It is my first duty to refer to Fellows who have recently passed away.

GEORGE ALBERT BOULENGER was a student of the University of Brussels, his native city. He began at a very early age the study of reptiles, batrachians and fishes in the Natural History Museum at Brussels, and in 1880 became assistant naturalist there. In 1882, he was appointed a first class assistant in the Department of Zoology in the British Museum; he held this position until he retired in 1920.

He has been described as a man of tremendous energy, an extremely methodical mind, and an amazing memory. These qualities were the foundation of the vast amount of work which he accomplished. He was one of the most distinguished of the descriptive biologists who have brought fame to the British Museum during the past hundred years. His most important contributions to science were the series of elaborate and detailed monographs, mostly published by the Museum. These still remain the basis of modern systematic work. They dealt with the groups of life which had interested him from the beginning, the batrachians, fishes, lizards, snakes and so forth. Thanks to his energy as a collector and as a stimulator of collectors, the Museum is rich in its possessions of these types; for example, it possesses an unparalleled collection of fresh water fishes.

Boulenger was elected a Fellow in 1894 and served on the Council from 1903 to 1905. He was for some years a Vice-president of the Zoological Society and received many honours at home and abroad. He was naturalized in this country.

Towards the end of his long life he forsook his reptiles and for twenty years devoted himself to the study of roses.

WILLIAM MCDougALL (1871–1938) was educated at a private school until he was 14, when he went for a year to a Real-Gymnasium at Weimar. The next four years were spent in the University of Manchester where he graduated with first class honours, making geology his special subject in his last year. He went to Cambridge in 1892, and obtained a 1st Class in both parts of the Natural Sciences Tripos, taking Physiology and Human Anatomy in Part II. He obtained the medical degree in 1897.

In 1897, while holding a house appointment at St Thomas’s Hospital, he...
joined the Cambridge Anthropological Expedition in the Torres Straits. After a while he left the expedition to work with Dr Charles Hose on a study of the head-hunting tribes.

On his return to England his researches reverted to the physiological. He did much work on colour vision and took a great interest in the current controversies between the theories of Helmholtz and Hering. His investigations were made in the border country between sense physiology and the psychology of special senses; he insisted on the necessary correlation of the two subjects. Gradually he found most to do on the psychological side; his election to the Society in 1912 may be said to mark in time when he was rather on this side than the other. He held a post in Sully's department at University College (London) until 1904 when he was appointed to the Wilde Readership in Mental Philosophy at Oxford. McDougall drove a French ambulance in the earlier years of the war. Subsequently he was attached to the R.A.M.C. and put in charge of nervous patients: a duty for which he was especially fitted. At the same time it provided much material for his own line of work.

In 1920 he accepted an invitation to Harvard University; in 1927 he joined the staff of Duke University, North Carolina. He made a great name for himself in America. When I attended recent celebrations at Duke University on behalf of our Society I was much impressed by what was said to me of the esteem in which he was held and the value placed upon his work.

He himself considered *Body and Mind*, published in 1911, as his best written work: and its title may be taken to indicate the field of science in which he was eminent.

By the sudden death of George Barger, at the early age of 60 years, science has lost a chemist of great distinction, whose personal and scientific influence spread far beyond this country. After a distinguished University course at Cambridge, Barger began his work in research while teaching Botany for a year in the University of Brussels. Then came a period as Chemist to the Wellcome Physiological Laboratories, where research on the active substances in ergot, from which came so much of unexpected biological interest, helped to give a Biochemical turn to Barger's activities. In later years he wrote a brilliant and scholarly monograph on ergot, dealing with all aspects of knowledge concerning that curious drug. After holding several academic appointments for shorter terms, he became in 1919 the first Professor of Chemistry in relation to Medicine in the University of Edinburgh, and held the Chair till 1938, when he became Regius
Professor of Chemistry in the University of Glasgow. Though his range was a wide one, he always regarded himself as essentially an organic chemist, and the researches of his own choice were on the stable end products of vital activity, rather than on the chemical changes involved in life itself. He received the Davy Medal of the Society a month before his death. Bilingual from his earliest years though British by birth, schooled in the major European tongues in Holland, Barger retained throughout his life a zest for learning new languages, and used them to make scientific and personal friendships in many countries. To an unusual degree he became an international figure in science, striving with honest enthusiasm to promote understanding and friendship among men of science throughout the world. He was elected a Fellow in 1919 and served on the Council from 1930 to 1932.

Alfred William Porter, born in 1863, was educated at the University Colleges of Liverpool and London. He was a Fellow of University College London and Assistant Professor of Physics for many years, until in 1923 he was appointed to a University Chair. He retired in 1928.

Porter was essentially a man of learning: he was gifted also with the power of clear statement. His wide knowledge and his generous readiness to place it at the service of others made him the subject of frequent appeals for assistance. He had a penetrating and critical mind, and was particularly at home in the discussion of the fundamentals of physics and chemistry. He was especially interested in the border subjects between these two sciences, and his Presidency for a few years of the Faraday Society was well suited to his knowledge and abilities. His translation (with Carey Foster) of the Joubert treatise on Electricity and Magnetism and his new edition of Preston’s *Theory of Light* were considerable developments of the originals, and being so gave him good opportunity for the use of his powers of construction and exposition. He gave a remarkably interesting address on “The Volta effect and kindred subjects” as President of Section A of the British Association, when it met at Glasgow in 1928.

He was the highly respected teacher of large numbers of University College students. He also did great service to physics in various administrative capacities: he was secretary to the University of London Board of Studies in Physics, and the first honorary secretary of the Institute of Physics. He was elected a Fellow of the Royal Society in 1911. He served a term as President of the Röntgen Society; and also of the Faraday Society. At the time of his death he was one of the editors of *The Philosophical Magazine*. 
Herbert Henry Woollard was born in Victoria, Australia in 1889. He studied medicine at the University of Melbourne, qualifying at the early age of 21. He served with the Australian forces in the war, attaining to the rank of Lieutenant-Colonel in the Australian Army Medical Service. After demobilization he began a course of study at University College, London, where he came under the influence of Elliot-Smith, and determined to take up the study of Anatomy as a scientific career. In 1923, he was appointed Assistant Professor of Anatomy. From 1928 to 1930 he held the Chair of Anatomy and Histology in the University of Adelaide. He returned to England to become Professor of Anatomy at St Bartholomew’s Hospital Medical College. Finally he succeeded Elliot-Smith in the Chair of Anatomy at University College.

Woollard was a brilliant worker, full of energy and eager to suggest and carry out new ideas. Anatomy was to be far more than a descriptive science: it was to be linked with experiment. His researches dealt especially with the problems of histology, and he laid stress on the need for their consideration in conjunction with those of anatomy.

