SUMMARY AND CONCLUSIONS

Of the many subjects of common interest to taxonomists, geneticists and ecologists, those mentioned here have, for convenience only, been referred to under the two headings, genetical and ecological. This division is artificial and unsound in practice. It is only when all methods are used, so far as possible on the same material, that taxonomic judgments can have any final value. It can be justly urged that the professional taxonomist is frequently too overwhelmed with the mass of material he is expected to identify and classify to have time to carry out slow time-consuming experiments, even if he has facilities for them. On the other hand, those taxonomists who have had a recent botanical training should have a sufficient grounding in plant ecology and plant genetics to be able to appreciate those ecological and genetical methods and results which bear on their own studies, and should be keen to co-operate with their colleagues. It is also probable that a continual personal acquaintance with experiments on living plants, even if on a small scale, is advantageous to the taxonomist in keeping his outlook broader than it can be with herbarium routine not merely dominant but absolute. The judicious use of an experimental ground attached to a taxonomic institution pays over and over again in increased interest in major problems and in efficiency in solving taxonomic difficulties.

It may be an overbold thing for a taxonomist to suggest to his genetical and ecological colleagues that, if he were consulted, he could set them problems the solution of which would not only have first-class value in the special domain of genetics or ecology respectively, but would also directly assist the taxonomist. The taxonomist often regrets that relatively so much more genetical research has been concerned with cultivated than with wild plants. He realises the economic reasons for this, but hopes that more research can be undertaken which has not an economic end directly or immediately in view. If botanists with opportunities would undertake intensive studies on small groups of allied species, with a taxonomic ideal but using genetical, ecological and other experimental and observational methods, they would produce work of permanent value, and help to the unity of botanical science.

Obituary

Prof. J. S. Haldane, C.H., F.R.S.

"IL montra que si le physiologiste doit sans cesse recourir aux notions que lui fournissent l'anatomie, l'histologie, la médecine, l'histoire naturelle, la chimie, la physique, il doit en rester le maître, les subordonner à ses propres visées ;" . . .

Thus a distinguished worker in Haldane's own special sphere, namely, Paul Bert, summed up the teaching of another great physiologist—Claude Bernard. The words are no less applicable to Haldane himself, for, remarkable as were his researches and writings on many aspects of pure and applied physiology, their value was founded in his deep insight and his search for a philosophical basis on which he could build up an intelligible interpretation of the phenomena of life, which he saw could only be understood as a whole.

It is a proof of the acuteness of Haldane's insight that, so early as his days as a medical student at Edinburgh, he was not content to accept without inquiry a teaching of physiology which did not satisfy his demands for a consistent description of its various aspects. His impatience with superficiality and desire to penetrate to fundamental conceptions of phenomena lasted throughout his life and found expression in a series of philosophical essays and books, which began with an "Essay in Philosophical Criticism" published in 1883 in collaboration with his brother Lord Haldane, and culminated in "The Philosophy of a Biologist", 1935. Between these times he never lost his interest in philosophy and, despite the great amount of work he did in pure and applied physiology, found time to write "Mechanism, Life and Personality", 1913, "The New Physiology", 1919, "The Sciences and Philosophy", 1928 (Gifford Lectures), "The Philosophical Basis of Biology", 1931 (Donellan Lectures) and "Materialism", 1932.

Though Haldane always maintained his insistence on the necessity for broad conceptions, he became particularly interested in the physiology of respiration at the very beginning of his scientific work. This interest in respiration led him in turn to another aspect of physiology of which he was a brilliant pioneer, namely, its applications to problems of industrial hygiene. His thoughts perhaps turned in this direction owing to the fact that he became demonstrator at University College, Dundee, under Prof. Carnelley, with whom he carried out an investigation of the various impurities present in the air in buildings and sewers, which was published in 1887.

Soon afterwards Haldane went to Oxford, where he became demonstrator in physiological chemistry under his uncle, Sir John Burdon Sanderson, and where he remained for the rest of his life. Here he soon began the work which led to the publication, mainly in the *Journal of Physiology*, of an important series of papers on the blood and respiration, which not only did much to establish his own fame, but also made world-wide the reputation of the Oxford Schools of Physiology and Medicine and led to general recognition of the importance of the study of human physiology. The earliest of these papers was a short note in which he disproved D'Arsonval's idea that some poisonous impurity was given off in expired air. This note contains his first suggestion that carbon dioxide is the most important factor in regulating the respiration, and was amplified in 1893 in two papers in the *Journal of Pathology and Bacteriology*. Two papers on respiratory exchange followed, and then in 1894 Haldane and Lorrain Smith visited Christian Bohr's laboratory at Copenhagen, where they worked on the specific oxygen capacity of the blood, and learned much about gas analysis.

