In Memoriam Martin D. Kamen (1913–2002), Nuclear Scientist and Biochemist

George B. Kauffman

Department of Chemistry, California State University, Fresno, Fresno, CA 93740-8034,georgek@csufresno.edu

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Abstract: The life and work of Martin D. Kamen, codiscoverer of carbon-14 and a distinguished Nobel-caliber nuclear scientist and biochemist, are briefly recounted on the occasion of his recent death.

Martin D. Kamen, codiscoverer of the radioactive isotope carbon-14 and an eminent nuclear and biochemical pioneer, died of pneumonia in his home in Montecito, a suburb of Santa Barbara, California on August 31, 2002 at the age of 89. His heavy exposure to radiation early in his career had left him with chronic low-grade leukemia; as a result, he had been in poor health for the last few years. He had also suffered a series of small strokes that had drastically impaired his short-term memory. He is survived by his son David M. Kamen, a translator and précis writer for the United Nations in New York; David's wife, Eileen Hsu, an independent researcher; their son Alexander; and Martin's sister, Lillian Smith, of Chapel Hill, North Carolina.

His son David (born in 1950) recalls how his father, an accomplished raconteur and amateur musician, often took him along on visits to friends' homes, where the adults played chamber music and had wide-ranging discussions lasting far into the night. David did not become a musician, but he sees a connection between his love and interest in languages and the fact that his gregarious father played host to friends and scientific colleagues from foreign lands whose various languages filled the family home. Kamen was married three times—first to Esther Hudson, next to Beka Doherty, a science and medical journalist, and finally to Virginia Swanson, a pathologist and medical researcher.

Beginning in Spring 1983, I corresponded with Kamen about my research on his Doktorvater, the eminent physical chemist William Draper Harkins of the University of Chicago [1]; my review of Kamen's critically acclaimed autobiography [2]; and Charlene Steinberg's and my translation of a biography of chemist–composer Aleksandr Porfir'evich Borodin, which he critically read and for which he wrote the introduction [3]. It was only later that I finally met him, an encounter resulting in a wide-ranging interview for The Chemical Educator [4], in which he discussed his life, career, and views of science, education, and politics. In agreement with the prevailing opinion of his numerous friends and colleagues I found him to be a real mensch—"an upright, honorable, decent person; someone of consequence; someone to admire and emulate; someone of noble character" [5].

In 1940 Martin D. Kamen (1913–2002) and Samuel Ruben (1913–1943), two 26-year-old American chemists, discovered carbon-14—the long-lived radioisotope that revolutionized tracer methodology, played a crucial role in our understanding of biological mechanisms, and paved the way for radiocarbon dating of archeological and historical artifacts [6]. Ruben was killed by phosgene in a laboratory accident in 1943, and Kamen, dismissed from his classified war work in 1944, went on to begin a second career in biochemistry, beginning in 1945. The career of this brilliant early pioneer in nuclear science, who as a child of immigrant parents was motivated by the need to earn a living during the years of the Great Depression, culminated in revolutionary scientific work which earned him international recognition. The vicissitudes, injustices, security problems, and persecutions that this Nobel-prize-caliber scientist was forced to endure from his own government and an irresponsible press provides us with a cautionary tale less well known than that of J. Robert Oppenheimer but no less poignant or instructive.

Kamen's Early Life

Aaron Kamenetsky, a photographer, and his wife Goldie (née Achber), moved from Toronto, Canada to Chicago after their marriage in 1911. So that she could be cared for by family rather than by strangers, late in her pregnancy Goldie returned to Toronto, where she remained until December and where her son Menachem David (Martin David) was born on August 27, 1913 [7].

Martin grew up in Chicago, where he received top grades and was an actual *Wunderkind*, first on the violin and then on the viola. He continued to play chamber music and symphonic music until the early 1990s. Everyone expected him to become a musician, but he did not pursue a career in music as there were no jobs for musicians in Chicago during the Depression. He decided to stay in school, and in 1930 he entered the University of Chicago because it had a good reputation and he could live and eat at home. Because he had a very strong interest in the classics, he became an English major.

As the only son in an immigrant Jewish family, Martin was expected to be a professional—"a doctor or something that would be highly respectable—something in a learned profession" [7b]. He was even considered possible rabbinical material. He recollected,

> There's a certain mystique in Jewish families, especially immigrant families, to have their children become important members of the community, and to them, people who were important members of the community were teachers, lawyers, or doctors. My parents' aspirations were

[*] Series Editor Contribution.

both intellectual and artistic, but the question was always "Can you make a living at it?" [7b].

When Martin's father showed him an advertisement for International Correspondence Schools that said, in effect, "Be a chemist and make millions," he switched his major to chemistry. In 1933 he received his B.S. degree *cum laude*. Mathematician and musician Arthur C. Lunn was the only professor who exerted any great influence on him, but Martin decided to continue graduate work at Chicago under nuclear chemist William Draper Harkins (1873–1951) because he was a senior professor, and, as his student, Martin would have a better chance of getting a job. He received his doctorate in physical chemistry (1936) for an article [8] that was accepted as his dissertation.

