *Rediscovery* project. Most were visited where they worked, in their museums, laboratories, university departments; and a few are well known in the history of chemistry community: Günther Beer of Göttingen; William Brock of Leicester (on Crookes); Norman Craig, Oberlin (Aluminum); Roald Hoffmann, Cornell; George Kauffman (on Döbereiner); Peter Morris, Science Museum, London; Alan Rocke; Oliver Sacks.

In one section called "Additional Explanatory Notes" the authors mainly discuss GPS geographical data, compass orientations, and latitude and longitude given with a precision of 0.01 minutes of ark. "Background and Scope," partially discussed above, is a fascinating account of all that went into the creation of *Rediscovery*. We also learn that multi-volume background print sets have been deposited in the Library of Congress and a few other sites. There follow a historical sketch of discoveries, from the ancients and alchemists to our time, covering over a hundred pages; Tables of Auxiliary Sites, comprising a list of statues, monuments, each with GPS specifications (134 entries); then a table of museums; a table of "primary discovery sites"—element discovery events, GPS etc. (398 entries), with ratings: b++ = building still exists, or lab still functional, q- = quarry filled in; 65 pages including specifications for every element.

Thinking back to my boring high school exposure to the elements (I only chose chemistry because of a "sixth form" exposure to organic compounds), I am certain this DVD would have transformed the experience: allowing faculty and students to view the elements on the screen, search for the elements' origins, meet with the discoverers, and pursue student questions probably towards convincing answers. This DVD is a monumental achievement. *Theodor Benfey, Greensboro, NC*.

The Age of Wonder: How the Romantic Generation Discovered the Beauty and Terror of Science. Richard Holmes, Vintage Books, New York, NY, 2008, xxi + 552 pp, ISBN 978-1-4000-3187-0. $17.95

The phrase "Romantic Science" sounds like either the caption of a lobby poster for the 1940s movie about Marie Curie or else perhaps an oxymoron. The late 18th century movement called Romanticism emphasized imagination and emotions rather than the rationality usually associated with science; surely it is a mistake to conflate these two very different ideas. On the contrary, Richard Holmes argues that there was a tremendous overlap between these two concepts, both in terms of the people involved as well as the way the world was being viewed. Romanticism was an attempt to focus more directly on the study of nature, and the scientific advances of the early part of the 19th century were just as much a part of that change as were the books and poems that are now identified as Romantic.

The Age of Wonder is literally bookended by voyages of discovery. It begins in 1768 with Joseph Banks, setting sail with James Cook as a botanist on the HM Bark *Endeavour* and ends with Darwin's voyage on the *Beagle*, which began in 1831. Banks' activities provide continuity throughout the rest of the book, first with his adventures, both scientific and amorous, in the South Seas, and then as the long-time President of the Royal Society, where he often played a key role in the development of science policy. However, Holmes places two men at the center of his narrative: the astronomer William Herschel and the chemist Humphry Davy. Two chapters deal with Herschel who discovered the planet Uranus, and his sister Caroline, who made significant astronomical contributions. Together, they changed the way humans looked at space and time. If any scientist ever reached the sublime that was so longed for by the Romantics, it was Herschel, with his new visions of the heavens gained from the powerful telescopes he produced.

Sir Humphrey Davy is the name that is most likely to catch the eye of historians of chemistry. Holmes discusses Davy's personal relations with many of the most important personalities of the Romantic period, like Coleridge, Shelley, and Southey, and quotes extensively from Davy's own poetry. It should not be surprising to hear Davy called a Romantic scientist. As early as 1812 Thomas Young, who was Davy's colleague at the Royal Institute, wrote, "Davy was born a poet and has only become a chemist by accident." (1) Fullmer points out that Wilhelm Ostwald labeled Davy as a "romantic" scientific personality as early as 1907, and this label has been reasserted several times since then (2). David Knight's biography of Davy was notable for describing not only Davy's scientific work but also his poetry and his relations with the major figures of the Romantic movement (3).

