John Dalton

was conducted by a cousin of his. At nineteen years of age he became, with his brother, joint principal of this school. In this position he remained till 1793, or until he was twenty-seven years of age. During all the years of his Keswick life he was indefatigable in his studies, the natural sciences and mathematics being his principal pursuits, though he also studied Latin, Greek, and French. But early in his life at Keswick he began to study nature directly. His first interest was in meteorology. Meteorology, indeed, continued to be all through his life his great absorbing passion. He is said to have made personally over 200,000 distinct meteorological observations and records.

Dalton had few characteristics to win popularity, but his enthusiasm in the study of natural phenomena secured him friends wherever he was. Even as a boy in Eaglesfield he had the friendship of a distant relative who was a gentleman of wealth, leisure, and scholarly tastes, and who assisted him in his studies. At Keswick he had the friendship of a Mr. Gough, who, though blind, had extraordinary ability, and who, because of his attainments in science, was known as the "blind philosopher." Through Mr. Gough's influence Dalton, in 1793, secured the appointment of tutor in mathematics and natural philosophy in an academy at Manchester established by the Presbyterians, afterward known as New College. His salary here was only £80 ($400) a year, but Dalton's habits were simple and his expenses always frugal. The great advantage of the place was that it concentrated his energies wholly upon the kind of work that his genius was most in sympathy with. However, he remained in it only six years. In 1799 he resigned the post, and thenceforth supported himself wholly by taking private pupils. Even when in the very height of his fame as an original discoverer, even when eminent savants came from all parts of the world to visit him, he had no more important occupation than "helping," as he used to phrase it, young people in arithmetic, algebra, etc., and no more distinguished place to receive his guests in than a little room belonging to the Manchester Philosophical Society which he had fitted up as a laboratory.

Dalton went to Manchester in 1793. He remained there till his death, a period of over fifty years. He never married. For a long time he lived in the house of a Rev. William Johns, and to this gentleman's family he left a substantial legacy. The only hours he did not spend in his laboratory were those of Sundays and of Thursday afternoons, and meal times and sleeping times. His life went as by clockwork. "A lady who lived nearly opposite his laboratory used to say that she knew the time to a minute by seeing Dr. Dalton open his window to read off the height of his thermometers." In summer he spent a few weeks each year in the "lake country," but his passion even then was for meteorological observation. His only indulgence was the pipe; but even this he resorted to only in the companionship of old acquaintances like Mr. Johns. Of the pipe, however, he was really fond, and when he met Sir Humphry Davy he testified that the only defect in Sir Humphry's character was that he did not smoke! Even the Thursday afternoons that he took to play at bowls he spent in watching others play while he regaled himself with gentle pulls at his "churchwarden."

All Dalton's scientific work was given to the world in papers read before the Manchester Philosophical Society.

Of this society he was elected a member in 1794. He became its secretary in 1800, its vice-president in 1808, and its president in 1817. He remained president until the time of his death, a period of twenty-seven years. It was before this society, in 1803, that he first propounded his theory of atomic combination, although he did not publish a full account of it till several years later. The real introducer of the theory to the world was Dr. Thomas Thomson, a professor of chemistry at Glasgow. In August, 1804, Dr. Thomson spent some days with Dalton at Manchester, and learned of the theory, and he soon became an ardent disciple of it. He published an account of it, and almost immediately it was taken up by the great chemists Gay Lussac of France and Berzelius of Sweden. Sir Humphry Davy, in England, however, did not at once accept, it, but when he did so it was with a heartiness that made amends for his previous dubitancy.

Dalton's discovery of the law of atomic combination is such a great one that his other discoveries, which are by no means few or unimportant, are overshadowed by it. It was that discovery, however, that first made him famous, and which still keeps him so. In 1822 he was elected a member of the Royal Society. Four years later he was awarded the medal of the society. In 1830, upon the death of Sir Humphry Davy, he was elected one of the eight foreign associates of the French Academy of Sciences, an honor that Sir Henry Roscoe calls one of the very highest a man of science can receive. In 1832 Oxford made him a D. C. L., in company with Brewster and Faraday. A little later he received the degree of LL. D. from the University of Edinburgh. In 1833 the government granted him a pension of £150 a year, afterwards

increased to £250. He continued his simple life of study and experiment to the very end. On Friday, July 26, 1844, he recorded his meteorological observations as usual. The next morning he passed away—" imperceptibly, as an infant sinks to sleep." Manchester gave his remains a public funeral. Forty thousand people came to visit the place where his body lay before it was finally entombed. Such was the honor in death of the poor weaver's son of Eaglesfield.

