now presents diagrams and formulae for some four thousand organic substances.

A symposium of contributions on processes of geologic sedimentation prepared under auspices of a committee of the Council has been published by the American Association of Petroleum Geologists. Arrangements are also being made for the commercial publication of a "Symposium on Some Relations of Structural Features to Ore Deposition."

The Council has subscribed for a table at the Naples Zoological Station, which is at the disposal of American zoologists on request. Committees of the Council have prepared programs of investigation on the biological processes of aging and for studies of inheritance in man.

A committee of the Council's Division of Anthropology and Psychology has advised in recent years in the conduct of archeological excavations made in the Tennessee Valley in areas to be inundated by the building of power dams, and the division has also been requested to advise the Work Projects Administration in regard to basic problems of American archeology. A second edition of an international directory of anthropologists is now in preparation.

Among other new undertakings of the Council, as represented by the appointment of committees during the year, are the following:

The application of x-rays to physics and chemistry, and the use of spectroscopy in analytical chemistry.

The compilation of thermochemical data for the chemical industries.

The technology of organic plastics.

The organization of basic geographic data and the development of new techniques for geographical research.

The construction of a Pleistocene glacial map for North America.

The importance of breeding pure-line strains of animals for scientific purposes.

International Scientific Meetings

The Council has been represented at international scientific congresses abroad as follows:

15th International Geographical Congress and General Assembly of the International Geographical Union, Amsterdam, July 18–28, 1938 (at which cartography in the United States was represented by an extensive exhibit); 4 representatives.

6th General Assembly of the International Astronomical Union, Stockholm, August 3–10, 1938; 6 representatives.

6th General Assembly of the International Scientific Radio Union, Venice, September 5–15, 1938; 5 representatives.

7th International Congress of Genetics, Edinburgh, August 23–30, 1939; 5 representatives.

AWARD OF THE MEDALS OF THE ROYAL SOCIETY[1]

By Sir WILLIAM BRAGG

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 possi-

[1] From the address of the president at the anniversary meeting, November 30, 1939.

bility of controlling hereditary diseases in man. Thus the influence of genetics is already very wide-spread, 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 centered 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 connection 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.

Professor 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 Anthomyidae and on the remarkable life-cycle of the parasite of *Pollenia rudis* deserve especial mention.

Professor 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 cooperation 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 coworkers.

Other work of Professor 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 ultra-centrifuge 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.