A TRIBUTE TO JOHN DALTON AT HIS 250TH BIRTH ANNIVERSARY (2016)

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September 6, 2016 was celebrated as the 250th birth anniversary of the eminent English scientist John Dalton, the Father of Chemical Atomic Theory, a pioneer in Colour Blindness and the discoverer of the Law of Partial Pressures and the Law of Multiple Proportions. A Quaker by origin, Dalton did not have much formal education. Yet, by sheer diligence, perseverance and merit, Dalton rose to a great height of eminence by working mainly in Manchester during his last fifty years. An attempt has been made in this article to depict how Dalton prospered, academically speaking, from a poor Cumbrian village to become a savant of Manchester. His early life and education, his scientific activities and accomplishments in Manchester, the awards he received and his last life have been dealt with in this article. Although it is a tribute to Dalton, a few things have also been discussed about Daltonian doubts only to complete the story. Useful references and supporting photographs have also been included.

September 6, 2016 was celebrated across the globe as the 250th birth anniversary of the legendary British scientist John Dalton, the Father of Meteorology, a pioneer in studies on Colour Blindness, known as Daltonism, the discoverer of the Law of Partial Pressures and the Law of Multiple Proportions and, above all, the Father of Chemical Atomic Theory. A brief account of the life and work of John Dalton (Fig. 1) is presented herein as a tribute to this illustrious personality.

Fig. 1: Bust of John Dalton

Source : https://learnodo-newtonic.com/john-dalton-facts

Dalton's Birth

Dalton was born to Joseph Dalton and Deborah Greenup in a small cottage (Fig. 2) in Eaglesfield, a small village in Cumberland (or, Cumbria), England, U.K. The inscription inserted above its doorway towards the end of the 19th century (Fig. 3) and the R.S.C. plaque marking his birthplace (Fig. 4) are shown herein. Dalton was born in 1766, but his exact date of birth is uncertain – it is either the 5th or the 6th of September, although 6th September is stated as Dalton's actual date of birth in most of the articles on Dalton. The reason behind this discrepancy is that Dalton's parents did not record this information in their family bible – the way it was used to be done those days. But Dalton was informed much later in his life that 6th September was his date of birth, and that is how it goes on record.

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Fig. 2: Birthplace of Dalton in Eaglesfield, Cumbria, England
Source : https://learnodo-newtonic.com/john-dalton-facts

Family History and Early Education

Dalton's father was a handloom weaver of modest means who owned a small cottage and inherited an estate of about 60 acres only in 1786, a year before his death. But Dalton's mother Deborah hailed from a rich English landowner family. Both of his parents were 'Quakers', members of a Christian movement whose ideology was based on a verse of the New Testament. In fact, Dalton's grandfather, who was a shoemaker, became a Quaker in around 1695 when he got married. Since Quakers were considered as 'dissenters' by the established Church of England, Dalton received his early education and pursued his early teaching career only in dissenter schools.

Fig. 3: Inscription above the doorway of Dalton's birthplace
Source : www.sciencephoto.com/media/224682/view

Dalton's parents had six children, of which only three survived to adulthood – his elder brother Jonathan, his elder sister Mary and John himself. Dalton grew up working in the fields and in the family shop dealing with cloth, paper, pen, ink, etc. But the overall income of the family was relatively poor, for which he and Jonathan did not receive much formal education. He received basic training in the three R's in a local Quaker grammar school, John Fletcher's Pardshaw Hall. He was rather fortunate in this respect since one out of two hundred people could even read at that point of time. John Fletcher, who was also one of his teachers, inspired him to take interest in mathematics. He quickly mastered the skill of solving mathematical problems. When Dalton was ten years old, his skill in mathematics drew the attention of, *inter alia*, Elihu Robinson, a rich Quaker and an accomplished meteorologist who mentored him in mathematics, science and meteorology.

Fig. 4: Plaque marking the birthplace of Dalton at Eaglesfield
Source : https://en.wikipedia.org/wiki/List_of_blue_plaques_erected_by_the_Royal_Society_of_Chemistry

Dalton's Years at Kendal

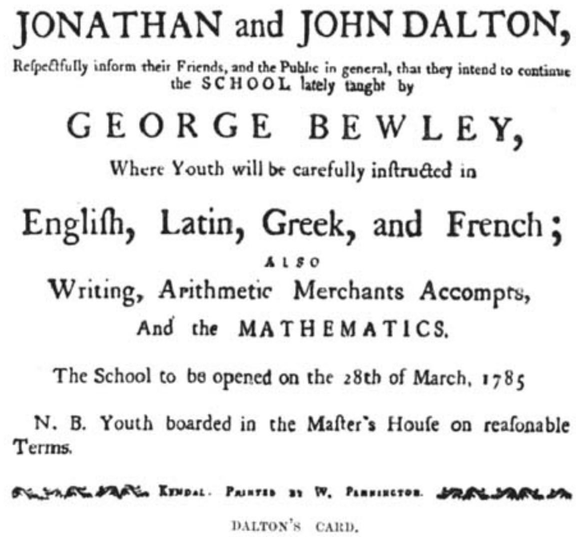
In 1778, Fletcher retired and handed over the school to Jonathan, and John started assisting his elder brother by teaching in this school. He then set up a school in his family cottage and later in the Quaker Meeting House. It wasn't a success, and the school was wound up. After two years of work on the lands, he was invited in 1781 to join, as Assistant, a Quaker boarding school in Kendal, Cumbria which was some 40 miles away from Eaglesfield, where his distant cousin George Bewley was the Principal. Dalton offered courses on a range of subjects including science, mathematics and languages, viz. Latin, Greek and French. Although the school had significant number of pupils, Dalton brothers could not earn sufficiently.

