THURSDAY, OCTOBER 24, 1889.

JAMES PRESCOTT JOULE.

THROUGHOUT the world of science there has spread a feeling of profound regret at the death of Mr. Joule, which was announced a week ago in the columns of NATURE. On the evening of the 11th of this month he passed away at his residence in Wardle Street, Sale, near Manchester. For many years past he was in very feeble health. Indeed, as long ago as 1872 it was known publicly that he was far from strong. In that year he was President-elect of the British Association, but before the time of the autumn meeting he was obliged to relinquish the honour on account of physical weakness; and Prof. Williamson was called upon to occupy the position. In recent years Mr. Joule was living in complete retirement, carrying on, so far as his health would permit, such observations and experiments as could be conducted without bodily fatigue; and during this period he was able to edit with occasional brief notes, the two volumes of his collected papers which have been published by the Physical Society of London. The first of these important volumes appeared in 1884, and was noticed in NATURE (vol. xxx. p. 27). The second was published in 1887 (see NATURE, vol. xxxv. p. 461), and contained the papers which Joule wrote jointly with Dr. Scoresby, Sir Lyon Playfair, and Sir William Thomson. At the end of the latter volume there is a list of no less than 115 contributions to the various scientific societies and journals which were enriched by communications from his pen. The papers of Joule are remarkable in form as they are in substance. Of mathematics there is scarcely a line; but they are models of clearness, of depth, and of penetration into the hidden things of Nature; and the mathematician finds the experimental results stated and arranged in such a manner as to lend themselves readily to representation in mathematical symbols. Of experimenting he was a perfect master—full of elegant device, and clear in mind as to points of difficulty and places where error might creep in. That which, in the hands of almost anyone else, would have proved too difficult to lead to a trustworthy conclusion, in his hands was often made to yield an important law or generalization, or to afford an accurate numerical result.

In NATURE (vol. xxvi. p. 617) there appeared a biographical sketch of Mr. Joule; a few words may, however, be permitted here, in order to fulfil our duty to one of the greatest scientific leaders of the present century.

His work, taken as a whole, and without considering the relative importance to physical discoveries—that is to say, judged by the originality of the objects, and the means employed, the philosophic direction, the patient and persevering labour, and the results obtained—would be such as to place him in the front rank of philosophers. If account be taken of the importance and generality of his discoveries, as shown by their influence on the philosophical thought and material progress of the world, then, as the discoverer of the law that energy is in the same degree as indestructible and uncreatable as matter, it is with Newton and Dalton that he finds his place in the history of physical science.

The law of the conservation of energy, which in all schools of science, even ne most elementary, is now taught as the foundation of each and all the branches of physical science—mechanics, physics, and chemistry—was, in 1841, as far from recognition as at any time since the discoveries of Newton had shown that, in their observed motions, the heavenly bodies strictly obeyed the laws of motion. The properties of friction, internal and external, with which it was found necessary to endow terrestrial material, and which properties were apparently nothing less than those of destroying energy, were still as far from explanation as the property of gravitation itself; while the continued production in the steam-engine of energy from the same material by the agency of heat, without any consumption of heat, as was then not only supposed, but counted as proved by the equality of the heat received from the boiler and discharged into the condenser, showed apparently nothing less than the creation of energy.

The study of heat which had taken place in the meantime had done nothing to remove these difficulties, for the observed fact that heat was susceptible of quantitative measurement, independent of temperature, had led to the hypothesis that heat was an imponderable substance —"caloric"—capable of penetrating matter and altering its temperature and state, but neither creatable nor destructible. The discoveries of electric phenomena tended to strengthen the caloric hypothesis by affording another imponderable substance. Nor was it only such difficulties in the way of the acceptance of the conservation of energy which kept back its discovery.

Energy, as a measure of mechanical potency, had never assumed a prominent place in mechanical philosophy, while the action by which it is converted into motion against resistance, had scarcely been recognized as a general measure of mechanical action, so that when. as continually happened, the idea of heat being a mechanical action thrust itself forward, there was no distinct measure of mechanical action at hand in which to gauge the equivalent.

Outside the schools of mechanical philosophy engineers engaged in constructing and using the steam-engine had long been led to recognize motion against resistance as the mechanical and commercial measure of potency. Under the names "work" and "accumulated work," these men had become familiar with what are now known as work and energy (actual and potential). It may be noticed that Rumford first recognized the true nature of the relation between heat and mechanical action by observing that two horses working steadily produced heat at a steady rate, but he did not reduce his results further; while Joule was so familiar with the action work, that he never hesitated as to the nature of the relation.