His technique was of a high order. He perfected certain methods of staining, and was able to advance by their means the general problem of innervation. He used his own body for experiments, which were often far from painless. He made a great number of important observations. He was able, for example, to identify specific types of nerve terminal subserving touch and temperature.

He was elected a Fellow in 1938. He was a fine teacher, researcher and administrator. Anatomical science suffers severely by his death when many more years of good work might have been expected from him.

Arthur Smithells (1860–1939) was in his early days a student at Glasgow University and attended some lectures by Kelvin. At the age of 18, having acquired a passion for science and especially for chemistry, he entered Owens College, Manchester, where he was a pupil of Henry Roscoe. In 1882, he graduated B.Sc. of London University. He then went to Germany and studied in the first place under von Baeyer in Munich and afterwards under Bunsen in Heidelberg. In 1883, he lectured on chemistry at Owens College and in 1885 he succeeded Thorpe in the Professorship of Chemistry at Yorkshire College, afterwards the University of Leeds. He resigned his Chair in 1923, and went to London to take the Directorship of the Salters’ Institute of Industrial Chemistry. He was elected a Fellow in 1901. Smithells when a young man gave proof of great ability as an experimenter; his work on “Flame” is well known and his beautiful illustrations
are often repeated. But his main contribution to science has been elsewhere. His love for chemistry was not satisfied with the growth of chemical knowledge: he had a vision of the important part that science could play in the work and the social life of men, in their doings and in their thoughts. Chemistry was not merely a subject for academic study, nor was it only a tool of industry: it was both these and it was also a link between them, and in their combination it could be a lively force. As he held these views enthusiastically and had remarkable powers of exposition and of organization, he was able to assist notably in their realization. The University of Leeds with its considerable chemical school, its technical departments of fuel, leather, dyeing and textiles, all designed on broad lines, is greatly indebted to him for its success and for its true University character.

Henry Balfour (1863–1939) was educated at Charterhouse and at Trinity College, Oxford, where in 1885 he took honours in the final school of animal morphology. A year previously the University had accepted the collection of ethnological and archaeological specimens made by General Pitt Rivers. Prof. H. N. Moseley, in whose charge the Pitt Rivers Museum had been placed, invited Balfour to assist him in its arrangement. He worked under Moseley until the latter’s death in 1891, when he himself became Director of the Museum. In subsequent years the Museum grew in size and richness under his care.

The main principle in Balfour’s work was in the first instance that which Pitt Rivers followed, and sought to illustrate by his collections and the method of their display. The evolution of mankind could be followed by examining the evolution of his tools, weapons and other objects which he used. In order to show this it was necessary both to collect and to arrange with a definite purpose and in an orderly fashion. No one could have been better suited than Balfour to develop this conception and to extend it. He had received a classical education, he was zoologist, field naturalist and artist all in one. He travelled widely in his search for evidence. The use which he made of his acquisitions established his own fame and that of the Pitt Rivers Museum.

He published many essays on such subjects as flint instruments, the crossbow, the fire-piston, kite-fishing, thorn-lined traps and many others of like nature; always arranging his material to show its evolutionary lesson and its contribution to ethnology.

Arthur Philemon Coleman was born at Lachute, Quebec, in 1852. He studied at the Victoria University at Cobourg in Canada and at the University
of Breslau. He became Professor of Geology at his old University in 1881 and at the University of Toronto in 1890. He retired in 1922.

Coleman belonged to a type of public servant to whom the British Dominions are greatly in debt: men well versed in the knowledge of their day, and possessed of a physical vigour, a breadth of mind, and an adaptability which enabled them to attack the problems of wide territories, only half explored. The ordered development of the new countries has been made possible by their accurate and comprehensive observations and inferences.

Coleman was an explorer as well as geologist, and it needed much laborious travelling to map the dispositions of the strata in the Canadian wilderness. He is distinguished for his description of the great metal ore-field of Sudbury, and its place in the complicated series of the pre-Cambrian strata. He was interested in the history of past ice ages, and travelled widely in search of evidence. He published a well-known book on the subject. One of his water-colour sketches is probably the earliest picture of Mystery Mountain (Mt Waddington) in the Coast Range of British Columbia.

Coleman was elected a Fellow in 1910.

EDMUND BEECHER WILSON (1856–1939) was elected a Foreign Member of the Royal Society in 1921. He was one of the foremost zoologists in the United States. He began his academic studies at Yale University, and continued them at Johns Hopkins, Cambridge, Leipzig and Naples. He was in succession a lecturer at the Massachusetts Institute of Technology, Professor at Bryn Mawr College, and Director of the Zoological Laboratories at Columbia University. He was the Professor of Zoology at Columbia from 1891 until his resignation in 1928.

Prof. Wilson was particularly interested in all questions of heredity. He introduced into biology the conception of "cell-lineage". He wrote a number of books on microscopical anatomy, embryology, zoology and kindred subjects. His work gave him an international reputation, and he was a member of learned societies all over the world and an honorary graduate of many Universities. He was the Croonian Lecturer of the Royal Society in 1913.

HARRY MEDFORTH DAWSON died on 9 March at the age of 63. All his life, with the exception of three years of study in Germany, was spent at Leeds. He was a scholar at the Leeds Modern High School, and afterwards he was in turn student, demonstrator, lecturer and professor of chemistry in the University.
In the last year of his course of study in the University he was engaged on research work in collaboration with Prof. Smithells, whom also we have lost during the past year. He won an 1851 Exhibition scholarship and spent three years at Berlin, Leipzig and Giessen. He was one of a group of able young men who represented the growth in England, at that time, of a new spirit of research, and like many of his chemical contemporaries sought to develop it in Germany.

Dawson’s work was centred round the mechanics of solutions. He was an enthusiastic student, to whom no pains were too great for the purpose of accuracy and fullness of proof. He did a fine piece of work in his establishment of the multiple theory of catalysis.

Dawson was essentially a laboratory worker. He inspired a number of student collaborators and he was greatly interested in the researches of others in fields apart from his own. He was for some time the secretary of the Priestley Club with a membership which included many outside the University. His own kindly nature enabled him to maintain with success the friendly informality of the Club. He was elected to the Royal Society in 1933.

Sir Henry Oram who died on 5 May of this year, at the age of 81, was a very distinguished naval engineer. After years of great promise at the Engineering College at Keyham and the Royal Naval College at Greenwich and two years at sea he was appointed at the Admiralty in 1884. For thirty-three years he took a prominent part in those radical transformations of the machinery of the Navy which were necessitated by modern science and inventiveness. Water-tube boilers were introduced while he was deputy under the Engineer-in-Chief, Sir John Durston. He took a prominent part in the change from reciprocating engines to turbines. It was largely due to his advocacy and skill that turbines were successfully fitted in H.M.S. Amethyst and subsequently in the first Dreadnought. When oil came to the front as a fuel, and a Royal Commission under Lord Fisher reported on oil fuel and oil engines, Oram was warmly praised by the Commission who “without his aid, could not have so confidently expressed their unanimous conviction of the vital necessity for fighting ships of oil fuel and oil engines”. Under his directorship, Diesel-type machinery was adapted for use in submarines, a work requiring the highest skill.