It is in Kendal where he came in contact with the English philosopher John Gough, a Quaker and the blind son of a wealthy Kendal merchant, with wide-ranging scientific interests including in optics. Gough had a profound influence in shaping Dalton as a matured scientist with multifarious interests. He inspired, instructed and mentored Dalton in science in general and meteorology in particular. It is indeed at the suggestion of Gough that Dalton started keeping a daily record of his observations on weather and meteorological matters since 1787. Since Dalton was born and reared in the mountainous Lake District, he was in a position to observe meteorological phenomena. His first entry was on the 24th March, 1787, and he maintained his daily record throughout his life. He recorded over 20,000 meteorological observations, and his last entry, which reads "*a little rain this day*", was recorded on the 27th July, 1844 when he breathed his last.

In a letter written in 1783 to his friend and naturalist, Peter Crosthwaite at Keswick, Dalton candidly acknowledged the help and teachings that he received from John Gough: "*John Gough is … a perfect master of Latin, Greek, and French tongues … but under his tution have since acquired a good knowledge of them. He understands well all the different branches of mathematics … he knows by the touch, taste and smell, almost every plant within twenty miles of this place … He is a good proficient in astronomy, chemistry, medicine, etc. … He and I have been for a long time very intimate; as our pursuits are common – viz. mathematical and philosophical …*" Pertinently, Frederick Daniell, the inventor of Daniell cell, later hailed Dalton as 'The Father of Meteorology'.

Another passion of Dalton was to collect plant parts, air-dry and press them and prepare the voucher specimens which he passed on to Crosthwaite for preservation at the Keswick Museum. He compiled an eleven-volume botanical collection, 'Hortus Siccus' (the word stemming from the Latin roots 'hortus' meaning 'garden' and 'siccus' meaning 'dry'). In his own words: "*I have at length compared the book of plants and made an index both to the Linnaen* (the word stemming from Linnaeus' *Species Plantarum* of 1753, the starting point for modern botanical nomenclature) *and English names*." This herbarium compiled by Dalton is still preserved at the Manchester Public Library. He also made observations on the metamorphosis of caterpillars.

In 1785, Bewley retired from the Kendal school, and Dalton joined the school as the Joint Principal along with his elder brother, and his sister Mary moved from Eaglesfield to Kendal to become the housekeeper. Dalton continued in this position till the age of 26. A copy of Dalton's Card at Kendal school, 1785 is shown in Fig. 5.


JONATHAN and JOHN DALTON,

Refpectfully inform their Friends, and the Public in general, that they intend to continue the SCHOOL lately taught by

GEORGE BEWLEY,

Where Youth will be carefully inftructed in

Englifh, Latin, Greek, and French;

ALSO

Writing, Arithmetic Merchants Accompts,

And the MATHEMATICS.

The School to be opened on the 28th of March, 1785

N. B. Youth boarded in the Mafter's Houfe on reafonable Terms.

KENDAL. PRINTED BY W. PENNINGTON.

DALTON'S CARD.

Fig. 5: Dalton's Card at Kendal school (1785)

Source : From Ref. 9

From 1787 onwards, Dalton, the 'teacher of the mathematics in Kendal', enjoyed increasing reputation for his successes in the yearly puzzles and prize competitions of the *'Ladies' Diary'*. This journal, also known as 'Women's Almanack', was first published in London in 1704. Thereafter it appeared annually till 1841, after which it was succeeded by '*The Lady's and Gentleman's Diary*'. The *Ladies' Diary* was one of the most popular mathematical periodicals, in which both men and women contributed mathematical problems and matters of debate. It also featured items like information on sunrise and sunset times, phases of the moon, eclipses, holidays, school terms and even a chronology of remarkable events.

But despite all his successes, Dalton had to give public lectures in order to make money. In 1787, he gave a course of 12 lectures in Kendal on mechanics, optics, pneumatics and astronomy (fees: 10 shillings) and later a lecture on fire (fees: 5 shillings), in which he used school's apparatus including globes. He even offered to sell his extensive botanical collection, stated above, to a local museum only to make his living.

In Dalton's view, the emoluments of a Quaker school master "*are not sufficient to support a small family with the decency and reputation I could wish.*" Clearly, he was driven by a desire to shift to a new profession with '*expectation of greater emolument*'. In 1790, Dalton carried out another experiment which was an indicator of his desire to shift to medicine - he measured his own intake of food and his loss by excretion in order to determine the loss by respiration and perspiration. Indeed, Dalton wrote in 1790 to Bewley, Robinson and his uncle Thomas Greenup, a

London Barrister, seeking their advice on the prospect of his studying medicine. But the replies were in the negative. Greenup, in particular, strongly advocated against studying medicine and suggested instead that he should better study apothecary or law.

Years at Manchester: Golden Era

In 1791, Dalton offered another series of public lectures. In 1792, he paid his first visit to London to attend the annual meeting of the Society of Friends (i.e. Quakers' Society). At this stage, Dalton was once again rescued by Gough who exerted his influence (recommendation) to get Dalton in 1793 the position of a Tutor (Professor) in mathematics and natural philosophy in a dissenter college, called the 'New College', founded in 1786, in Manchester where he started earning £ 80 annually. The city of Manchester was at that point of time dramatically expanding and was a hubbub of activities – the base of famous 'industrial revolution' and a place of intellectual exercises. The Governing Body of the New College included Officers of the Manchester Literary and Philosophical Society, founded in 1781 and commonly known as the 'Lit. & Phil.'.

