IT was in 1909 that I first came into contact with Rutherford, in my second year in the honours school in Manchester. Owing to some changes in the staff, Rutherford took over a course of lectures on electromagnetism. This was a stimulating experience, for Rutherford was interested in the subject and his account of his own early work remains with me a vivid memory. In our third year some of us were drafted into research work—into the firing line as he would put it—to our great joy and, on occasions, alarm and terror. At that time his main line of work was the study of the properties of the α-particle, already begun in Montreal and continued with increased vigour in Manchester. The counting of the α-particles and the measurement of their charge (both with Geiger) gave a value for the unit of charge which was accepted for some years and showed that the α-particle should be a helium atom. The direct proof followed in the beautiful experiment with Royds. At the same time, the phenomena accompanying the passage of the particles through matter were investigated—the ionization, the ranges of the particles from the different radioactive bodies, the change of velocity and the scattering of the particles.

These latter experiments, carried out by Geiger and Marsden, proved to be of special importance, for they led Rutherford to his conception of the atom as a heavy, positively charged nucleus surrounded by a cloud of electrons in appropriate number. I remember well the occasion on which this idea was first put forward. It was at a meeting of the Manchester Literary and Philosophical Society, to which all workers in the laboratory were invited. Rutherford's account of his theory, backed by Geiger with a description of some new experimental evidence, created a profound impression.

The nuclear theory was the culmination of Rutherford's work on the α-rays, and the finest of all his great contributions to physics. It is scarcely necessary to say that it is the foundation on which all the subsequent developments of atomic physics have been built. The history of this discovery shows very clearly one of the most typical aspects of Rutherford's genius—his extraordinary gift for seizing on the vital point. The discrepancy between Geiger's measurements of the scattering of α-particles through small angles and the apparently trivial observation that a small fraction of the particles which fell on a thin foil were scattered backwards led him straight to the goal. These simple experiments were sufficient to give him the general picture of atomic structure, though further work was necessary to fill in the details. A complete proof of the theory was given some time later by Geiger and Marsden in a series of magnificent experiments, which also showed that the atomic nucleus was of very small dimensions, and gave (roughly) the size of its charge.

The full implications of the nuclear theory were only gradually appreciated. There followed van den Brock's suggestion that the charge on the atomic nucleus was determined by the atomic number, established in Rutherford's laboratory by the famous experiments of Moseley on the X-ray spectra of the elements. The story of Bohr's visit and his development of the nuclear atom to explain spectroscopic series and atomic phenomena is so well known that it needs no repetition here, although this development now covers the whole field of atomic physics. There was further the application by Russell in Manchester, and elsewhere at the same time by Soddy and by Fajans, to explain the chemical properties of the radio-elements.

Meanwhile, Rutherford, continuing work on the α-rays, also began to turn his attention to the β- and γ-rays. With Andrade, he obtained for the first time a spectrum of the γ-rays by diffraction from a crystal; while, with Robinson, he investigated in great detail the line spectrum of β-rays and also showed the connexion between the γ-rays and the β-ray lines, a connexion which in later years has been used with great effect in the study of both β- and γ-ray spectra.

These years, 1907–14, were perhaps Rutherford's greatest period. A stream of papers on all aspects of radioactivity poured from his laboratory, nearly all of outstanding importance. There would be generally about twenty or so workers, including the staff of the laboratory, who in spite of heavy teaching duties yet found time for research. A large proportion of the workers were visitors, for he attracted men from many countries. It seems invidious to mention any names when it is impossible to give all, but as I have already transgressed perhaps I may be forgiven for adding those of Boltwood (a great friend of Rutherford's), von Hevesy, Fajans, Gray, Boyle, Kovarik, Darwin, Russ, Makower, Evans and Florance. And I am sure Rutherford himself would have wished me to add again the name of Geiger, who collaborated in so much of his work and who helped him in many different ways.

