The Right Hon. Lord Rutherford of Nelson, O.M., F.R.S.

ERNEST RUTHERFORD was born in New Zealand on August 30, 1871, and he was well educated at schools in Brightwater and Nelson, where his headmaster was the famous cricketer W. J. Ford, formerly a classical master at Marlborough. Rutherford went with a scholarship to Canterbury College, Christchurch, where he quickly made his mark by carrying out an interesting and important research with a magnetic detector of wireless waves. There is a striking similarity between Rutherford's work and that of the famous American physicist, Henry. Both used an aerial, a coil of many turns round a bundle of fine sewing needles and a small magnet which was deflected by the changed magnetism of the needles due to the current in the aerial produced by the wireless waves. Henry, however, detected lightning flashes up to ten miles' distance; Rutherford the sparks from an induction coil, two miles away. I once asked Rutherford if he had then already heard of Henry's work, and he replied, "No"! The two minds converged independently. The genius of Marconi afterwards developed an important magnetic detector which, before the age of valves, was in common use for wireless detection in ships.

The Commissioners of the 1851 Exhibition made a good choice when they elected Rutherford as a scholar. Indeed, has any money ever been better invested ? This award enabled Rutherford to go to the Cavendish Laboratory at Cambridge, where Sir J. J. Thomson was conducting his own famous researches and guiding the first great group in England of young physicists, including such men as C. T. R. Wilson, Townsend, H. A. Wilson and Rutherford.

It was at that time a novelty for a young physicist to arrive at the Cavendish from near the antipodes, and there was a slight tendency to ridicule. However, formidable questions from the new arrival were received with some awe, and the rumour soon spread that there was "a young rabbit come from New Zealand, who burrows very deep".

The Cavendish group were at this time measuring the properties of electrons and ions, and in particular there was an interesting method of Rutherford's whereby ultra-violet light shining on a metal plate released electrons, which were made to leap up and down in cycloidal paths by a controlled intensity of alternating potential.

In the meantime the first research professor, the brilliant Hugh L. Callendar, had left McGill for the Imperial College and so the director of the Macdonald Physics Laboratory, John Cox, visited England (1898) and was so wise and so fortunate as to secure Rutherford as successor to Callendar.

Rutherford even then had a very intimate knowledge of ions, whether produced by ultraviolet light or X-rays. In fact he once remarked, "Ions are such jolly little beggars, you can almost see them." He was therefore able to pursue with swiftness and accuracy his investigation of the radiations from radioactive substances which had been discovered by the genius of Becquerel, Pierre and Marie Curie, and others. Moreover, Sir William Macdonald presented his laboratory with a liquid-air machine, and three hundred dollars (£60) with which were bought 60 milligrams of radium at cost price from Giesel, who scorned to make a profit from a colleague.

In the Department of Chemistry at McGill University, there was a young Oxford physical chemist who joined Rutherford in the investigation of the relation between thorium and thorium X, obtaining results somewhat similar to those of Sir William Crookes with uranium and uranium X. They, Rutherford and Soddy, were able to put forth a most bold and startling theory, which was received at first with scepticism and opposition. Indeed, Lord Kelvin died in unbelief of this great principle, which has now stood the test of time and multitudinous experiments. Atoms were no longer to be regarded as permanent, everlasting and indivisible. Radioactive elements disintegrated spontaneously; they broke up by 'chance', independently of their age or their physical surroundings, or their chemical combinations. The mortality rate was constant for one species, but varied from one type of atom to another. In each case the disintegration took place by internal energy with the projection of an alpha particle (He^{++}) or of an electron (beta ray) and the residual atom was of a new type different from its parent atom. This theory was rapidly developed and applied skilfully to radium, its emanation (radon) and three successive products with the prosaic but useful terminology—radium A, B and C. Rutherford was asked to give the Bakerian Lecture to the Royal Society (1904) and was awarded in consequence the Rumford Medal, and he soon published his first book (1906), entitled "Radioactivity", written with a breathless enthusiasm.

Rutherford's direct advance along the royal road of physics—for he seldom wandered into byways and blind alleys—deterred him from adventures in mathematical physics. Yet he never seemed to lack the necessary mathematical equipment essential for the interpretation and calculations of his work. Witness the masterly use of exponentials in his Bakerian Lecture, where nothing to-day need be altered or removed. The whole scheme of such calculations, transformations and graphs is familiar enough now to physicists, but it was all new near the beginning of the century.