Initially, Dalton was very happy with this new assignment because he got access into a well equipped laboratory where he could pursue his experiments and into a rich library where he could read the best of books in various subjects. His satisfaction was vividly expressed in his letter to Robinson: "*There is in this town a large library [Chetham's], furnished with the best books in every art, science and language, which is open to all gratis; when thou are apprised of this and such like circumstances, thou considerest me in my private apartments, undisturbed, having a good fire, and a philosophical apparatus around me, thou wilt be able to form an opinion whether I spend my time slothful inactivity of body and mind*."

After coming to Manchester, Dalton published his first book on meteorology entitled 'Meteorological Observations and Essays' (London, 1793; 2nd ed., 1834), a collection of essays based on his observations and on those of Gough and Crosthwaite. This work provided tables of barometric pressure, temperature, wind, humidity and rainfall and details on the occurrence of snow, thunder and '*Aurora Borealis*'. He hypothesised on the origin and nature of the auroral arches. He calculated the height of the auroral arches twice – first time on the aurora of the 15th February, 1793 when the height was calculated to be 150 miles above the earth's surface, and later on the aurora of the 29th March, 1826 when the height was measured to be 100 miles above the surface of the earth. Indeed, a catalogue of auroræ observed between 1796 and 1834 was later added to the book.

Dalton's early research work in meteorology created in him a deep interest in the state of water vapour in the atmosphere. His essays included his ideas on evaporation, and he advanced a theory on it, "*which as far as I can discover, is entirely new, and will be found, I believe, to solve all the phenomena of vapour we are acquainted with*." In fact, the ideas that air is not a vast chemical solvent and that every gas in a mixture of gases acts as an independent entity (later developed as Law of Partial Pressures) was first stated in his aforesaid book on meteorology. Dalton was elected a Member of the Manchester Society in October, 1794.

On Dalton's Colour Blindness

The British website QI (i.e. Quite Interesting) described how Dalton realised for the first time that his vision was different from that of others. When Dalton was 26 years old, he purchased a pair of stockings, which looked blue to him, as a gift to her mother on her birthday. But the colour was actually scarlet, which caused a bit of scandal in his family since this colour was incompatible to the dress code of a devout Quaker, her mother. This incidence was an eye-opener to one of Dalton's traits, viz. his colour blindness.

It was not until this point of time did he realise that he could not distinguish between green and red colours. The pink flowers of 'zonal geranium' or 'horshoe geranium' (*Pelargonium hortorum*; family: Geraniaceae) appeared sky-blue to him in the daylight but nearly yellow with a reddish tinge in candle light. Dalton knew that his brother had the same problem and that brothers in other families also suffered from a similar defect. He rightly realised that this defect was hereditary. To him, red sealing wax was a good match for the outer face of a laurel leaf, and the colour of a crimson ribbon matched that of mud. In contrast to a normal observer's seven colours in the solar spectrum, Dalton saw mainly two hues - one corresponding to the normal observer's green, yellow, orange and red and the other corresponding to violet, indigo and blue.

It's true that this defect of vision had been known earlier, but Dalton was the first person to try to trace the cause of it scientifically. In order to explain this failure of colour constancy, he hypothesised that the vitreous humour of his eyes was tinted blue, selectively absorbing longer wavelengths of light. He was the first person to present a paper entitled '**Extraordinary Facts Relating to the Vision of Colours, with Observations**' on colour blindness in the Manchester Society on October 31, 1794. This paper was published later in 1798 (*Manchester Memoires*, vol. 28) and reprinted elsewhere in 1831.

Dalton was so dedicated to science that he wanted his hypothesis to be checked after his death by dissecting his eyes. In fact, on the day following Dalton's death, his medical attendant, Joseph Ransome did an autopsy and collected the humour of one of Dalton's eyes, but it was found to be perfectly alright. Thus, Dalton's hypothesis that colour blindness is due to a pre-retinal filter proved to be wrong. It is now known that hereditary colour blindness seldom arises from either a pre-retinal filter or a central defect but is rather due to the absence or alteration of either or more of the three types (shortwave, middlewave and longwave) of photosensitive pigments of retina.

Indeed, two centuries after Dalton's paper was presented, a group of scientists from the University of London and the University of Cambridge made experiments with the DNA extracted from the tissue of Dalton's second eye (Fig. 6), preserved initially at Dalton-Ellis Hall (one of the Halls of Residence owned by the University of Manchester) and later passed on to the Manchester Literary and Philosophical Society, and demonstrated that his retina lacked the middlewave pigment – he was a deuteranope.[12] Although Dalton's theory was proven to be wrong, colour blindness is often referred to as "Daltonism" not only in English but also in French, Russian and Spanish in honour of Dalton's pioneering work in this field.

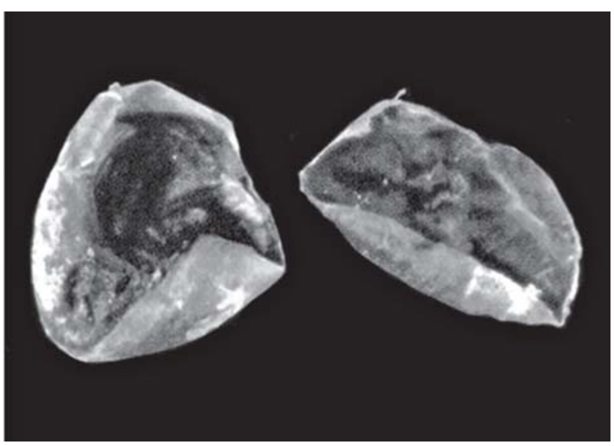


Fig. 6: Preserved fragments of Dalton's eyes (photographed: 1892)

Source : From Ref. 12

Throughout his life, Dalton remained a bachelor. As early as 1794, Dalton's comment on marriage was: "… *my head is too full of triangles, chemical processes, and electrical experiments, etc., to think much of marriage*."