The period of the Great War was, of course, relatively unproductive; but in the intervals snatched from other activities, Rutherford pursued his course. He was now speculating about the structure of the nucleus, and when I returned to the laboratory at the beginning of 1919, he had just succeeded in showing that the nucleus of nitrogen could be disintegrated by bombardment with an α-particle. This was a discovery second only to his nuclear theory and the transformation theory, but its great importance was not fully recognized at the time, probably because it remained an isolated fact for some years. With this experiment, however, he opened up a new field of inquiry, nuclear physics, in which there is now such great activity.

In 1919, Rutherford succeeded J. J. Thomson as Cavendish professor of experimental physics in Cambridge. He left Manchester with many regrets, for he had been very happy there and he had made many friends both in the laboratory and outside it. He began in Cambridge to pursue with characteristic energy the paths marked out by his work in Manchester. It was at this time that I came to know him well, for he invited me to join him in continuing the experiments on the artificial disintegration of elements by α-particles. He had long had a special love for the α-particle, but now the nucleus also was admitted to the same intimacy, and the experiments bearing on nuclear structure were his main interest. After the first rapid advances, progress became rather slow, owing to difficulties inherent in the method of experiment. But Rutherford never lost his faith in the ultimate success of this work. The development of electrical methods of counting particles enabled many striking advances to be made, elsewhere as well as in the Cavendish, and the subject of nuclear physics began to open up rapidly.

The real reward for his efforts to develop this field of work came in the spring of 1932, first with the discovery of the neutron, a particle the properties of which he had anticipated several years before and for which he, and I, and others in the laboratory, had previously searched in vain, and shortly afterwards with Cockcroft and Walton's disintegration of elements by protons—disintegration for the first time by means under human control. I mention these two discoveries particularly, not only because of their special significance but also because they are the fruit of his policy and direction. If they do not bear his name, these discoveries bear the stamp of his laboratory, and his delight in them was as great as if he had made them himself.

Many advances of almost equal importance were made during this period 1919–37, so many that it is impossible to mention them one by one. The number of men who took part in these advances is so large that a list of only the most notable names would be inordinately long. The reputation of the Cavendish Laboratory won under Maxwell, Rayleigh and J. J. Thomson was maintained and even increased. The laboratory itself spread in size and received, as an independent satellite, the Royal Society Mond Laboratory under Kapitza.

I have said that the Manchester days were Rutherford's greatest period. This is true so far as his own direct contributions to physics are concerned, but it is not true in other ways. In Manchester his research students were mostly senior men who had already won a reputation. In Cambridge conditions were different. There were, of course, a number of senior workers, but the young men with little or no previous training far outnumbered them. Rutherford recognized very clearly that the training of such large numbers of students would hamper the progress of his own work, but he accepted it as his duty. He gave the most careful thought to the problems on which he put his students, so that these should begin within their powers and lead to a well-marked and profitable line of research. He kept his eye on every man, expecting and at times demanding the best the man could do, and inspiring him with his own enthusiasm. When the time for publication came he read the paper with the greatest care, often making what changes in presentation he thought desirable, even to the extent of re-writing whole sections. No paper left the laboratory until he was satisfied. It would be difficult to overestimate his services and his influence in these directions, for there can be few if any universities in the British Empire which do not contain at least one of Rutherford's students. He came to regard the training of students in methods of research as of almost equal importance to the advancement of knowledge.

Even the casual reader of Rutherford's papers must be deeply impressed by his power in experiment. One experiment after the other is so directly conceived, so clean and so convincing as to produce a feeling almost of awe, and they come in such profusion that one marvels that one man could do so much. He had, of course, a volcanic energy and an intense enthusiasm—his most obvious characteristic—and an immense capacity for work. A 'clever' man with these advantages can produce notable work, but he would not be a Rutherford. Rutherford had no cleverness—just greatness. He had the most astonishing insight into physical processes, and in a few remarks he would illuminate a whole subject. There is a stock phrase—"to throw light on a subject". This is exactly what Rutherford did. To work with him was a continual joy and wonder. He seemed to know the answer before the experiment was made, and was ready to push on with irresistible urge to the next. He was indeed a pioneer—a word he often used—at his best in exploring an unknown country, pointing out the really important features and leaving the rest for others to survey at leisure. He was, in my opinion, the greatest experimental physicist since Faraday.

