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FAMOUS NAMES IN CHEMICAL HISTORY

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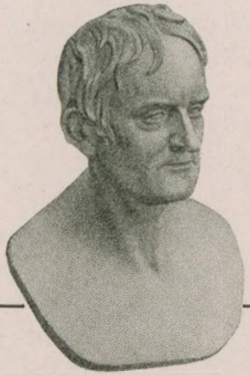
LABORATORY AND PHARMACEUTICAL DIVISION
CORNING GLASS WORKS, CORNING, N. Y.



JOHN DALTON

The Quaker School Teacher Who Gave To The World The Atomic Theory

A TEACHER who never went to school after he was eleven years old. A voluminous writer who seldom read books. A public speaker with a harsh voice and mumbling speech. A pioneer in chemistry who was color-blind and had little skill in the laboratory. Such was John Dalton, father of the Atomic Theory and the Law of Multiple Proportions. Sir John Herschel called his achievement "next to the law of mechanics, the most important which the study of nature has yet disclosed."

He was born in rural England in 1766, one of several children. His father was a weaver. None of his family or relatives rose above the commonplace, but in him there was a strain of something very like genius.

At the age of twelve, he secured permission to start a school in his native village of Eaglesfield in Cumberland, and was its sole teacher for two winters. He had previously completed a course in mensuration, surveying and navigation.

Then he took a position as assistant to his older brother who was conducting a school for Quaker children. At the age of eighteen he became the principal and for eight years held this position, studying Latin, Greek, French, mathematics and natural philosophy (physics) in his spare time. During this period two habits were started that were to continue throughout most of his life: The recreation of bowling on the green, and the hobby of filling a long succession of note books with detailed observations on the weather.

After eleven years in this school he was for six years a tutor in mathematics and natural philosophy at the New College in Manchester, starting with a salary of "not less than eighty pounds per year."

We are dealing up to this point with a bony, wiry school teacher, of unattractive appearance and "ungainly" manners, little inclined to change his job, and distinguished only by habits of self-reliance, perseverance and concentration of thought.

His first published paper was "Meteorological Observations and Essays," in 1793. The following year he joined the Manchester Literary and Philosophical Society, before which he read a paper on color-blindness, in which he maintained it resulted "because one of the humours of my eye is a colored medium, probably some modification of blue." So novel was his attempt to study this defect in vision in a scientific spirit that this inability to distinguish red was called "Daltonism."

Dalton never married, but always enjoyed conversing with alert-minded intelligent women. At one time, romance seemed near. In 1796 he wrote to his brother pages in praise of two sisters, especially one of them. He said, "I dwell with pleasure upon the character of these two amiable creatures." He was even moved to write poems, but he was better in mathematics.

And so he came to the age of twenty-five, and thirty, and still no hint of any special interest in chemistry. But his delight in intensive thinking, making notes and recording figures, together with a never-flagging interest in the weather led him to a study of air, vapor and water. Several papers for the Philosophical Society are on this general theme.

At this time, with the aid of rough experiments, and using crude instruments that he made himself, he discovered the general laws of evaporation that are still the basis of meteorological science. What he actually did was to reach certain beliefs through general observations and intensive thinking and then perform a few experiments to prove to himself that he was right. This was his characteristic method throughout his research.

He wrote in 1803 of being "fully engaged in all my leisure hours in the pursuit of chemical and philosophical inquiries, having got into a track that has not been much trod on before." He was, in fact, beginning his study of "ultimate particles"—atoms. He pictured them as definite, concrete grains of matter, indivisible, unaffected by the most violent chemical change. Chemical change was just a union of atoms.

This led to the question: Are all atoms alike in size and weight? Dalton advanced the theory that the atoms of the same element are all alike, but that atoms of different elements differ both in size and in weight. He had never seen nor weighed an atom, nor conducted any delicate experiments, but he had hit upon a conception that still stands.

THE BEGINNING OF THE ATOMIC THEORY

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DALTON USED SYMBOLS LIKE THESE TO DESIGNATE OXYGEN

THIS line of thinking naturally suggested the problem of determining the weights of these atoms—different weights, for different kinds, but always uniform for the same element. To establish correct weights was beyond the possibilities of the laboratory methods of the times. But, at least, he could determine their relative weights.

