The Bicentenary of Joseph Black.

THOUGH the event has apparently passed unnoticed, on April 16 last occurred the bicentenary of the birth of Joseph Black, whose name is rendered immortal by his epoch-making chemical discovery of the nature of 'fixed air,' or carbon dioxide, and by his enunciation of the doctrine of latent heat. These two important additions to knowledge were made by Black in early manhood, but though he lived to the age of seventy years, history records no further contribution to scientific discovery by him, while of all men of science his writings are of the scantiest. His fame, however, was world-wide. His great contemporaries in England were Priestley and Cavendish; in France, Lavoisier, Berthollet, and Fourcroy, and it was the last who once referred to Black as "the Nestor of the chemistry of the eighteenth century." Proust, also on Black's name being mentioned, exclaimed: "Ah! c'est le Patriarche de la Chimie." Of Black's career and work, practically all that will probably be known is contained in "The Life and Letters of Joseph Black, M.D.," the last published work of the late Sir William Ramsay. From a scrap of autobiography given in this we learn that Black was born at Bordeaux on April 16, 1728, his father and mother both being of Scotch descent. He was one of a family of eight boys and five girls, and was taught English by his mother. At the age of twelve years he was sent to school at Belfast. At sixteen he entered the University of Glasgow, at twenty-one he removed to Edinburgh, and in 1754, at the age of twenty-six, took his degree of M.D. with the thesis, "De Humere Acido a Cibis Orto, et Magnesia Alba," which, developed and perfected, was read two years later to the Medical Society of Edinburgh with the title "Experiments upon Magnesia Alba, Quicklime, and other Substances."

At Glasgow, Black had come under the influence of Cullen, who saw that chemistry was not merely a curious and useful art, but a "vast department of the science of nature, which must be founded on principles as immutable as the laws of mechanism, and which may be one day formed into a great system of doctrines, of various degrees of subordination and dependence." Black probably began studying under Cullen in 1749, but his experiments for his thesis were begun in 1752. Black in 1754, in a letter to his father at Edinburgh, said, "Medicine is allowed on all hands to be in a very flourishing condition. It is practised in the most rational and simple manner," but the cause which led to his famous research was a curious one. A medicine invented by a Mrs. Joanna Stephens had apparently relieved both Sir Robert Walpole and his brother, who were troubled with the stone. Through them she received no less than £5000 to reveal the secret, which was published in the *London Gazette* of June 19, 1739. It ran as follows: "My medicines are a Powder, a Decoction, and Pills. The Powder consists of Egg-shells and Snails, both calcined. The decoction is made by boiling some Herbs (together with a Ball, which consists of Soap, Swines'-Cresses, burnt to a Blackness, and Honey) in water. The Pills consist of Snails calcined, Wild Carrot seeds, Burdock seeds, Ashen Keys, Hips and Hawes, all burnt to a Blackness, Soap and Honey." Cullen and his colleagues held opposing views as to such remedies, and it was with the object of discovering a 'milder alkali' that Black began his experiments on magnesia which led to the discovery of 'fixed air.'

After the publication of his thesis, Black practised medicine in Edinburgh for two years, and then, on Cullen's transference to that University, Black succeeded him at Glasgow, where he remained from 1756 until 1766. It was during these years that he enunciated and first taught the doctrine of latent heat, of which he read an account to a society in Glasgow on April 23, 1762. In his lecture notes occur the sentences: "To ascertain what I mean by the word Heat" to "ascertain the real difference between heat and cold" and "to mention some of the attempts which have been made to discover the nature of heat." He argued that heat is the positive thing and not cold, and goes on to say, "But our knowledge of heat is not brought to that state of perfection that might enable us to propose with confidence a theory of heat," but "when we have at last attained it, I presume that the discovery will not be chemical, but mechanical."

One or two of Black's experiments may be recalled. In the first he hung two globes 18 inches apart in a large hall; one contained 5 oz. of water the other 5 oz. of ice. The water in half an hour had increased in temperature from 33° to 40° F., whereas $10\frac{1}{2}$ hours elapsed before the ice had melted and attained the same temperature, from which he argued that 139 or 140 "degrees had been absorbed by the melting ice, and were concealed in the water into which it had changed." He next tried adding equal weights of ice and water at 32° to equal quantities of warm water, and deduced the figure 143° F. In the third experiment he proved that a lump of ice placed in an equal weight of water at 176° F. lowered the temperature to 32°. Somewhat similar experiments were made by Black on the latent heat of steam, in which he compared the time required for a known weight of water to rise through a definite interval of temperature when exposed to a constant supply of heat with that required to dissipate the water into steam, and it was the results of these experiments which Black communicated to Watt just at the time the latter was pondering over the problems raised by the irregular working of the model Newcomen steam engine in the University of Glasgow.

