Description	Sample No.	Age (yr)
Estimated by Coe to date about A.D. 1500 and to just precede the Clarksville focus.		
Charcoal associated with cord-marked and fabric-marked Woodland pottery from features 20, 55, 102, and 105. Unfortunately, feature 55 belongs to the Clements level and this date is probably somewhat too recent.	M-526	1040 ± 200
Charcoal from the Clarksville focus, feature 148, which is the last prehistoric cultural material in the area.	M-527	215 ± 200
Bland Cave, Harlan County, Ky. Charcoal from station 11, in entrance to cave. Associated with a late Archaic complex. Excavated by Edward Ray, Roscommon County, Mich., and Roger Leatherman, University of Michigan; Submitted by R. Leatherman.	M-561	3030 ± 250

E. O. Lawrence—Physicist, Engineer, Statesman of Science

Ernest Orlando Lawrence's scientific accomplishments and influence on science are almost unique in this generation and rank among the most outstanding in history. His cyclotron is to nuclear science what Galileo's telescope was to astronomy. A foremost symbol of the rise of indigenous American science in the 20th century, Lawrence, perhaps more than any other man, brought engineering to the laboratory, to the great benefit of scientific progress. He originated a new pattern of research, of the group type and on the grand scale, which has been emulated the world over. Rarely, if ever, has any person given so many others, in such a small span of years, the opportunity to make careers for themselves in science. Lawrence was a leader in bringing the daring of science to technology, in wedding science to the general welfare, and in integrating science into national policy.

Lawrence was born between two pioneering eras, on 8 August 1901, in the small town of Canton, South Dakota, on the Big Sioux River—the second-generation product of educated Norwegian immigrants. When Lawrence was born, the echoes of the taming of the Great Plains had hardly died away. From this pioneering heritage and through some biogenetic conjugation still beyond the grasp of science, Lawrence derived qualities that uniquely fitted him for grand explorations in the nascent science of the 20th century. Lawrence was a big, robust son of his Norwegian forebears, with virtually unlimited energy, which he expended without reserve in long hours in the laboratory, in consultation with colleagues, in planning new projects, and in the taxing airplane trips and conferences important to national policy. He was characterized by boldness, enterprise, innate modesty, and an open, friendly spirit. His *joie de vivre* and his buoyant optimism spread to everyone around him and accounted for the attainment of many an "impossible" objective.

Lawrence attended the public schools of Canton and Pierre, South Dakota. He began college work at St. Olaf's College, in Northfield, Minnesota, and went on to the University of South Dakota for his B.S. degree. Inspired by South Dakota's Dean, Lewis E. Akeley, he entered the University of Minnesota to study physics and obtained the M.A. For two years he studied at the University of Chicago, transferring to Yale, where he received the Ph.D. in 1925. After three more years at Yale, as a National Research Fellow and as an assistant professor of physics, Lawrence (already a promising young physicist) came to the University of California in 1928 as an associate professor. In 1930, at the age of 29, he became the youngest full professor on the Berkeley faculty.

Lawrence's reputation of the late 1920's was solidly based. His doctor's thesis was in photoelectricity. Later, he made the most precise determination, to that time, of the ionization potential of the mercury atom. With J. W. Beams he devised a method of obtaining time intervals as small as three billionths of a second, and he applied this technique to study the early stages of electric spark discharge. He originated a new and more precise method for measuring e/m which was perfected by F. G. Dunnington.

In 1929 young Lawrence, who for some time had been contemplating the problem of accelerating ions, chanced, while scanning the literature, upon a sketch in a German publication. He forthwith formulated, within minutes, the principles of the cyclotron and the linear accelerator and so set himself upon a course that was to influence, fundamentally, scientific research and human events.

Between the brilliant, simple concept and operating machines lay engineering barriers not previously encountered. Lawrence's willingness to tackle new engineering problems and his success in solving them, as he reached for successively new energy ranges, was a departure in scientific research that is an important part of his contribution. The hard road he chose was recognized when W. D. Coolidge, presenting the National Academy of Science's valued Comstock Prize in 1937, said in part, "Dr. Lawrence envisioned a radically different course . . . [which] called for boldness and faith and persistence to a degree rarely matched." By 1936 the scale of research and supporting engineering development was so large that the Radiation Laboratory was created at the University of California to satisfy the administrative requirements. The prototype of the big laboratory had been born.