Holmes brings an unusual perspective to this work, since he is best known for his prize-winning studies of the Romantic poets, like Percy Bysshe Shelley and Samuel Taylor Coleridge. Holmes' work on Coleridge led him to recognize how active Coleridge was in the science of his time and also the friendship that existed between the English Romantics and those, like Davy, who were creating a new scientific revolution. Holmes brings the eye of a literary critic to this discussion. When he writes that Davy's *Consolations in Travel, or The Last Days of a Philosopher* is the "first ever scientific autobiography in English" and classifies it with other romantic memoirs of the time, like Wordsworth's *Prelude* and Coleridge's *Biographia Literaria*, his evaluation is not to be taken lightly. The *Consolations* was written as Davy felt death approaching and is a set of dialogues that summarize his life, a mixture of autobiography, travelogue, geology, imaginary voyages, philosophy, and even an early form of science fiction. One of these dialogues, titled "The Chemical Philosopher" argues that science is a progressive force for good and stated that, "It may be said of modern chemistry, that its beginning is pleasure, its progress knowledge, and its objects truth and utility." It is easy to see why Davy's last work became a guidebook for many in the next generation of scientists.

Holmes suggests that the era of romantic science was rather brief, lasting only a few decades. He argues that unlike the scientific revolution of the late seventeenth century, the most important characteristic of Romantic science may well have been the commitment to communicate with the general public. It was the age of public science, lectures, laboratory demonstrations, and popular textbooks. Davy was certainly successful at attaining this goal; his lectures at the Royal Institute being extremely popular. Perhaps most interesting, he was very successful at attracting young women to his lectures, even though originally the intended audience had been middle-class artisans. (Holmes mentions the large number of Valentine's Day cards that Davy received from his admirers.) In the process a new audience was created for popular science, which prepared the way for authors like Jane Mercet (4), who wrote textbooks for young women.

Over one fourth of the book is devoted to Davy. Even a chapter on Vitalism and the novel *Frankenstein* points out that Mary Shelley's novel was inspired, in part, upon hearing one of Davy's lectures when she was only fourteen years old. Many of the stories Holmes tells may already be familiar, such as Davy's early experiments inhaling various gases, and his work on the chemical effects of electricity, chemical theory, and the safety lamp for miners. Holmes also discusses the personal side of Davy's life, including his puzzling relationship with Michael Faraday, his curious marriage, and his attempts as President of the Royal Society to reconcile the conservatism of that society with the demands of a new generation of young scientists, like John Herschel (William's son) and Charles Babbage. His failure to satisfy these young scientists eventually led to the founding of the British Association for the Advancement of Science in 1831 and a move towards increased professionalization of science. This trend continued into the next generation with Thomas Huxley and the X-men (5).

The general impression that the Romantic poets were anti-scientific seems to have resulted mainly from an 1817 dinner party (Holmes suggests that it was more like an extended drunken luncheon) attended by Wordsworth, Keats, and Charles Lamb among others (p 318). During the rowdy discussion that resulted, both Lamb and Keats mocked the reductive approach of science. These comments were recorded and publicized by the party host, Benjamin Haydon, who was a passionate fundamentalist Christian and was eager to hear any criticism of what he considered to be godless science. Holmes suggests that the absence of both Shelley and Coleridge from this event was especially significant, since if either had been present, the discussion would have likely gone in a much different direction, assumedly more favorable to science.

On the other hand, a later story (p 429) describes how Davy and Coleridge argued about whether science or the arts had the greater effect on humankind. Coleridge said that, "My opinion is this - that deep Thinking is only attainable by a man of deep Feeling, that all truth is a species of Revelation. The more I understand of Newton's work, the more boldly I dare utter to my own mind . . . that I believe the Souls of 500 Sir Isaac Newtons would go to the making up of a Shakespeare or a Milton . . . " In a footnote, Holmes explains that when the quote by Coleridge was repeated at a symposium sponsored by the Royal Society in November, 2000, one of the distinguished scientific participants (whom Holmes does not name) exclaimed, "That is complete and utter *balls* . . . , We don't have to put up with such Rubbish." Apparently, Coleridge may have been less enthusiastic about science than Holmes suggests. It is amusing that even 200 years after his death this dispute between science and the arts could still produce such a strong reaction.

