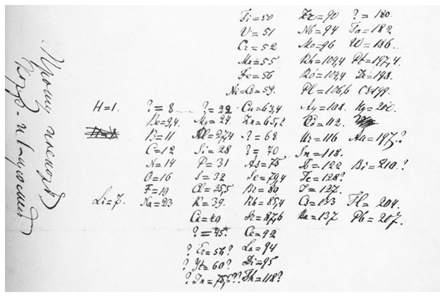
Chemistry's table of contents

The United Nations has declared 2019 to be the International Year of the Periodic Table to coincide with this iconic chemical chart turning 150 years old. We join in with the celebrations by publishing a collection of articles that explore the edges of the periodic system and look at some of the elements that do — and don't — make up the table.

The periodic table catalogues all of the known atomic building blocks, neatly organized in a system that reflects their structures, characteristics and reactivities — yet it is far more than a cleverly arranged list. As chemistry has progressed, scientists have brought new elements to the table, gained a better understanding of their properties and classified them into a chart, the shape of which has evolved accordingly. Over time, the table has become a widely recognized symbol of the field, and understanding its evolution reveals much about the history and culture of chemistry.

Chemists noticed early on that some elements displayed similar properties and attempted to classify them on this basis. By 1789, Antoine Lavoisier had compiled a list of 33 'elements' — or substances that could not be broken down further — divided into gases (which included light and caloric, the 'substance' of heat), metals, non-metals and earths ('salifiable simple earthy substances' such as chalk and clay). By 1829, Johann Wolfgang Döbereiner had grouped together several sets ('triads') of three elements and observed linear relationships in some of their properties (such as atomic weight or density). In the middle of the 19th century, around sixty elements were known.

In the 1860s, Julius Lothar Meyer and Dmitri Mendeleev independently developed similar systems to classify these elements and were both awarded the Royal Society's Davy Medal in 1882 'for their discovery of the periodic relations of the atomic weights'. John Newlands proposed a related classification in 1866 that followed a 'law of octaves', but it did not gain much traction at the time. Recognition came later, however, and in 1887 he was also awarded the Davy Medal 'for his discovery of the periodic law of the chemical elements'. Nevertheless, it is Mendeleev (who published his chart in 1869) that is nowadays widely credited for devising the original version of the modern periodic table. Meyer's was published just one year later, although a preliminary version appeared in an 1864 textbook; the clinching factor, however, may be that Mendeleev not only included all known elements, but also used the gaps in his table to (correctly) predict the properties of elements that were yet to be discovered.



Early version of Mendeleev's table. Credit: ITAR-TASS News Agency / Alamy Stock Photo

The International Year of the Periodic Table of Chemical Elements (IYPT; https://www.iypt2019.org/) provides chemists with a platform to promote the fundamental importance of the periodic table, the elements and their applications in modern society — particularly the key role that chemistry can, and must, play in addressing many of the world's critical challenges, such as ensuring food and water security, better health and achieving a sustainable future. The IYPT may also prompt chemists to take a closer look at some of the elements that make up the periodic table — as well as some that don't. A collection of articles in this issue reconciles elements old and new, natural and synthetic, established and discredited.

The gaps in the early version of the periodic table inspired chemists and non-chemists alike to imagine and/or search for new elements — though more often than not claims of a discovery lacked rock-solid evidence. In a Comment article, Michelle Francl ponders on those elements that never were. Although their existence was mere wishful thinking, some of these phantoms that didn't stand up to scrutiny linger on, particularly through their names. Once a name has been suggested (but not ultimately adopted) for an element it cannot be reused, and Francl muses on whether ill-intentioned scientists could use this to hinder a nemesis's chance to ever have an eponymous element!

To have the honour of naming an element, one first needs to discover it — and this is easier said than done. The days of painstakingly searching through ores for a substance that may or may not be there are long gone, and 'discovering' a new element now means 'synthesizing' it. As Hiromitsu Haba explains in a Comment article, this involves some serious calculations and heavy instrumentation, as well as a good deal of patience. One needs to bombard target nuclei with projectile nuclei — accelerated at just the right speed for them to be able to fuse — and hope to be able to detect a few fleeting fused nuclei through their decay pattern.

In this month's In Your Element essay, element-hunter Yuri Oganessian recounts such a superheavy synthesis — that of the 'doubly odd' moscovium, whose odd number of protons and of neutrons confer it greater stability than its even-numbered counterparts. Oganessian is one of only two scientists to have had an element named after them in their lifetime, the other being Glenn Seaborg. With its 118 protons, his eponymous element oganesson is the heaviest element yet made on Earth.

But what is the heaviest element that is naturally formed, ask Brett Thornton and Shawn Burdette in a Comment article — and can we detect it? The answer is far from straightforward, courtesy of the many transuranium isotopes that decay into one another at different rates, fleetingly appear in ores and even fall from the sky. Of course, elements that fall from the sky have captured the imagination of many through their appearances in fiction. Vibranium for example, which makes up Black Panther's suit, is mined from a meteorite. In a Comment article, Suze Kundu considers this and other elements of fantasy — and discusses their perhaps surprisingly close relationship to real-life materials.

The periodic table is an icon — one that contains within it the code for all atomic building blocks that we know of. As such, it underpins the field of chemistry and any other scientific discipline that relies on it, such as materials science, nanotechnology and biology to name but a few. The periodic table offers fact and inspires fiction. It should be celebrated and the articles mentioned above do just that; they are gathered together in an online collection, to which further pieces will also be added throughout the IYPT — so please do check back periodically. ❐

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