The range of contributions that have flowed from Lawrence's invention and his leadership are evident from some important examples: world leadership, for more than a quarter of a century, in the development and use of high-energy accelerators; the discovery of hundreds of radioactive isotopes, such as carbon-14,

iodine-131, tritium, and uranium-233; the discovery of 12 (two with the collaboration of other laboratories) out of 14 of the synthetic elements, including plutonium, the atomic energy fuel; the first laboratory production and study of mesons; the discovery of antiparticles; pioneering tracer experiments with radioactive isotopes; the initiation of treatment of human disease with radioactive isotopes and with heavy particles from cyclotrons.

A fundamental factor in such achievements was Lawrence's character and energy. He had the vision to glimpse the limitless nature of the horizon and the generosity to make room for others. His personal credo was, "There is enough research for all of us to do." He interceded, with his rare persuasiveness, to create new facilities for worthy projects. He rejoiced as jubilantly in the success of others as in his own. As a result, the careers of many scientists, my own included, are founded on his large contributions and his generous nature. Indeed, so great was the opportunity he created that he was influential in the training of a significant portion of the present corps of nuclear scientists.

From the beginning, the Radiation Laboratory attracted scientists from all over the world, and it has been an international center of nuclear and biological research. When radioisotopes were first being produced in quantities large enough for tracer studies, Lawrence characteristically shipped part of the supply of radiophosphorus to Belgium for the use of G. Hevesy, who had initiated tracer studies with lead in the 1920's. Thereafter, radioisotopes were shipped to many individuals and laboratories abroad.

Lawrence's catholic interests made him a dedicated disciple of the new concept of interdisciplinary collaboration, and nowhere did such research flourish more than in his laboratory. In the early 1930's he personally initiated and carried through the construction, at the University of California Medical Center in San Francisco, of one of the earliest million-volt x-ray machines—the tube suggested by David Sloan. He strongly encouraged physicists to work with biologists. He set up his own radioisotope distribution system, supplying isotopes to hundreds of doctors and numerous institutions in the prewar period.

Ernest Orlando Lawrence

Lawrence helped bring big science to government. His contributions were crucial to the success of the Manhattan Project. He was instrumental in organizing the Los Alamos Scientific Laboratory. In the postwar period Lawrence continued to influence national policy decisions, advocating accelerated development of thermonuclear weapons and insisting that America maintain her nuclear strength in the absence of adequate safeguards. The Livermore Laboratory is one consequence of this view.

Lawrence's uncompromising conviction that free institutions must be protected, through strength, against tyrannies was accompanied by an optimistic hope that peace could be made permanent. His trip to Geneva last July to take part in developing an agreement on means for detecting nuclear weapon tests was one of many expressions of this optimism and of his deep devotion to duty. The pressures of the deliberations apparently precipitated Lawrence's final illness, forced him to leave Geneva in the midst of negotiations, and brought his career to a premature end in Palo Alto, California, on 27 August 1958. Literally, Ernest Lawrence gave his life for peace.

Lawrence was honored in full measure. The awards to him included the Nobel Prize for 1939, the Hughes Medal of the Royal Society, the Medal for Merit, the Faraday Medal, the American Cancer Society Medal, the Enrico Fermi Award, and the first Sylvanus Thayer Award. He was a member of such learned societies as the National Academy of Sciences and the American Philosophical Society and recipient of many honorary degrees and memberships in foreign societies.

To his large and handsome family, Lawrence gave devotion and a full measure of his cheerful spirit—to Mary Blumer, his wife, and to his children John Eric, Margaret Bradley, Mary Kimberly, Robert Don, Barbara Hundale, and Susan. With his brother, John Hundale, who came to Berkeley in 1935 to pioneer in the use of the products of the cyclotrons, Ernest maintained an affectionate camaraderie.

In speaking of Lawrence's own work, the research that radiated from it, and his influence upon his time, one is not merely tempted but, rather, compelled to use the superlative. One effort to assess the work of the man who, throughout his life, remained very much an uncomplicated son of the Great Plains was made in the citation of the Research Corporation's Scientific Award of 1937, which read in part: "Ernest Orlando Lawrence has made accessible a new world within the nucleus . . . is a vigorous and inspired pioneer in its exploration . . . [has opened] vast new areas of knowledge. . . . His achievements stand with the great work of the ages."

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