JOHN DALTON

SELECTED STUDIES AND REMINISCENCES

DALTON'S HUMBLE WAY OF LIVING

In the year 1826, when Dalton had achieved a European renown, M. Pelletier, a well-known Parisian *savant*, came to Manchester with the express purpose of visiting the illustrious author of the Atomic Theory. Doubtless, he expected to find the philosopher well-known and appreciated by his fellow-citizens—probably occupying an official dwelling in a large national building devoted to the prosecution of science, resembling, possibly, his own Collège de France or Sorbonne. There he would expect to find the great chemist lecturing to a large and appreciative audience of advanced students. What was the surprise of the Frenchman to find, on his arrival in Cottonopolis, that the whereabouts of Dalton could only be found after diligent search; and that when at last he discovered the Manchester philosopher, he found him in a small room of a house in a back street, engaged looking over the shoulders of a small boy who was working his "cyphering" on a slate. "*Est-ce que jai l'honneur de m'addresser à M. Dalton?*" for he could hardly believe his eyes that this was the chemist of European fame,

teaching a boy his first four rules. "Yes," said the matter-of-fact Quaker, "wilt thou sit down whilst I put this lad right about his arithmetic?"—SIR HENRY E. ROSCOE, LL. D., F. R. S., *in "John Dalton, and the Rise of Modern Chemistry," in "The Century Science Series."*

DALTON AS AN EXPERIMENTER

Although in all his experiments Dalton made use of rough apparatus—very different from that now necessary for physical or chemical research—it is interesting to find how nearly many of his numerical results approach those since obtained by much more careful work, and by infinitely more accurate methods and instruments. Moreover, Dalton was fully aware of the existence of the experimental errors which his processes involved. His mode of arriving at results was, however, always ingenious, though often rough; indeed, as Angus Smith says, he seems to have begun his experiments with his hands and finished them off with his head.—SIR HENRY E. ROSCOE, LL. D., F. R. S.

DALTON'S POWER OF PERSEVERANCE

Up to the year 1796 [Dalton was then thirty years old] we have no evidence that Dalton had taken any special interest in chemical research, or even had carried on any practical laboratory work. His first introduction to the science, giving him an impetus to its study, seems to have been a course of lectures on chemistry which he attended, given in Manchester by Dr. Garnet. From that time onwards, however, both his mind and his hands were alike

VI. JOHN DALTON

1766-1844

BIOGRAPHICAL STUDY

BY JOHN EBENEZER BRYANT, M. A.

Dalton, the discoverer of the great fundamental law upon which the science of modern chemistry is based, "the law of atomic combination," does not hold the commanding position in the temple of fame that his genius, and the merit of his work as an original investigator of nature, entitle him to. By those who know he is ranked as one of the most eminent men of science of this century. He is called, indeed, the "lawgiver" of chemistry. Sir Henry Roscoe, one of the most eminent chemists living, speaks of his discoveries as "the greatest landmarks" in the whole realm of chemical knowledge. Sir Humphry Davy, who was his contemporary, spoke of them as comparable only to the laws of Kepler in astronomy. The distinguished geologist, Professor Sedgwick, when president of the British Association for the Advancement of Science, at its meeting in Cambridge in 1836, spoke of Dalton as "having obtained a name not perhaps equaled by any other living philosopher in the world." The distinguished French chemist, Wurtz, in his "*History of Chemistry*" speaks of his name as "one of the greatest in chemistry." The distinguished astronomer, Sir John Herschel, called Dalton's atomic theory an "immeasurable step in our knowledge of nature."

But this reputation which Dalton has among men of science has not extended to the general public. In his own city, indeed, Manchester, his memory is honored as the greatest of her sons. His statue, sculptured by Chantrey and costing $10,000, stands in the entrance of Manchester's magnificent Town Hall, the most highly prized of all her art possessions. A scholarship, subscribed for by the citizens to the amount of $20,000, established in the Victoria University of Manchester, commemorates by its perpetual aid to scientific research both the greatness of Dalton's name and the chief interest of his life. But the world in general knows little about Dalton. He lived a humble, almost an obscure life. He rarely appeared to public view in any capacity, and never either strikingly or interestingly. He made no discoveries or inventions that were of immediate practical use, or that impressed the popular imagination. For many years he was scarcely known even to other men in the same branches of science as he himself labored in. He was a self-contained, self-absorbed, self-directed, self-reliant man, who took but little interest in any work, even in science, that was not his own. Nor did he make haste to put his discoveries before the world, or claim for them the priority which was their due. His whole life, indeed, was such as won him neither reputation nor emolument, except what came to him spontaneously despite his indifference.

