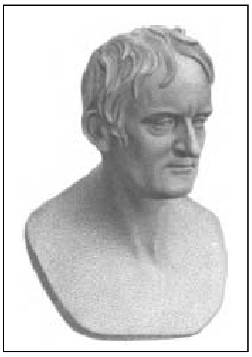
John Dalton (1766–1844)



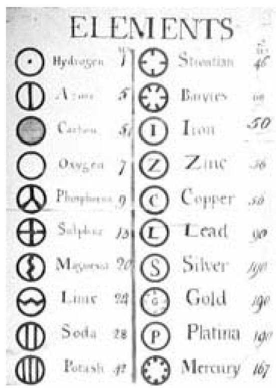
The 17th and 18th centuries saw the beginning of the systematic study of matter and the development of science in the world, especially in Europe. During this period, many important findings were made along with the development of theories in all branches of science. One of the major contributors to the developments was John Dalton. He can be considered as a chemist, a meteorologist as well as a physicist. He is best known for his pioneering work in the development of the modern atomic theory.

John Dalton was born on September 6, 1766 in the village of Eaglesfield, Cumberland, England to Joseph Dalton and Deborah Greenup, who were into farming and weaving. He had one brother, Jonathan and a sister, Mary. He belonged to a family of Quakers (Society of Friends) and had his early education at the Quaker School (Pardshow Hall) under the tutelage of his father (initially) and John Fletcher. He was a bright student and very quick in solving mathematical problems. His mathematical knowledge was brought to the attention of another wealthy Quaker, Elihu Robinson, who mentored him further in mathematics, along with science and meteorology.

In 1781, Dalton left his native village to become an assistant in a school run by his cousin, George Bewley at Kendal. In 1785, Dalton and his elder bother took over this school, after the formal retirement of Bewley, and offered courses that included languages, mathematics and sciences. In 1793, Dalton moved to Manchester to further his education and experimentation. During this period, Dalton came under the influence of John Gough, who suggested that he maintain a record of the weather and meteorological matters – which he did until his death (a sum total of 200,000 observations). John Gough was also instrumental in placing Dalton as a tutor in physics at the Manchester College (New College, founded by Presbyterians). Manchester being the epicenter of the Industrial Revolution helped Dalton in his intellectual pursuit. In 1794, Dalton was elected a member of the Manchester Literary and Philosophical Society. As part of the election to this elite body, he communicated a paper on 'extraordinary facts relating to the vision of colors' – in this paper he discusses the color blindness of some people, who see only blue, purple and yellow colors due to the optical peculiarity. This is known as Daltonism (color blindness) as he himself was color blind (See *Box* 1 on p.5).

In 1800, Dalton became the secretary of the Manchester Literary and Philosophical Society and started a systematic study of the behavior of gases. He examined the constitution of mixed gases, the pressure of steam and other vapors at different temperatures as well as the thermal expansion of gases. The various studies conducted by him enabled him to lay the foundations of the theory of gases, especially partial pressure of gases. When two elastic fluids (gases), A and B, are mixed together, there is no mutual repulsion between A and B – so the mixing would lead to an increase of total pressure in the system. During these studies he also established a mathematical relationship between the pressure of a vapor and its ambient temperature (P–T relationships). He, in fact, developed the law of the expansion of the gases, which was later stated by Joseph Louis Gay-Lussac. Many of the findings of Dalton were published in a series of articles in the *Memoirs of the Lit & Phil* in 1802.

In 1803, Dalton realized that not all gases mixed harmlessly and discovered that nitric oxide reacted with oxygen to produce a third type of gas. Thus, he investigated the formation of oxides of nitrogen by mixing nitric oxide and oxygen. His studies established that oxygen combines with a certain portion of nitrous gas or with twice that portion, but with no intermediate quantity ($NO + O \rightarrow NO_2$) or ($2\,NO + O \rightarrow N_2O_3$). This observation led to his law of *multiple proportions* – elements always combine with each other in small whole number ratios of their masses. All matter is made up of hard round particles, called 'atoms' and the differences between them arise only due to their different masses. Chemical combinations consist of the interaction of atoms of definite and characteristic mass, wherein the idea of atom itself is considered as purely a physical concept.