It is true that at the time when Joule commenced his work, not only had mechanical philosophy, as applied to astronomy and such abstractions as frictionless and perfectly elastic matter, reached to nearly its highest level, but the other branches of physical science, studied independently, were fast approaching their present stages. Dalton's discoveries of chemical equivalents had been made thirty years before, and chemistry had been advancing by leaps and bounds. The phenomena of electricity had been subject to the masterly handling of

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Faraday. The law of the motion of heat had not only been experimentally determined, but had been theoretically discussed by Fourier. The specific heats of the elementary bodies, as well as the heat developed in combination, had to some extent been determined by Dulong. And the law connecting the quantity of electricity produced in voltaic batteries with the number of chemical elements separated, had been discovered by Faraday. So far, however, these various branches of physics and chemistry had been subjects of separate and distinct study. No suggestion of equivalence had been made between the heat of combination of the elements and the electric current that would be produced by the same combination effected in the battery. That heat was developed in conductors by electric currents was known, but again there had been no suggestion of an equivalence between the heat and the resistance overcome. What are now known as the dynamo and motor had been invented by Sturgeon, showing that work could be done by the agency of electricity and electric separation effected by the agency of work, but again no equivalence between the amount of work and the energy of combination of the element in the battery had been surmised.

It was for Joule not only to suggest all these equivalences, but to experimentally determine all their numerical values[1] before he came to the equivalence of the work[2] spent in overcoming fluid, or solid, friction and the heat produced; and, again, between the work spent in compressing air and the heat produced.

The discovery of the mechanical equivalent of heat, important as it is, is but a poor expression for the outcome of this work, in which Joule converted what had till then seemed unquestionable cases of the destruction of energy into the most striking cases of its indestructibility. And although he propounded no theory, but simply declared himself to have believed in the indestructibility of *vis-viva*, or living force, he had, in the truest sense of the word, discovered the universal law that energy is indestructible and uncreatable. As Joule's work came to be apprehended, this law became accepted as its natural consequence in greater and greater significance, until now it stands the most general recognized law in the universe; relating not only to all matter but also the medium of space, which is thus found to possess the mechanical properties of matter and to be subject to the laws of motion.

The discovery of this law, bringing as it does the several branches of physical science into the domain of mechanical philosophy, fitly crowned all the work in physical science of the previous 150 years, of which it was the result. It also opened out a fresh platform for further discoveries—a platform which was immediately occupied in the erection of the compound sciences of thermodynamics, electrodynamics, and the dynamical theory of gases.

Joule was never prominently before the public. Ready to give himself with absolute devotion to the cause of science and the advancement of human knowledge, he yet preferred retirement and the calm labour of his laboratory to the excitement of public lectures and demonstrations. While he was keenly alive to the sympathy of friends, yet he worked for the most part alone, or in conjunction with one or other of the friends mentioned in the earlier part of this notice. He sought not at all for fame, but only for truth.

And yet honours in plenty came to him. He received honorary degrees from the most important Universities; he was honorary Fellow of many learned Societies at home and abroad. He was a Fellow of the Royal Society, and received from it the Gold Royal Medal in 1852, and the Copley Gold Medal in 1870. The Albert Medal of the Society of Arts was delivered to him from the hands of the Prince of Wales in 1880. In 1878 he received a letter from Lord Beaconsfield, announcing that the Queen had been pleased to grant him a pension of £200 per annum. This recognition by his country of his life of scientific labour was a subject of much gratification to Mr. Joule.

Special reference may be made to his connection with the Literary and Philosophical Society of Manchester. This commencing, as it practically did, at the age of fifteen, when he studied chemistry under Dalton in the rooms of the Society, continuing, by the most regular attendance at all the meetings, so long as his health permitted, and practically terminating with his death, must have been one of the most important circumstances of his life. Elected a member in the year of his greatest discoveries, 1842, he was Secretary in 1846, Vice-President in 1850, which office he held till his death, except during the ten years when he was President. He took the greatest interest in the welfare of the Society, and secured not only the veneration but love of all the members.

A man of science who left so deep a mark on his age ought to have been buried in Westminster Abbey, but unfortunately the necessary application could not be made, in consequence of the delay in the public announcement of his death. Prof. Osborne Reynolds, President of the Manchester Literary and Philosophical Society, has written to the *Times* urging that a monument should be erected in the Abbey, and that steps should immediately be taken to obtain, if possible, the consent of the Dean. This suggestion ought to meet with cordial and unanimous approval. Joule's name is one of which Englishmen may justly be proud, and the erection of a monument in Westminster Abbey would be the most fitting way in which they could express their appreciation of the splendour of his contributions to science.

[1] Man. Lit. and Phil. Soc., 1841–43; *Phil. Mag.*, ser. 3, vol. xix. p. 200.
[2] *Phil. Mag.*, ser. 3, vol. xxiii.

THE LIFE OF SIR WILLIAM ROWAN HAMILTON.

Life of Sir William Rowan Hamilton. By Robert Percival Graves, M.A. Vol. III. "Dublin University Press Series." (Dublin: Hodges, Figgis, and Co. 1889.)

At last the third and final volume of Graves's life of Sir William Rowan Hamilton has seen the light. It was our pleasure in former numbers of NATURE (vols. xxviii. p. 1, and xxxii. p. 619) to have reviewed the two earlier volumes, and we have now to congratulate the University of Dublin on the completion of an adequate biography of the most illustrious student that has ever issued from its halls. This present volume, of which we are now to speak, is as portly as its predecessors. It contains not less than 673 pages, and a very important

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