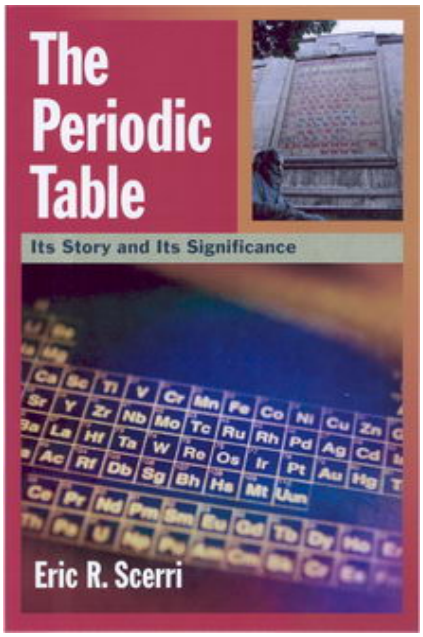
UCLA Chemist Provides New Insights into one of Science's Icons and its History



Eric Scerri is author of “The Periodic Table: Its Story and Its Significance” (Oxford University Press) Credit: Oxford University Press

The periodic table of chemical elements hangs in front of chemistry classrooms and in science laboratories worldwide. Yet much was unknown about its history and evolution until now.

"The moment I discovered there was this elegant, orderly chart that encompassed chemistry, I fell in love with the periodic table," said Eric Scerri, a UCLA chemist and author of the recently published "The Periodic Table: Its Story and Its Significance" (Oxford University Press). "It captured my imagination, and it still does. It is completely unique in science. Chemistry is the only field with one simple chart that embodies the essence of the field. This wonderful tool serves to organize the whole of chemistry."

Who discovered the periodic table of elements --the fundamental materials of which all matter is composed? There is no simple answer. The story begins with the ancient Greek philosophers. Aristotle, among others, identified four elements: earth, water, fire and air. Some elements -- such as iron, copper, gold and other metals -- have been known since antiquity.

Today, the periodic table has 116 elements, the most recent of which was added just last month -- an element that for now is known as element 118 for the number of protons in its nucleus, more than in any other element. (Two other elements are predicted from the existence of spaces in the periodic table, but have not yet been synthesized.)

The modern periodic table dates to the 1860s, when six scientists -- most of them obscure -- independently produced different versions of the table, writes Scerri, whose book is a history of modern chemistry and physics.

A French geologist named Alexandre Emile Bйguyer de Chancourtois essentially discovered the periodic system, but his publisher was unable to publish the complex diagram of the periodic table that he submitted with the article in which he made his case, Scerri said. As a result, de Chancourtois received very little credit for the periodic table, and is not widely known.

Most of the credit for the periodic table has gone to a distinguished Russian scientist named Dimitri

Ivanovich Mendelev, who was the last of the six scientists to present a periodic table in the 1860s. He claimed he did not see any of the other periodic tables from his contemporaries.

"I frankly don't believe it," said Scerri, a philosopher-historian of chemistry. "Mendelev wasn't isolated in Siberia, which is the way he is sometimes portrayed. He spoke all the major European languages, was familiar with the literature and had traveled in Europe. He mentioned the precursors of the periodic table, but not the ones who actually devised systems. He surely must have known about them."

Yet Mendelev rightfully can be credited with devising the periodic table, Scerri said.

"The person who gets the credit in science is typically the one who develops and champions the idea and analyzes its ramifications, not necessarily the first person to come up with the idea," he said. "Mendelev's name is justifiably connected with the periodic system, to the same extent perhaps as Darwin's name is synonymous with the theory of evolution and Einstein's with the theory of relativity."

Mendelev's genius, Scerri writes, "lay in his ability to sift intuitively through the mass of correct and incorrect knowledge of the elements that had accumulated to produce a system, an idea, that was both elegant and durable enough to withstand the chemical and physical discoveries that would follow."