Oram was elected a Fellow in 1912 in recognition of the fact that his labours led not only to engineering achievements but also to the advancement of science. Those who worked with him at the Admiralty testify to a personality which ensured their grateful and devoted service.
Frank Watson Dyson was born in 1868, and was educated at Bradford Grammar School and Cambridge. He was second wrangler in the Mathematical Tripos in 1889 and was elected to a fellowship in Trinity College. In 1894, he was appointed chief assistant at the Greenwich Observatory. He became Astronomer-Royal for Scotland in 1905 and returned to Greenwich as Astronomer-Royal in 1910, retiring in 1933. He was knighted in 1915.

Dyson's first important work was a completely new reduction of the Groombridge observations of circumpolar stars. The results were so accurate and reliable that Eddington was able to use them in his extensions of Kapteyn's principle of star-streaming. When he returned to Greenwich he took in hand the collection of accurate information respecting the stars comprised in the zone extending from 65° N. to the pole, this being the zone allotted to Greenwich by international agreement. Proper motions of the stars were deduced from differential measures of photographs taken at sufficient intervals.

Dyson took a great interest in the problems that could be solved by observations taken during total eclipses of the sun. He took part in several expeditions: he was always remarkably lucky in his weather. He had much to do with the famous expeditions that went to Principe and Brazil with the intention of testing the Einstein theory.

Dyson was universally popular among scientists at home and abroad, and was therefore able to play a prominent part in the formation of the International Astronomical Union.

The success of Dyson's career as an astronomer was due not only to his mathematical and experimental abilities and his organizing capacity, but also to personal qualities which made friends and helpers of all who had to work with him and under him.

John Mellanby, born in 1878, was one of the first students of the biochemical school founded by Gowland Hopkins in Cambridge. After taking his degree he went in 1900 to the research laboratories which Burroughs and Welcome had recently founded at Brockwell Hall. Inspired no doubt by the teaching he had received as an undergraduate he began a research on the properties of serum proteins and their relation to antitoxins. After studying medicine at Manchester he took his M.D. at Cambridge in 1907. For a short time he continued his researches at the Cambridge laboratory, being particularly interested in the phenomenon of clotting in blood and milk.

In 1909 Mellanby left Cambridge for St Thomas's Hospital, where he used the clotting-time of milk to determine the quantity of active trypsin
in pancreatic juice, and thus to observe the formation of trypsin from trypsinogen. From the properties of trypsin he went on to the mechanism of its secretion and it is perhaps his work on this and on the purification of secretin which, together with his earlier investigations of clotting, form his most prominent contributions to knowledge. In 1937 Mellanby became Professor of Physiology at Oxford where he continued his highly important researches.

Mellanby was elected to our Fellowship in 1929, and was at the time of his death a valued member of our Council. He was also a member of the Medical Research Council. He was not only a fine investigator but also a man of wide views who was influential in asserting and strengthening the ties between physiology and medicine. In this work he was helped by the respect and affection which his kindly and earnest nature inspired in his fellow-workers.

**Alfred Harker** (1859–1939) graduated at Cambridge as eighth wrangler in 1882. He was elected to a Fellowship at St John’s College in 1885 and was appointed a demonstrator in geology under McKenny Hughes. In 1918 he was elected to a special readership in petrology.

Throughout his long and active life Harker devoted himself, in the main, to the relations between the characteristics of igneous rocks and the controlling influence of tectonic environment. His first papers dealt with the cleavage properties of slates; his mathematics were here of great assistance to him. This work led him to study the petrology of the igneous rocks associated with the Cambrian system of Caernarvonshire. It is described in the Sedgwick Prize Essay of 1889. In 1889–93 he was engaged with J. E. Marr on parallel problems in the Lake District. In 1895 and succeeding years he was attached to the Geological Survey of Scotland. He devoted himself to the stratigraphy and petrology of several of the Western Isles and completed a successful survey of the mountainous groups of central Skye.

In 1909 the wide knowledge which he had by that time acquired was embodied in his *Natural History of Igneous Rocks*, an outstanding book which has been of fundamental importance in the growth of petrologic science. When advanced in years he continued to write with power, and his *Metamorphism* published in 1932 is a fine piece of work. He completed the revision of the MS. for a second edition shortly before his death.

Harker was elected to our Society in 1902. He was awarded a Royal Medal in 1935; and received many other recognitions from other Societies, and from Universities. His influence on petrology at Cambridge and
throughout the world was very great: the Harker Collection of some 40,000 specimens of rock slices will ever serve as a monument of his work. Many senior students found inspiration in his lectures and remember him with affection and respect.

SIGMUND FREUD was born in 1856 in Moravia. He took up the study of medicine, and while still in the twenties went to Paris to study psychiatry under Charcot. At the age of thirty-one he returned to Vienna where he lived until the recent advance of Germany into Austria forced him to take refuge in England.

Freud was the originator of a form of research to which the term psycho-analysis is now applied. It has been described as the empirical study of unconscious mental processes. Considering the elusive character of work in this new field, and the extraordinary and unconventional conclusions to which it has led under the guidance of Freud and an enthusiastic body of collaborators, it is not surprising that Freud’s ideas have provoked both bitter opposition and warm approval. It may well be too early to estimate correctly the value of this novel work, but certainly it has provoked much thought and experiment, and its supporters maintain that it has done much to explain and alleviate human distress.

Britain was glad to welcome the old man when he came as a refugee to spend his last years here. The Society elected him a Foreign Member in 1936. When he came to this country the opportunity was taken to obtain his signature in the Charter-book of the Society. In deference to his ill-health and in recognition of his great distinction, the Officers of the Society took the book to his home for signature, a step which had never been taken before.

ROBERT SCOTT TROUP was born in 1874, and was educated at the University of Aberdeen and at Coopers Hill College. He joined the Indian Forestry Service in 1897, and was Deputy and Assistant Conservator of Forests in Burma until 1905. He was then appointed to the Forest Research Institute at Dehra Dun. From 1915–19 he was Assistant Inspector General of Forests to the Government of India. He left India to become Professor of Forestry at Oxford.

