As a historian I wanted the rest of the book to have focused on Baekeland, his products, and its cultural significance but this was not the case. From this point on, the book does feel more like a haphazard, though important, presentation of symposium talks which all fall under the impossibly broad topic of "100+ years of plastics." The editors themselves admit this thematic divergence and rationalize it by saying that "Leo Baekeland's invention brought forth a flowering of polymer products, so the remaining chapters are much more diverse" (p. x). Les H. Sperling's article explores improvements in interpenetrating networks, while James Economy and Zeba Parkar contribute two co-written articles in which they examine resoles, novolaks, and related chemicals. James G. Traynham conveys the story of two of the "plastics pioneers" (Irvin I. Rubin and John L. Hull) in fabrication techniques with research coming from the oral history archive at the Chemical Heritage Foundation. Mehmet Demirors then tackles the history of what many consider the most widely used polymer—polyethylene. Co-editor Rasmussen follows with an examination of conducting polymers polypyrrole and polyaniline. As if there were not enough aspects of plastics history to explore in the 20th century, Wen-Bin Zhang, Stephen Z. D. Cheng, and Mike J. Yaszemski take the analysis into the 21st century with a history of musculoskeletal regenerative and reconstructive medicine.

Indeed, as the editors suggest, this is a "selective rather than a comprehensive survey of polymer history" (p. x). While chemists will enjoy learning more about these diverse topics, historians should demand more analysis on the genesis of the plastics age itself and its cultural ramifications (3). And that is a good thing, because this is a specialization in the history of chemistry that clearly needs more attention. Perhaps the real issue is: if the argument can be made that the 20th century gave birth to the "Age of Plastics," and if Leo Baekeland is the so-called "father of plastics" without a published biography, then there is a scholarly lacuna the size of a material epoch that needs to be filled.

Mark D. Bowles, Professor of History, American Military University, mdbowles@gmail.com

References and Notes

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Neither Physics nor Chemistry: A History of Quantum Chemistry, Kostas Gavroglu and Ana Simões, MIT Press, Cambridge, MA, and London, 2012, xiv + 351 pp, ISBN 978-0-262-01618-6, $40.

Neither Physics nor Chemistry is a multifaceted history of an "in between" discipline written by two of its foremost historians. The authors set out the parameters of their study in the brief introduction. They describe the development of the discipline from its origins through roughly 1970. Along the way, they concern themselves with six "clusters of issues." The first cluster has to do with "the historical becoming of the epistemic aspects of quantum chemistry" or what might be called the knowledge content of quantum chemistry and the foundations of that knowledge. The second is about the accretion of the trappings of a recognized academic discipline such as conferences, textbooks, and chairs. Third is the "contingent character" of the development of quantum chemistry, the assertion that it could have taken different form had its developers had different research agendas, personalities, relationships, or modes of reasoning. Next is the reconsideration of the discipline's practices and goals that accompanied its adoption of digital computing. The fifth cluster is philosophical in nature, involving questions of reductionism, visualizability, and the roles of theory, rules, and mathematics. The final cluster is about "styles of reasoning" in quantum chemistry.

These clusters of issues certainly inform the narrative, but they do not structure it. Instead, the structure is mainly disciplinary, roughly geographical, and partly chronological. That is, the titles of the four chapters that contain the book's main narrative explicitly refer to disciplines that contributed to quantum chemistry. Each chapter also has a geographic focus that is not explicit in its title. The first chapter, on quantum chemistry *qua* physics treats mainly developments in continental Europe. Chapter two, on quantum chemistry *qua* chemistry, is populated mainly by Americans. The third chapter, treating quantum chemistry *qua* applied mathematics, has a British focus. The fourth chapter is geographically cosmopolitan; it is also more disciplinarily diverse, beginning with researchers interested in biomolecules before it settles into the theme of its title, quantum chemistry *qua* programming. Within each of these chapters, the narrative is largely chronological, and the four chapters themselves form a slightly overlapping chronological sequence.

These four chapters of the book's main historical study are followed by a concluding chapter of historiographical considerations, largely reflecting on the role and nature of theory in chemistry. Notes, a bibliography, and an index occupy the final pages of the book. The bibliography of primary sources in quantum chemistry and historical works about it is extensive and impressive.

In the first chapter, the authors treat the application of quantum concepts to questions of chemical interest by the physicists who developed the old quantum theory and later quantum mechanics. They treat the first successful application of quantum mechanics to the chemical problem of binding, the 1927 paper by Walter Heitler and Fritz London in some detail. Not long afterwards, Paul Dirac would formulate both the promise and challenge of quantum chemistry from the perspective of many physicists: "The underlying physical laws necessary for the mathematical theory of a large part of physics and the whole of chemistry are thus completely known, and the difficulty is only that the exact application of these laws leads to equations much too complicated to be soluble." In other words, Dirac asserted that chemistry is in principle reduced to quantum mechanics and that to solve problems of chemical interest requires finding mathematically tractable approximations within the framework of quantum mechanics.