Haldane was remarkable for his skill in devising methods of investigation no less than for the broad view he took of physiological problems, and from the knowledge he acquired from Bohr he developed his technique of gas analysis, which has been generally adopted. He published his first description of his apparatus for air analysis in the *Journal of Physiology* in 1898, and afterwards gave a further account of his methods in "Methods of Air Analysis", 1912. This book obtained wide recognition, and in the preparation of subsequent editions Haldane was helped by his colleague, Dr. Ivon Graham. As was written of another—"The very air we breathe, he has taught us to analyze, to examine, to improve".

In 1895 Haldane began an inquiry into the nature and action of the suffocative gases met with in the air of coal mines, and was thus led to investigate the physiological action of carbon monoxide, the poisonous effect of which he showed to be due solely to its power of combining with hæmoglobin and so putting it out of action as an oxygen carrier. It was with astonishing insight that Haldane saw how this work opened the way to an effective attack on many important problems. He devised a simple method of detecting and estimating carbon monoxide in air by carmine titration of blood with which the air was shaken; he found that the stability of the carbon monoxide–hæmoglobin complex in the presence of oxygen was much decreased by the action of light; he devised a method of deducing the oxygen tension of human arterial blood from its saturation with carbon monoxide after breathing air containing this gas; he investigated the evidence that carbon monoxide is oxidised in the body and found it unsatisfactory; he determined the mass and oxygen capacity of the blood in man by the carbon monoxide method and he devised his modification of Gowers' hæmoglobinometer, which is still unequalled.

During these years Haldane did other important work on the blood pigment and its derivatives. He investigated the action of ferricyanide on the oxygen —and carbon monoxide—hæmoglobin complexes and showed that this reaction could be used to determine accurately, without the use of the blood-pump, the volume of oxygen capable of being absorbed by hæmoglobin. On this basis in 1902 he designed, with Barcroft, an apparatus for accurately measuring the oxygen and carbonic acid in small quantities of blood. Later this apparatus was improved by Brodie, and Barcroft developed from it his well-known 'differential' apparatus. In 1920 Haldane improved the method by substituting measurement of the gas liberated at constant pressure instead of at constant volume.

In 1903 Haldane turned again to the important, but then obscure, problem of the regulation of the respiration, the key to the solution of which he had already indicated in 1893. With the help of his own methods of gas analysis and by the simplest means, he proved that it was possible to obtain and analyse samples of 'alveolar air', and he made many observations on the composition of this alveolar air in human subjects at rest and during muscular work, as well as when they were exposed to widely differing barometric pressures or were breathing air containing excess or deficiency of oxygen or carbon dioxide. He was thus able to show the exquisite sensitiveness of the respiratory centre to changes in arterial carbon dioxide pressure, and to afford an insight into the means by which the breathing is so regulated as to satisfy the varying requirements of the body from moment to moment. It is on this fundamental basis that the whole of our knowledge of the physiological regulation of the breathing is securely founded.

This work, which was published in 1905, was undoubtedly the most important of Haldane's physiological researches, and the results formed perhaps the strongest foundations on which he based his philosophy of biology. Apart from revolutionising the ideas then prevalent about the regulation of the breathing, it indicated far more clearly than had been done before the amazing delicacy with which different physiological functions are co-ordinated, and it made intelligible the responses of the body to differing conditions. Later he extended the results of this paper, and then turned to the investigation of the effects of low atmospheric pressure and want of oxygen on the respiration, and showed the explanation of periodic breathing.

In 1911 Haldane led an expedition to Pike's Peak to study the effects of low atmospheric pressures and the process of acclimatisation, and afterwards published further work on this subject. In his last years he was keenly interested in the physiological problems of very high flights.

In 1913 and 1914 Haldane investigated the absorption and dissociation of carbon dioxide by human blood and devised a method of determining the circulation rate in man which was founded on the results so obtained. In 1916 he took up the question of the nervous regulation of the respiration and showed how this was related to the chemical regulation. His later work on respiration was concerned with the respiratory response to anoxæmia and the effects of shallow breathing and resistance to the respiration.

His measurements by his carbon monoxide method of the oxygen pressure of arterial blood together with many other observations had convinced him that in certain circumstances secretion of oxygen inwards must occur in the lungs. Krogh's aerotonometer measurements, however, indicated equally clearly that diffusion alone sufficed to account for the facts. Both methods seemed to be reliable and the discrepancy between the results they gave remained unexplained until Haldane proved from his observations on shallow breathing that they did not measure the same thing. The aerotonometer method measures the oxygen pressure of the mixed arterial blood leaving the lungs, while the carbon monoxide method measures the average of the oxygen pressures of the blood in different parts of the lungs, some of which are well, but others poorly, ventilated.