Resignation from New College

The joy and enthusiasm that initially overwhelmed Dalton at the new College slowly sublimed with the passage of time. The reasons were manifold. For the first time, he had to offer college level mathematics and natural philosophy, for which he had to devote a lot of time for the preparation. Secondly, he had to attend upon students 21 hours a week and undertake walking tours in the summer vacations. Also, he used to attend regular local and occasional regional Quaker meetings and periodically visit his home town in the Lake District. Additionally, he had to deliver yet another set of Kendal lectures in 1796. All these activities consumed most of his energy and left him with little time for his own academic and intellectual pursuits. The fact that he was the lowest paid (£ 52.10 p.a. plus *ca*. £ 50 in fees) of the three Professors might have contributed to his dissatisfaction over the teaching job. No wonder, he announced on March 26, 1800 his intention to resign from the Kendal assignment at the end of the course. Clearly, he planned to start an independent career. Nevertheless, Dalton's twelve years in Kendal played a crucial role in his intellectual development.

In 1800, Dalton opened his private 'Manchester Academy', in which he offered tuition in mathematics, experimental philosophy and chemistry. In no time it became a success. After a period of two years, Dalton observed: "*My Academy has done very well for me hitherto. I have about eight or nine day pupils at a medium, at ten guineas per annum, and am now going upwards of twenty lessons per week, privately, at two shillings each besides. I am not yet rich enough to retire, notwithstanding*." It is widely acknowledged that Dalton's Academy, amongst other similar Academies, contributed enormously to the build up of English science in that era.

Golden Era: Development of Two Laws and Atomic Theory

In 1800, Dalton became the Secretary of the Manchester Society, founded in 1781. During 1799-1800, he presented three papers to the Society. In the first one, he discussed on the balance between rain, dew, river water run-off and evaporation in nature, where he provided the earliest definition of dew point. His two subsequent lectures dealt with his belief in fluid of heat and his acceptance of calorific theory of heat proposed earlier by Irvine and Crawford.

Then came the dramatic development in 1801 – in September this year, Dalton published his paper entitled 'New Theory of the Constitution of Mixed Aeriform Fluids, and particularly of the Atmosphere' in the monthly *Journal of Natural Philosophy, Chemistry and the Arts*. His theory of mixed gases presented in this paper was quickly supplemented by three papers to the Manchester Society, wherein he stated "*When two elastic fluids, denoted by A and B, are mixed together, there is no mutual repulsion amongst their particles; that is, the particles of A do not repel those of B, as they do one another. Consequently, the pressure or whole weight upon any one particle arises solely from those of its own kind*." This was the first formal enunciation of Dalton's Law of Partial Pressures (gases). Put simply, this law states that in a mixture of non-reacting gases, the total pressure exerted by the gas mixture is equal to the sum of the partial pressures of the individual gases. Pertinently, in the same year (1801), his second book entitled 'Elements of English Grammar: or a New System of Grammatical Instruction for the Use of Schools and Academies' (R & W. Dean, Manchester, 1801; 2nd ed., London, 1803) was published.

The three papers of Dalton published in *Manchester Memoirs* were abstracted and reprinted in the continent, and it triggered rapid and widespread mixed reactions amongst the chemists. Some accepted it, some were sceptical and some even vehemently opposed it. Criticism came from chemists like Berthollet and Humphry Davy (*System of Chemistry,* 1st ed., 1802)**.** In defence of his theory, Dalton wrote in two journals, but to no avail. Solid experimental proof in support of his theory was the need of the hour.

Dalton's search for a proof was thus on. He began experiments into the proportions of various gases in the atmosphere, which raised the whole issue of the solubility of gases in water. Thus, what began as Dalton's interest in meteorology ended up in his discovery of the atomic theory. In November, 1802, he presented in the Manchester Society his new findings in a paper entitled 'On the proportion of the Several Gases or Elastic Fluids, Constituting the Atmosphere; With an Enquiry into the Circumstances Which Distinguish the Chemical and Mechanical Absorption of Gases by Liquids'. What he stated therein is that carbon dioxide is held in water merely by the pressure of the gas and not guided by chemical affinity. Later, William Henry, a close friend of Dalton, made his own experiments to ascertain the order of affinities of gases for water. The results not only supported Dalton's views on the mechanical nature of absorption of gases in water, but also additionally revealed that the mass of gas absorbed by a given volume of water at a given temperature is proportional to the pressure of the gas, later known as Henry's Law.

Dalton continued to grapple with 'the theory of the absorption of gases in water and other liquids'. On October 21, 1803, he presented to the Manchester Society a paper (published later in 1805) with the aforesaid title. Therein he dealt with the issue, put crudely, as to '*why does water not admit its bulk of every kind of gas alike*'*?* His reply was: "*This question I have duly considered,… I am nearly persuaded that the circumstance depends upon the weight and number of the ultimate particles of the several gases; …. An enquiry into the relative weights of the ultimate particles of bodies is a subject, as far as I know, entirely new; I have lately been prosecuting this enquiry with remarkable success…* ". This paper was followed by a 'Table of the relative weights of the ultimate particles of gaseous and other bodies' which was the first list of what we now call 'atomic weights'. In this paper, he hinted at the supposed existence of atoms.

