NOBEL PRIZE WINNERS

An H. W. Wilson Biographical Dictionary

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Brazilian Order of the Southern Cross and the Legion of Honor of France. He holds many honorary doctorates. He is a fellow and former president (1950) of the American Physical Society and a member of the National Academy of Sciences, the American Philosophical Society, the American Academy of Arts and Sciences, and the Brazilian and Japanese scientific academies. He has served on international committees concerned with arms control and the uses of nuclear power. In 1985 Columbia honored his achievements by establishing the Isidor Isaac Rabi Chair in Physics.

SELECTED WORKS: Nuclear Physics, 1941, with others; My Life and Times as a Physicist, 1960; Science and Public Policy, 1963; Man and Science, 1968; Science: The Center of Culture, 1970.

ABOUT: Current Biography April 1948; Libby, L. M. The Uranium People, 1979; Motz, L. (ed.) A Festschrift for I. I. Rabi, 1977; New Yorker October 13, 1975; October 20, 1975; New York Times November 21, 1985; Rigden, J. S. Rabi: American Physicist, 1987.

JAMES RAINWATER

RAINWATER, JAMES

(December 9, 1917–May 31, 1986)
Nobel Prize for Physics, 1975
(shared with Aage Bohr and Ben R. Mottelson)

The American physicist Leo James Rainwater was born in Council, Idaho, to Leo Jasper Rainwater, a civil engineer and general store manager, and Edna Eliza (Teague) Rainwater. After his father's death in the 1918 influenza epidemic, the family moved to Hanford, California, where his mother remarried. Raised in Hanford, Rainwater was an outstanding student in chemistry, physics, and mathematics. After excelling in a chemistry competition sponsored by the California Institute of Technology (Caltech), he was admitted to the school as a chemistry student; soon, however, he changed his major to physics. At Caltech, he studied physics with CARL D. ANDERSON and took a biology class taught by THOMAS HUNT MORGAN. After receiving his B.S. in physics in 1939, Rainwater entered Columbia University for graduate studies under I. I. RABI, ENRICO FERMI, Edward Teller, and other noted physicists.

When the United States entered World War II, Rainwater interrupted his thesis research to participate in the Manhattan Project as a member of the Office of Scientific Research and Development. Working under J. R. Dunning, he used Columbia's cyclotron (a type of particle accelerator) to investigate the behavior of atomic nuclei under neutron bombardment. After the war, Rainwater's data were declassified, and in 1946 he was awarded a Ph.D. for this work.

Remaining at Columbia as a physics instructor, he pursued research in experimental physics. In 1946 Columbia received funds to build the Nevis Cyclotron Laboratory, containing a synchrocyclotron that produced particles of much higher energy than the earlier cyclotron. From the beginning, Rainwater was involved in the construction of the accelerator, which began operation in 1950. By then, Rainwater and his colleagues William W. Havens Jr. and Chien-Shiung Wu had already measured the strength with which neutrons interact with most nuclei. The new accelerator allowed similar experiments to be carried out with particles other than neutrons, namely with muons (which resemble electrons except that they are approximately 200 times more massive and are unstable, decaying in only 2.2 millionths of a second) and pi-mesons (the short-lived particles that carry the strong nuclear force responsible for holding nuclei together).

In 1949–1950 the Danish physicist AAGE BOHR conducted research at Columbia, where he shared an office with Rainwater. The two scientists had long discussions on the fundamental structure of the nucleus. At the time there were two principal models of the nucleus, the liquid-drop model and the shell model. Both models took as their starting point the fundamental forces known to act between the protons and neutrons (together called nucleons) that make up a nucleus. The problem addressed by the models was to predict the properties of dozens or hundreds of nucleons interacting through these forces.

The liquid-drop model had been advanced by Aage Bohr's father, NIELS BOHR, in 1936. It supposed that the nucleus acts like a liquid drop capable of vibrating and changing shape. Although the liquid-drop model offered a satisfactory explanation of nuclear fission, it failed to account for other important properties of the nucleus. In the shell model, proposed in 1949 by MARIA GOEPPERT MAYER and J. HANS D. JENSEN, the nucleons move in independent concentric orbits, or shells; their motion is much like that of the electrons in an atom, except that there is no central force affecting their movement. According to the shell model, the force acting on one nucleon is the sum of the forces exerted by all the other nucleons in the nucleus. The sum of these forces constitutes a force field, which Mayer and Jensen assumed to be spherical. Although the shell model successfully predicted the energies of certain excited states of the nucleus, it failed elsewhere. In particular, it could not account for the discovery that the distribution of electric charge around some nuclei is not at all spherical.

In late 1949 CHARLES H. TOWNES spoke at Columbia on the disparities between the predictions of the shell theory and experimental data. Listening to Townes's talk, Rainwater thought of a way to explain these discrepancies. It occurred to him that the orbited shells in the nucleus might be distorted by centrifugal forces into a shape more like a football than a sphere. After convincing Aage Bohr that the arguments had merit, Rainwater published his hypothesis in 1950 and then returned to his experimental studies.

Bohr, who had been thinking along similar lines, returned to Copenhagen later that year determined to develop a complete theory of nuclear behavior. He and BEN R. MOTTELSON published their collective model of the nucleus in 1952, using Rainwater's insight to combine the liquidlike behavior of the nucleus described in the liquid-drop model with the orbiting-nucleon properties of the shell model.

According to Bohr and Mottelson, the collective action of the nucleons causes the surface of the nucleus to behave like that of a liquid drop. The nucleus, however, has a shell structure capable of being deformed into a football-like shape; these deformations appear on the surface as oscillations and rotations. When its outermost shell has a full complement of nucleons, the nucleus remains spherical. When the outermost shell is only partly filled, however, the shape of the nucleus is distorted. Bohr and Mottelson found that such distorted nuclei could exhibit oscillations in size, surface waves, and rotation. These new collective modes could not be predicted by the shell model because it ignored interactions among nucleons. Using the collective model to calculate the properties of the deformed nuclei and reviewing a wealth of experimental data, Mottelson and Bohr confirmed Rainwater's hypothesis in 1953.

Meanwhile, Rainwater had returned to his experimental work with the Columbia synchrocyclotron. While collaborating with VAL L. FITCH in 1953 on studies of X rays given off by muons, he discovered that current estimates of the size of the proton were too large.

Rainwater was appointed a full professor at Columbia in 1952 and was named Michael I. Pupin Professor of Physics in 1983. He was associated with the Nevis Cyclotron Laboratory from 1946 until 1978, serving as its director between 1951 and 1953, and again from 1956 until 1961.

Rainwater, Bohr, and Mottelson shared the 1975 Nobel Prize for Physics "for the discovery of the connection between collective motion and particle motion in atomic nuclei and the development of the theory of the structure of the atomic nucleus based on this connection." In his presentation speech, Sven Johansson of the Royal Swedish Academy of Sciences called their work "an inspiration to an intensive research activity in nuclear structure physics." Rainwater's Nobel lecture summarized the background leading to his discoveries and their confirmation.

In 1942 Rainwater married Emma Louise Smith. The couple had a daughter who died in infancy and three sons. Rainwater enjoyed studying geology and astronomy and liked listening to classical music. He died in Yonkers, New York, on May 31, 1986, shortly after retiring from Columbia.

In addition to the Nobel Prize, Rainwater received the Ernest Orlando Lawrence Memorial Award for Physics of the United States Atomic Energy Commission (1963). He was a member of the National Academy of Sciences, the Institute of Electrical and Electronics Engineers, the New York Academy of Sciences, the American Association for the Advancement of Science, and the American Physical Society.