So now we come to Dalton's greatest discovery. And it was announced in a most casual way. A paper he had read before the Manchester Society in 1803 on "The Absorption of Gases by

Water" was about to be printed in 1805, and at this time he added a paragraph in which he refers to an inquiry he had been making "into the relative weights of the ultimate particles of bodies—a subject, as far as I know, entirely new." And he adds, "The principle cannot be entered upon in this paper; but I shall just subjoin the results, as far as they appear to be ascertained by my experiments."

This is followed by a "Table of the Relative Weights of the Ultimate Particles of Gaseous and Other Bodies." Twenty-one substances are listed in this table, with their weights in relation to hydrogen, which is taken as unity.

Here was his announcement of the Atomic Theory as a general physical conception, and its first practical application to chemistry. It was the first statement of a law which made chemistry a mathematical science.

In 1808 was published Part I of his longest and most important work—his "New System of Chemical Philosophy." This dealt with three general subjects—heat, the constitution of bodies, and chemical synthesis. His theories of heat as stated in this book are an achievement in reasoning rather than in demonstration. They were the inspiration and the starting point of the more exact research that was carried on by others.

THE FIRST LAW OF MULTIPLE PROPORTIONS

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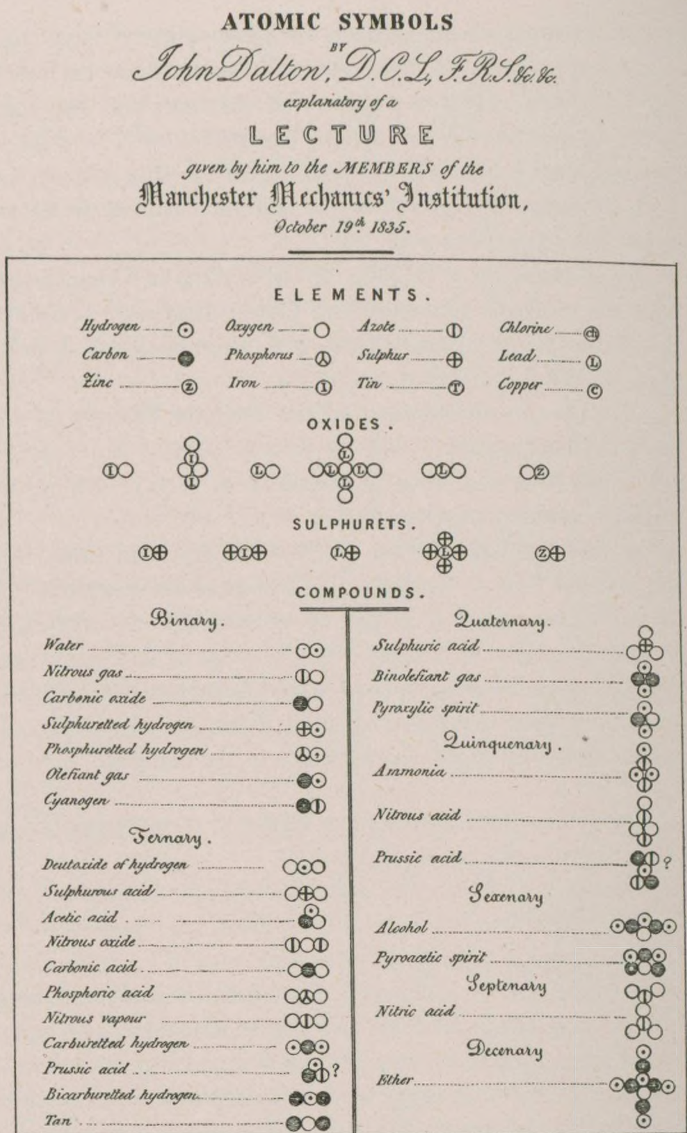
DALTON USED SYMBOLS LIKE THESE TO DESIGNATE HYDROGEN

IN the third section of Part I he outlines for the first time the Law of Simple Multiples, or unvarying proportions, and remarks, "From the novelty as well as the importance of the ideas suggested in this chapter, it is deemed expedient to give plates, exhibiting the mode of combination in



some of the more simple cases." He was presenting a definite theory of homogeneous fluids being constituted of particles that repel each other. Three diagrams were included in this volume. Small circles, with identifying marks within, were used to indicate the different elements. These were grouped in the diagrams in different ways to indicate different substances. Water was indicated by two circles, one oxygen and one hydrogen.

