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Topics for Teaching: Elemental Stories

From Glyph to Element Symbol – A Story of Names

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Abstract: When I write the symbol Fe, all scientists know that I am talking about iron. Today's chemists use element symbols in formulae without thinking where they came from. This article looks at the history of element symbols and why we use the ones we do.

Keywords: Elements · Periodic table · Symbols

Mankind names things to understand them and to position them in an ordered universe. In the mystical tradition, knowledge of the real or true name endows power over a thing or a person. These ideas still persist today and are seen, for example, in T.S. Eliot's poem 'The naming of cats'.[1]

The concept of four roots of matter (*πάντων ῥιζώματα*, earth, air, fire and water) was first proposed by Empedocles (*ca.* 490 – *ca.* 430 BCE) and the description element (*stoicheia, στοιχεῖα*) introduced by Plato (*ca.* 427 – *ca.* 347 BCE). These ideas were consolidated by Aristotle (384–322 BCE) who combined them with the fundamental properties of wet, dry, hot and cold to give a philosophical structure which persisted for almost two millennia. Despite attempts to associate them with physical materials in the alchemical period, the empedoclean or aristoteleian elements did not refer to actual chemical substances and the notation used to depict them, whilst beautiful and elegant, does not concern us. In early Greek texts (dating back to at least 200 CE), the notation used for identifying astronomical objects was also used in an astrological sense to describe metals thought to possess similar properties, Thus, gold was associated with the Sun and given the symbol ☉, silver with the Moon and ☽, lead with Saturn and ♄, tin with either Jupiter or Venus and the symbols ♃ or ♀, iron with Mars and ☿ or ♂, copper with Venus and ♀, and mercury with Mercury and ☿ or ☽. The difficulties with this system become immediately obvious – the five planets known to the ancients together with additional astronomical objects such as the Sun and the Moon had to be used to describe a larger number of metals. Depending on the literary source, ♀ could stand for either tin or copper. Nevertheless, this was the beginning of a standard symbolic notation which evolved into our modern nomenclature. However, in contrast to our modern systems of nomenclature, which are intended to uniquely identify substances and enable clear and unambiguous communication, the symbols of the alchemists were designed to obscure and obfuscate, preventing the uninitiated from understanding.

In general, the principle of using a single symbol was extended to chemical compounds and Fig. 1 shows a compilation of such symbols from 1671.[2] A number of similar tables were published at this time which often differ in the detail of which symbol depicts which substance. In parallel, and again predicated upon secrecy rather than openness, symbols were introduced to describe chemical operations such as sublimation 🝞, dissolution 🝇 or distillation 🝫. In general, the symbols have little systematic meaning, and compounds are not easily related to elements; nevertheless, a few symbols hint at familial relationships, for example nitric acid (*aqua fortis*) 🜅 and *aqua regia* 🜆 have a common origin and the symbol for mercury(II) chloride (corrosive sublimate) 🜎 or 🜍 is a fusion of the symbols for mercury ☿ and sublimation 🝞.

