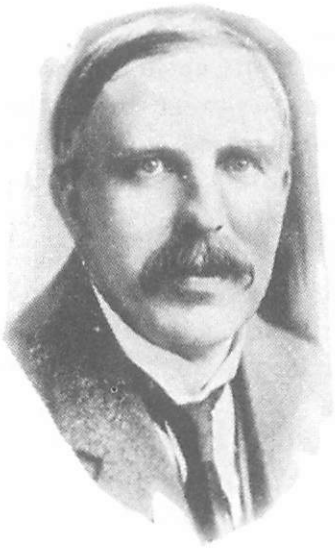

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ERNEST RUTHERFORD

1871–1937

Ernest Rutherford is generally considered to have been the greatest experimental physicist of the twentieth century. He is the central figure in our knowledge of radioactivity, and is also the man who originated the study of nuclear physics. In addition to their enormous theoretical importance, his discoveries have had a wide range of important applications including: nuclear weapons, nuclear power plants, radioactive tracers, and radioactive dating. His influence on the world has therefore been profound, is probably still growing, and will likely be enduring.

Rutherford was born and raised in New Zealand. He attended Canterbury College there, obtaining three degrees (B.A., M.A., B.Sc.) by the time he was twenty-three. The following year he was awarded a scholarship to Cambridge University in England, where he spent three years as a research student under J. J. Thomson, one of the leading scientists of the day. When he was twenty-seven he became professor of physics at McGill University in Canada, where he stayed for nine years. He went back to England in 1907 to head the physics department at Manchester University. In 1919 he returned to Cambridge, this time as Director of the Cavendish Laboratory, and he remained there for the rest of his life.

Radioactivity had been discovered in 1896 by the French scientist Antoine Henri Becquerel, while he was doing some experiments with uranium compounds. But Becquerel soon lost interest in the subject, and most of our basic knowledge in the field comes from Rutherford's extensive research. (Marie and Pierre Curie found two more radioactive elements—polonium and radium—but made no discoveries of fundamental importance.)

One of Rutherford's first findings was that the radioactive emissions from uranium consist of two quite different components, which he called alpha rays and beta rays. He later demonstrated the nature of each component (they consist of fast-moving particles) and showed that there is also a third component, which he called gamma rays.

An important feature of radioactivity is the energy involved. Becquerel, the Curies, and most other scientists had thought that the energy had an external source. But Rutherford proved that the energy involved—which was much greater than that released in chemical reactions—was coming from the interior of the individual uranium atoms! By so doing, he originated the important concept of atomic energy.

Scientists had always assumed that individual atoms were indestructible and unchangeable. But Rutherford (with the aide of a very talented young assistant, Frederick Soddy), was able to show that whenever an atom emits alpha or beta rays it is transformed

into an atom of a different sort. At first, chemists found this hard to believe; but Rutherford and Soddy worked out the whole series of radioactive decays that transform uranium to lead. He also measured the rates of decay and formulated the important concept of "half-life." This soon led to the technique of radioactive dating, which has become one of the most useful of scientific tools, with important applications in geology, archaeology, astronomy, and many other fields.

This stunning set of discoveries earned Rutherford a Nobel prize in 1908 (Soddy later received a Nobel prize also), but his greatest achievement was yet to come. He had noticed that fast-moving alpha particles could go right through a thin foil of gold (leaving no visible puncture!), although they were slightly deflected by the passage. This suggested that gold atoms, rather than being hard, impenetrable objects, like "tiny billiard balls"—as scientists had previously believed—were soft inside! It seemed as if the smaller, harder alpha particles could go right through the gold atoms like a high-speed bullet going through jello.

But Rutherford (working with Geiger and Marsden, two younger associates) found that some of the alpha particles were sharply deflected when they struck the gold foil; in fact, some even bounced right back! Rutherford, sensing that something important was involved, had the experiment repeated many times, carefully counting the number of particles scattered in each direction. Then, by a very difficult but utterly convincing mathematical analysis, he showed that there was only one way of explaining the experimental results: A gold atom consisted almost entirely of empty space, with almost all of the atom's mass concentrated in a minute "nucleus" in the center!

At a single blow, Rutherford's paper (1911) shattered forever our common-sense picture of the world. If even a piece of metal—seemingly the solidest of objects—was mostly empty space, then *everything* which we had regarded as substantial had suddenly dissolved into tiny specks rushing about in an immense void!

Rutherford's discovery of the atomic nucleus is the foundation

of all modern theories of atomic structure. When Niels Bohr, two years later, published his famous paper describing the atom as a miniature solar system governed by quantum mechanics, he used Rutherford's nuclear atom as the starting point of his model. So did Heisenberg and Schrodinger when they constructed their more sophisticated atomic models using matrix mechanics and wave mechanics.

Rutherford's discovery also led to a new branch of science: the study of the nucleus itself. In this field too, Rutherford proved to be a pioneer. In 1919, he succeeded in transforming nitrogen nuclei into oxygen nuclei by bombarding them with fast-moving alpha particles. It was an achievement to dazzle the dreams of the ancient alchemists.

It was soon realized that nuclear transformations might be the source of the Sun's energy. Furthermore, inducing the transformation of atomic nuclei is the key process in atomic weapons, and also in nuclear power plants. Rutherford's discovery has therefore been of far more than academic interest.

Rutherford's "larger than life" personality constantly impressed those who met him. He was a big man, with a loud voice, boundless energy and confidence, and a conspicuous lack of modesty. When a colleague commented on Rutherford's uncanny ability to always be "on the crest of the wave" of scientific research, he replied promptly, "Well, why not? After all, I made the wave, didn't I!" Few scientists would disagree with that assessment.