This was the system he used throughout his life. He always insisted that no conception can be clearly grasped by the mind, unless it can be indicated visually. He never accepted the symbols now in general use, in fact called them "horrifying"—"A young student might as soon learn Hebrew. They cloud the beauty and simplicity of the Atomic Theory."

This interest in visualizing abstract ideas led him to secure a quantity of one-inch wooden balls, for classroom use. Some were provided with a number of holes, to receive pins, so that other balls could be attached. This gave a configuration very close to his diagrams. He used these balls in his teaching for thirty years.

Part II of his "New System," published in 1810, had as its objective to determine, by the rules laid down in Part I, the atomic weights of elementary and compound bodies. While this work can no longer be used as a guide for the student, it still commands the respect of all who are interested in famous names in chemical history.

One of Dalton's pioneering studies was the relative size or diameters of what he was still inclined to call "particles." He worked out sizes that were correct for oxygen, and nearly right for chlorine. Later chemists, of course, found it more convenient to deal with volumes, rather than diameters.

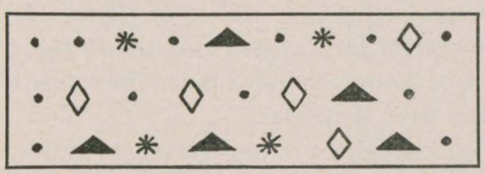
And so, on through the years, he continued to teach, think, experiment, write and read papers on the properties of various gases and solids. Although elected a member of the

French Academy of Sciences in 1816, he was not received into the Royal Society until 1822, a rather tardy recognition of his extraordinary services to science.

In the summer of that year he visited Paris where at the climax of his career, he was given an ovation by such leading scientists of the day as Laplace, Berthollet, Cuvier. Then he went back to tutoring private students in arithmetic, to earn the money required for his simple needs.

Ten years later, Oxford University conferred on him and on Faraday the honorary degree of D.C.L. Up to this time, he had never received any reward or encouragement from the government, but in 1833, Dr. Dalton, as we may call him now, was given an annual pension of 150 pounds; which, three years later, was increased to 300 pounds. In 1837, at the age of 71, he suffered a stroke of paralysis, but he partially recovered, and continued to write papers for the British Association. One of these was devoted to proving that the assistance of plants is not needed to purify the air of carbonic acid; and another announced that certain salts, when dissolved in water, cause no increase in its volume, a discovery which he immediately applied to the analysis of sugar.

He still spent hours daily in his laboratory, and in a letter states "I succeed in doing chemical experiments, taking about three or four times the usual time." In July, 1844, came a return of his malady—and the end of his career. His last written words, entered in a note book, were "Little rain this day."



DALTON USED DIAGRAMS LIKE THIS TO ILLUSTRATE TO STUDENTS THE DIFFUSED GASES PRESENT IN THE ATMOSPHERE

* *Water Vapor* • *Nitrogen* ◊ *Oxygen* ▲ *Carbon Dioxide*

THE ATOMIC THEORY CONTROVERSY

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DALTON USED SYMBOLS LIKE THESE TO DESIGNATE SULPHUR

It was perhaps inevitable that credit for originating the Atomic Theory became a matter of controversy. Speculation as to the ultimate constitution of matter dates back to the ancient Greeks. And in 1802, Fischer, making use of experiments reported by Richter, had prepared the earliest table of atomic weights, taking sulphuric acid at 1000 as the standard of reference. But these were empirical facts, not specific discoveries, until Dalton declared them to be universal truths.

Furthermore, Dr. Bryan Higgins, as early as 1786, maintained that "elastic fluids unite with each other in limited proportions, only." And a relative, William Higgins, in 1791 had written "In sulphurous acid a single ultimate particle of sulphur is intimately united only to a single particle of oxygen . . . Water is composed of molecules, formed by the union of a single particle of oxygen to an ultimate particle of hydrogen."

On the basis of these statements, which were in fact little more than conjectures, Mr. Higgins in a later work makes definite claim to be the author of the Atomic Theory. It is certain that Dalton never read this earlier book until some years after the publication of his "New System," and certainly Higgins made no claim to have discovered a general law until after this work had attracted attention and had been widely accepted.

It was Dalton who had made the Atomic Theory, dimly seen and vaguely discussed for two thousand years, an acceptable working hypothesis. In this, most writers on chemical history have agreed. Berzelius says, "To Dalton belongs the honour of the discovery of multiple proportions, which none of his predecessors had observed." And Herman Kopp, in his extended history of chemistry states, "The discovery of multiple proportions, and the determination that the atomic weight of a compound as given by the sum of the atomic weights of its constituents, are Dalton's uncontested property."

