IN MEMORIAM

James R. Arnold
Professor Emeritus of Chemistry and Biochemistry
UC San Diego
1926-2012

James R. Arnold, founding chairman of the Department of Chemistry at UC San Diego, passed away on Friday, January 6, 2012 at age 88. Among his many scientific accomplishments were the development of radiocarbon and other radioisotopic dating methods used to determine the age of historic and prehistoric archaeological sites, the cosmic ray exposure age and space history of meteorites, and the approximate constancy of galactic cosmic radiation over millions of years. Jim played a key role in the planning for, and the conduct of, analyses of lunar samples from the Apollo missions. He was especially proud of his role in the development of UC San Diego following his recruitment by Roger Revelle to join the initial faculty in 1958.

Jim was born May 5, 1923 in Metuchen, New Jersey. He was the only child of Abraham S. Arnold, who had emigrated from Romania at age 11, became a lawyer and served as a bank officer, and Julia Jacobs Arnold, a schoolteacher. Both of his parents considered education important and Jim felt that a great deal of his early education occurred at home. His father pursued Egyptian archeology as a hobby and this led to Jim becoming interested in archeology at an early age. He entered Princeton University in 1939 at the outbreak of World War II, completed his degree in chemistry in 1943, and stayed at Princeton for graduate studies. He later claimed that he helped the war effort in two ways: by working on the Manhattan Project and by not serving on the front lines. He received his Ph.D. degree in 1946 for studies associated with the Manhattan Project but his thesis remains classified.

Arnold pursued postdoctoral studies with George Kistiakowsky at Harvard and with Willard Libby at the University of Chicago. The project with Libby demonstrated that the measurement of radioactive carbon-14 (radiocarbon) could be used to determine the age of materials derived from atmospheric carbon dioxide. Radiocarbon is generated in the atmosphere by cosmic rays and is incorporated as carbon dioxide into plant material during photosynthesis and subsequently into animals. Following the death of the plant or animal the incorporation ceases and the radiocarbon present decays with a half- life of 5,730 years. Determination of the amount of radiocarbon remaining in a carbon sample derived from carbon dioxide provides the basis for estimating the time at which the radiocarbon was produced and incorporated into the sample and thereby the time at which the organism died. The radiocarbon project was a perfect fit with Jim's interest in archeology, instilled in him by his father, and the successful completion of this project around 1950 provided archeologists with a powerful new method for dating samples from historical and prehistorical sites. It remains the cornerstone of archeological dating and continues to enjoy expanding application as more sensitive and convenient methods of radiocarbon measurement are developed. Radiocarbon dating earned the Nobel Prize for Willard Libby in 1960.

Having worked on the Manhattan Project Jim was concerned about the dangers posed by the nuclear arms race and by nuclear weapons testing. He joined the Council for a Livable World founded by Leo Szilard and the World Federalist Movement, and he later contributed articles on the dangers of nuclear weapons to the Bulletin of Atomic Scientists. It was at a 1950 World Federalist meeting in Chicago that he met Louise Clark and they were married two years later. Their first son, Bob, was born in Chicago in 1954.

Jim found the University of Chicago to be an exceptionally stimulating environment cultivated by many great scientists, including Enrico Fermi and Harold Urey, as well as Willard Libby. Following his work with Libby, Jim received an Assistant Professor appointment at Chicago and began developing his own research program. He turned his attention to the development of scintillation counting for measurement of radioisotopes and to the identification of cosmic ray produced radioisotopes other than radiocarbon. The first of these was berryllium-7 (half- life 53 days), which has proven useful for assessing the rate of downward mixing of stratospheric air.

In 1955, when promotions at Chicago were frozen by budgetary constraints, Jim accepted an offer to return to Princeton as a faculty member. There he and Louise welcomed their second son, Ted, in 1956. Jim continued his work on cosmic ray produced radioisotopes, identifying berryllium-10 isolated from cores of Pacific clay sediments provided by Ed Goldberg of Scripps Institution of Oceanography in La Jolla. Berrylium-10 would prove to be a long- lived cosmogenic radioisotope of great value in determining the terrestrial ages of meteorites. He was joined at Princeton by Masatake Honda, who Jim would later describe as "The best laboratory radiochemist I will ever meet", initiating a collaboration that would continue throughout Jim's career.

In the summer of 1957, Jim took his family and coworkers to the Scripps Institution of Oceanography (SIO) in La Jolla to work on determining the beryllium content of seawater. There he met with Roger Revelle who wanted him to join him in the development of a new University of California campus in La Jolla. This was a tempting but serious decision for Jim and Louise with two young sons and a third child expected. But when he learned that Harold Urey had accepted a position at La Jolla, the decision became easy. When he announced his plan to leave Princeton for La Jolla, his department chairman asked "How could you possibly leave a venerable old university like Princeton for an unknown, proposed new University of California campus?" Jim replied, "I am not a priest, I'm a missionary". In the summer of 1958, following the birth of their third son, Ken, Jim and Louise moved their family to La Jolla. Jim joined Harold Urey and Hans Suess at SIO, starting the chemistry department with a focus in cosmochemistry.