Dalton was immediately invited by the Royal Institution, London to explain his work. In December, 1803, Dalton explained before a coterie of eminent scientists including Humphry Davy how the various nitrogen oxides might be given formulae as well as particle weights that were in agreement to Davy's own experimental results. Yet, Davy dismissed Dalton's ideas as 'merely speculative'. This dismissal was perhaps a kind of blow to Dalton as Davy was a highly regarded chemist at that time. The following year witnessed mainly the controversy over Dalton's theory of mixed gases, particularly the denial of its weak chemical affinity forces, and over the failure of his particle weight studies to provide convincing evidence in its support. During 1805, Dalton revised his theory on mixed gases, which appeared to strengthen the view that his work on particle weight studies was of fundamental importance.

In 1804, Dalton had a private meeting with Thomas Thomson in the house of William Henry, a student of Thomson. This meeting was important because it was Thomson who gave the first publicity to Dalton's views in his book 'A New System of Chemistry' published (3rd ed.) in 1807. The series of lectures that Dalton delivered in London in 1803, in Manchester in 1805 and in Edinburgh in 1807 clearly reflected that Dalton's initial interest in mechanics, meteorology and mixed gases was slowly drifting towards chemistry. While Dalton spoke on his ideas on the properties of matter in his 1803 lectures in an orthodox fashion, he talked on "General properties of matter - extension - divisibility - original ideas on the division of matter into elements and their composition - …" in his 1807 lectures. He increasingly felt the need to define the exact nature of the ultimate particles whose relative weights he was dealing with. In his 1807 lecture series, he for the first time made mention of the word ‘atom’ in the sense of “smallest particle possessing a given nature.” In his lectures, he considered elastic fluids, liquids and solids as consisting of matter, surrounded with atmosphere of heat. He reckoned, fifteen of the eighteen fluids known to him were compounds.

The concept of atoms wasn’t really new. It was already there in both the Hindu and the Greek philosophies. Kanãda, a Hindu sage-cum-philosopher, founded around the 6^{th} or the 2^{nd} century BC the Vaisheshika school of philosophy which stated that all matters are made up of an indestructible particle named ‘*anu*’ (atoms or molecules?), that these particles can combine with each other to form ‘dvyanuka’ (i.e. diatomic molecules) and ‘tryanuka’ (i.e. triatomic molecules) and that these particles could be combined in many ways to bring about (chemical) changes using external factors such as heat. Most importantly, the name ‘kanada’ stemming from the Sanskrit roots ‘kana’ (interpreted as ‘atom’, particle or grain) and ‘ad’ (meaning ‘to eat’) meant ‘atom eater’.

In 430 BC, Democritus, a disciple of a well known Greek philosopher Leucippus, first proposed (i) that all matters are built up of ‘*atomos*’, literally meaning ‘indivisible’, which are uniform, solid, hard, incompressible and indestructible, (ii) that they move in infinite numbers through empty space until stopped and (iii) that differences in atomic shape and size determined the various properties of matter. But both the views were only of historical importance and had no scientific value since neither was based on observations or experiments. It was Dalton who first put the atomic theory on a scientific basis by virtue of his numerous chemical experiments carried out during the period 1803-1807.

Dalton published his results in 1808 in his new book ‘A New System of Chemical Philosophy’ (1^{st} ed., vol. I, pt. 1, 1808; pt. 2, 1810; vol. II, pt. 1, 1827; 2^{nd} ed. of pt. 1, 1842). Hereto he appended extended and revised tables of atomic weights (pt. 1, p. 219; pt. 2, p. 546), and he published a new law, now known as ‘Dalton’s Law of Multiple Proportions.’ Based on the results of his own experiments and keeping in view Lavoisier’s Law of Conservation of Mass (1789) and Proust’s Law of Definite Proportions (1799), Dalton developed his law: ‘If two elements form more than one compound between them, the ratios of the masses of the second element which combine with a fixed mass of the first element will be ratios of small whole numbers.’ This law can be best explained in terms of carbon dioxide. He found that 12 grams of carbon could combine with 16 grams of oxygen to form what we now call carbon monoxide and with 32 grams of oxygen to form what we call carbon dioxide. The ratio of the masses of oxygen is 16:32, i.e. 1:2. Of course, now it is known this law holds good only for simple molecules and fails in many cases.

In response to Dalton’s Law of Multiple Proportions, the Swedish chemist Berzelius wrote to Dalton: “*The law of multiple proportions is a mystery without the atomic theory*”. And Dalton proposed his atomic theory which says: 1. Elements are made up of tiny particles, too small to see, called atoms. 2. Atoms of a particular element are identical in all respects. 3. Atoms of different elements have different masses (atomic weights), their properties are different and their chemical reactions are different. 4. Atoms can neither be created nor destroyed in any chemical reaction, only the grouping changes. 5. Atoms of elements combine (in whole number ratios) to form compounds.

