Who Found the Elements?

By Alex Madonik

People are always looking for better materials to use in building, crafts, and art. Ancient metal workers were some of the first chemists. They learned to use the elements copper, gold, iron, lead, silver, tin, and zinc. Ancient chemists also knew the mysterious liquid metal, mercury, distilled from the red mineral, cinnabar. Metals could be combined to make useful alloys. For example, copper plus zinc gives brass, and copper plus tin gives bronze. Combining molten iron with the element carbon in charcoal makes steel.

Alchemists were early chemists who tried to convert different substances into gold. They realized that elements are pure substances . Elements cannot be separated into any other chemical components. Phosphorous is the first element whose discoverer we know by name. A German alchemist named Hennig Brand prepared phosphorus from urine in 1669. Cobalt was the next element to be discovered (in 1735), when a Swedish chemist proved it makes the blue color in "cobalt" glass. Soon after, a Spanish general extracted platinum from gold in Ecuador and published his discovery in 1748.

By the time Antoine Lavoisier discovered oxygen in the 1780s, 31 different chemical elements were known. His "Treatise on Chemistry" (1789) launched modern chemical science. Elements combine to make all of the other materials we know. For example, oxygen combines with most other elements to make minerals called oxides; rust (iron oxide) is a familiar example.

Some elements, such as sodium and potassium, were only known as salts or alkali (basic) oxide compounds. The English chemist Joseph Black (1755) recognized that magnesium oxide and calcium oxide contained different, alkali elements. He showed that they combine with another gas (we now know it's carbon dioxide) to form carbonates; chalk is calcium carbonate. Wilhelm Scheele (co-discoverer of oxygen) identified another alkaline oxide (the mineral pyrolusite, which contains barium) in 1772. In 1808, Sir Humphrey Davies and Michael Faraday learned how to separate these very reactive metals using electricity.

Chemists searched for new elements in mines all over the world. From 1770 to 1825, 17 more metallic elements were discovered, including titanium, chromium, tungsten, and uranium. Lavoisier recognized that alumina was a new metal oxide, but Danish chemist Hans Christian Ørsted was the first to purify aluminum metal (Al, element 13) in 1825. In 1869, the Russian chemist Dmitri Mendeleev organized the elements into the Periodic Table. Mendeleyev realized that Groups of elements have similar chemical properties that repeat in each row of the Table. For example, lithium, sodium, and potassium (Group 1) all form 1:1 salts with chlorine (sodium chloride is table salt). Magnesium, calcium, and barium (Group 2) all form 1:1 oxides, but 1:2 salts with chlorine. This year, we celebrate the 150th anniversary of the Periodic Table of the Elements (IYPT2019).

With Mendeleev's Table to guide them, chemists discovered yet more elements, starting with Gallium (Ga, element 31, directly below Aluminum). There were still plenty of surprises waiting; it turned out that Lanthanum (La, element 57) was the first of a whole new family of 14 elements, the Rare Earths. Even more surprising was the discovery in 1894 of Argon (Ar, element 18), a gas that makes up 1% of the air we breathe. Unlike other chemical elements, Argon forms no compounds at all. Lord Raleigh and William Ramsey went on to discover three more Noble Gases (Neon, Krypton, and Xenon); these elements joined Helium (He, element 2) as a new group on the right side of the Periodic Table.

The transformation of one element into another never occurs in a chemical reaction. At the end of the 19th century, physicists discovered that some elements are radioactive. These unstable elements are converted by nuclear reactions that change them into another element. These reactions happen when high energy particles or x-rays escape from the nucleus. Marie and Pierre Curie were pioneers in discovering radioactive elements such as Polonium (Po, element 84) and Radium (Ra, element 88).

By 1908, all of the Transition Metals (the big group in the middle of the Periodic Table) had been found, except for Element 43. Mendeleev predicted that there should be another element between molybdenum (element 42) and ruthenium (element 44); it should be similar to manganese (element 25, directly above it in the Table). Italian scientists found the new element, technetium, in a sample of radioactive molybdenum. The molybdenum was converted to technetium by high-energy particles in the cyclotron at the Berkeley Radiation Laboratory (now Lawrence Berkeley National Laboratory). Technetium was the first of many new elements created in this laboratory by nuclear reactions. Most are heavier than uranium (element 92), the heaviest element found in nature. The next to be made were neptunium (element 93) and plutonium (element 94) in 1940.

Element discovery continues, using particle accelerators that shoot atoms of one element at targets where nuclear fusion can occur with another element. Scientists at Lawrence Livermore National Laboratory in California and the Joint Institute for Nuclear Research in Dubna, Russia worked together to create the heaviest elements we know, including livermorium (element 116) and oganesson (element 118).

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This article was inspired in part by the series, "The Rediscovery of the Elements" by James L. Marshall, Professor of Chemistry at North Texas State University, and his late wife, Virginia "Jenny" R. Marshall. This series appeared over many years in the Alpha Chi Sigma newsletter, The Hexagon.

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