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BOOK REVIEW

Geoff Rayner-Canham: The periodic table: past present, and future

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I would like to begin this review by stating that this is an absolutely wonderful book that is full of gems about the elements and the periodic table. In my own 2007 book on the periodic table I concluded that we should perhaps think of the variety of tables that have appeared as spanning a spectrum running from the most abstract and 'perfect' tables such as Janet's left-step table representation, to the unruly tables that emphasize the uniqueness of elements. To illustrate the latter category, I featured an image of Rayner-Canham's table that is also the table shown on the front cover of his new book now under review. Rayner Canham's book is all about the individuality of elements and how so many of the commonly held trends in the periodic table are far more complicated than we normally acknowledge.

The book adopts a historical approach, in each of 15 chapters, and provides ample references to the literature, including many citations to articles that have appeared in this journal incidentally. It begins by taking an unusually fundamental approach, for a chemistry book, in discussing the nuclear structure of isotopes of the elements. For example, the author gives a detailed explanation of why tellurium has a higher atomic weight than iodine even though its atomic number is one unit lower. Chapter 2 begins to review some selected atomic properties starting with the different approaches to electronegativity, the Van Arkel triangle and several related properties like ionization energy, the half-filled subshell myth and electron affinity.

The author has a deep aversion to the idea that chemistry might be boring, something that he repeats several times and strives to justify throughout his book. In chapter 3 the positions of hydrogen and helium are discussed in great detail. Chapter 4 concerns a further topic that has been a personal interest, namely the question of which elements should be placed in group 3 of the periodic table (Scerri 2020). Further disputed issues are covered in chapter 5 which discusses the categorization of elements into metalloids, weak metals and normal metals, none of which have clear-cut meanings among chemists.

In the remaining chapters the emphasis is on the sheer individuality of the elements and their lack of conformity to the well-known and simplified trends that are typically described in elementary books and courses in inorganic chemistry. The author's

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interests shine through especially clearly when discussing transition metals where we are told that, "chemists like smooth patterns but that such behavior simply does not occur when details are examined more closely".

Another very illuminating chapter concerns the relationship between the *n* groups that the groups that are numbered $n + 10$. For example, it is well known that aluminum which is officially placed in group 13 shows many resemblances with group 3 elements like scandium and yttrium, and that titanium in group 4 behaves very much in like silicon in group 14. What I especially liked about the treatment was the manner in which the author linked it to the original 8-column periodic tables as first proposed by Newlands, Mendeleev and other pioneering chemists. The 8-column table captures this relationship in a natural manner whereas, as has often been pointed out, the generally accepted 18-column table seems to mask it somewhat.

Chapter 10 is another very interesting one which features the Knight's Move relationship that was first proposed by the late Michael Laing who published some articles in *Foundations of Chemistry* (Laing 2005). It consists of the bizarre fact that in the lower right-hand corner of the modern periodic table that are several pairs of elements that are related to each other in the same way as the starting and end point in the moves that a knight can make in the game of chess. For example, starting at zinc one can move one place down the table and two places across, just as a knight would move on a chess-board, to arrive at the element tin. Both of these elements exhibit amphoteric behavior and aqueous solutions of their divalent chlorides hydrolyze to give insoluble precipitates. In the presence of a high chloride ion concentration their chlorides produce analogous chloro-complex ions of $ZnCl_3^-$ and $SnCl_3^-$ and $ZnCl_4^{2-}$ and $SnCl_4^{2-}$. Both elements also form dialkyl compounds of the form R_2Zn and R_2Sn and so on. It should also me mentioned that there is still no explanation for why the Knight's Move relationship even exists.

Many more relationships which complicate the simple trends that are often assumed are presented in the remaining chapters. A further example lies in the inert pair effect which, for example, causes tin and lead to adopt an oxidation state of + 2 rather than the + 4 state that is typical of the group they find themselves in. These days the explanation lies in relativistic effects and the fact that the outer s-electrons in these elements are moving at such high speeds that the orbitals contract in size and so make it that they are not ionized along with the two outermost p-orbital electrons (Pyykko 1977). Yet a further long-observed feature among many elements is that of diagonal relationship as seen in the close similarities between lithium and magnesium, beryllium and aluminum, boron and silicon and so on, all the way to oxygen and chlorine.

In the final three chapters the author discusses the lanthanoids, actinoids and finally pseudo-elements like the ammonium ion that behaves very much like the heavier alkali metal atoms and the cyanide ion which shows striking similarities to several halogen atoms. Returning to the front cover of the book, one finds that the author has included the ammonium ion in group 1 between potassium and rubidium while also placing the cyanide ion between chlorine and bromine.

All in all, the book is highly recommended to philosophers of chemistry. As philosophers we have a natural tendency to concentrate on generalities and not to get too involved in the specifics and the details. Above all else, this new book reminds us that such an approach needs to be tempered by a detailed knowledge of the exceptions and features that go against the simplified generalities which we so cherish.

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