The greatness of Dalton's discovery of the law of

atomic combination lies in the fact that, like Newton's law of gravity, it is fundamental. It forms the basis upon which the whole science of chemistry rests. The doctrine that matter is composed of "atoms," infinitely small particles, incapable of division, and for each sort of matter, all alike, is, as the phrase is, "as old as the hills." It was Dalton, however, who first took this doctrine, barren and useless as it had always been, and made it the fundamental element in our conception of the constitution of the universe. For example, it was known before Dalton's time that water is a chemical compound; that is to say, a combination of two elementary sorts of matter—hydrogen and oxygen. But Dalton reasoned that if the elementary particles or "atoms" of hydrogen are all alike, in size, shape, weight, etc., and if the elementary particles or "atoms" of oxygen are all alike, in size, shape, weight, etc., then, since these elementary particles or "atoms" of hydrogen and oxygen are "indivisible," union between the two can be effected to form water only by one elementary particle or "atom" of hydrogen becoming united with one elementary particle or "atom" of oxygen, to form one elementary particle of water; or else by one of hydrogen uniting with two of oxygen to form one of water; or else by two of hydrogen uniting with one of oxygen to form one of water; etc. And continuing his reasoning he saw that if, for example, an elementary particle of oxygen were considered to be sixteen times heavier than an elementary paritcle of hydrogen (he knew that bulk for bulk oxygen is sixteen times heavier than hydrogen), the proportion (by weight) of hydrogen to oxygen in water must be as 1 is to 16, or as 1 is to twice 16, or as twice 1 is to 16, etc. Having got thus

JOHN DALTON

far he made an analysis of water and found that the actual ratio was as 1 to 8; that is, as 2 to 16. That is to say, if the "atomic" constitution of matter be admitted, and if, further, the theory of "atomic combination" be admitted, an elementary particle of water must consist of the union of two elementary particles or "atoms" of hydrogen with one elementary particle or "atom" of oxygen.

Having discovered what the "combining weights" of hydrogen and oxygen were for water, it was next his task to find what they were for other substances. And not only had he to pursue an investigation like this for oxygen and hydrogen, but he had to pursue similar investigations for nitrogen, carbon, sulphur, phosphorus, and every other element then known, and to test the results he obtained in these investigations by seeing if they would hold good in every compound, such as carbonic acid, nitrous gas, sulphuric acid, etc., that he could possibly examine. This, roughly explained, is the route Dalton had to pursue even to get "indications" of the truth of his theory. But Dalton was able to get not merely "indications;" he was able to establish the truth of his theory so firmly that it was accepted by most of the scientists of the world almost as soon as they had opportunity of examining it.

It must be remembered that what is called the law of "atomic combination" is in part only a "theory." That the elements of matter, as they are called—hydrogen, oxygen, nitrogen, carbon, sulphur, etc.—do enter into combinations with one another in the proportions 1, 16, 14, 12, 32, etc., or multiples of these numbers, and in no other way, has been established (first by Dalton and later by hundreds of other scientists) in thousands upon thousands of instances of analysis and synthesis beyond all possible doubt. This "law of multiple proportions," as it is called, is, strictly speaking, all of the Daltonian law that is established. The rest of it is only ingenious hypothesis. But it is to Dalton's undying honor that he did not rest satisfied with the discovery of a mere blind law. The greatness of his achievements lies in the fact that he saw that this "law of multiple proportions" could be explained, and explained only, by the assumption (or "hypothesis," as it is called) that matter in its "elementary" states is composed of "atoms," so that when different elements combine (inasmuch as the atoms are for each element all alike, in size, shape, weight, etc.) they must always combine in the proportions of their relative atomic weights. That is to say, if carbon and oxygen, for example, combine, the relative weights of whose elementary particles or "atoms" are as 12 and 16, they must always do so in the proportion of 12 to 16, or in the proportion of some multiple of 12 to some multiple of 16; the reason being that every elementary particle of matter which is composed of carbon and oxygen must consist of one or more (whole) atoms of carbon united to one or more (whole) atoms of oxygen, fractional atoms being, of course, impossible of existence.

The importance of the discovery of the law of atomic combination can only be very faintly indicated here. It at once lifted chemistry from approximation and conjecture to exactness and certitude. The processes of nature and of art are largely chemical processes—combinations of atoms, dissolutions, and recombinations. The growth of every animated being, of every living substance, the changes effected in the condition of all inert

matter by those great agents, heat, light and electricity, are all chemical changes; that is to say, once more, combinations of atoms, dissolutions, and recombinations. But in every chemical combination and dissolution the great law discovered by Dalton must hold good. Not a single change in the constitution of matter throughout the universe can take place except it be that in that change the law of atomic proportion is observed. Matter is indestructible. It disappears in one phase and reappears in another. But in every such disappearance or reappearance not an atom is lost, or increased, or diminished. Individual atoms remain in size, in shape, in weight, etc., yesterday, to-day and forever the same.

John Dalton was born in the village of Eaglesfield, near Cockermouth, Cumberland, England, September 6, 1766. His father was a weaver in the village. His mother helped to support the family by keeping for sale a little supply of stationery. The circumstances of the Dalton's were, as the general opinion of the world is, very humble. They were poor. And they had no outlook. But they were high-minded people, and sincerely religious. Besides, they were "Friends," or, as is generally said, "Quakers." And as many of the people of the vicinity were also Friends, and as the social feeling among Friends is always more or less fraternal, the Daltons were not without compensations in their poverty. The facilities for education, however, open to a family so very poor were not good, and John Dalton's whole education was obtained only in the little village school and from his father. At twelve years of age he opened a school on his own account, and he conducted it for two years. At fifteen years of age he went to Keswick and became a teacher in a school that