The Age of Wonder is an excellent book, not just because it places science firmly in the context of the culture of the time but also because it tells great stories. Beyond the many stories about Davy, chemistry teachers will find that the chapter on the early history of ballooning will provide some fascinating anecdotes they can use in their lectures. The book has been widely reviewed and recommended in nonscience publications. *It* won the Royal Society Prize for Science Books in 2009 and was named the number-one nonfiction title for 2009 by *Time* magazine. It seems unusually appropriate for a book that describes the romantic desire to communicate the wonder and meaning of science to the general public to be so widely popular in modern times.

1. T. E. Thorpe, Ed.., *Humphry Davy, Poet and Philosopher*, Nonsuch Publishing, Dublin, 2007.
2. J. Z.Fullmer, *Davy's Biographers: Notes on Scientific Biography. Science,* **1967,** *155*,. 285-291.
3. D. Knight, *Humphry Davy, Science and Power*, Cambridge University Press, Cambridge, 1996.
4. J. Mercet, *Conversations in Chemistry*, Oliver D. Cooke and Co., Hartford, CT, 1826.
5. A. Desmond, *Huxley: From Devil's Disciple to Evoution's High Priest*, Addison-Wesley, Reading, MA, 1994.

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The Alchemy of Glass: Counterfeit, Imitation, and Transmutation in Ancient Glassmaking. Marco Beretta, Science History Publ., Watson Publ., Sagamore Beach, MA, 2009, xv + 198 pp, ISBN 978-0-88135-350-1, $59.95

This short but ambitious treatise summarizes the conclusions of a project that began as an interdisciplinary seminar on glass and its relationship to the development of the chemical sciences from Antiquity to Byzantium and the Early Modern era. The seminar was held at the Department of Cultural Heritage of the University of Bologna in 2002, where the author Marco Beretta teaches history of science in addition to his other appointment, as vice-director of the Institute and Museum of History of Science in Florence. Thinking of alchemy as only a futile and often deceitful attempt at the transmutation of base metals to gold has often distracted scholars from the study of ancient alchemical texts that describe chemical operations and the intellectual efforts of early alchemists to develop a theoretical framework for the interpretation of such transformations. Beretta brings a fresh and innovative approach to the study of these texts. His strategy is to study the evolution of alchemical thought by tracing the history of a specific material, in this instance glass. In the process he offers us inspiring insights into the early debate about the structure and identity of matter.

Four of the five chapters examine the history of glass making from ancient Egypt and Mesopotamia through Greece, Rome, and Byzantium to the early modern era. Chapter Four is reserved for a more in-depth discussion of glass and alchemy. The thorough bibliography of primary and secondary sources alone makes acquiring this book a sound investment. The challenging ideas of the text are further amplified in copious footnotes, which, however, to be appreciated fully require a working knowledge of French, Italian, and Latin.

In Chapter 1, Beretta follows the origins of glass to Ancient Mesopotamia (in ca. 2500 BC) and its migration to Egypt around 1400 BC, correcting along the way the common misconception of glass as a Phoenician discovery. While the Mesopotamian glassmakers were no alchemists, the literary style of Mesopotamian glass recipes and the belief in propitious days for the performance of certain experiments were adopted by alchemy. But already Egyptian glass technology is viewed as giving rise to one of the central questions of alchemical thought, the possibility of artificially producing natural bodies. The question is raised in conjunction with the equivalence of natural and man-made lapis lazuli. Color emerges as a key property and color change as indicative of transmutation.

In Chapter 2, the diverse views on the nature of matter in Greek philosophy are examined, with Greek speculations about the nature of glass as the backdrop. The classification of glass together with rock crystal and metals as different manifestations of water icosahedra is seen as hinting at the possibility of transmutation. Glassmaking is also thought to have inspired Heraclitus' emphasis on the centrality of fire in the transformations of matter. Chapter 3 is dedicated to an analysis of the rise of glass blowing and its economic impact. This technological revolution transformed the glass industry both qualitatively and quantitatively. The author is even able to connect glass blowing to the development of theories of vision and the descriptive anatomy of the human eye.