But at the time, and for many years after, his hypothesis is more accurately described as acceptable than as accepted. The father of Dr. William J. Mayo, the American surgeon, studied under Dalton and recalls him as a gaunt, awkward scholar, with an atomic theory that was regarded as the vagary of a scientist.

England's foremost chemist of Dalton's day, Sir Humphrey Davy, was not only sceptical but actively hostile, although in the end he too was converted. President Eliot of Harvard, when he was teaching chemistry, even as late as 1868, told his students "the existence of atoms is itself an hypothesis, and not a probable one."

CHEMICAL FORMULAE, A TRIBUTE TO DALTON

DALTON USED SYMBOLS LIKE THESE TO DESIGNATE NITROGEN

WHILE the Atomic Theory came earlier than many of the facts of chemistry which are now well known, it still serves to interpret them. All chemical formulae are still a tribute to Dalton, justifying his belief that "through the Atomic Theory, chemists will ultimately be referred to mathematical laws."

Berzelius calls it "one of the greatest steps which chemistry has yet made toward perfection." Mitscherlich says, "This hypothesis, like every other, must undergo changes, in proportion as observations are multiplied. It may be wholly superseded. Yet the history of science adduces scarcely any law, and

certainly no theory, which has conducted the inquirer to so many discoveries."

Dalton was said to look remarkably like Sir Isaac Newton. He was of moderate height, strong and wiry, and delighted in long walks. Perhaps as a result of his early environment, he always had a gruff, indistinct voice, and his carriage and general appearance were quite lacking in grace.

He was calm rather than vivacious, prosaic rather than imaginative, steadfast in his friendships. Always a Quaker, he went to church faithfully twice every Sunday. He never was able to learn to swim, and explained this to his own satisfaction by determining that his own specific gravity was greater than that of water.

He had so little interest in books that he once remarked he could carry his whole library on his back, and half of the books would be ones he had never read. His inclination to work everything out for himself led him into errors that might easily have been avoided.

At one time, when a doctor gave him a powder, he deferred taking it until he could subject it to chemical analysis.

FAME THAT RESTS ON REASONING

DALTON USED SYMBOLS LIKE THESE TO DESIGNATE IRON

DALTON'S fame rests on his reasoning rather than on his work in the laboratory. He was not a great experimenter—his apparatus was too crude, his technique too careless. He was given to apriori reasoning, as when he declared, "No man can split an atom." His table of relative atomic weights was mostly wrong, but his bold generalizations had the very great merit of being mostly right.

His early training and his natural tastes were in the field of mathematics, and his great contribution to chemistry was to transform it into a mathematical science. His own opinion of his abilities was one also held by Newton: that there was no such thing as genius, and that if he had accomplished anything which the world considered valuable, it had been done by persevering industry directed to a single practicable object. And undoubtedly it is true that this trait of persevering industry established one of the basic principles of modern science, and made the name of a self-taught Quaker school teacher one of the famous names in chemical history.

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ANOTHER FAMOUS NAME IN CHEMICAL HISTORY

After Six Thousand Years Chemistry Transforms a Product as Old as Civilization

ONE of the curious facts of chemical history is that a product as difficult to produce as glass is found among the earliest relics that have come down to us from one of the world's oldest races. Ancient Egyptian tombs have preserved for us pottery made with a glazed finish—articles that were evidently in common use from 4,000 to 5,000 years before the start of the Christian era.

A thousand years later, this amazing people along the banks of the Nile were casting blue and green beads in a primitive form of glass called faience. And it took another thousand years to progress from glass beads to the making of glass vessels. The original process was long and difficult. First a mold was made of clay. Around the mold were wrapped threads of hot, plastic glass. Then the windings were fused together in an oven. And, finally, the clay was scraped out. Such glass containers were luxuries, ranking in value with gold and silver.

Another jump—this time of twenty centuries—brings us to the days of Augustus Caesar, first ruler of the Roman Empire. In a distant city of his domain, Tyre, at the eastern end of the Mediterranean Sea, a radically new process was developed—the art of glass blowing. As a result, articles of glass became as cheap as pottery.

