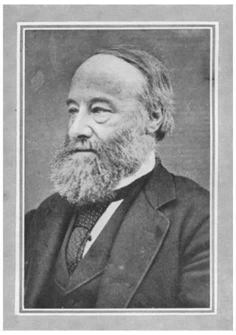
Biography: James Prescott Joule

James Prescott Joule, an 'amateur' scientist and inventor, combined brilliant scientific thinking and innovation with the brewer's interest in highly accurate measurements. His findings and publications greatly improved the efficiency of many 19th century industrial machines and processes including steam engines, electric motors and transmission of electrical power. The principles that Joule described directly led to the important developments of arc welding and refrigeration. Joule's best known legacy is the eponymous unit that was officially adopted as the S.I. unit for energy by the 'Bureau International des Poids et Mesures' in 1948.



James Prescott Joule was born on Christmas Eve 1818 as the second son of a prosperous brewer in Manchester, England. Young Joule was a delicate child, and was not sent to school. His early education was commenced by his mother's half-sister, and was carried on at his father's house, Broomhill, Pendlebury, by tutors till he was about fifteen years of age. At fifteen he commenced working in the brewery, which, as his father's health declined, fell entirely into the hands of his brother Benjamin and himself. At the age of 16 Joule was sent to the Manchester Literary and Philosophy Society (Lit & Phil) to be taught chemistry, physics, mathematics. His father hired the eminent Manchester scientist John Dalton (1766-1844; developer of the atomic theory of matter) as a private tutor for his two sons. Dalton met with the boys twice a week, guided them through Euclid's books on geometry, and covered a vast range of natural phenomena. There was also a wilder side of Joule's science education: he blew his eyebrows off in a gun experiment; he flew kites in thunderstorms. He asked a servant girl to report her sensations as he gave her increasing electric shocks, but stopped when she fell unconscious.

Joule managed the family brewery from 1837 to 1856 which enabled him to experiment on the relationships between heat and electricity in a laboratory built in the cellar of his father's home. His earliest experiments explored the relationships between electricity and work. In 1840, at the age of 22, he established that a conductor carrying an electric current became hot, and that *the rate of heating for a current* I *flowing through a resistance* R *was given by* I^2R *for any kind of wire*, and even for electric currents in fluids. This was a kind of heat production no-one had seen before—previously, heat had only come from either chemical combustion, or friction, or radiation.

Up to then most scientists believed in the caloric theory that heat could neither be created nor destroyed. Joule's theory was so controversial that he could not find a scientific journal to publish it. It first appeared in a local Manchester newspaper. Finally he published a paper in the Proceedings of the Royal Society describing the first of the eponymous laws which predicts the heat generated by a conductor from its resistance and the current applied (later in Joule's life this information was to prove instrumental in determining that high-voltage power lines were the most efficient way of conveying electricity from power stations to consumers). From a London perspective, Manchester was the boondocks. When Joule submitted his paper on the discovery of the electrical I^2R heating (now known as Joule heating) to the Royal Society, it was rejected, except for a short abstract. Much later, when asked if that cursory treatment surprised him, he replied: "I was not surprised - I could imagine those gentleman in London sitting round a table and saying to each other *what good can come out of a town where they dine in the middle of the day?*"

Joule's work was so impressive that his provincial origins were forgiven, and by the late 1840's he was regularly presenting papers to the British Association and the Royal Society.

In 1843, Joule showed that heat was a form of energy and determined the physical constant now used as the S.I. unit for energy, the Joule (J). He demonstrated the mechanical equivalent of heat by measuring change in the temperature of water caused by the friction of a paddlewheel attached to a falling weight. Joule realized that the electrical apparatus was an unnecessary intermediary - heat could be produced directly by a falling weight. He arranged for the falling weight to drive paddle wheels in a calorimeter, churning up the water. This led to a slight, but measurable rise in temperature. He found one BTU (British Thermal Unit) - the amount of heat required to raise the temperature of one pound of water by 1°F) which was generated by an energy expenditure of 772 foot*pounds (switching his results to the metric system, that one calorie was the equivalent of ≈ 4.2 newton*meters, or, as we now say, 4.2 Joules). His experiments establishing the equivalence of heat and mechanical work, the cornerstone of the principle of conservation of energy, are among the greatest achievements of nineteenth-century science.

