BOOK REVIEWS

The Lost Elements: The Periodic Table's Shadow Side, Marco Fontani, Mariagrazia Costa, and Mary Virginia Orna, Oxford University Press, New York, 2014, 576 pp, ISBN 978-0-19-938334-4, $39.95

It is easy to fall into the trap of presenting the history of chemistry as nothing but a succession of successes as the frontiers of knowledge move triumphantly from one new discovery to another. Chemical historians recognize that this is untrue, but there is rarely time, even in a multi-credit historical survey course, to focus on the false pathways and mistaken ideas that bedeviled scientific progress. This book provides a welcome antidote to this oversight by focusing on the history of new elements that were incorrectly proposed to be added to the periodic table, what these authors call lost elements. The authors estimate (see page 417) that over 200 incorrect claims of new elements have been proposed, so the false claims actually outnumber the elements known today.

The book is divided into seven sections, which present the various spurious claims of new elements in roughly historical order. The first section deals with the period from 1750 to 1789, that is, prior to the development of the modern definition of an element. This is the shortest section of the book due to a combination of the limited number of individuals doing chemical research at the time and the lack of sophisticated methods of analysis. Perhaps the most interesting historical figure considered in this section is Christian Friedrich Samuel Hahnemann (1755-1843). In 1801, Hahnemann announced that he had discovered a new alkali metal that would expand up to twenty times in volume upon heating. He named the new element *pneum-alkali*, since its behavior seemed to resemble that of the lung. When his proposal was ridiculed to extinction, Hahnemann turned his attention to medicine, where he espoused the theory of homeopathy, that is, the medicine should be chosen based on the similarity of its effect to the symptoms of the disease to be treated. This approach was not well received either, although the idea continues to attract followers even today.

The second section, 1789-1869, deals with the period between Lavoisier's definition of a chemical element and the formulation of the periodic table of the elements by Dmitri Mendeleev. One of this reviewer's favorite chapters in this section identifies new elements that were proposed with so little confidence that the "discoverers" didn't even bother to propose a name. The authors of *Lost Elements* call these ghost elements. Part of the attraction may be due to surprise that someone who was proposing a new element would lack enough commitment to even suggest a name, but also it is interesting that the scientists who fall into this category include Charles Frederick Chandler, one of the founders of the American Chemical Society and a former President of the Society, as well as Friedrich Genth, who also served as President of the ACS. Obviously even the most reputable of chemists can make these kinds of mistakes.

The third section, 1869 to 1913, focuses on the time between Mendeleev's creation of the periodic table and Moseley's recognition of the importance of atomic number. Although more powerful techniques, like spectroscopy and chromatography, became available for elemental separation and identification, isolation of the elements continued to be very challenging. Many of the lanthanides were so difficult to separate that there were frequent cases were mixtures of these elements were announced as being pure samples of new elements. Hafnium represented another difficult situation. It was the next to last of the nonradioactive elements to be identified, and before this happened there were more false claims to have isolated it than any other element in the periodic table. Also during this time period Sir William Ramsay had the distinction of being the only scientist

to have discovered or contributed to the discovery of an entire periodic group, the noble gases or Group 0 on the modern periodic table. Even as careful a scientist as Ramsay was not perfect; he was forced to admit that he had erroneously identified the presence of an inert gas in the atmosphere which he called *metaargon*.

In the fifth section, covering from 1939 to the present, most of the new elements beyond uranium are discovered either by physicists or by the chemistry group led by Glenn T. Seaborg. Searching for transuranium elements was a very expensive process, and the main competition to find the missing pieces of the periodic puzzle developed between teams in Dubna, Russia, and Berkeley, California, USA. From the beginning of the process there were incorrect reports of new elements. Enrico Fermi and his team claimed to have discovered several transuranium elements, but it was recognized later that they had actually created nuclear fission. Some scientists claimed to have discovered evidence for superheavy elements in meteorite fragments, and one researcher even claimed that heavy elements were involved in the metabolism of fish and other invertebrates. In another case, the claim of a new element was outright fraud, something that is surprisingly rare in the stories of this book.

One might expect that the general acceptance of periodicity would result in fewer false claims of new elements. After all, as the periodic table was filled in there were fewer empty positions where a new element might be placed. This is not the case, as described in section six, which discusses what the authors call "bizarre elements" that have no place in the periodic table. Various scientists proposed the existence of new elements lighter than hydrogen that were basic building blocks of matter. Some of these false elements came in both male and female forms. Even Mendeleev fell into this trap by not only proposing that the imponderable fluid, *ether*, was an element lighter than hydrogen but also by extrapolating its atomic weight. Perhaps most bizarre of all, a small group of clairvoyants announced that they could "see" the microscopic world of atoms and molecules, which certainly would be a helpful skill if it actually existed. They proposed a new element, with the suggestive name, *occultum*, and eventually claimed to have detected 59 new elements by means of their special talent.

The chapters in section seven of the book do not deal as much with incorrect claims of new elements as they do with spurious reports of elemental transmutations, that is, modern alchemy. Radioactive decay as well as transmutation by subatomic particle bombardment are well known, but the transmutations described in this section were supposed to have occurred by other means, including even biological action. Various scientists reported transmutations of mercury into gold, silver into gold, lead into mercury, hydrogen into helium and neon, and dozens of other elemental transformations in biological systems. The book also includes a brief description of the reports of room temperature (i.e. "cold") fusion reactions.

The authors summarize by writing that the main lesson to be learned from the history of false claims of new elements is that individual scientists are not always right, but the scientific process continually moves towards a more accurate understanding of nature. Some scientists publically retract their mistakes (although they may hide their retraction by writing it in Latin and in an obscure journal), and unfortunately some obstinately refuse to admit that they were wrong. Obviously, the process is not as clear and straightforward as one might desire, but it is valuable to understand that true science must be based on theories that can survive testing by the scientific community.

Overall, this book gives a fascinating insight into an aspect of science that is sometimes overlooked, the recognition and correction of scientific error. The book is by no means light reading for the non-scientist, but historians of chemistry should enjoy reading about both the careers of many lesser known chemists as well as finding some familiar characters caught in rather embarrassing situations.

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