He laid the foundation of chemical notation by publishing diagrams of atoms and of how atoms combine to form compounds - binary, ternary and quaternary (Figs. 7, 8). In this diagram, he represented atoms of different

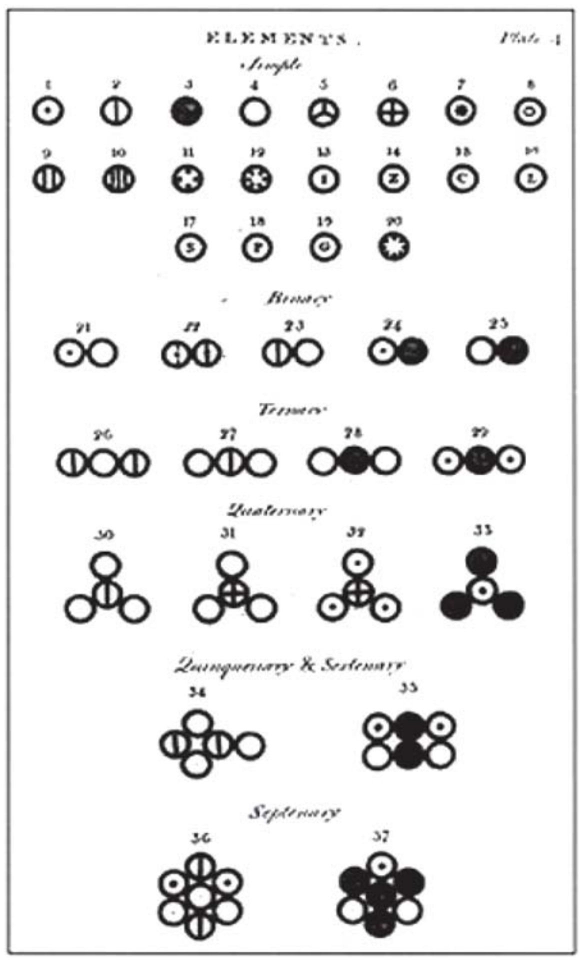


Fig. 7: Dalton’s representation: aoms and molecules
Source : https://learnodo-newtonic.com/john-dalton-contribution

elements by circles and assigned numbers to atoms of different elements, e.g. 1 to hydrogen, 2 to nitrogen, 3 to carbon, 4 to oxygen, 5 to phosphorous, etc. Atoms of different elements could be differentiated by the contents within the circles. Although some of his representations of compounds are now known to be wrong, his system of atoms and molecules is almost identical to how we might represent them today. Dalton used three-dimensional 'ball-and-stick' models, made for him by his Civil Engineer friend Peter Ewart in 1810, for teaching in classes as well as for his own studies. These models are preserved in the Science Museum, London.

Dalton became a Vice-President of the Manchester Society in 1808.

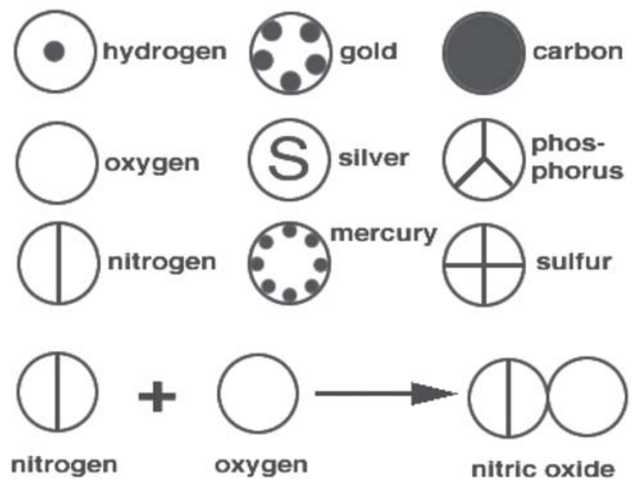


Fig. 8: Dalton's representation: formation of compounds

Source : www.brooklyn.cuny.edu/bc/ahp/FonF/dalton.html

In his second series of lectures in the Royal Institution in 1810, published as the part II of his book 'A New System of Chemical Philosophy', he elaborated and defended his own ideas on atomic theory. There he publicly abandoned for the first time the unity of matter by saying: *"… it has been imagined by some philosophers that all matter, however unlike, is probably the same thing. … this does not appear to have been [Newton's] idea. Neither is it mine. I should apprehend there are a considerable number of what may be called elementary principles, which can never be metamorphosed, one into another, by any power we can control."*

Dalton continued to defend his atomic theory in his 1811 publication in Nicholson's *Journal*. He stated: "*…atoms of different bodies may be made of matter of different densities. … mercury, the atom of which weighs almost 170 times as much as that of hydrogen, I should conjecture was larger, but by no means in proportion of the weights.*"

Flaws of Dalton's Atomic Theory

It is now known that Dalton's atomic theory was not fully correct. With the subsequent discovery of electrons, protons and neutrons by Thomson, Rutherford and Bohr, atoms can no longer be considered to be indivisible. Also, the idea that atoms of any particular element are identical in all respects has been rendered invalid since the discovery of isotopes, i.e. atoms with same atomic number but different mass numbers, e.g. ^{35}Cl and ^{37}Cl. Further, another important flaw of Dalton's atomic theory was the existence of both atoms and molecules. This flaw was corrected in 1811 by Avogadro who clearly distinguished between atoms and molecules. Based on his studies on the volumes at which various gases reacted, Avogadro deduced the diatomic nature of many gases and was able to give a more accurate estimate of the atomic masses of numerous gaseous elements.

The flaws of Dalton's atomic theory notwithstanding, Dalon's work received much acclaim from the scientific community "*because, in simple terms, he indicated the way ahead,*" as was noted by Cardwell, the Editor of *John Dalton and the Progress of Science* (papers presented in the two Conferences held to commemorate the Bicentenary of Dalton's birth), Manchester University Press, 1968. Even Humphry Davy, who strongly opposed Dalton's atomic theory, admitted some fifty years later that Dalton was right and that all matters were atomic in nature. Dalton's atomic theory triumphed over its weaknesses primarily because his foundational argument was correct.