The care of forests has become of recognized importance in the economy of the Empire, and men such as Troup have been of the greatest value in the development of the necessary knowledge and technique. The forestry of Burma was already famous when he began his apprenticeship there. When he went to India with a reputation already considerable he entered upon a term of service which proved to be of the highest value to the forests.
of India and to forestry in general. He wrote fully and well of his experiences, so that his books, particularly The Silviculture of Indian Trees, are widely studied, and accepted as authoritative by the Indian and Burmese staffs. He wrote also on forestry in other countries and only a year ago he published a very interesting book on Forestry and State Control.

Troup was elected a Fellow in 1926. He did much for the development of Forestry science, and because of his knowledge and his devotion to his work, he served the nation well.

In October death removed from our Foreign Membership, Harvey Cushing, a man of great professional accomplishment, and of singular personal charm. Six months ago his 70th birthday had brought together to Yale a remarkable gathering of his old pupils and others, to testify to him their admiration and affection. The spirit prompting the gathering is indicated by the circumstance that one of those present crossed and recrossed the Atlantic though able to stay the one day of the celebration only.

Dr Harvey Cushing will be remembered as a great Surgeon. He was great in surgery not only by reason of his successes as a skilled operator, and of his experience in a field he had practically made his own. He was great also by reason of the new approaches he brought with him to his subject. With him the neuro-surgeon was not limited to being an executant at the behest of the physician. Cushing was, where the nervous system was concerned, his own physician and combined within himself the skill and knowledge of the physician as well as of the surgeon. He attracted pupils and followers from many parts of the world. The way in which he proceeded with a case, the details gone into, the deliberateness of the steps, the patient protractedness, as if time were but for slaves, led sometimes to the remark that his work was like a physiological experiment carried out on man. His surgery had notable repercussions upon physiology. He ascertained, by interrogation, the human being’s experience when the surface of the brain is electrically stimulated. His surgical dealings with and enquiries into the pituitary body greatly contributed to knowledge of that gland, and its inter-relations with an adjoining region at the base of the brain, and further of the ties between it and the nervous regulation of the viscera. He found therefore the influence of that forward-lying part of the brain to be more full and direct upon the viscera than had been previously ascertained or thought likely. Perhaps Cushing’s greatest contribution to the study of the brain regarded tumours affecting it, where his experience was unique in its extent.
In the war of 1914–18 Cushing served as a military surgeon first in the British Army and later in the American. Three years ago he published an ample volume of extracts from his Journal kept during the War years. But his chief literary production was his Life of his teacher and older friend, William Osler, the physician. Theirs was a fraternal friendship. Cushing was a most lovable as well as gifted character.

Sir William Jackson Pope, who died on 17 October 1939, aged 69 years, was an outstanding figure in the world of chemistry.

A pupil of H. E. Armstrong, he occupied successively the positions of head of the chemical department at the Goldsmiths’ Institute at New Cross, and at the Manchester Municipal Technical College, and was in 1908 elected to the Chair of Chemistry at Cambridge.

His scientific work was chiefly concerned with the molecular configuration of organic compounds and he extended our knowledge of this branch of chemistry in many directions. His early achievements in resolving compounds of nitrogen, sulphur and selenium into optical antipodes form a landmark in the history of stereochemistry and opened a wide field of investigation. His work on methylcyclohexylidene acetic acid was no less notable. The conception of this compound, its synthesis (with Perkin and Wallach) and its resolution into enantiomorphous forms was pioneer work, revealing the existence of classes of compounds whose dissymmetry was better referred to the configuration of the molecule as a whole than to the presence of an asymmetric atom.

The exceptional breadth and accuracy of his chemical knowledge and his strong practical sense enabled him to render conspicuous service to the Government during the last war and in 1919 he was made a K.B.E.

Endowed with a strong personality and unusual administrative power he took a prominent part in chemical affairs. He served as President of the Chemical Society and of the Society of Chemical Industry. He was the first chairman of the Federal Council for Chemistry. In 1922 he was chosen to preside over the International Union for Pure and Applied Chemistry in the formation of which he had been intimately concerned. He was for many years President of the Solvay Chemical Conferences at Brussels, a position for which he was exceptionally qualified by his fluent command of French and German.

He was elected a Fellow of our Society in 1902 and in 1914 received the Davy Medal. Numerous honours were conferred on him; he was a foreign member of many chemical societies and a Corresponding Member of the Académie des Sciences.
RALPH ALLEN SAMPSON was Astronomer-Royal for Scotland from 1910 to 1937. Previously he had been Professor of Mathematics in the University of Durham. His greatest work was a study of the four Galilean satellites of Jupiter, for which he received the Royal Astronomical Society's Gold Medal in 1928. This was a comparison of the accumulated observational data with the intricate dynamical theory of the motions. A memoir on the Sun which he published in 1892 is remarkable as being the first application of the conception of radiative equilibrium to the structure of the stars; in this he was much ahead of his time, but progress was then limited by the backward state of the physical theory of radiation. At Edinburgh he took up especially the practical determination of the colour temperatures of stars.

Sampson took great interest in the optical problems of telescope construction and in the accurate measurement of time. He was deeply versed in the history of astronomy and mathematics.

He was born in County Cork in 1866; he was elected a Fellow in 1903.

The tragic happenings of these times have necessarily had their effect on the activities of the Society. On the outbreak of War, the offices were moved—as had been decided sometime beforehand—to Trinity College, Cambridge, and I take this opportunity of expressing the gratitude of the Society for the hospitality which we have found there. We could not have wished, if we were to be in exile, any greater happiness than to be housed in the College of Isaac Newton and many another of our Fellows, past and present. Many of our irreplaceable possessions were removed to places of safety.

The meetings for the reading of papers have been suspended temporarily, but their early resumption is possible, and will certainly take place if circumstances allow. The publication of papers has not been interrupted though it has seemed well to place some limits on their length. Most of the other activities of the Society, including the administration of funds for research, are proceeding as usual.

The Council's Report deals with the business of the Society during the past year, and the second volume of Notes and Records tells of many other matters of interest. I am thereby relieved of the necessity of referring in this Address to several subjects already considered. I propose to say a few words on the general position of the Royal Society at this special time. But first I would speak of the debt which the Society owes to its retiring Treasurer, Sir Henry Lyons. We owe to him the complete and valuable
reform of our finances carried out during years when the monetary transactions and responsibilities of the Society have been growing at a great rate; he has made welcome improvements in the conduct of our business; our house and rooms are much the better for his care: nor can we forget the successful introduction and maintenance of "Notes and Records" to which I have already referred. In very many other ways we are his debtors. The Society parts reluctantly with the Treasurer who has so splendidly filled his office for the past ten years. Perhaps his effectiveness does not disappear with the tenure of his office, for as long as he is with us his critical yet friendly eye will make it impossible for any one to be careless in the Society's business.