Few scientific discoveries have had a greater influence on the work of engineers than those made in the effects and properties of heat, of which Black's was one of the most important. Up to the seventeenth century all had been conjecture. The first real step in progress was the invention and improvement of the thermometer. This first appeared in Italy about the same time as the barometer, and the conception of the steam engine may be traced directly to the introduction of those philosophical instruments and the enlargement of human knowledge they brought in their train. Fahrenheit, the German instrument maker of Amsterdam, was the first to make thermometers with adequate skill, and he also fixed, first the freezing point, then the blood heat, thirdly the extreme cold of a mixture of ice, water, and sal-ammoniac, and then the boiling point of water. Writing a hundred years later, Sir John Leslie, himself a great experimenter, said: "The Doctrine of Heat has in the course of the eighteenth century been advanced to the rank of a science. Its transfusion through the mechanical arts has communicated a grand movement to society and wonderfully augmented our natural wealth and resources." Leslie then went on to recall some of the most important discoveries: Fahrenheit's thermometric scale; Cullen's observation of the lowering of the boiling point under a decrease of pressure; Black's theory of latent heat and sensible heat; the introduction of the terms 'capacity for heat' and 'specific heat'; Lavoisier's and Laplace's experiments on calorimetry; Wedgwood's pyrometers; the registering thermometers of Six, and the production of artificial cold; but like Black he felt that the true theory of heat had yet to be discovered, remarking, "What seems wanted at present to complete our knowledge of heat, is not the vague repetition of experiments already carefully performed, but a nice investigation of several unexplored properties, directed with scrupulous accuracy on a large scale." Had Leslie but known it, even at the time he wrote, the famous essay of Carnot had already been published, while Joule, Rankine, Kelvin, Mayer, Clausius, Tyndall, and others were just beginning the careers during which they were to demonstrate by means of "nice investigations," "directed with scrupulous accuracy," that, as suggested by Black, the true theory of heat is not "chemical, but mechanical."

With Black's work on latent heat his course of discovery came to a close. In 1766 he removed to Edinburgh as professor of chemistry, and there for more than thirty years lectured on his favourite subjects. The friend of Watt, Adam Smith, Robison, Hume, Playfair, and Hutton, he passed his life in the quiet performance of his congenial duties, somewhat indifferent to honours, but cheerful and courteous to all alike. His death took place suddenly as he sat in his chair, on Dec. 6, 1799. Robison, who wrote a sketch of him and published his lectures, gave the date of his death as Nov. 10, and Ferguson gave it as Nov. 26, another mistake. It was Muirhead who first pointed out the discrepancy; the date Dec. 6 being confirmed from the newspapers of the time.

Life's Unsuspected Partnerships.[1]

By Prof. DORIS L. MACKINNON.

SYMBIOSIS is the word used by biologists to describe the state of affairs in which two or more different kinds of organisms are closely, and in some cases inseparably, associated for the greater part of their lives in a partnership from which both, in some degree, probably draw benefit. Within the last few years, many unsuspected interdependences have been revealed, and a vast field has been opened up for further research.

It has recently been claimed by Pierantoni and other workers that the luminescence of surface-living cuttle-fishes, pelagic tunicates, and certain reef-inhabiting fishes is produced by bacteria that are in constant symbiosis with them. Saprophytic light-giving bacteria are abundant in the sea, and are inevitably swallowed by feeding animals, in the dead bodies of which they multiply exceedingly, and, still glowing, produce the disconcerting phenomenon of phosphorescence which may be noticed, for example, in rotting fish.

Among the little sand-hoppers of the genus *Talitrus*, which are normally not luminescent, one is occasionally found glowing with a mysterious inward light. Such individuals are always diseased, and if their infected blood be injected into the bodies of other like crustaceans, these also begin to glow and soon die. It would look therefore as though, for some animals, the incursion of luminescent bacteria is directly harmful. But others have acquired immunity against the invaders, and have even turned the invasion to account. Such are the pelagic tunicates and the cuttle-fishes. The best-known example of tunicate phosphorescence is that of the creatures known as *Pyrosoma*, which form transparent, gelatinous, tube-shaped colonies floating on the surface of the warmer seas. The walls of the tube are composed of numerous individuals seated in a common gelatinous envelope and adding to their number by budding. The mouth of each person is directed outwards, and close behind it is a patch of tissue which is the light-organ. It has been discovered that the cells composing this organ contain luminescent bacteria, and it is the glowing of these that gives the animals their phosphorescence. It is not easy to imagine what advantage the *Pyrosoma* colony derives from this; the animals have no eyes, they are hermaphrodite, and they lie in close association; but some important advantage there must be, for the eggs that will give rise to new colonies are always furnished with a certain quantity of the bacteria, handed on from the parent.

When the *Pyrosoma* individual is sexually mature, some of the bacteria in its light-organ begin to form spores, which then leave the shelter of the cells in which they have developed and are carried by the blood-stream to the little sac in which the single egg is developing. Invading the cells of this sac, they seem to induce these to divide, and one of the

[1] From a Friday evening discourse delivered at the Royal Institution on May 11.