In 1903, Rutherford had worked out the short-period group of the radium family, but he was faced with really puzzling properties of the long-period group, which necessarily involved observations extending over months. He had, however, 'grown' from radon, and he had detected and isolated, by most ingenious methods, both radio-tellurium (now radium E) and the first radioactive substance found by Mme. Curie—polonium (radium F). These atoms were in the direct line of descent of the radium family, but there was a gap ! Radium C did not turn directly into radium E ; there was some intermediate body the radiations from which Rutherford was at that time unable to detect. He therefore postulated a 'rayless' change of long period, ten or twenty years, and called the substance radium D, sometimes now called radio-lead, which really ejects beta rays, thoroughly investigated by many workers. But, at the time, this bold prediction of the existence of a material substance, of which no single physical property was known, beyond the fact that there should be an inevitable successor to C, and a forerunner to E, struck me as most remarkable, and on recalling, thirty years later, these circumstances to Rutherford, he was himself impressed. Men may well believe in an undetectable æther, because of its known physical properties, but here was belief in a substance without any properties except that of a go-between !

A great part of the scientific life of Rutherford was spent in his investigation of the properties of alpha particles, and the wisdom of this choice has been abundantly justified by a series of successes. He deflected alpha particles with a magnetic field, and proved that they carried a positive electric charge. He then deflected them to a measured extent both in magnetic and electrostatic fields and thus found both the velocities and the ratio of mass to charge of alpha particles. The inference was that an alpha particle had a mass four times that of a hydrogen atom, and a double positive, electronic charge. This result suggested helium, and the presence of that gas in pitchblende and thorianite was evidence in the same direction. In 1904 Ramsay and Soddy definitely obtained the helium spectrum from aged radon, and five years later Rutherford and Royds collected the alpha particles, ejected from radon, after their passage through the exceedingly thin walls of a glass container, and again verified the nature of their catch with the spectrum obtained. To forestall a little, it may be pointed out here that Rutherford also used alpha particles in the scattering experiments which proved the existence in the atom of the minute massive nucleus with its positive electrical charge ; and yet again in his most remarkable experiments on the artificial disintegration of nitrogen, etc., and on the transmutation of matter, it was alpha particles which he employed as his directed agents.

In the meantime, Rutherford was building up a school of research physicists in his laboratory at McGill. For example, he suggested to H. L. Cooke that because there was radium in the ground, there must be some penetrating radiation (gamma rays) coming upwards from the earth. At first Cooke was not successful in finding what was wanted, but Rutherford persisted : "Try more lead !" There followed a toilsome experiment with very much lead, and finally Cooke not only proved the existence of a penetrating radiation, but also he was astute enough to show that the radiation came from all directions, even from above. This was attributed at the time as coming from the bricks of the wall, etc., but he may have been unconsciously screening his electroscope from cosmic rays !

The arrival of Otto Hahn at McGill was a noteworthy event. He had been working with Ramsay, who had given him some thorianite with the object of extracting some *radium* from that ore, using Mme. Curie's method of fractional crystallization. To the surprise of both Ramsay and Hahn, the residue became more and more powerfully radioactive, while the production of radium was small. The concentration of the residues led to the discovery of a material many thousands of times more radioactive, weight for weight, than the parent thorium. This was an experience similar to that of Mme. Curie when she extracted radium from uraninite. The question was : What was the nature and position of this new substance which Hahn had discovered ? He came to Rutherford at McGill to find out. Now on arrival Hahn was naturally excited and enthusiastic, and his English at that time was not altogether adequate, so that at first Rutherford seemed somewhat puzzled and sceptical, but when Hahn showed him the presence of the emanation of thorium (thoron), with a period of 53 seconds, Rutherford was enthusiastic over this discovery of *radiothorium*, an important and powerful member of the thorium family, which decays to half-value in 1·9 years. Hahn continued to work with Rutherford at McGill for a year or so, discovering radioactinium, and carrying out further investigations of the thorium family, which he has continued with brilliancy in Berlin, and which have justly brought him fame.