A very large number of our Fellows are serving in different capacities for the prosecution of the War. Twenty-five years ago the War, which to so many of us seems to have been resumed after a very short interval, taught the world the importance of science and its application, and that not merely in the war itself but in many subsidiary activities and indeed by example and by inference in all human undertakings. The lesson has not been forgotten in the years that have intervened, and the present outbreak finds all our Defence Services far ahead of 1914 in the employment of science and scientific men. For this we must be profoundly thankful; for it is clear now that any nation which fell behind in this respect by even a few years of study and application would quickly be overwhelmed. It is early to form a complete estimate of the effectiveness in the present war of the attention that has been given to science in the last twenty years, but there is no little promise in what we are permitted to know of what is going on. There is evidence that the application of science in all sections of war-activity, land, sea and air, are proving their value and more than justify all that has been spent upon them.

There is indeed a widespread recognition of the general effectiveness of science. The ways of using science and scientific men are being slowly discovered. But the process is slow. It would, I think, be hastened, if certain fundamental truths were generally known and recognized. I venture to state them in the form of a few propositions:

1. Science, that is to say, the knowledge of Nature, is of fundamental importance to the successful prosecution of any enterprise.

For example, a nation is obliged to make all possible use of science in preparation for war, whether aggressive or defensive: and, again by way of example, in the maintenance of public health and social welfare. Of course, science is not alone in being a necessity in either case.

2. Science is of general application. There are not one science of
chemistry, another of electricity, another of medicine and so on: there are not even distinct sciences of peace and war. There is only one natural world, and there is only one knowledge of it.

Experience shows that an advance in knowledge or technique or skill in any direction may be based on some item of knowledge acquired in a far distant field of research. For that reason, it is necessary to resist strongly a natural tendency for those who study science or apply it, to separate into groups without mutual communication.

3. Fruitful inventions are always due to a combination of knowledge and of experience on the spot. Unless the man with knowledge is present at the place and the time when some experience reveals the problem to be solved he misses the fertilizing suggestion. Neither can the mastering idea suggest itself to the man who has the experience only but no knowledge by which to read the lesson that the experience teaches. The man with knowledge may be a temporary or special introduction, or, which is much better, he may be the man who meets with the experience.

4. There are difficulties peculiar to the application of science to war purposes. While the war proceeds scientists as a body are anxious to put all their knowledge at the service of their country: but when the time comes they are anxious to get away to their work on pure science or the applications of science to the problems of peace. Government may preserve and most fortunately has preserved a nucleus of able scientific effort during the last 20 years of peace, so that a certain connexion is maintained between these particular applications and the general body of science; but from the very nature of their respective occupations, and on account of a certain secrecy which one of the two bodies is forced to maintain, the connexion is not always strong. It can easily happen that the solution of a particular difficulty in the war service may lie in some piece of knowledge far away from the immediate science of the enterprise and unknown to those who need it.

I believe that the four statements which I have just made and briefly amplified are true, and must be acknowledged to be true by all careful observers. That being the case, it is of the utmost importance to move in the direction in which they point. We must ourselves be interested in any attempt to do so. We must wish to see that the vast and growing body of natural knowledge is most effectively employed in the service of the nation.

The tremendous use of science in the present war compels us to think about the method of its use. Many suggestions have already been made: as, for example, that a Ministry of Science should be formed immediately.
In my opinion there is no solution here. A ministry would be too formal and rigid at any rate for immediate needs; the most successful ways of using knowledge are personal and elastic. We must not attempt too much at once. We might be content if we could in some way bring Science as a whole into close relation with Government as a whole, if we could attach a central authority of science to the central authority of the country. The immediate application of science in any department of the country's business should be made from within the department, not from without, and we have already a number of instances in which this principle is followed. The Department of Scientific and Industrial Research, which we are proud to think of as an original device of the Society, correlates many branches of industry with science: it is entrusted with the administration of large funds, and has had great successes. Similarly, the Medical Research Council administers funds and encourages research in the interests of the health of the people, and again the Agricultural Research Council has its own field of action. Each department of the Defence forces takes care of its own applications of science. This is satisfactory so far as it goes. The need is rather for means whereby the Government, in its care for the whole sweep of the country's business, can rely on and make use of the whole range of scientific knowledge.

It would seem that our Society itself is a body which is not used as it might be, though, as I have said already, a large number of our Fellows are individually taking part in the application of natural knowledge. Within its ranks are to be found men with knowledge of every form of natural science. It would be well if by way of some small group of Fellows, selected for the purpose, it were consulted without hesitation whenever the need arose, and if it were kept so well informed that it might foresee occasions and needs. If that could be achieved, a forward step would be made, which in due time would be followed by others. It would be a very proper step to take, being a continuation and extension of a process which already exists. To use a modern term, science is irresistibly making its way into general use by a "peaceful penetration", which in the end is far more effective than a violent movement; all the more so because science is not out to fight present methods of rule and economy but rather to strengthen with new knowledge of facts and principles. We have often proved in this country the practical value of making use of existing institutions rather than founding new ones, when the old are full of vigour and can carry new grafts without strain. That is why the Royal Society, as a body of high consultative value, is ideally fitted to form the next link between knowledge and practice.
There are two subsidiary consequences of the present position of science which need to be remembered. We have not long passed the stage, if indeed we have quite gone past it, when our knowledge of Nature is used as a reference library is used. The knowledge is there, on the shelves, to be taken down when anyone wants information on a particular point and happens to remember where possibly it may be obtained.

Anyone who wants to use a library effectively must already have some knowledge of the same nature as that which he hopes to find there. If not, he does not know where or how to look; nor can he grasp fully what he finds, even if he happens to hit upon the right book. For a parallel reason, it is most important that a general knowledge of science should be diffused among the people, and especially among those to whom it falls to guide and govern.

A second consequence is that the supply of men capable of the study and interpretation of the natural world must be made continuous. An instance, special to the moment, is the present policy of reserving able men in their final year at Universities and technical institutions so that they are not absorbed too early into the fighting services nor into inappropriate branches thereof. This is necessary; but it is not all that is necessary. National interests demand that the water shall not be diverted higher up the stream.

And it may be well to add here, that the care for those who can in due course be expected to supply the knowledge of Nature and to assist in its use, is not the nation’s only care. It would be absurd to overlook other knowledge: I am but limiting myself to matters with which the Society is especially concerned.

Let me now turn to a question of pure science. When the new methods of X-ray analysis were first introduced a quarter of a century ago there was naturally no clear realization of the extent and character of the fields of research in which they would eventually be employed. Certain applications were found for them at once, but the years have brought wide and unexpected developments. Some of these are gathering themselves together, and, in conjunction with other methods of physics and chemistry, begin to form what might well be called a new branch of science.