For the historian of alchemy and chemistry, Chapter 4 is where the central arguments of the book come together. In the first half of the chapter Beretta revisits the debate about the relationship of the artificial to the natural, which was to become, as mentioned above, a central theme of alchemy. The expansion of the Roman Empire had broadened the gemological experience of its citizenry. With it came the attempt to imitate precious stones with similar objects made of colored glass. Conservative philosophers like Pliny and Seneca derided the attempt to imitate nature, while alchemists like Bolus of Mendes and Pseudo-Democritus viewed such activity as an actual fabrication of the real thing. Here color becomes once again a key property, indicative of the equivalence of real and man-made gemstones just as the ancient Egyptians used color when postulating the equivalence of real and artificial lapis lazuli.

The second part examines the role glassblowing has played in the development of alchemical/chemical laboratory equipment. A thorough survey of Roman and Alexandrian laboratory glassware is given together with the obligatory reference to the inventions of Mary the Jewess as chronicled by Zosimos of Panopolis. While familiar territory for the chemical historian, the section is an excellent source of bibliographical information on the subject.

One of the book's greater contributions is the innovative approach of concentrating on the history of one particular material, glass, to shed light on the evolution of broader issues in the philosophy of matter. It is perhaps interesting to note that an analogous situation arises when we examine the attempts of Islamic and European potters to duplicate Chinese porcelain. They, too, were guided by alchemical reasoning both in developing their ceramic formulations and in deciding on the equivalence of their materials to the "white gold" from China. *Dr. Nicholas Zumbulyadis, Independent Scholar (retired Eastman Kodak Research Laboratories), Rochester, NY 14613.*

Image and Reality: Kekulé, Kopp, and the Scientific Imagination. A. J. Rocke, University of Chicago Press, Chicago, IL, 2010, xxvi + 340 pp, ISBN 978-0-226-72332-7; $45.

There can be little doubt that the development of the structural theory of organic chemistry during approximately the years 1850-1874 marked one of the greatest intellectual achievements of 19th-century science. Regrettably, the teaching of organic chemistry now usually skates lightly over this crucial period. Of course, the argument has been made that the time constraints of standard courses necessitate this omission to permit coverage of material of more immediate relevance to the modern state of the field itself and to cognate disciplines such as cell biology, pharmacology, and medicine. But I believe there is another reason for our reluctance to teach that history: the events and ideas of that time are extraordinarily hard to unravel and set out in some kind of logical development. Modern students would be likely to ask, with some justification, why they have to learn about all those early vague and mostly erroneous formulations, which have no practical application to the present day. Yet modern chemists, after years of research creating and using advanced tools and ideas, surely must look back and reflect on how we got to this point. We have needed a guide to lead us through the thickets of conflicting notional (and notational) schemes of our forbears of that period and to show us how our present ideas emerged. It is hard to think of someone more qualified to do this than the distinguished historian of chemistry, Alan Rocke. Fortunately for us, he has produced the present work which speaks directly to this issue.

The connective thread of Rocke's narrative is the development of the concept of molecular structure. In the first half of the 19th century, key ideas that the modern chemist takes for granted, such as molecules, equivalents, valences, and bonds, were hazy and imprecise. Even the atomic weights of the atoms were in dispute. It was not obvious that chemists could ever enter what Rocke aptly calls the "microworld" and determine the actual relative dispositions of atoms. How the community of organic chemists surmounted these difficulties is not a straightforward chronicle of events. It required chemists to realize explicitly that each molecule has a specific structure. From the perspective of the 21st century, it is hard to understand how something now so commonplace took so long to become established. Rocke does a masterful job of teasing out the exchanges of ideas and the interactions of diverse personalities that fueled this growth. A special feature of the book is its fascinating exploration, in the final two chapters, of the role of the imagination in scientific discovery. The influence of dreams, the "Eureka moment," and the contributions of modern cognitive science in illuminating the actual mental processes of discovery are examined perceptively.

Chemists will enjoy several prose portraits of some of the pioneers of the structural revolution. Among them was Alexander Williamson, an English chemist of Scottish background. I venture to say that many present-day chemists would be surprised by this assessment, for Williamson is remembered now mostly for his synthesis of unsymmetrical ethers. Rocke, however, convincingly describes his contributions as having much deeper significance in the powerful impetus they gave to the concept of structure, leading the great August Kekulé to call Williamson "that wisest of men and most learned of philosophers." Other fascinating portraits include those of the brilliant but troubled and tragically unstable Archibald Scott Couper, the feisty Alexander Crum Brown, and the delightful polymath Herrmann Kopp. Ever the combative rear-guardsman, Herrmann Kolbe (whose life Rocke has examined in detail in an earlier book), tenaciously contested the full flood of the revolution almost to the bitter end.