Haldane maintained that oxygen secretion by the lungs is one of the most important factors in acclimatisation to high altitudes, and that it may be aroused in other circumstances when the body is subject to deficiency of oxygen; he also believed that it may come into play during muscular work.

Haldane's physiological work was by no means confined to respiration. He studied the responses of the body to high external temperatures, and found that activity of the sweat glands evokes adjustment of other physiological functions in a particularly interesting manner. He also showed that the activities of the kidneys are closely connected with those of other organs and that their response to chemical stimuli is of the same order of delicacy as that of the respiratory centre. From his observations of coloured shadows and contrast he found further support for his interpretation of physiological phenomena.

Work with Haldane was at once an education and a delight. His wide views based on his philosophy enabled him to see essentials and disregard non-essentials so surely that the true value of his clear and simple conclusions could perhaps be fully appreciated only by those who had the privilege of working with him. Of practical experimental procedure, too, he was a master. His results could scarcely be surpassed in accuracy, though his methods were his own. His adherence, for example, to the use of a wooden match as an aid in reading a burette remained unshaken by the introduction of electric torches. He was not upset by conditions which would fill many with dismay. His analyses were just as efficiently conducted at the bottom of Dolcoath mine or in the middle of the night in the Station Hotel at Inverness as in his laboratory at Oxford. Those who worked with him had to conform to his customs. Work generally did not begin before midday, despite any arrangements which might have been made previously for a special occasion. Once begun, it was apt to continue until 2 or 3 a.m., though tea and dinner were not lightly disregarded. Though these ways were occasionally a little trying to those adapted to a different routine, they only increased an affection which was founded on admiration of his genius and his never-failing kindness, and appreciation of his humour. Though he was an acute critic, there is no record among those who worked with him of Haldane's ever being out of temper, and the bond between them is one of the most remarkable tributes to his character.

Great as Haldane was as a physiologist, he was equally great indeed unique as an investigator of the physiological problems of industrial hygiene. In 1896 he made a report on his investigations of the cause of death in three colliery explosions. He had already shown that the then prevalent view as to the symptoms produced by exposure to black damp and after-damp was inaccurate, and his report forms the basis of the measures which have been devised and are in force throughout the world for dealing with the dangers due to fires and explosions underground. From that time Haldane's interest in problems affecting the health of miners never slackened, and he was untiring in his investigation of such matters as the ventilation of mines and the prevention of underground explosions, ankylostomiasis among Cornish miners, the effects on underground workers of inadequate illumination and of high atmospheric temperatures, and liability to silicosis in consequence of the inhalation of different kinds of dust. His never-failing devotion to the welfare of the miners, and the value of his work, were recognised in 1912 by his appointment as Director of the Doncaster Coal Owners' Research Laboratory, and brought him the unique honour for a physiologist of being elected to the presidency of the Institution of Mining Engineers in 1924.

As one of the Gas Referees under the Board of Trade, Haldane did invaluable work on the composition and properties of illuminating gas.

The Home Office, the Army and the Navy, too, owed much to Haldane. He served on many commissions and was a member of a committee which inquired into the physiology of the soldiers' food, clothing and training, and the report of which brought about important reforms. During the Great War, he was called upon to advise about protection against poison gases, and not only did valuable work with regard to emergency provision of respirators but also pointed out that only some form of box respirator could ensure protection. He did valuable work on the pathology and treatment of gas poisoning and made clear the physiological effects of shallow breathing, which was a prominent symptom in chronic cases. Recognising the grave dangers of anoxæmia, he devised an apparatus for the economical and effective administration of oxygen.

For the Navy, Haldane investigated the ventilation of battleships and submarines, but his most important work was his inquiry into the difficulties and dangers besetting divers. His characteristic insight enabled him to grasp at once the cause of the serious limitation of the divers' capacity to do muscular work, of which complaint was made. He showed that this was due to the high pressure of carbon dioxide present in their helmets owing to the inadequacy of the pumps then in use. Having made sure that the divers' air supply was sufficient, he began a thorough investigation of compressed air illness and its prevention, and set to work to devise a method of decompression both safe and time-saving. He noticed that symptoms in animals and men only occurred after rapid decompression from a pressure at least one atmosphere in excess of normal to sea-level pressure, and proved by an extensive experimental investigation that the method of very slow decompression was in some respects actually harmful. He also proved that a method of 'stage decompression' was both safer and quicker. He calculated tables for regulating the safe rate of decompression of divers by stages corresponding to the pressures to which they had been exposed and the duration of their exposure. He again took up this problem in 1935 and worked out tables for still greater pressures. His stage decompression is now generally used and has undoubtedly saved many lives, besides making it possible for divers and tunnellers to work at pressures otherwise unattainable.