In the early phase of the X-ray crystal studies the object of interest was the perfect crystal; in the later phase attention is directed towards the departures from perfection, which turn out to be of the greatest interest and importance.

It will be remembered that the method of analysis of the structure of matter by means of X-rays was based upon a suggestion made by Dr Laue.
If the atoms in a crystal were in regular array, the passage of ether waves through the crystal should be accompanied by diffraction effects provided that the lengths of the waves were of the same order of magnitude as the spacings of the atoms. In the case of the ether waves emitted by an X-ray bulb—if indeed the X-rays were ether waves, of which there was some doubt at the time—there were reasons to suppose that the wave-lengths were of the magnitude required. The experiment was made, and was successful.

The diffraction effects provided means whereby the crystalline arrangements could be calculated. The researches of the first few years of X-ray analysis were therefore concerned with the character of the crystalline arrangement in a number of the simpler cases. As confidence grew and skill increased more difficult structures were attacked, and indeed it has been very surprising to find what complicated structures can be unravelled. One helpful circumstance has been the existence of families of substances, since the progressive differences in the members of a family gave rise to corresponding changes in the diffraction patterns. Thus, for example, the large family of silicates was examined and the connexions between composition and diffraction effects, and again between the latter and structure, were observed and compared. Certain simplicities and uniformities then appeared and it became possible to put in order a mass of details which had not previously appeared to have any relation with each other.

It was not long before the results in the field of research became so numerous that books of no small size were required to contain them. In thousands of cases the dimensions of the unit cell of the crystal were determined, and at least the space-group or character of the arrangement of the atoms within the cell. In a number of these cases the exact relative positions of the atoms could be found, though this additional task has often been formidable. Work of this kind continues, and rightly so, to be the occupation of many investigators. All such work belongs to the first phase to which I have referred.

The application of the X-ray methods has for some time been entering on a second phase. It now deals with a natural phenomenon differing entirely from that which was the first to be examined. The earlier work was concerned with the arrangement of the atoms in a perfect crystal, that is to say a body in which the mutual forces are balanced, and the arrangement is complete. Thermal movements may still be there, but the average dispositions of the atoms are settled, and are uniform throughout the body of the crystal.
It is doubtful whether there is such a thing as a perfect crystal large enough to be handled; perhaps the crystals of diamond and graphite are nearest to perfection. In almost all cases there are deviations from complete uniformity. A crystal that has every appearance of being perfect may consist of an assemblage of minute crystallites, more nearly perfect individually but lacking uniformity of orientation to a greater or less degree. Other bodies that do not appear to be crystalline at all may consist of crystallites oriented so irregularly that the bodies seem to be isotropic. The crystallites may vary in size as well as in relative orientation. Two or more crystal forms may be present in the same body, so mixed together that only the X-ray methods can make any attempt to disentangle them. Sometimes one greater lattice overrides in a more or less regular fashion a smaller lattice as a pattern of ploughed fields may override a pattern of furrows. Also a lattice may be distorted by strain. In a substance in the liquid state there may be associations and partial arrangements sufficient to show X-ray diffraction.

Moreover, arrangements and dimensions may vary with time, both in solids and liquids; some forms or extents of arrangement may even disappear, new forms may appear at the expense of the old. Perfection of crystalline arrangement is a goal which is never achieved. And in fact the processes of the world are based upon such deviations from perfection, and their continuous modification. If all arrangements of atoms were complete, there would be nothing left but stagnation and the peace of death.

It will be seen therefore that a new field of research of extraordinary interest is being opened up. It is in this field that the physicist and chemist and indeed scientists of every persuasion must look for explanations of many of the properties of their materials such as their relations to magnetism and electricity, thermal conductivity, tensile strength, various surface effects and so on: as also the time-changes in these properties, such as the creep to which the engineer has to give so much attention. Properties such as these have been called by Orowan and others the "sensitive" properties since they depend on the particular state of a body, which state in turn depends largely on the conditions of the new field of which I am speaking. The biologist finds interest in it, because the life processes seem to involve the relations between large aggregates, molecules or assemblages of molecules, with one another or with media in which they are imbedded. Somewhere in this field life and matter are first found in association.

It may seem unreasonable to expect help in the resolution of such complications from the X-ray diffraction effects. It is to be remembered,
however, that the X-ray photographs are very rich in information. The gratings are three-dimensional and may be examined from a variety of aspects; each photograph or spectrometer record is a two-dimensional diagram of positions and intensities of diffracted spots. A light spectrum of the ordinary kind is uni-dimensional only. The photographs vary in definition, being less easy to read as they deal with more complicated cases; but the technique is rapidly improving.

The earliest of these phenomena of the larger field was the so-called mosaic effect. A crystal of rocksalt, for example, is a mass of small crystals, each of which approaches to regularity far more completely than the whole. The separate crystallites are not in perfect alignment with each other. Hence arose one of the perplexities of the early days. It was extraordinary to find that the less perfect crystal reflected the X-rays in greater intensity than the more perfect and that the reflections from the face of a crystal, quartz, for example, might be increased if the surface was roughened. The puzzle is solved if we remember that, as Darwin and others pointed out, one crystallite may screen another. If the orientations of the two are exactly the same, and they are set at the proper angle for reflecting the incident X-rays the first crystallite will partly absorb the rays in producing its own reflection and the lower will not have its full opportunity. But if, as is usual, the crystal is moved through small angles about the above setting so as to give every crystallite its chance—provided that the X-rays can penetrate the crystal so far as to reach it—and if the second is in the right orientation for reflection when the first is not, then the incident rays get through the first and are reflected by the second; the integration of all effects therefore gives a larger total when the crystallites are not parallel. This mosaic character is very common, even in crystals of the purest material. There are indications, as remarked by Goetz and others, that in some cases at least it is the state of greater equilibrium. Thus W. A. Wood shows that crystals of copper and other metals of extreme purity are reduced by cold working to crystallites in more or less complete disarray. The substances do not then return to their former state, though they can be taken some way towards it by moderate heating. To restore them to their original state it would be necessary to begin over again from the melt. A similar effect was shown by Ewald to occur in the case of rocksalt. It may also be significant that of the two forms of diamond examined by Robertson and Fox, that which is the more transparent to infra-red and ultra-violet and may therefore be taken to be in greater internal equilibrium, is also the one in which there is some mosaic character.

If this form of disintegration of a larger crystal into crystallites is really
due to the release of energy, it might be expected to proceed until the
process was complete and the substance became amorphous. Wood shows
that it does not proceed indefinitely and that the copper crystallites have
an average linear dimension of about 700 Å; for silver the figure is 800, for
nickel 1200, and so on. The disintegration ceases at a certain point. The
metals were of extreme purity. Unless it appears that the mere trace of
impurity governs the effect, it must be supposed that the disposition to form
aggregates of definite magnitude is present in the copper atoms themselves.