Special Honours Received by Dalton

In 1816, Dalton willingly accepted his election as a Corresponding Member of the 'French Académie des Sciences'. He visited Paris where he came in contact with eminent scientists like Berthollet, Gay Lussac, Ampère and the like. He even attended a meeting of the Academy where he was introduced by Gay Lussac, the then President. In 1817, Dalton became the President of the Manchester Society – a position that he continued till the end of his life. Although Dalton had declined an invitation to become a Fellow of the Royal Society of London in 1810, he was elected a F.R.S. in 1822 without his knowledge and consent. In 1826, Dalton received (one of the first two recipients) the Society's Royal Medal 'for his development of the chemical theory of Definite Proportions, usually called the Atomic Theory, and other discoveries.' In his Presidential address, Humphry Davy said: "*Mr. Dalton's permanent reputation will rest upon his having discovered a simple principle, universally applicable to the facts of chemistry*

– *in fixing the proportions in which bodies combine, and thus laying the foundation for future labors … his merits in this respect resemble those of Kepler in astronomy*." One can't perhaps imagine a better compliment to Dalton's contribution.

After the death of Humphry Davy, Dalton earned the honour of being elected a 'Foreign Associate' (out of a total of eight Foreign Associates) of the French Academy in 1830. In 1834, he was elected a Foreign Honorary Member of the American Academy of Arts and Sciences. Dalton was intimately associated with the British Association for the Advancement of Scince since its foundation meeting in York in 1831. From 1805 to 1835, Dalton delivered many lactures in Manchester, Edinburgh, Glasgow, London, Birmingham and Leeds. He also delivered lectures in Pharmaceutical Chemistry in Pine Street Medical School, Manchester during 1824-1825 and also in Manchester School of Medicine and Surgery for six years from 1824 onwards. All these lectures helped him earn substantial income. He received many civil honours – he received the honorary degrees of D. C. L. (University of Oxford, 1932) and L. L. D. (University of Edinburgh, 1834). From 1832 to 1836, Dalton chaired many committees of the British Association and became Sectional Vice-President twice – in Dublin (1835) and in Bristol (1836). He was to become the President of the Association in its 1842 session, but by then he became too ill to officiate and he was declared the Vice-President. Dalton was also honoured by the Berlin Academy of Science, the Munich Academy of Science and the Natural History Society of Moscow.

Rejection of Dalton's Last Paper

Indeed, the Manchester Society immensely encouraged Dalton's scientific pursuits and played a crucial role in shaping his future as a highly regarded scientist. Dalton presented 117 papers to the Society. Pertinently, Dalton's last paper to the Society was read only three months before his death. Dalton had submitted only four papers to the *Philosophical Transactions of the Royal Society*. Of these, the last paper entitled 'On the Phosphates and Arsenites', submitted in 1839, was rejected for publication on the ground that it was too feeble and obscure. Dalton had to get it printed privately. Deeply mortified at this rejection, Dalton lamented that "*Cavendish, Davy, Wollaston and Gilbert are no more*." But much of Dalton's papers documented in the Society's publications, the *Manchester Memoirs*, were destroyed in an air-raid of 36, George Street, the seat of the Manchester Society, on the 24^{th} December, 1940, and only 26 papers could be saved and restored. A replica (original copy destroyed in air-raid of 1940) of Dalton's portrait (W. Allen, 1814) kept at the Manchester Society is shown in Fig. 9.

Fig. 9: Dalton's portrait (replica) at the Manchester Society

Source : From Ref. 9

Dalton's Last Days in Manchester

Although a Cumbrian, Dalton was always claimed by the people of Manchester as one of their own. In order to honour this savant of Manchester, they set up a committee who raised £ 2,000 for a statue. In May, 1834, Dalton

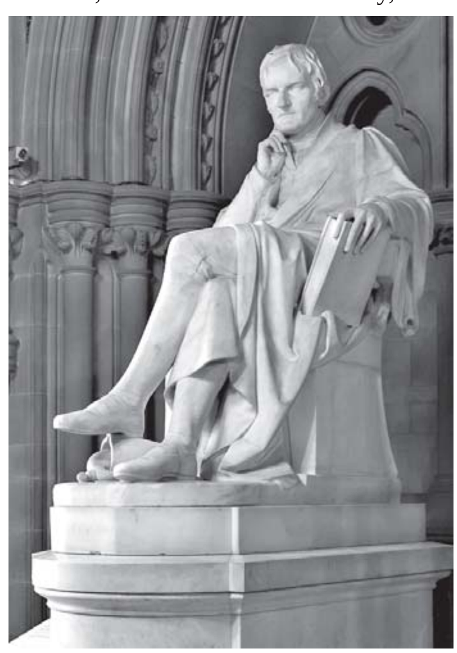


Fig. 10: Statue of Dalton at Manchester Royal Institution

Source : https://learnodo-newtonic.com/john-dalton-facts went to London to sit before the famous English sculptor Francis Leggatt Chantrey, and the statue, delivered in 1938, was set up in Manchester Town Hall (Fig. 10). Dalton is perhaps the only scientist who had a statue in his lifetime. In fact, there are three statues of Dalton in the Manchester city. Besides, the science building of the Manchester Metropolitan University is named after Dalton.