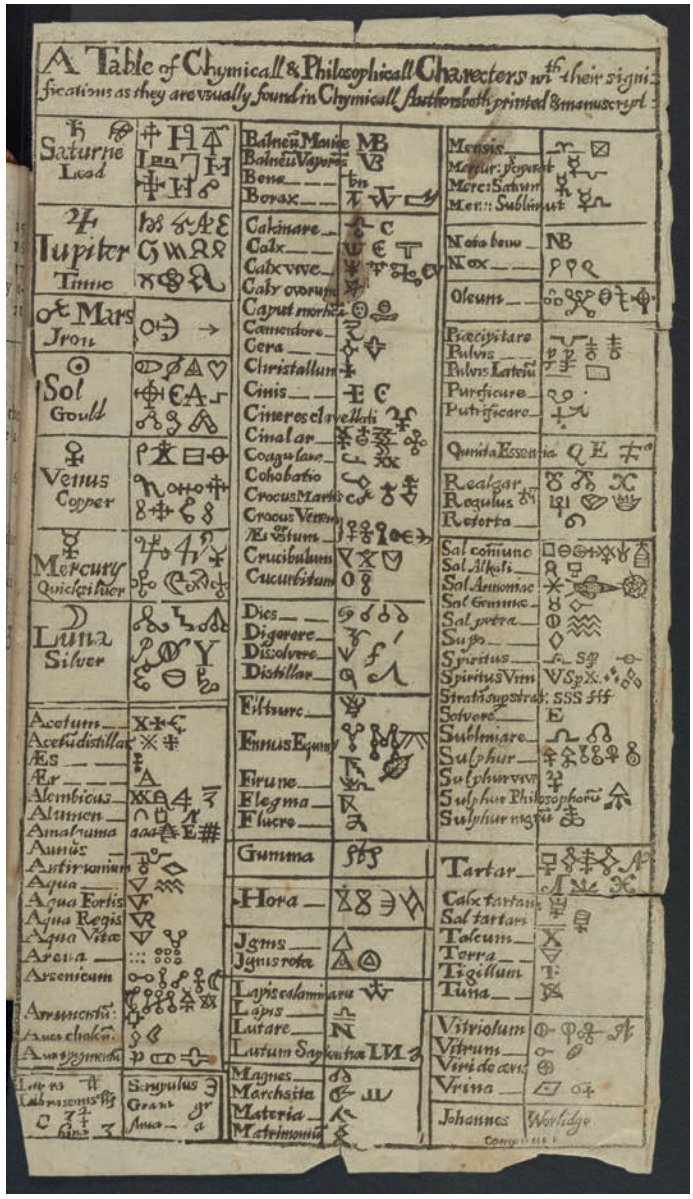

Fig. 1. A table of chemical substances and the symbols used to portray them.[2] Notable is the fact that a variety of symbols were used to portray a single substance (reproduced from *https://digital.sciencehistory.org/works/9306sz691*)

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It was only in 1789 that Antione Laurent Lavoisier (1743–1794) published his modern definition of an element.[3] His table of 33 elements contains not only elements such as iron (fer), copper (cuivre), sulfur (soufre) and lead (plomb), but also light (lumière) and heat (calorique). Remarkably, Lavoisier uses neither symbols nor abbreviations for the elements and substances that he discusses. His work on nomenclature is embodied in the publication *Méthode de nomenclature chimique* published together with Louis-Bernard Guyton de Morveau, Antoine-François Fourcroy and Claude-Louis Berthollet in 1787.[4]

It remained for another of the early greats of chemistry, John Dalton (1766–1844), to propose a notation in which elements were denoted by symbols *which could then be combined to depict molecules and compounds*. Dalton was responsible for the public acceptance of the atomic theory and this is, for the most part, due to his recognition that atoms of elements had fixed and different atomic weights. Although the ideas were first developed in 1803, the first general publication was in his book *A New System of Chemical Philosophy* published in 1808.[5] The elements in Dalton's table are arranged in order of atomic weight, and these values themselves are of some interest, with H = 1, O = 7 and N (*azote*) = 5. The discrepancies from the modern values (O = 16, N = 14) arise from an unjustified use of Occam's razor in his assumptions concerning chemical synthesis "*When only one combination of two bodies can be obtained, it must be presumed to be a binary one, unless some cause appear to the contrary*". This rule leads directly to the formulae for water and ammonia of HO and HN, and it follows from analytical results that the atomic weights of oxygen and nitrogen are one half and one third of the modern values respectively. This in turn, resulted in a confusion in chemistry that led to formulae with doubled-atoms and different workers using different molecular weights. It was only with the convening of the Karlsruhe Congress in 1860 that these difficulties were resolved with the recognition that (i) elementary hydrogen and oxygen were the diatomic molecules H_2 and O_2 respectively and (ii) that the formulae of water and ammonia were H_2O and NH_3 respectively. The set of atomic weights established at the congress has been refined in terms of accuracy, but has undergone no major changes in the past 160 years. It is also worth noting that Dalton used the term *atom* to describe both atoms and molecules, leading to an *atomic weight* for ammonia (NH) of 6. Dalton's atomic symbols consisted of a circle modified by its contents to uniquely describe an element and was a mixture of the old and the new. Some of the symbols contained few clues to identify the element (for example, symbols 1–6 in the table representing O, H, N, C, S and P, Fig. 2). More interesting are the symbols 11–25, in which the circle contains the first, the first two or the first three letters of the English name of the element (C, Fe, Ni, Sn, Pb, Zn, Bi, Sb, As, Co, Mn, U, W, Ti and Ce respectively). Nevertheless, and most importantly, the symbols could be combined to represent molecules, as in formula 37 for water (HO). The mistaken assumptions about the formulae of simple substances, combined with the fact that chlorine had not yet been isolated, resulted in rather strange representations of muriatic acid (hydrochloric acid) in symbol 39 which depicts the molecule H_3O and oxymuriatic acid (chlorine) in symbol 40 depicting the molecule H_4O.