I cannot end this tribute to Rutherford without some words about his personal qualities. He knew his worth but he was and remained, amidst his many honours, innately modest. Pomposity and humbug he disliked, and he himself never presumed on his reputation or position. He treated his students, even the most junior, as brother workers in the same field—and when necessary spoke to them 'like a father'. These virtues, with his large, generous nature and his robust common sense, endeared him to all his students. All over the world workers in radioactivity, nuclear physics and allied subjects regarded Rutherford as the great authority and paid him tribute of high admiration; but we, his students, bore him also a very deep affection. The world mourns the death of a great scientist, but we have lost our friend, our counsellor, our staff and our leader.

J. CHADWICK.

I HAVE been asked by the Editor to give a brief account of my personal recollections of the late Lord Rutherford. I met him first in October 1895, when a regulation had just come into force by which graduates of other universities were admitted to Cambridge as 'research students', and after two years residence were eligible for the B.A. degree. Rutherford was the first student to apply; he was succeeded in an hour or so by J. S. Townsend, who has since become Wykeham professor of physics at Oxford, so that the first two research students became professor of physics at Cambridge and Oxford respectively. Rutherford when in New Zealand had invented a magnetic detector of wireless waves and his first work in the Cavendish Laboratory was to try to improve its sensitiveness. He showed even at this early stage that he possessed exceptional 'driving' power and ability as an organizer. To test his detector, it was necessary to take observations simultaneously at two places, and the transport of the instrument required organization. He surmounted these difficulties by getting assistance from his friends, and at one time held the record for long-distance wireless in England, having observed at the Laboratory signals which came from the Observatory about two miles away. He had not worked for more than a very few weeks before I became convinced that he was a student of quite exceptional ability.

Whilst Rutherford was engaged with this research, Röntgen rays were discovered and we had found at the Laboratory that when these passed through a gas they made it conduct electricity even with the smallest electric forces. For ten years experiments on the passage of electricity through gases had been going on in the Laboratory; these were excessively difficult as the only ways of getting the electricity to pass through the gas were to use large electric forces and so get sparks, or make the gas so hot that you got flames. Both these were exceedingly capricious in their behaviour. The Röntgen rays gave a very simple and reliable means of making the gas conduct electricity even under the smallest forces, put researches on gases on quite a different footing and promised to add greatly to our knowledge of the subject. Rutherford devised very ingenious methods for measuring various fundamental quantities connected with this subject, and obtained very valuable results which helped to make the subject metrical, whereas before it had been only descriptive.

Yet another fundamental discovery was made while Rutherford was working in the Laboratory, that of radioactivity, which in one form or another occupied his attention for more than twenty years. Henri Becquerel found in 1896 that salts of uranium gave out radiation which, like Röntgen rays, could penetrate opaque bodies and affect a photographic plate. The radiation was not all of one type: one part of it was very easily absorbed; another part could penetrate much greater distances and was defected by magnetic force in the same direction as a negatively electrified body, and a third, present only in small quantities, seemed even more penetrating than the second. In 1918 Rutherford made a careful study of these types of radiation, which he called α, β, γ, a notation which is now universally used; he did not find any irregularities, and commenced a study of the radiation from thorium. He had not completed this when he was elected to the professorship of physics in Montreal in succession to H. L. Callendar, who was also a Trinity man and who had worked in the Cavendish Laboratory with remarkable success.

Rutherford had not been long enough in Cambridge to entitle him to be able to sit for a fellowship when he was elected to the professorship and left Cambridge for Montreal. When he got there, he resumed the experiments on the thorium radiation. These, until the clue was found, were terribly perplexing; what seemed a trivial thing such as a puff of air would produce a great difference in the radiation, while large changes in temperature produced no effect. The thorium seemed to infect bodies placed near it and make them radioactive; they recover after a time if the thorium is taken away. These anomalies, though troublesome, were really a blessing in disguise, for in his attempt to account for them, Rutherford arrived at the view about the processes going on in radioactive substances which is now universally accepted. His view was that the thorium, besides giving out radiations, gives out a radioactive gas which he