Haldane gave a full account of his work on the physiology of respiration and of some of his investigations in applied physiology in his Silliman Lectures, which were published under the title "Respiration" in 1922. A new edition, to the rewriting of which he devoted much time and care, appeared in 1935. In this book, unrivalled since it first appeared, he has left a record worthy of his genius.

Haldane was created a Companion of Honour in 1928 in recognition of his scientific work on industrial hygiene. The many other honours which he received, and which are recorded elsewhere, included the Copley Medal of the Royal Society in 1934.

Only a few weeks before his death, which occurred after a short illness on March 14, in his seventy-sixth year, Haldane had returned, apparently in good health, from a visit to Persia and Iraq, whither he had gone to study heat-stroke.

Haldane's influence on all aspects of physiological thought has been enormous and his loss is not only a bitter blow to those who knew and loved him, but also leaves a gap in the application of physiology to industrial and medical problems which will indeed be hard to fill. J. G. P.

Mr. Maurice C. Macmillan

A MONTH ago we recorded with much regret the death of Mr. George A. Macmillan, one of the directors of Messrs. Macmillan and Co., Ltd., the publishers of NATURE. Another link connecting the journal with this publishing firm has now been broken by the death on Monday last, March 30, at eighty-two years of age, of Mr. Maurice Crawford Macmillan, brother of Sir Frederick Macmillan, the chairman of the company, and cousin of Mr. George Macmillan.

The firm was founded in 1843, when Mr. Daniel Macmillan, the father of Sir Frederick and Mr. Maurice Macmillan, was joined by his younger brother Alexander and published the first volume with the name of Macmillan on the title-page, namely, A. R. Craig's "Philosophy of Training". Seven years later the firm adopted the title Macmillan and Co., which it has retained ever since.

Mr. Maurice Macmillan entered the business in 1882, after a distinguished career at Uppingham and Cambridge, followed by five years' experience as an assistant master at St. Paul's School, under Dr. Walker. He devoted himself particularly to the educational side of the business, and to him is largely due the comprehensive list of standard books for students of all standards and subjects published by the firm. He was keenly interested in every aspect of educational work, from the primary school to the university, and he followed with close attention all developments in methods of teaching scientific and other subjects. He was chiefly responsible for the establishment of branches of the firm in India, Australia and other centres where the educational publications of the firm are largely used.

Though NATURE was founded several years before Mr. Maurice Macmillan came into the firm, he was always an encouraging supporter of it and was keenly interested in many scientific subjects dealt with in these columns. In this, as well as in the selection of books of high standard, he rendered valuable service to science, and we pay a grateful tribute to him for his great work and beneficial influence over a period of many years. He leaves three sons, two of whom, Mr. Daniel Macmillan and Mr. Harold Macmillan, M.P., are directors of the firm.

MR. GEORGE HUBBARD, a London architect of distinction, who was twice a vice-president of the Royal Institute of British Architects, died at his residence at Eltham on March 19, his seventy-seventh birthday. Mr. Hubbard was well known as an archæologist and collector of antiquities. His most noteworthy contributions to archæological studies were a paper on "Architecture on the Eastern Side of the Adriatic", and in prehistoric archæology a book written in conjunction with his brother, A. J. Hubbard, on "Neolithic Dew Ponds and Cattleways", published in 1905, which went far to settle finally the problem of the construction and uses of this primitive method of dealing with deficiencies of water supply.

WE regret to announce the death at the age of sixty-nine years on February 27 of Prof. Charles Jules Henri Nicolle, for more than thirty years director of the Pasteur Institute of Tunis, and professor at the Collège de France. He is best known for his work on typhus, which in 1909 he proved to be transmitted by the clothes louse. He was also a pioneer in the prophylaxis of this disease and of measles, in addition to much valuable work on other infectious diseases, for which he was awarded the Osiris Prize of the Institut de France in 1927, and a Nobel Prize in 1928. Prof. Nicolle was a member of the Paris Academies of Sciences and Medicine, and an honorary fellow of the Royal Society of Medicine.

WE regret to announce the following deaths:

Sir Archibald Garrod, K.C.M.G., F.R.S., formerly regius professor of medicine in the University of Oxford and consulting physician to St. Bartholomew's Hospital, on March 28, aged seventy-eight years.

Sir Joseph Petavel, K.B.E., F.R.S., director of the National Physical Laboratory, Teddington, on March 31, aged sixty-two years.