The presence of crystallites of a definite pattern, their dimensions, their
preference for any particular orientation in relation to the body which
contains them and their proportional amounts are all determined by the
X-ray photographs. It is to be remembered that the diffraction spectra of
a compound of different crystallites do not modify nor disturb each other’s
evidence. The data on which calculations are based are the forms and
intensities of the spots and lines in the X-ray photography. The calcula-
tions are often difficult and lengthy because so many factors have to be
taken into consideration; in fact there is plenty of evidence, and the most
troublesome part of the business is its interpretation.

It will be readily understood that such measurements as these can be of
great assistance in the study of metals. It is possible to examine in a new
and most effective way the phase diagrams of the metallurgist, and the
various effects of composition, temperature and time, and this not only for
binary alloys but also for ternary and still more complicated mixtures.

With these powers in hand, and with the remarkable accuracy of the
modern X-ray spectrometer which can show minute changes of form due to
temperature or an admixture of foreign atoms and can show also any
variations in the extent of order and disorder in the atomic arrangements,
it is not surprising that theoretical metallurgy has acquired a new life and
that practical metallurgy begins to gain thereby.

Since the X-ray methods can do so much to discover the composition of
molecules, even very large molecules such as the phthalocyanines (Robert-
son) or the sterols (Bernal, Crowfoot and others), and also to determine
the arrangement of the molecules in crystalline aggregates and yet further to
find any preferred orientations that there may be, the methods can be
fitly used for the examination of fibrous materials. In cotton, silk, rubber
and many other substances there are long chain molecules which are linked
together into crystallites having preferred orientations along the length of
the fibre. So also nerve, muscle, horn and such like contain proteins and
keratins in fibrous forms. It is even possible, as Bernal has shown, to find
some details of the composition, structure and arrangement of immense
molecules such as those of a virus. Very interesting papers on these subjects have been communicated to our Society, some of them during the present year.

It is to be observed that the extension of the X-ray methods to these larger scale problems is greatly facilitated by extrapolation from simpler observations. In the case of organic substances the modes of assemblage into characteristic combinations of atoms, such as the association of carbon atoms in the benzene ring, are governed by rules which are so closely followed in the simpler cases that they can be assumed to hold in the more complicated. These rules relate to the distance from atom to atom in various cases, and the mutual orientations of atoms. In this way very important suggestions have been made in respect to the construction of the more difficult assemblages.

It is to be remembered, of course, that there are other physical methods of observation which contribute to the understanding of the complex substances of Nature, which are all the more efficient now that the X-ray methods are able to make their characteristic contribution. First of all comes chemical science, the power of which is so obvious and well known that I need not do more than refer to it. Optical properties have been found to be extremely useful. So also the magnetic properties are found to be closely related to structure. Thus, for example, the disposition of a molecule containing benzene rings can often be predicted from diamagnetic measurements.

The sum total of these powers, some new some old, all reinforcing each other in a common advance, is so great that, as I have already said, a new field of enquiry of first rate importance has been well entered. That which the eye can see is one thing: that which the microscope reveals is another. Far beyond any vision is the individual atom and the atomic nucleus, of which so much has been discovered in recent years. But a vast range of magnitudes, lying approximately between 10 and 10,000 Å has never been accessible to the direct attack which the ranges on either side of it have experienced. Within this range lie all the processes which are concerned in the building of living substances, animal and vegetable, and in the changes of growth and decay. In this range, lie also elements that are the origin of the properties of our materials, alloys, glasses, fibrous substances of all kinds, and here take place transformations which change these properties some of them rapid especially when urged by heat, some so slowly that centuries must pass before they become visible or effective. The recent advance into this new field is only the preliminary to what is sure to follow. We have before us an enquiry of supreme interest.
The Copley Medal has been awarded to Professor Thomas Hunt Morgan.

In those branches of biology which are called Botany and Zoology the most important advance during the present century has been the development of Genetics. The establishment of definite laws of heredity, and the discovery of the mechanism, the gene, by which hereditary qualities are carried on from generation to generation, has revolutionized our outlook on the function of the nucleus of the cell and of the chromosomes it contains; it has enabled us to understand the significance of the maturation of the germ cells and of fertilization as they occur in higher animals and plants, and thus led to a very rapid development of nuclear cytology. The theory of the gene has given us a new outlook on the determination of the development of an animal or plant. But nowhere has genetics produced greater changes than in our attitude to evolution. The observation that mutations arise de novo at a definite rate, that the number of different mutations occurring in a single species may be very large and that the mutations in allied species are essentially identical, have shown us for the first time the materials which are available as a basis for evolutionary change. The quantitative nature of genetics has made it possible to examine the effects which result after many generations from the establishment of a community by a few individuals of different hereditary composition, and to estimate the effect of a definite advantage attaching to one particular quality on the ultimate composition of a population. It has thus put the Theory of Natural Selection on a sound theoretical basis. Furthermore it has enabled us to observe indirectly the effects of natural selection in wild populations, and to plan experiments to determine its effects.

The practical applications of genetics are as important as its influence on theory. The whole of the breeding of many cultivated plants including maize is now firmly based, and the process of improvement immensely hastened by cytological examination. Genetics is already influencing animal breeding, and in its modern developments is throwing much light on the possibility of controlling hereditary diseases in man. Thus the influence of genetics is already very widespread, and it will become important even in fields in which it is now little appreciated.

In the development of genetics the work of the Morgan school has been paramount. It is to Morgan that we owe that exploitation of *Drosophila melanogaster* which is the basis of most modern developments. To him we owe the theory of the gene, which is fundamental, and the explanation of
"crossing over" which forms the basis of the conception of the linear arrangement of the genes and the chromosomes. From these starting points all other work springs, and much of this work comes from Morgan himself, his associates and his students. Thus, although in the case of a man working for many years in the closest association with very able men, it is impossible to isolate his individual contributions, it is evident that Morgan has done more than any other man to establish genetics and thus to revolutionize our ideas in many different fields of work, in practical affairs as in pure theory.

A Royal Medal has been awarded to Professor Paul Adrien Maurice Dirac.

Dirac's chief work has centred around the fundamental principles of modern theoretical physics. The new quantum mechanics was discovered by Heisenberg in 1925. Dirac at once realized the great importance of this discovery, started to work out its fuller implications and by a remarkable combination of originality, mathematical skill and uncanny instinct rapidly established himself as a great leader in this field. His earliest efforts were directed towards tidying up the intermediate field between that of the new quantum mechanics and the Newtonian. In this connexion he established the importance of the Poisson bracket expressions of the old mechanics. An early and very important paper was on the fundamental equations of quantum mechanics. This was a generalization of any earlier work in this field and for the purpose he introduced a new algebra, that of non-commutative numbers.

