Book Review

Eric R. Scerri, *The Periodic Table: Its Story and Its Significance*, Oxford University Press, Oxford, 2007, XXII + 346 pp. (ISBN-13-978-0-19-530573-9)

This new book by Eric Scerri is published on the centenary of the death of Dmitrii Mendeleev (1834-1907). His readable narrative is philosophical as well as historical. The first five chapters of this ten-chapter book deal with the origins, discoverers, and the acceptance of the periodic system. After the introduction and a brief overview of the evolution of the periodic system in chapter one, he discusses the history of chemistry from Lavoisier's empirical definition of elements and Dalton's atomic theory to the realization of quantitative relationships among the elements in terms of atomic weights, including various kinds of triads, in chapter two. In the following chapter, Scerri follows his precursor in the study of the history of the periodic system, J. W. van Spronsen's *The Periodic System of Chemical Elements* (Amsterdam et al.: Elesevier, 1969), published in the year of the hundredth anniversary of the periodic system. Van Spronsen identified six independent discoverers of the periodic system: Béguyer de Chancourtois, Newlands, Odling, Hinrichs, Lothar Meyer and Mendeleev. Scerri recognizes the contributions of these six discoverers, even though he gives Mendeleev credit for the leading role. While some historians of chemistry have denied Hinrichs as a discoverer, Scerri provides a good argument for the value of Hinrichs' tables after careful reexamination.

Scerri examines Mendeleev's contributions to the periodic system in detail in chapters four and five. His most important contribution here to the understanding of Mendeleev's work is his philosophical analysis of Mendeleev's distinction between abstract elements and simple substances. Such an approach is lacking in van Spronsen's book. During the 19th century the concept of abstract elements served an explanatory function, even though a chemist like Mendeleev could be skeptical of atomism. The abstract elements were bearers of properties and unobservable material ingredients of simple bodies and compounds, whereas simple substances were the observable part, which could not be decomposed by any known means. There were uncertainties concerning the correspondence between a simple substance and an abstract element, which was clarified only at the end of the 19th century. One can ask in what sense the elements sodium and chlorine continue to exist in sodium chloride, common salt. Mendeleev would answer that simple substances do not survive in the compound, only abstract elements do. Scerri rightly states Mendeleev's understanding of atomic weight as the only measurable attribute of an abstract element that would remain unchanged in all its chemical combinations. (See also Masanori Kaji: 2003, 'Mendeleev's Discovery of the Periodic Law: The Origin and the Reception', *Foundations of Chemistry*, **5**, 189-214, where I have emphasized the importance of these points and pointed out that Mendeleev's study on so-called indefinite compounds in the 1860s is the origin of his distinction between elements and simple bodies.) This understanding carried him far ahead of his contemporaries.

In chapter five, at the end of the first part, Scerri explores the complicated path to the full acceptance of the periodic system by the chemical community. He reveals that contrary to a popular myth, even though Mendeleev's successful predictions of new elements brought the system to the attention of the scientific community, the ability of the system to explain already known facts persuasively played an important role. For example, the placement of difficult elements such as beryllium or the newly discovered noble gases, which were not predicted, and the ongoing struggle to position the rare earths, all helped to produce an atmosphere of productive debate surrounding the periodic system. These factors contributed to the eventual acceptance of the periodic system as much as the predictions.

In these excellent chapters on Mendeleev, however, there are some minor mistakes. Scerri uses 'Dimtrii' instead of the usual form 'Dmitrii' in Russian for Mendeleev's first name. In chapter four, figure 4.3 is not the one Mendeleev first published in 1869, as Scerri notes, but the one from the German journal *Annalen der Chemie und Pharmacie*, which was a little different from the first published version in 1869. Figure 4.4 is again taken from the same German journal, and not the Russian journal, indicated incorrectly in the text. In chapter five there is a misunderstanding about the calculation of the atomic weight of newtonium. Mendeleev introduced newtonium as a chemical ether which could explain radioactivity without referring to the notion of the disintegration of elements. Mendeleev did not give atomic weight 0.17 to newtonium, as Scerri assumes (p. 140), but only suggested that this was its maximum possible value. In fact, Mendeleev thought its atomic weight to be far less. Since newtonium must be mobile and permeate throughout the universe, it must escape from the gravity of stars. He supposed that the largest star would be 50 times bigger than the sun and, using the kinetic theory of gases, he deduced the value of 0.000 00096 as the possible atomic weight for newtonium (D. Mendeléeff: 1905, 'An Attempt Toward a Chemical Conception of the Ether', in his *The Principles of Chemistry*, third English edn., vol. II, London et al: Longmans and Green [Reprint: New York: Kraus, 1969], Appendix III, pp. 509-29, esp. pp. 522-6).

The second half of the book, the last five chapters, deals with the attempts to explain the periodic system in terms of physics, especially from the advent of quantum mechanics to the present. In this part Scerri repeatedly emphasizes the irreducibility of chemistry to physics and the independent role of chemistry. He shows that Bohr relied on intuition as well as on spectroscopic and purely chemical considerations when producing his first version of an electronic periodic table in 1913. Bohr appreciated electronic explanations of the periodic system that were developed by chemists such as Gilbert Newton Lewis, Irving Langmuir, and Charles Bury, before the advent of quantum mechanics. Even though the prediction and eventual confirmation that element 72 is not a rare earth element is usually regarded as a triumph for Bohr's theory of the periodic system, most chemists then already thought that hafnium would not be a rare earth and that Bohr's quantum theory of periodicity only rationalized chemistry.

Paul Dirac once declared that all of chemistry can be calculated from first principles. However, Scerri persuasively shows that the periodic system is resistant to the kind of deductive generalization physics offers. He concludes that the reduction of chemistry to quantum mechanics has neither failed completely, as some philosophers of science claimed, nor has it been a complete success, as some contemporary historians have claimed.

In the last chapter Scerri explores the evolution of chemistry and several additional chemical relationships found in the periodic table that are difficult to understand theoretically, such as diagonal behavior, secondary periodicity, and the knight's move relationship. In the last part of the book he discusses the best form for the periodic table. Scerri advocates the general adoption of the left-step periodic system first proposed in 1929 by Charles Janet, called the Janet table, in which hydrogen is placed above lithium and helium above beryllium. In this last chapter Scerri also indicates that F. A. Paneth, a Vienna-born English chemist, redefined elements as basic substances that are characterized by their atomic numbers alone. By regarding isotopes as simple substances, Paneth saved the periodic system from a major crisis because of the discoveries of many isotopes. Paneth's approach was a starting point for understanding the contributions to the history of the periodic system in the 19^{th} century, especially that of Mendeleev.

As one of the pioneering scholars in the philosophy of chemistry, Scerri has produced a comprehensive new book on the history and philosophy of the periodic system, which surpasses van Spronsen's book, and the result is a good antidote to researchers who claim that chemistry is now only a reduced science or a service science. This book is especially recommendable to educators and chemists as a clear and readable history and philosophy of the essential ideas of chemistry.

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