Mendelev, who called himself the Newton of chemistry, conceived the periodic system while writing a textbook, "The Principles of Chemistry," and spent at least four years refining the periodic table. He also developed the Russian oil industry, served as director of the Russian institute for weights and measures and was a consultant to Russian cheese factories. On the day he devised the periodic system, he was supposed to inspect a cheese factory, Scerri said, and decided not to go; Mendelev sketched his first periodic table on the back of an invitation that day, Feb. 17, 1869.

Mendelev produced the first version of a full periodic table that included most of the known elements, even though the background ideas may have been developing over a period of about 10 years, Scerri said. The first published periodic system of Mendelev's contains divisions into main and subgroups. Significantly, there are several vacant spaces in the table, and in this first publication, Mendelev made several predictions, anticipating many unknown elements -- far more predictions than any of the co-discoverers of the periodic system.

He made highly accurate entries for the expected atomic weights of two unknown elements in the form of ? = 68 and ? = 70 in the columns containing aluminum and silicon; these new elements and their atomic weights turned out to be gallium (69.2) and germanium (72). Not only did Mendelev predict the atomic weights of new elements as early as 1869, but he also made predictions of some of their properties.

"He successfully predicted new elements, corrected the atomic weights of a number of known elements and correctly reversed the positions of the elements tellurium and iodine," Scerri said.

Mendelev published an extensive 96-page article in 1871 in which he grouped elements vertically as well as horizontally. In all, Mendelev published some 30 periodic tables and designed 30 more in manuscript form that were not published.

In the century that followed, some 700 versions of the periodic table were published, Scerri said. The modern periodic table has 18 columns. Elements within a vertical column share chemical properties; elements are especially similar to the ones directly above and below, Scerri noted.

Neither Mendelev nor anyone else successfully predicted the "noble gases" -- including helium, neon, krypton and radon -- which posed a formidable challenge to the periodic system, Scerri said. It was not clear where to place them because of technical issues concerning their weights. In the 1860s and 1870s,

Scerri said, they seemed not to form molecules. Some scientists thought these elements exposed a fundamental weakness in the periodic system, but they were successfully incorporated as column 18.

To this day, there are still alternative versions of the periodic table and still disputes about which version is the best, Scerri said.

Attempts to explain the periodic system have led to major advances in areas of science besides chemistry, especially theoretical physics. The notion of electronic configurations --specific arrangements of electrons -- originated when British physicist J.J. Thompson tried to explain the order of the elements in the periodic table, said Scerri, who also cites other examples. Electronic configurations did not have to wait for the introduction of quantum theory, contrary to most textbook accounts, Scerri said.

The periodic table, Scerri said, is both a teaching tool and a research tool.

"When chemists discovered high-temperature superconductors not too long ago, they wanted to raise the temperature even higher," Scerri said. "The way they did it was to simply look on the periodic table and to reason that if an element like lanthanum is a component of a superconductor, why not try actinium, which lies directly below it?"

The periodic table's elements include the well-known -- oxygen, hydrogen, carbon, silicon -- and the exotic: molybdenum, holmium, ytterbium. Some elements are named for people (Einsteinium), geographic locations (Californium) or Greek gods (Promethium).

If there were no periodic table, students would have to memorize many reactions and chemical properties, said Scerri, who this month received the Herbert Newby McCoy award by the UCLA Department of Chemistry and Biochemistry for "making the greatest contribution of the year to the science of chemistry."

"We often take familiar things for granted," said Scerri, whose book covers the philosophy of the periodic table, as well as how the elements evolved in the Big Bang and the interior of stars. His topics also includes how the splitting of the atom relates to the periodic system.

"The periodic table is an icon for science, not just for chemistry, and it reflects deep truths about the elements," said Scerri, who noted that many chemists carry it in their wallets. "It simplified the learning of chemistry at a stroke.

"All this information is embedded in the periodic table, there when you need it. Knowledge lies dormant within the table, waiting to be discovered and put to good use."

Source: University of California - Los Angeles