In chapter two, one finds many American chemists and physicists whose names and concepts still appear in chemistry textbooks. Gilbert Lewis's model of bonding, involving shared electron pairs and octets, is described as arising out of pedagogical considerations. Linus Pauling is a key actor as both a developer of and advocate for the valence bond approach to quantum chemistry and the concept of resonance. Robert Mulliken's work on molecular spectroscopy and on the united-atom limit of diatomic molecules are shown to inform his molecular orbital approach. John Slater, John Van Vleck, and George Wheland are also important figures in this chapter. The authors describe the connections among these figures, noting that American chemists and physicists communicated with each other, and so both chemists and physicists tackled problems of chemical interest. They contrast this situation with that in Europe, where physicists generally had little interest in chemical problems and chemists little mathematical training.

In chapter three, Charles Coulson emerges as a central figure, one who advocated a methodological diversity in quantum chemistry. His 1952 book *Valence* presented both the valence bond and molecular orbital approaches as useful within their ranges of applicability and asserted that trusting either alone would be foolish. (Slater and Van Vleck had written earlier on the complementarity of these two approaches and the mathematical equivalence of refinements to them.) John Lennard-Jones, who held the first chair of theoretical chemistry in the world (at Cambridge) and Douglas Hartree, of self-consistent field fame, are other principals in this chapter.

Chapter four begins in France, where quantum chemistry had been retarded by a long-standing aversion to theoretical science. The discipline "caught on" in inauspicious times—during and immediately after the German occupation of World War II. Investigations of the relationship between molecular structure and carcinogenesis gave French quantum chemistry a large-molecule biological flavor, and led to the "invention" of quantum biochemistry by Alberte and Bernard Pullman. Much of the rest of the chapter deals with the changes digital computers began to bring into quantum chemistry. The qualifier "digital" is needed in this context because in the earliest days of quantum chemistry, computers were people, not machines. The new computing machines gave quantum chemists the ability to increase the size of molecules they could treat or the accuracy of numerical calculations on small systems. The debate between advocates of *ab initio* and semi-empirical approaches, which had long been somewhat dormant because of the intractability of *ab initio* treatments for all but the smallest problems, re-emerged. During this time quantum chemistry became more of a mainstream part of chemistry, offering insights to practitioners of its more traditional subdisciplines. It also became more international, as exemplified by Masao Kotani's organizing international meetings in Japan and by Per-Olov Löwdin's *International Journal of Quantum Chemistry*.

The final chapter is on historiographical considerations of the emergence of quantum chemistry. It has a great deal of material relevant to the philosophy of chemistry, particularly on the role of theory in chemistry, the character of chemical theory, and the independence of chemistry from physics. Much of this chapter (and the end of the previous one) seems to me to belie the book's title, *Neither Physics nor Chemistry*. Rather it is consistent with the notion that quantum chemistry is a kind of chemistry with (at least some of) the character of chemistry and in service to the discipline of chemistry. At least that is where quantum chemistry landed, even though it clearly did not emerge entirely from within chemistry and it was certainly not shaped exclusively by chemists.

I am not a researcher in the history of this field, but I am familiar with the content of quantum mechanics and quantum chemistry and with the outlines of their history. It did not take long for me to come across historical facts I had not known. For example, quantization was applied to molecules before atoms: Niels Bjerrum formulated a treatment of vibrational and rotational spectroscopy that quantized rotation and assumed, semi-classically, that the frequency of the electromagnetic radiation matched the frequency of the motion. Fritz London was trained as a philosopher before he turned to physics. Unlike the philosophical writings of many early researchers in quantum mechanics, which were mainly popular accounts of the philosophical implications of their physical work, London's philosophical writings preceded his work in physics and were written for an audience of scholars in philosophy. Hans Hellmann, like many better-known scientists working in the 1930s, was caught up in the political upheavals that plagued Europe at the time: he left Nazi Germany for the Soviet Union, where he was executed in 1938 in Stalin's purges.

To praise the book primarily for such historical tidbits, however interesting, would be to trivialize its scholarship. One of its real strengths is the attention devoted to divisions or tensions of all sorts within the "in between" discipline of quantum chemistry. These include binary choices of valence bond vs. molecular orbital (personified by Pauling vs. Mulliken), quantitative vs. qualitative, visualizable vs. non-visualizable, and *ab initio* vs. semiempirical, as well as multipolar tensions among physics, chemistry, mathematics, biology, and computation, and among continental (German), American, British, and international approaches. One might even identify a tension between the either/or approaches of methodological partisans and the both/and approaches of pluralists.

I must, however, close with a caveat about the book's treatment of the technical content of quantum chemistry. Readers interested in details of methods like Hückel theory, self-consistent field calculations, or Slater-type orbitals, and in their development will be disappointed. To be fair, the stated theme of the book is the development of the subdiscipline of quantum chemistry, not the development of technical specifics within it. At the same time, the treatment of technical details when they do arise is not always done well. For example, the exposition of the Heitler-London paper states that only one of the two wavefunctions developed for the hydrogen atom is consistent with the Pauli exclusion principle. Heitler and London actually note that both hydrogen wavefunctions they consider are consistent with the Pauli principle, one with two different spins and the other with two identical spins; the former is the one that represents the bound molecule because that is the one that has an energy lower than isolated hydrogen atoms.

More often than not, technical details are absent, and rightly so for the purposes of the authors. What is present is a thoughtful, careful, and extensive study of the development of quantum chemistry from a strongly historical perspective informed by sociological and philosophical sensibilities.

Carmen J. Giunta, Professor of Chemistry, Le Moyne College, giunta@lemoyne.edu