Rocke's analysis of Kekulé's leading role in the new thinking is based not only on the published record of scientific papers and books but also on a meticulous and illuminating study of letters, unpublished writings, and other sources. An intriguing insight is the importance of Kekulé's early training as an architect.

Among its other virtues, the present book shows Rocke's singular ability to project his thoughts into the historical situation as the proponents experienced it. This helps us to put aside our own advantage of hindsight and live through the discovery process ourselves. A prime instance of this is his account in Chapter 5 of the debate between Kekulé and Crum Brown on the structure of "pyrotartaric acid," (methylsuccinic acid). As Rocke shows, Crum Brown won the argument at the time. However, what Rocke does not show, but what the alert modern reader will detect, is that although Crum Brown's structure was correct, in the light of what we now know, his reasoning was erroneous. I leave this (as I suspect that Rocke did) for a study problem.

This superb history is one that chemists and general readers, be they students, teachers, practitioners, historians of science, or just persons interested in the growth of ideas, will read with deep interest and pleasure. *Jerome A. Berson, Department of Chemistry, Yale University, New Haven, CT 06520. Mailing address: 200 Leeder Hill Drive, Apt. 205, Hamden, CT 06517,*

Erich Hückel (1896-1980) From Physics to Quantum Chemistry. Andreas Karachalios, translated by Ann M. Hentschel, Boston Studies in the Philosophy of Science, Vol. 283, Springer-Verlag, Dordrecht, Heidelberg, London, New York, 2010, x + 200 pp. ISBN 978-90-481-3559-2; $139.

Erich Hückel and the late American comedian Rodney Dangerfield shared one thing in common. They "got no respect!" Hückel's contributions to molecular orbital theory have been undervalued by the quantum chemistry community for many years. Jerome Berson's 1996 article in the centennial year of Hückel's birth (*Angew. Chem. Int. Ed. Engl*., **1996**, *35*, 2750-2764) played a big part in calling attention to Hückel's contributions, and now we have this fine biography by Andreas Karachalios of the University of Mainz that will allow English-reading scientists to evaluate Hückel's work in detail. Although Hückel wrote an autobiography shortly before his death in 1980 (*Ein Gelehrtenleben Ernst und Satire*, Verlag Chemie, Weinheim, 1975), the lamentable lack of knowledge of German among present day American chemists (your reviewer among them) means that an English language biography is absolutely necessary for US readers to appreciate Hückel's accomplishments.

Karachalios obviously used Hückel's autobiography a great deal in crafting this work, but he also made use of many supporting documents—letters to, from, and about Hückel, minutes from his oral examinations, evaluations in connection with job searches, reports to the Rockefeller Foundation, etc. The result is a thorough description of Hückel's life coupled with a detailed description of his work in quantum chemistry. Over three-fourths of the book touches on events prior to the outbreak of World War II. Sadly, there was not much of significance to report on after the war was over.

The author points out the significance to quantum chemistry of the year 1896, for Robert Mulliken and Friedrich Hund were born in that year along with Hückel. His father Armand was a doctor and an amateur scientist. He encouraged the scientific interests of his three sons, Walter, Erich, and Rudi. Walter, who went on to become an outstanding organic chemist, undoubtedly helped move Erich's research into areas of significance to organic chemistry. Hückel took a doctorate in physics from Peter Debye, worked for David Hilbert and then Max Born, and then took a second degree (the Habilitation) from Debye. His degree was on the theory of strong electrolytes. This resulted in the famous Debye-Hückel theory of electrolytic solutions, probably the introduction for most of us to the name of Hückel. Receiving an international fellowship, Hückel spent time at the Niels Bohr Institute in Copenhagen in 1929, a stay that probably inspired him to apply quantum mechanics to chemistry.