After the barbarians conquered Rome, in 490 A.D., came the Dark Ages when glass making was almost a lost art. It was revived and carried to new perfection at Venice during the Crusades. Glass ground into lenses for spectacles led to Galileo's invention, in 1608, of the telescope, the basic tool of modern astronomy. And about the same time came the microscope, the most important single instrument in the whole field of present-day science.

Glass—America's First Export

Oddly enough, the first American-made product to be exported was glass. Eight glass blowers were sent over to Captain John Smith's colony at Jamestown, the same year the telescope was invented. They made glass beads for bartering with the Indians, as well as bottles for use by the colonists, some of which were shipped back to England.

When American industry took up glass making in earnest, toward the close of the last century, progress centered around methods of making glass products more quickly and cheaply, so that they could be sold in larger quantities. The material, itself, was regarded as well standardized and not subject to any great improvement. The fabrication of glass, as recently as 1900, was still, generally speaking, a handicraft, dependent on the skill of the individual worker and on jealously guarded trade secrets.

But long before the turn of the century, Corning Glass Works was at work to change the art into a science, and the handicraft into an industry. Its progress in this field soon attracted attention. And so it was that, on a morning in 1879, a man stepped out of a train at the Corning station, walked over to the Glass Works, and inquired if it would be possible to make "a thin bubble of glass" to surround a filament heated by an electric current. The answer was "Yes!" and Corning proceeded to make for their visitor, Thomas A. Edison, the glass bulb for the world's first incandescent electric light.

As early as 1904, Corning Glass Works took what at that time was an unprecedented step. It established a factory research laboratory for the scientific study of glass, its properties and its uses. This was the beginning of "Corning Research"—a phrase that has come to mean much in the scientific and the industrial world.

From Corning Research have come discoveries and improvements that have definitely contributed to science, to commerce and industry and to the home. Many of these contributions trace their beginnings back to an early problem presented to Corning Research for solution. As far back as 1872, Corning had developed optical units and colors which gave to the railroads for the first time red signal lights that would not turn a sickly white when seen through mist and fog.

This time it was a different problem—one that concerned lantern globes. When heated by the oil flame and then suddenly chilled by rain or sleet, they were apt to crack or break. And a timely signal from a lantern often meant the difference between life and death. What was wanted was a lantern globe that would last.

The Development of "Pyrex" Glass

Hit-or-miss experiment might have found the answer, in time; but science achieved it promptly. Ordinary glass breaks under sudden temperature changes because it expands when heated and contracts when cooled. Corning produced lantern globes that stood up, by developing a glass with amazingly slight expansion. The linear co-efficient of expansion of this glass is expressed by the decimal .0000036.*

Here was glass with such remarkable resistance to heat and cold that it opened the door to further development and many new uses. The first, in a series of developments that is constantly being extended even at the present time, was glass

**NOTE: Further research resulted in the development of the present "PYREX" Brand Chemical Glass with a linear co-efficient of expansion of .0000032 from which "PYREX" Laboratory Ware is manufactured.*

baking dishes. Today these glass cooking dishes are so widely used that the trade-mark "Pyrex," under which they are sold, is a household word. Other developments quickly followed.

Meanwhile, the World War had opened another new field for Corning products. In 1914, imports of heat-resistant laboratory glassware from Germany were abruptly cut off. "Pyrex" brand Laboratory Ware promptly stepped into the gap and soon set new world standards for laboratory use.

"Balance" in Technical Glass

Here was not only a heat-resistant glass but a *balanced* glass—mechanically strong and chemically stable. It was the first and only glass whose three essential qualities—thermal resistance—chemical stability and mechanical strength were scientifically *balanced*—one with the other. No one property is sacrificed to enhance another—all are adjusted—*balanced*—for maximum value and all around laboratory use.

And so through the years Corning Research has carried on in many fields—painstakingly, laboriously, persistently improving its product—*glass*. Occasionally its accomplishments are highly dramatic such as the making of the 200-inch disc of "Pyrex" brand glass for what will be incomparably the largest and most powerful telescope in the world. Or Corning's newest development of fibre products in spun glass—1/10 the diameter of a human hair.

But it is the day-in and day-out achievements that count most—the improvements that only the laboratory world or the industrial world sees—discoveries of which the general public is only vaguely aware.

And so Corning Research goes on. The one-man laboratory has become an outstanding organization of chemists, physicists and engineers—pioneering, progressing, adding new chapters to the story of how a six-thousand-year-old product serves mankind.

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