Although his atomic theory slowly gained acceptance to assume its present status at the core of chemistry, his elemental symbols were less well-received. It is not unlikely that public acceptance of the Dalton system would have eventually led to the modern alphabetic system. However, that innovation was due to a third of the great chemists of the period, Jöns Jacob Berzelius (1779–1848). The contributions of Berzelius to the naming of the elements are contained in a five-part paper of which the fifth part entitled "*Essay on the Cause of Chemical Proportions, and on Some Circumstances Relating to Them; together with a short and easy Method of expressing them*" is the most relevant.[6] It seems appropriate to quote this text at length, as it is the basis for the element names that persist to this day "*The chemical signs ought to be letters, for the greater facility of writing, and not to disfigure a printed book. … I shall take, therefore, for the chemical sign, the initial letter of the Latin name of each elementary substance: but as several have the same initial letter, I shall distinguish them in the following manner : – 1. In the class which I call metalloids, I shall employ the initial letter only, even when this letter is common to the metalloid and to some metal. 2. In the class of metals, I shall distinguish those that have the same initials with another metal, or a metalloid, by writing the first two letters of the word. 3. If the first two letters be common to two metals, I shall, in that case, add to the initial letter the first consonant which they have not in common: for example, S = sulphur, Si = silicium, St = stibium (antimony), Sn = stannum (tin), C = carbonicum, Co = cobaltium (cobalt), Cu = cuprum (copper), O = oxygen, Os = osmium, &c*".

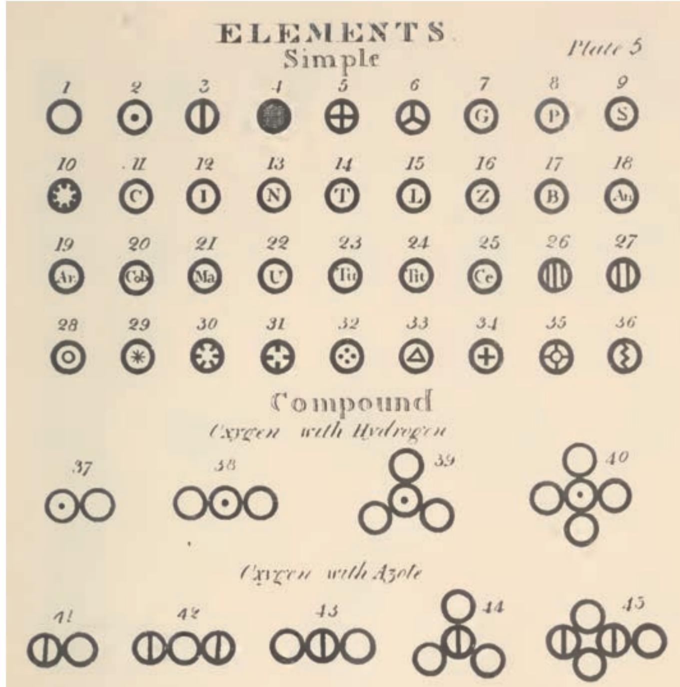

Fig. 2. Dalton's symbols and their combination to depict molecules.[5] The representations of HCl and Cl_2 in formulae 39 and 40 as H_3O and H_4O respectively are very strange to modern eyes.

In this paragraph, we see the origins of all the modern names together with emphasis on the Latin origin, which has confused generations of English schoolchildren ever since (Hg, Sn, Fe, Sb, Au, Ag *etc*…). His choice of Latin parallels the classification of living creatures by his fellow Swede Carl von Linné (Linnaeus). Berzelius also combined symbols to generate formulae, with stoichiometry expressed by superscript numbers *over* the symbol, an example being his formula for copper(II) sulfate ($CuO + SO^3$). Dalton was not a fan of the new notation from Berzelius and even after most of the rest of the scientific world had accepted the alphabetic notation, Dalton retained the symbolic form in his 1827 book[7] and in a letter to Thomas Graham in 1837 described the proposals as horrifying. His principal objection was that the Berzelius system did not allow the representation of the arrangement of atoms.

Today we accept the alphabetic system without a thought. The 726 possibilities (26 × 27) of arranging one or two letters will allow us to name any elements identified in the conceivable future. The naming of elements and assignment of the atomic symbol is not now in the remit of individuals but is delegated to International Union of Pure and Applied Chemistry (IUPAC)

Inorganic Chemistry Division and ratified by the Council of IUPAC.[8] For a more detailed discussion of the origins of chemical nomenclature and symbology, the reader is referred to the excellent book by Crosland.[9]

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