The Evolution of the Periodic Table

From Observation to Prediciton

By Dave Ashworth

Cast your eyes at the walls of almost every chemistry laboratory, from high school to high-tech drug discovery labs, and the likelihood is that you will observe only a modern-day version of the Periodic Table.

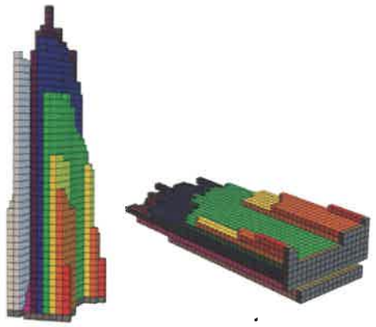
In celebration of 150 years since Mendeleev's initial arrangement of the 63 then-known elements in 1869, the United Nations has designated 2019 as the Year of the Periodic Table. However, although his groupings bear the most resemblance to the accepted form of the Table now, he was not the first to propose such an idea.

In fact, Johann Döbereiner reported trends in properties of groups of elements in 1809. He grouped "triads" of elements together based on their average atomic mass. He proposed four of these triads, an incredible feat considering there were only *six* correct atomic weights available at the time.

In 1860, Stanislao Cannizaro gave an inspiring speech at the Karlsruhe Congress – the first worldwide international conference of chemists. As a result of this conference, various chemical definitions were put in place, importantly including "atomic weight." In light of this, over the next few years, many chemists grouped and ordered the known (~60) elements according to their atomic weight, characteristics, and properties. Important contributions included recognitions that (1) properties were functions of atomic weight, (2) periodicity existed across groups of elements, and (3) valence influenced properties.

Until Mendeleev, orderings and groupings had only included and ordered the known elements. The first element Mendeleev predicted was discovered just 6 years later: Gallium. It had atomic mass and properties similar to those outlined by Mendeleev. As increasingly accurate atomic weights have been determined, and new elements discovered, the Periodic Table has been shaped and refined to that which we know now. However, naturally occurring elements have not sated scientists' thirst. Of the 118, only 94 are naturally occurring on Earth, and only 80 have at least one stable isotope, meaning there are 38 exclusively synthetic elements.

Despite the accepted working definition of the element, there are still questions over whether this is fit-for-purpose, or even chemically correct. Prof. Michelle Francl's (Bryn Mawr College, PA, USA) anecdote of students responding with 35.45 when asked for the mass of a chlorine atom illustrates why. There are more than 3300 known elemental isotopes, which can instil subtle (or not-so-subtle) differences in chemical and physical properties within the same element. Mercury has the most known isotopes (46), and oganesson the fewest (2). This has led to an IUPAC pie-chart representation of elements and a 3D representation shown below.



A 3D representation of the periodic table, highlighting all known isotopes of each element.

With the recent acceptance of elements Nh, Mc, Ts, and Og, our well-loved Table is now in the most complete form it ever has been, as each period is now full. But science does not stand still to admire its work! Scientists are currently working on the synthesis of heavier elements, which would sit within a new row – the 8th Period. Although new elements will almost certainly be discovered, it may prove impossible to fill this Period, as heavier and heavier elements are more likely to be unstable and instantaneously decay upon formation. As such, the Periodic Table may well be in the most complete form it ever will be!

> "The genius of Mendeleev is characterised by the division [of elements] into main and subgroups, the vacant spaces left for undiscovered elements together with the prediction of some of their properties. i.e., the homologues of aluminium and silicon, the classification of the transition metals, and the reversal of tellurium-iodine."
>
> - van Spronsen, 1969

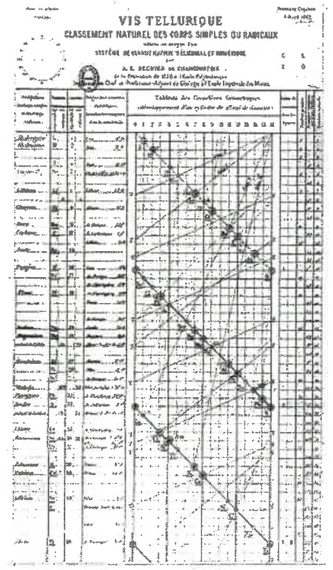
1661
Robert Boyle defined an element as "those primitive and simple Bodies of which the mixt [mixed] ones are said to be composed, and into which they are ultimately resolved."

1789
Antoine-Laurent de Lavoisier wrote his Elementary Treatise of Chemistry, defining an element as a substance that cannot be broken down into a simpler substance by a chemical reaction. This included 33 elements, of which 22 are recognised now.

1815
William Prout observed atomic weights seemed to be multiples of that of hydrogen.

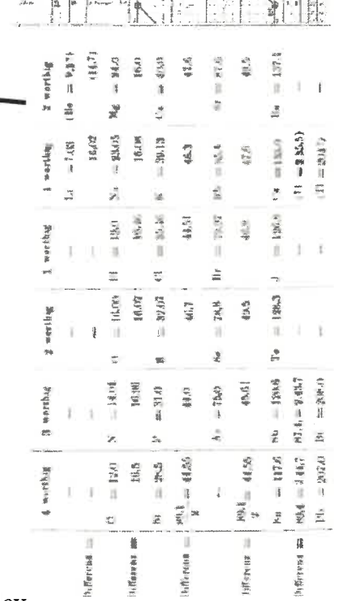
1817
Johann Döbereiner observed the connection between atomic weights of elemental "triads."

1862
The first international conference of chemistry took place - the Karlsuhe Congress. Alexandre-Emile de Chancourtois recognised properties of elements were a function of atomic weight, and were periodic. He presented a helical system of classification, the "telluric helix."



1863
John Newlands divided 62 elements into 8 groups based on characteristics and contributed "periodic" within chemistry.

1864
Julius Meyer classified elements by valance into 6 families. William Odling arranged 57 elements in order of atomic weight.



1869
Dimitri Mendeleev started to develop the Periodic Table by atomic mass.

1875
Paul de Boisbaudran discovered the first "predicted" element – gallium.

1894
William Ramsey discovered argon, with other noble gases following.

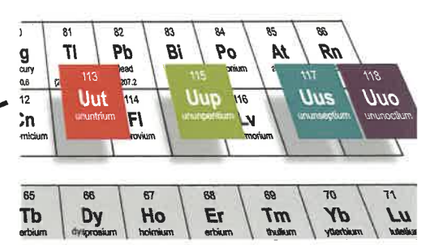
1903
Ernest Rutherford announced that atomic breakdown causes radioactivity, Rutherford and Geiger then discovered that electrons orbit atomic nuclei.

1913
Niels Bohr found electrons travel in orbitals. Frederick Soddy discovered elements emitt different radiation, allowing isotope identification.

1914
Rutherford identified protons within the atomic nucleus. Henry Moseley provided atomic numbers based on electron number rather than atomic mass. James Chadwick then discovered neutrons in 1932.

1945
Glenn Seaborg identified the lanthanides and actinides.

2015
IUPAC accepted the latest elements: Nh, Mc, Ts and Og.



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The first period 8 element is discovered!