Godlewski—a clever and charming Pole—came from Lemberg to work with Rutherford at McGill. We were trying, without much hope, to deflect the gamma rays of radium in a very powerful magnetic field. As expected, it was a null experiment, but Godlewski thought that there might be a better chance with the softer rays of actinium. One morning he showed me his photographic plate with two distinct lines half an inch long, branching like the two horns of an antelope. He had used a magnetic field and reversed it. Again he was dancing with joy and greeted Rutherford: "I have completely deflected the gamma rays of actinium." Rutherford glanced at the plate. "Do it again," he said with a smile. "Certainly, I will do it at once," replied Godlewski; but he tried week after week without a shadow of success, and it may well be wondered what malignant sprite had placed that flaw in just the very place to delude the enthusiastic Godlewski. Alas! he, a physical chemist, died in Lemberg the victim of a slow and undetected escape of gas containing carbon monoxide.

Rutherford and Barnes measured with fair accuracy the heating effect of radium and its products, assigning the proportions between the three types of radiation. Such measurements, in combination with Lord Rayleigh's determinations of the amount of radium in various primary and sedimentary rocks, have settled the long drawn-out controversy between Kelvin and Huxley as to the age of the earth. Indeed there is now an embarrassment of riches, for there is more than sufficient radium in the earth to prevent its cooling, so that, as Rutherford said, the geologist can fill up a blank cheque as he will, and can postulate successive heatings and coolings such as the series of ice ages, and mountain building, and volcanic activity seem to require. Moreover, the amount of lead (radium G), or of helium, accumulated in radioactive ore bodies of various ages affords a useful measure of geological time. Thus it is possible to point to a piece of pitchblende (it may be), and to state with some precision that the specimen has existed in its present compacted form for a period of 700 million years, and it is further possible to give a higher limit (2×10^9 years ?) to the 'age' of the earth.

When Dewar discovered the selective absorption of various gases by coco-nut charcoal, he laid the foundation of the modern gas mask. (To Dewar, too, we owe the boon of the thermos flask.) Rutherford checked the selective absorption of radon and thoron and actinon by charcoal, and told me to measure the amount of radium emanation in the atmosphere, which was in due course completed. Note Rutherford's love of measurement, as a chief essential in physics. He took a lively interest, too, in the scattered or secondary radiations in matter, due to the beta and gamma rays of radium, but after a few months' work by me, suggested that there was not much more to be made of it! Yet this subject has been pursued ever since, culminating in the discovery of the Compton effect, which indicates that a photon ($h\nu$) can collide with an electron, an idea which would have been considered improbable or impossible in earlier times.

Rutherford later showed much interest and gave his powerful assistance in the development of the treatment of cancer by the gamma rays from five grams of radium in the Radium Beam Therapy Research, and he was a strong advocate of a National Radiological Institute, where the great advances in physics could be furthered and made available to physicians and surgeons for the alleviation of the sufferings of mankind. Such a step would be a fitting memorial to him.

It will be noted that Rutherford gave away freely quite important researches—indeed, he gave far more than he retained for himself. Whether at Montreal, Manchester or Cambridge, he not only made discoveries himself, but also at each place he was the centre of a galaxy of workers who became remarkably prolific both in the quantity and quality of their discoveries. In common with many others, I am deeply grateful for staunch help and unruffled kindness extending over more than a third of a century.

Here was a man of the greatest intellectual power, who has altered the whole viewpoint of science, who accomplished an amazing amount of work of the first order, a physicist who obtained the highest prizes in life, who ranks among the greatest scientific men of all ages; well, it is pleasing to remember that he enjoyed life to the full. True, the sudden death in 1930 of his only child Eileen, wife of Prof. R. H. Fowler, was indeed a staggering blow, only in part relieved by his great affection for his four grandchildren.

Much as we deplore the death of Rutherford while still at the peak of his powers, much as we anticipated a rich harvest from the recent improved facilities at the Cavendish, much as we miss and shall continue to miss his crystal-clear expositions and yet more his friendly and delightful personality, yet who would wish to have seen that bright intelligence wane or gradually fade? He was always a charming blend of boy, man and genius, and it may still be true that those whom the gods love die young.

A. S. EVE.