Physical Chemist Harold Clayton Urey (1893-1981)

Columbia Chemistry Professor Harold Urey experimentally discovered deuterium in 1931. Early in that year Urey conceived and worked out a method for concentration of a possible heavy hydrogen isotope by distillation of liquid hydrogen. Fractional distillation at low temperature was done in collaboration with Brickwedde at NBS in Washington DC; 5 liters of liquid hydrogen was distilled down to 1 cc. Urey detected deuterium by its predicted spectrum in a discharge through the vapor of this concentrated residue. High resolution atomic hydrogen visible spectra were obtained on a new 21 ft. spectrograph in the basement of Pupin Hall. The critical data clinching the discovery were taken by Urey and his assistant George Murphy on Thanksgiving Day morning. A few months later, Urey and Washburn showed that deuterium was efficiently concentrated by prolonged water electrolysis, creating “heavy water”. By 1935 Norsk Hydro was producing inexpensive 99% pure heavy water from electrolysis in volume, leading the way to wide availability of deuterium.

Chadwick discovered the neutron in early 1932. Together, the existence of deuterium and the neutron led to a much deeper understanding of nuclear physics, and indeed the evolution of the early universe. At age 41, Urey won the 1934 Nobel Prize in Chemistry, and the American Chemical Society Gibbs Medal, for his discovery. Urey shared his Nobel Prize money with his collaborators, giving one quarter each to Murphy and Brickwedde. When he obtained a research grant for his research from the Carnegie

Institution at this time, he spontaneously shared the money with colleague I. I. Rabi, thus enabling Rabi to build his first molecular beam machine.

Urey was a son of small town, pre-industrial America; he once told colleagues that the first time he saw an automobile was at age 17 in rural Montana. After graduating from high school, he taught in small country schools in Indiana for three years, before working his way through the University of Montana,. His original intention was to study psychology. He actually majored in zoology, combining it with chemistry courses. During WWI he worked as an industrial chemist, and then entered graduate school late in life at age 28. His interests turned to fundamental physical science, and he studied the old quantum theory, and its consequences in molecular statistical mechanics, as a PhD student with G. N. Lewis at Berkeley. He finished his PhD in 1923, taking just 2 years. Urey was the first of many Berkeley-educated PhD chemists to subsequently win a Nobel Prize. He then spent a year in Europe with Niels Bohr, followed by 5 years as junior faculty at Johns Hopkins, where he collaborated with F. O. Rice among others. He taught himself the new Heisenberg and Schrodinger approaches to quantum mechanics as the articles appeared in the literature. He joined the Columbia chemistry department in 1929. He was a pioneer in application of quantum mechanics to molecules, and wrote **Atoms, Molecules, and Quanta** in 1930 with A. E. Ruark. At Columbia he was founding editor of the Journal of Chemical Physics, and Chair of the department in 1939-1942.

In the 1930s Urey systematically found practical ways to concentrate isotopes, and used these isotopes to probe chemical reactions. With PhD student Mildred Cohn he explored O^{18} exchange reactions between water and organic compounds; she later joined the faculty at the University of Pennsylvania Medical School and pioneered the biological use of oxygen isotope tracers. Urey's student T. Ivan Taylor explored isotope effects in surface reactions, and joined the Columbia Chemistry Faculty after WWII. Urey and Taylor invented the modern industrial process for N^{15} concentration.

In January 1939 Bohr proposed that the minor isotope U235 was responsible for the recently discovered fission of uranium under neutron bombardment. In Europe WWII began in September 1939, and the question of possible nuclear weapons in the fight again Hitler became paramount. Urey and his colleagues were deeply concerned about the German nuclear effort headed by Heisenberg. At this time Urey analyzed both gaseous diffusion and centrifugal fractionation (in the countercurrent flow centrifuge) methods for U235 enrichment in UF_6. In May 1940 Urey and other Columbia faculty began experimental work on uranium separation in Havemeyer Hall. Shortly thereafter the Federal government began to fund isotope separation. By early 1941 Urey had assumed responsibility for formulating and coordinating all Federally-funded academic and industrial work in isotope separation and heavy water production. As this massive effort accelerated in late 1941, Urey was formally appointed Program Chief for uranium isotope separation by gaseous diffusion, in Section S-1 of the US Office of Scientific Research and Development. E. O. Lawrence became Program Chief for electromagnetic separation. This secret Federal organization directly under President Roosevelt initiated and supervised the Manhattan Project. Huge gaseous diffusion and electromagnetic separation plants were constructed at Oak Ridge, Tennessee within two years. During the war Urey supervised a broad range of US isotope separation programs, and also personally directed war-related isotope research in Havemeyer Hall. Many hundreds of scientists at various locations reported to him. This was a stressful administrative burden, which he gladly gave up in 1945. His mind then turned towards control of atomic energy, and he spoke widely on this subject.

After the war, both Urey and physics professor Enrico Fermi, who had built the first reactor demonstrating sustained nuclear reaction, moved from Columbia to the University of Chicago. Urey turned to new scientific questions. In the late 1940s Urey conceived and demonstrated the "paleotemperature" isotopic thermometer –which is now universally used to analyze climate warming and cooling cycles. By measuring the O^{16}/O^{18} ratio in carbonate minerals, and in ice as a function of depth in snow field core samples, one can determine temperature at the time of formation. This method uses temperature effects in isotopic ratios in evaporation of sea water(and subsequent condensation as rain and snow), and in the equilibrium between water and carbonate ion. He and colleagues developed mass spectrometric methods to measure the isotopic ratio to 2 parts in 10^4. He was widely honored in the geology community for this method.

After 1950 his interests turned to the chemistry of the planets, and he is credited with initiating rigorous study of "cosmochemistry", a term that he himself coined. In 1953 he and PhD student Stanley Miller performed a novel experiment on amino acid synthesis via electrical discharge, in gas above warm water, simulating the earth's original reducing atmosphere and ocean. This experiment had enormous influence in subsequent research on the origin of life.

At age 65 in 1958, Urey "retired" to the Scripps Institute in California. Here he helped build the University of California at San Diego as a new research university. In retirement he published 104 research papers, many focused on understanding earth's moon. At the time of Sputnik in the late 1950s, Urey led the effort to establish NASA for moon exploration. He continued doing research full time past age 80, until illness overtook him

Urey was a truly outstanding scientist, and an American patriot deeply concerned with liberty and freedom. He constantly drove himself to find novel problems, and to invent innovative methods to explore them. He explored the entire range of physical and natural science. He received honorary doctorates from 24 universities around the world. He was an especially close friend of Einstein and James Franck. He was a colleague of Rabi, Bohr, Kramers, Pauli, Szilard, Fermi, Teller, Lawrence, Oppenheimer, Compton, van Vleck, Mulliken, Joe Meyer, and Maria Groeppert Meyer.