Hückel's first important excursion into quantum chemistry dealt with the nature of the double bond (*Z. Phys*., **1930,** *60*, 423-456). Scientific thought at that time was of the view that the two bonds were chemically equivalent. Hückel's result was that there were two bonds, bonds that would correspond to what we now say are a π bond and a σ bond. The next year Hückel published his famous paper on aromaticity, a paper much more referenced than read (*Z, Phys*., **1931**, *70*, 204-286). Like the paper on double bonding, Karachalios goes over this 82-page paper in detail. Hückel actually treated the benzene problem with two methods—one equivalent to the valence bond method and the other with what we now call the Hückel MO theory. His MO results showed that benzene should have special stability but that cyclobutadiene and cyclooctatetraene would not, *i.e*., results consistent with what later chemists called the 4n + 2 rule. Karachalios devotes about 64 of his 200 pages to these two important papers.

Unfortunately, Hückel's treatment did not carry the day in the 1930s. Pauling and his coworkers pushed their use of resonance theory. Hückel was a weak communicator, while Pauling was superb in that area. In his autobiography Andrew Streitwieser states that Hückel molecular orbital theory did not come into its own until the 1940s (*A Lifetime of Synergy with Theory and Experiment*, ACS, Washington, DC, 1997, p181), and Streitwieser mentions that Hückel himself (p 182) attributed acceptance of HMO theory to Streitwieser's classic book, *Molecular Orbital Theory for Organic Chemists*. Perhaps Streitwieser summed up the situation best with these sentences I quote from p 181 of his autobiography:

> Erich Hückel was a physicist who worked between two worlds. Because he was a physicist, organic chemists paid no attention to him, and because he worked in chemistry, physicists paid him no heed.

Despite Debye's best efforts, he was unable to obtain a permanent position for Hückel. Hückel first wound up at Leipzig with the equivalent of a senior post-doctoral position and then in 1930 went to Stuttgart as a lecturer, where he remained until 1937. All this time he was supported by what we would call in the US "soft money." This probably played a part in his decision in 1934 to join an organization associated with the Nazi party. A position at the University of Marburg became open in 1937. The prime candidates were Hückel, Friedrich

Hund, and Helmut Hönl. The faculty favored Hund, but Hückel's favorable political activity won the day. After the war Hückel suffered various illnesses and fits of depression. He never regained his creativity and drive from the 1920s and 1930s. He retired in 1962 and died on February16, 1980.

I have often wondered why Hückel and for that matter Friedrich Hund never won the Nobel Prize. The optimum year would have been 1966—the year that Robert Mulliken won an unshared Nobel Prize in chemistry for his work on molecular orbital theory. There would have been room for two other people to share this prize. Indeed, in his autobiography (*Robert S. Mulliken: Life of a Scientist*, Bernard J. Ransil, Ed., Springer-Verlag, Berlin, Heidelberg, New York, 1989) Mulliken stated (p 192) that he would have been happy to share the prize with Hund. I imagine in 1966 Hückel would still have been viewed as not at the same level as Mulliken, but surely Hund's stature equaled that of Mulliken. It would be interesting to know whether in the '60s Hund and Hückel had been nominated for the award. Unfortunately, knowledge of Nobel nominations is not available until 50 years have passed after the nomination. So far as name recognition is concerned, present day chemistry students have all heard of Hund (Hund's Rule), those taking organic chemistry know about Hückel molecular orbital (HMO) theory;but very few will ever have heard of Mulliken. Still, I imagine Hückel and Hund would have gladly traded their posthumous fame for a share of the Nobel Prize. One strength of the book is the extensive set of footnotes. Readers should look at them in detail, because often they contain fascinating mini-biographies of significant figures in physics and chemistry. Occasionally the footnotes are used inefficiently. For example, the author uses several footnotes to give biographical details about noted chemists Hermann Mark and Christopher Ingold, when he could simply refer to Mark's autobiography (*From Small Organic Molecules to Large: A Century of Progress*) or to Kenneth Leffek's biography of Ingold (*Sir Christopher Ingold, A Major Prophet of Organic Chemistry*). Also, would it have cost too much to have included just one picture of Hückel? However, these are minor quibbles. This is an important and much needed book. I consider it a must buy for historians of quantum chemistry. Now what we need next is an English translation of Hückel's autobiography. Chemical Heritage Foundation, are you listening? *Dr. E. Thomas Strom, Department of Chemistry and Biochemistry, University of Texas at Arlington, Arlington, TX 76019-0065.*