This thinking and concept based on atomic mass and symbols was published in 1803 and formed the basis of the language of chemistry. He based the table of atomic masses using hydrogen as the basis by giving it an arbitrary value of 1. Compounds were listed as binary, ternary, quaternary, etc., (molecules composed of two, three, four, etc., atoms) in this *new system of chemical philosophy* depending on the number of atoms a compound had in its simplest, empirical form. The atomic masses of the compounds were calculated from the percentage of the compositions.

Dalton represented the atomic structure of compounds with his own visual symbols and postulated his atomic theory.

1. All matter consists of tiny particles known as atoms.
2. Atoms are indestructible and unchangeable – atoms of an element cannot be created, destroyed, broken into smaller parts or transformed into another element.

(These postulates were arrived at based on the hypothesis of the law of conservation of masses. The discovery of subatomic particles after Dalton's time shows that atoms can, indeed, be broken into smaller parts, but his postulates are still useful in explaining the law of conservation of mass in chemistry.)

3. Elements are characterized by the mass of their atoms – atoms of different elements have different masses (Dalton used the word weight rather than mass, which chemists use even today! With the discovery of isotopes, we now have the same element exhibiting different masses and the postulate has been modified as 'elements are characterized by the nuclear charge of their atoms'.)

4. When elements react, their atoms combine in simple, whole-number ratios – this postulate helps in the explanation of the 'law of definite proportions'.

5. When elements react, their atoms sometimes combine in more than one simple, whole-number ratio – this postulate explained the weight ratios of nitrogen to oxygen in various nitrogen oxides.

Dalton also included an additional postulate: 'When atoms combine in only one ratio, it must be a binary one – unless some cause appears to the contrary'. This was found to be controversial and, in fact, delayed the acceptance of Dalton's atomic theory for many years.

Dalton's atomic theory was first proposed on 21 October 1803, before the Manchester Literary and Philosophical Society. This fundamental breakthrough attracted attention and he was soon called to repeat his announcement before the Royal Institution of London, which had a more powerful and distinguished audience. Dalton's atomic theory was accepted immediately by many researchers (Thomas Thomson, William Hyde Wollaston), but there was considerable opposition (Humphrey Davy) before everyone accepted the role of atoms in matter.

In 1804, Dalton gave the most prestigious lecture series at the Royal Institution on natural philosophy and another one in 1809–1810. In 1810, Dalton was offered the fellowship of the Royal Society (FRS), which he declined. In 1822, however, he was proposed without his knowledge and elected to the fellowship. In 1816, he was elected as a corresponding member of the French Academie des Sciences and in 1830 as one of the eight foreign fellows in place of Davy. In 1833, the government granted him a pension of 150 pounds per year, which was raised to 300 pounds in 1836. Dalton was awarded honorary doctorates from the Universities of Oxford (1832) and Edinburgh (1834). He was also a co-founder of the British Association for the Advancement of Science.

Box 1. Color Blindness and Dalton

To explain his color deficiency, Dalton proposed that the vitreous humor of his eye was tinted blue – thereby selectively absorbing longer wavelengths only. As a true scientist, he left instructions that his eyes should be examined after his death to determine the cause of his color blindness. Joseph Ransome, his medical attendant, removed his eyes and the examination of one of the eyes revealed that the humors were perfectly clear. The other eye was preserved at the Royal Institution for future investigations on color blindness. A study on the extracted DNA of the eye in the 1990's showed that Dalton had lacked the pigment that gives sensitivity to green – the classic condition known as a *deuteranope*. (D M Hunt *et al*, *Science*, Vol.267, pp.984–988, 1995). *Deuteranope* lacks the middlewave photopigment of the retina and is compatible with the historical record of his phenotype.

Dalton's health started to deteriorate in 1837 (he suffered a minor stroke and another one in 1838, which left him with speech impediment) and on July 27th, 1844 he passed away – possibly due to a heart attack. Dalton was a bachelor. The city of Manchester buried Dalton with kingly honors and the funeral was performed as for a monarch; the funeral procession was more than a mile long and was viewed by more than 40,000 people.

In honor of Dalton's work, scientists use the unit Dalton (abbreviated Da) to denote one atomic mass unit. The color blindness of Dalton is referred to as Daltonism in France.

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