Despite Dalton's immense contribution to science, he was not reach enough – even at the age of 60 years, he had to do private tution to students to teach mathematics only to make a living. Some of his friends and admirers tried to get him a pension from the then Lord Grey's government only to be told that "… *it would be attended with great difficulty*." However, their efforts eventually met with success, and Dalton was granted a modest civil pension of £ 150 p.a. in 1833, which was doubled in 1836. Pertinently, Dalton used to undertake trekkings in Lakeland for one or two weeks every summer during 1812-1836 with the purpose of, as Dalton himself noted: "… *for relaxation from professional engagements, and … spent the time in breathing the salubrious air of the mountains and lakes near my native place, in the North of England*." Dalton also used to play game of bowls. Although Dalton was a devout Quaker and remained a bachelor throughout his life, he had 'affection and admiration of women', as was revealed from a letter written by him to Rev. William Johns in 1809 during his rail journey to the Royal Institution in the same year.

Dalton used a large number of simple apparatus for his research. The same were catalogued and preserved in the Mancheser Society, but it was almost destroyed in the 1940's air-raid. Nevertheless, a list was reproduced with the help of the photographs taken earlier in 1904 and is there in Cardwell's book of 1968. Some of the equipment he used are thermometer, barometer, manometer, hydrometer, eudiometer, lenses, specific gravity bottles, weight boxes, etc.

During 1804-1832, Dalton lived with the family of Rev. William Johns at 10, George Street, Manchester. In his last years, he was looked after by a Houskeeper at 27, Faulkner Street. In April,1837 when Dalton was 71 years old, he suffered a stroke which rendered him partially paralytic. A year later he had another mild stroke, after which he could not speak properly. At the age of 77, Dalton suffered a third stroke. In the morning of July 27, 1844, he fell from his bed to the floor, and his attendant found him dead when he came to serve him tea.

His body was laid to rest at the Manchester Town Hall for four days, during which period more than 4,000 people visited his body.The city of Manchester gave him a civic funeral, in which his coffin was carried in a one mile long procession of nearly one hundred carriages to the burial at the Ardwick Cemetery, then at 116, Hyde Road, Manchester and now destroyed (stones of Dalton Memorial at Ardwick Cemetery was later moved; Fig. 11). Even the shops and offices in Manchester city were kept closed for the day as a mark of respect. Two scholarships each in chemistry and mathematics were later instituted by the Owens College in honour of Dalton's memory. Dalton thus received recognition from both the scientific and the non-scientific communities at large at the end of his lifetime.

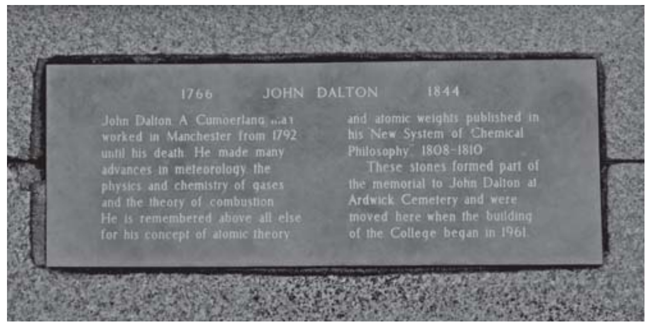


Fig. 11: John Dalton Green Plaque at Manchester
Source : openplaques.org/plaques/10198

Daltonian Doubts

Despite Dalton's tremendous accomplishments, the question as to how Dalton came up with his atomic theory has been debated over more than 150 years (1845-2005). Some historians alleged that Dalton was influenced by, or even aware of, the atomic theories proposed by the three London-based scientists Bryan Higgins, his nephew William Higgins and William Austin whose work had already been published by then. But most of the historians gave no credence to this allegation since Dalton was mostly isolated to Manchester throughout his lifetime and, as argued by Kelham: "*Dalton's ideas were almost certainly derived independently of this group [the London atomists], which only assisted him by paving the way for his ideas and making them readily acceptable in the metropolis.*"

Epilogue

The present article is by no means a full depiction of the life and work of John Dalton. Only an attempt has been made to cite and cover the more important and significant aspects of his personal life, his academic pursuit and his achievements. If it triggers curiosity even in the minds of some of the readers, this write-up may be considered to serve its purpose.

As one may imagine, there are a number of publications on the life and work of John Dalton. But W.C.

Henry, the son of William Henry famous for Henry's Law, was named by Dalton as his official biographer, and he produced a biography of Dalton in 1954. Some of the leading references are presented in the following bibliography[1-17]. A plaque to commemorate the bicentenary of Dalton's Atomic Theory is shown in Fig. 12.

Fig. 12: 'Bicentenary of Atomic Theory' plaque

Source : openplaques.org/plaques/968

The humility of Dalton is perhaps best expressed in his following statement (Fig. 13).

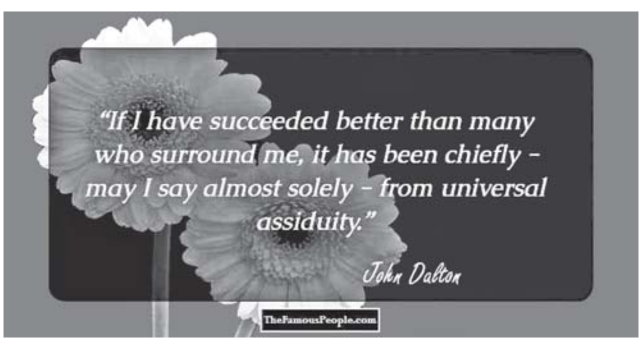


Fig. 13: Humbleness of John Dalton

Source : www.thefamouspeople.com/profiles/john-dalton-4880.php

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