Probably his greatest achievement was that of ending the conflict between quantum mechanics and relativity mechanics by showing how to make the fundamental equations of quantum mechanics invariant under a Lorenz transformation, at any rate to a first approximation which has not yet been improved on. This led to a revision of the theory of the hydrogen atom which confirmed Sommerfeld's formula for the fine structures of spectrum lines and X-ray levels. This formula had been derived hitherto from a mixture of empirical results and theoretical guidance but had not been deduced from general fundamental principles. The idea of a quantized electron spin also fitted naturally into the new theory. The harmonization of the quantum and relativity mechanics also required the introduction of the strange conception of negative energy states (holes) and this is generally regarded as a prediction of the existence of the positive electron (positron) since discovered by Anderson.

His book *The Principles of Quantum Mechanics* is an important and
original work, a comprehensive account of the subject by an acknowledged master in this field.

A Royal Medal has been awarded to Professor David Keilin.

Keilin’s contributions to entomology extend over nearly thirty years. In the main they concern the higher Diptera: with critical ability and a great capacity for detailed observation he has demonstrated the very close correlation that exists between larval structure and habits in these insects. As the result of Keilin’s work it has become possible to determine the habits of almost all such larvae from an examination of their mouthparts and pharyngeal ridges. Among his many papers those on carnivorous Anthomyiidae and on the remarkable life-cycle of the parasite of Pollenia rudis deserve especial mention.

Keilin’s main contributions to biochemistry have been his studies on cytochrome, published in a series of papers from 1925 onwards. These have filled an important gap in our knowledge of cell respiration and, in particular, have shown how various mechanisms, the existence of which was already known, are related to one another through the linking mechanisms which Keilin himself has discovered. He has shown that cells contain a respiratory pigment, cytochrome, composed of at least four components related to haematin. One of these is in all probability the enzyme previously known as indophenoloxidase. The catalytic activity of this enzyme depends entirely on co-operation with the other three components of cytochrome. The complete cytochrome system forms within the cell a highly active catalytic mechanism which by utilizing molecular oxygen can easily oxidize hydrogen atoms of certain substrate molecules which have been activated by dehydrogenase systems. This shows that the enzyme component of cytochrome may be identified with the previously undiscovered oxygen-transporting enzyme of Warburg and his co-workers.

Other work of Keilin in this field has included the characterization of certain oxidizing enzymes which make use of molecular oxygen, and the preparation in a pure condition of the polyphenol oxidase of mushrooms. The latter has been shown to be a copper protein compound. Recently he has also isolated in a pure state copper protein compounds from blood corpuscles and liver (haemocuprein and hepatocuprein) which may be of biological importance though they are not apparently concerned in oxidase reactions. Keilin has thus provided us with an integrated picture of cellular respiration which, though it does not cover all respiratory mechanisms, is an enormous advance on the much less systematized knowledge that we had before his work was published.
The Davy Medal has been awarded to Professor James William McBain.

McBain's claim to special recognition rests essentially on the circumstance that he created, and has led the development of, a new and important chapter of physical chemistry—the study of colloidal electrolytes. It was as the result of a long series of precision measurements on the electrical and thermodynamic properties of soap solutions that McBain originally defined this new class of materials, which combined in a special way the properties of colloids and electrolytes. The definition and constitutional theory proved to be the key to the orderly exploration, which thenceforth proceeded with continually growing impetus, of a large and fruitful field—incidentally one of considerable technical importance. The materials include soaps, nearly all modern synthetic detergents, a number of inorganic substances such as silicates and tellurates, as well as many dyes, proteins and biocolloids. The value from a physical point of view of their classification as colloidal electrolytes, and the general correctness of the micellar description of the thermodynamic and electrical properties which distinguish these materials, are to-day universally recognized.

In the continued investigation, in which numerous workers have contributed to the general development of the subject, McBain has been a leader, and his work has thrown much light not only on the special properties of the ionic micell, but also on the physical properties of colloidal particles as a whole. In the course of this work a great variety of experimental methods have been developed—chemical, electrical, optical and mechanical methods—which are novel in their application and are in some cases novel in themselves. Reference may be made to the quantitative study of "solubilization" and the elaboration of the air-borne ultracentrifuge in illustration of McBain's versatility of technique.

In addition to the composition and organization of a colloidal particle, its interface with the continuum has a decisive influence on its properties, and this gives special importance to the section of McBain's work which deals with the structure, composition and depth of macroscopic interfaces, especially of the surfaces of colloidal electrolyte solutions. Here also he has devised many methods of study, one of the most striking being the "microtome" method whereby the outermost layer of a solution can be peeled off with a rapidly moving knife blade so that the surface concentration of solute can be directly determined.
The Hughes Medal has been awarded to Professor George Paget Thomson.

Thomson's researches have been spread over a wide range of experimental and theoretical physics.

Most of his earlier experiments were connected in some way or another with positive rays, and in this field he obtained a number of valuable results. Probably the most important of these is his discovery that the small angle scattering of protons in hydrogen could not be accounted for by treating the protons and electrons as point charges obeying the inverse square law of force, but that there must be some other law of force operating at the small distances of approach during the very close encounters involved.

The scope of his work in pure physics is indicated by the titles of three books he has written or, in one case, helped to write. These are: The Atom, Wave Mechanics of the Free Electron and the third edition of Conduction of Electricity through Gases. The last is a joint effort with his father and is the most important work there is on the subject. Within this range his work is both experimental and theoretical, but the experimental part predominates both in quantity and in importance.

Thomson has also made notable contributions to aeronautics. They include research work for the fighting air services during the Great War of 1914–18, a book entitled Applied Aeronautics 1919, and various contributions to Government publications.

Thomson's most distinguished work is based on Davisson's discovery—finally established in 1927—that electrons were reflected by single crystals as if they were possessed of the characteristics of waves. By brilliant experiments and able reasonings thereon, Thomson has opened out a new field of research which has been singularly fruitful and is still full of promise. He has been able to prove by direct experiment the correctness of Louis de Broglie's ideas of wave mechanics, not merely qualitatively but also quantitatively. In fact electrons of mass $m$ and velocity $v$ on passing through a crystal give a diffraction pattern identical with that given by a beam of X-rays of wave-length $\lambda = h/mv$, where $h$ is Planck's constant, when passed in the same direction through the same crystal. In this way the lattice constants of the crystal can be measured instead of with X-rays, and in his first paper Thomson showed that the values he found using electron diffraction agreed to within one per cent with the values previously got by the use of X-rays.