Joule also calculated that the water just beyond the bottom of a waterfall will be one degree Fahrenheit warmer than the water at the top for every 800 feet of drop, approximately, the kinetic energy turning to heat as the water crashed into rocks at the bottom.

In 1847 Joule was married to Amelia, daughter of Mr. John Grimes, Comptroller of Customs, Liverpool. They spent their honeymoon at Chamonix in the French Alps, and Lord Kelvin claimed later that when he chanced to meet the honeymooners in Switzerland, Joule was armed with a large thermometer to check out the local waterfalls (the Sallanches).

In the same year during the meeting of the British Association at Oxford he met William Thompson (later Lord Kelvin). It was the beginning of their friendship and common work. William Thomson supported Joule's theory and collaborated with him to examine heat changes when gases expand and contract. Results of these studies paved the way for the development of the refrigerator. Their first joint research was on the thermal effects experienced by air rushing through small apertures. Subsequently, Joule and Thomson undertook more comprehensive investigations on the thermal effects of fluids in motion, and on the heat acquired by bodies moving rapidly through the air. They found the heat generated by a body moving at one mile per second through the air sufficient to account for its ignition. The phenomena of "shooting stars" were explained by Mr. Joule in 1847 by the heat developed by bodies rushing into our atmosphere.

Joule also did a series of beautiful experiments on electrolysis and combustion. Batteries work because some of the ions in solution are chemically attracted to the metal plates. For example, oxygen ions move to a zinc or iron plate, become chemically attached and deliver charge. By carefully measuring currents, Joule was able to find the "affinity" of oxygen with plates of various elements. He then compared this with the heat produced when zinc or iron, say, were burned in an oxygen atmosphere. He saw, correctly, that this was just another way for oxygen to attach itself to these metals, and he was able to confirm that the same heat was released in these very different-seeming reactions. These chemical investigations, carried out in 1842, were no doubt in the back of his mind when he found that heat was interchangeable with mechanical and electrical energy, and suggested that chemical energy, too, must be in the list.

Over the same years, Joule also invented 'arc' or electrical welding, and the displacement pump. Despite carrying out admirable research to improve the quality of beer, Joule's brewery was in a poor financial state and in 1875 his funds ran out. With the support of members of the Lit & Phil, Joule was granted a Civil List pension of £200 p.a. for services to science. Sickness dogged his final years and he died on 11 October 1889 in his house at 12, Wardle Road, Sale, Manchester.

Joule's gravestone in Brooklands Cemetery, Sale, Manchester is inscribed with the number 772.55, his 1878 determination of the weight in pounds that could be lifted one foot by the same amount of energy required to heat one pound of water by one degree.

Joule never took an academic appointment but was made FRS – Fellow of the Royal Society (1850) and awarded the prestigious Royal (1852) and Copley (1872) medals in recognition of his

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achievements. He received honorary doctorates from Dublin, Oxford and Edinburgh universities. His achievements are recognised by a memorial tablet in the South choir of Westminster Abbey and more recently, a crater on the moon has been named after him. After his death the Lit & Phil raised money from local industrial firms, many of which had directly benefited from his scientific findings, to commission a statue of Joule. Sculpted by Alfred Gilbert, this now stands opposite that of his former tutor, John Dalton, in the entrance foyer of Manchester Town Hall.

References

Prepared on the base of:

http://all-iographies.com/scientists/james_prescott_joule.htm

http://www.bad.org.uk/Portals/_Bad/History/Historical%20poster%2006.pdf

For more detailed information look at:

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James Joule: A Biography, *Donald S. L. Cardwell, Manchester University Press.*

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