During his initial years in La Jolla, Jim was deeply involved in the development and planning of the new University of California campus at San Diego. He became the first chair of the Department of Chemistry in 1960 and was heavily involved in the recruitment of new faculty. He expanded the department by adding Joe Mayer (along with Maria Mayer in Physics), Stanley Miller and Bruno Zimm that year and four additional appointments the following year.

From 1958 to 1963 Jim's laboratory was located next to Harold Urey's laboratory at SIO where it looked directly onto the beach, Scripp's pier and the Pacific Ocean. Jim asked Harold why he had not taken this lab instead of his own that had no view. Urey's response was that the view was too distracting. During the recruitment of new faculty Jim's laboratory on the beach became the routine first stop for visiting prospective candidates. Devandra Lal joined Jim in La Jolla beginning another long- term collaboration. Methods developed there by Honda, Lal and Arnold on the determination and use of the cosmic ray generated nuclides berryllium-10, manganese-53, aluminum-26 and chlorine-36 with half- lives ranging from 0.3 to 3.7 million years provided the basis for determining the ages of meteorites, and later of lunar rocks, and of the history of cosmic ray fluxes.

In 1985 Jim Arnold and Devendra Lal published a paper outlining the use of beryllium-10 and aluminum-26 produced by cosmic ray bombardment of terrestrial materials as a way of dating landform formation on the earth. This work opened up a wide array of terrestrial geochemical studies where a precise knowledge of the positions of geologic material over long periods is desirable. This would include continental motions, weathering processes, and climate alterations across the globe. This was information that could not have been obtained any other way and to this day there are numerous scientists applying this extraordinary technique.

As a fan of Buck Rogers and Jules Verne, Jim was a great advocate of space exploration. The goal of sending a man to the moon and back by the end of the decade stated by President John F. Kennedy in 1961 was exciting for Jim and he became deeply involved in planning experiments for the moon missions. He promoted the development and testing of a gamma- ray spectrometer that was flown on unmanned early Ranger missions. An improved instrument used on later Apollo missions provided data relating to the elemental composition and distribution on the moon's surface. Jim, Jerry Wasserberg, Robert Walker and Paul Gast comprised a group known as "the Four Horseman" who led the planning for the acquisition and analysis of moon rocks and soil. A total of some 840 pounds was obtained in the Apollo missions. Analysis of these samples, with ages up to 4.5 billion years for samples from the lunar highlands, provided information on the

composition, history and cosmic ray bombardment of the lunar surface. During Apollo 15 and Apollo 16 Jim alternated 12 hour shifts with Al Metzger at the monitors for the gamma- ray spectrometer in a trailer located at mission control in Houston and Jim later beamed for reporters at his lab at UC San Diego while showing a moon rock returned by Apollo. For Jim the only thing more exciting would have been going to the moon himself.

Jim Arnold was a dedicated and inspiring teacher at both the undergraduate and graduate level. A new graduate student, Candace Kohl, was delighted to be able to work on rocks from the moon in the Arnold lab but was apprehensive about her teaching of undergraduates. When she queried Arnold about the qualities that she should develop to be a good teacher, he replied, "To be a great teacher you have to be a character. Since you are one, you have a good start." Jim certainly qualified as a genuine original. One of his main characteristics was that he was a great storyteller. As his cosmochemistry colleague Mark Thiemens recalls, "One of the fun parts of Jim was that he loved to tell stories. He would always do it the same way when I posed a question. He would cross his arms over his chest and say 'That reminds me of a story'. So over the years I heard a lot of wonderful stories. They were consistent, they were always interesting, and they occasionally even had some relationship to my question." Recordings that include Jim telling many stories associated with the development of radioisotope dating, the early development of UC San Diego and the missions to the moon can be found in the Oral Histories archive of The History of UC San Diego at the UC San Diego library website.

Jim was the recipient of many honors and awards. He was elected to the National Academy of Sciences in 1964, received the E. O. Lawrence award from the Atomic Energy Commission in 1968, was presented the NASA "Exceptional Scientific Achievement" medal in 1970, and was awarded the Leonard Medal from the American Meteoritical Society in 1976. In 1980 an 8- mile- wide asteroid discovered by Eleanor Helin and Eugene Shoemaker was named "2143 jimarnold" in his honor. He was closely associated with Harold Urey ever since the Manhattan Project and it was fitting that he was honored in 1983 as the first holder of the Harold C. Urey Chair in Chemistry. In 1979 Jim founded the California Space Institute, a multi- campus consortium to inspire and promote the next generation of space scientists, and he served as its director until 1989.

At the memorial service held for Jim on May 6, 2012, on what would have been his 89th birthday, his son Bob recalled Jim's modification of a line from "In Memory of W. B. Yeats" by W. H Auden that Jim delivered at a memorial service for his friend Chip Rosenfeld. It seemed especially relevant to the family, friends, students, colleagues and collaborators who attended Jim Arnold's memorial service –

"At the moment of his passing, he became his admirers."

Robert C. Fahey
Candace Kohl
Kurt Marti
Mark Thiemens