The Saga of Carbon-14

Kamen used all his scanty savings to move to the University of California, Berkeley, where he worked at future (1939) Nobel physics laureate Ernest O. Lawrence's (1901–1958) Radiation Laboratory without salary for several months until he obtained a staff position as a minority chemist among a majority of physicists. Besides troubleshooting Lawrence's cyclotrons that were then somewhat unpredictable as well as preparing samples of phosphorus-32 and other radioisotopes, Kamen performed numerous photosynthetic studies with Samuel Ruben, using the short-lived carbon-11 (half life, 21 minutes). Because at the time very few persons could run a mass spectrometer, which was much more difficult to use than a Geiger counter, Lawrence mounted a campaign to find a long-lived radioisotope of carbon. In fall 1939 he assigned Kamen and Ruben the task of finding carbon-14 or any long-lived activity in that part of the periodic table. Harold C. Urey, the 1934 Nobel chemistry laureate, and his group at Columbia University were competing with Lawrence's Berkeley group in a race to use isotopes as biological tracers.

To help Kamen and Ruben in their search Lawrence offered both his 37-inch and 60-inch cyclotrons, all the time that they needed, and help from Emilio Segrè, Glenn T. Seaborg, and anyone else at the Rad Lab. In September 1939 Kamen planned a detailed program dealing with every conceivable method for preparing long-lived isotopes of carbon, nitrogen, and oxygen. He was especially interested in reactions that would produce isotopes chemically separable from the target material bombarded in the cyclotron—for example, carbon-14 from nitrogen-14 in ammonium nitrate—to prevent dilution of the radioactive isotope by its stable isotope.

Because of his experience in making carbon-11 by deuteron bombardment of boron oxide, with its convenient production of the radioisotope as gaseous ^{11}CO, Kamen first tried the same procedure using 16-Mev alpha-particle bombardment of B_2O_3 in the 37-inch cyclotron (September 27–29, 1939). By October 17 several more experiments convinced him that none of his planned alpha-particle-induced reactions were feasible. During January 1940, he, therefore, began continuous exposure of a graphite probe target allowed to collect stray deuterons in the internal beam of the 37-inch cyclotron as the most likely nuclear reaction to yield carbon-14:

$$^{12}C + {}^{2}H \rightarrow {}^{13}C + {}^{1}H$$

$$^{13}C + {}^{2}H \rightarrow {}^{14}C + {}^{1}H$$

Kamen inserted the probe to intercept almost all the deuterons during night operation and retracted it to allow normal operation of the cyclotron by others during the day. Because he had to examine the intensely radioactive probe every night to make certain that some graphite still clung to the target surface, he was exposed to considerable doses of radiation. "I must have been the most irradiated guy in the world" [4, 7b], he told me.

For three nights in a row Kamen did not sleep so that the target probe could accumulate a total exposure of 5,600 microampere-hours. Just before dawn on February 19, 1940 he withdrew the probe, scraped off the graphite, and left it on Ruben's desk in a weighing bottle. On his return home, during a thunderstorm, "with eyes red-rimmed from lack of sleep, unsteady gait from weariness, and a three-day growth of beard" [4, 7b], he "was picked up by the police as a likely suspect for a mass murder perpetrated a few hours earlier somewhere in the East Bay" [4, 7b]. When the victim of the crime failed to recognize him, he was released. On returning to his one-room apartment he collapsed into a twelve-hour sleep.

While Ruben processed the sample, Kamen was forced to remain at a distance and could not touch anything because he was so contaminated with radioactivity. By Tuesday afternoon, February 27, 1940, the two had removed the last uncertainty—that the activity of the sample might have resulted from the long-lived sulfur-35 produced by the reaction of deuterons on the sulfur as a possible contaminant of the graphite target. They estimated the half-life of carbon-14 as at least 1,000 years and wrote a preliminary account for publication as a short letter in *Physical Review* [9]. Because of Ruben's concern with departmental politics and with obtaining tenure, Kamen allowed his friend and collaborator to list his name first on the letter, and thus Kamen's contribution to one of the major discoveries in nuclear science was minimized.

Radiocarbon Dating

The 1960 Nobel Prize in Chemistry, received by Willard F. Libby (1908–1958) of the University of Chicago "for developing radio carbon dating techniques" was based on Kamen and Ruben's discovery of carbon-14. Although the duo's discovery was certainly of Nobel caliber, Ruben's death in 1943 arising from an accident involving phosgene precluded a joint award to him and Kamen (Nobel Prizes are not awarded posthumously).

Kamen later found the half-life of carbon-14 to be 5,730 years, a short time compared to the age of the earth but long enough for an equilibrium to occur between its production and decay. Because nitrogen, which constitutes ca. 80% of the atmosphere, absorbs neutrons easily and then decays into carbon-14, Libby proposed that traces of carbon-14 should always occur in atmospheric carbon dioxide. Because carbon dioxide is being incorporated continuously into plant tissues, plants should also contain traces of carbon-14. Because animal life depends on plant life, animals should also contain traces of carbon-14. After an organism dies, no more carbon-14 is incorporated into its tissues and that which was already present would begin to decay at a constant rate.

In his Nobel Prize presentation speech Arne Westgren, Chairman of the Nobel Committee for Chemistry of the Royal Swedish Academy of Sciences, stated, Because the activity of the carbon atoms decreases at a known rate, it should be possible, by measuring the remaining activity, to determine the time elapsed since death, if this occurred during the period between approximately 500 and 30,000 years ago [10a].

A scientist who had nominated Libby for the prize characterized his work as follows:

Seldom has a single discovery in chemistry had such an impact on the thinking in so many fields of human endeavour. Seldom has a single discovery generated such wide public interest [10b].

Neither Westgren's presentation speech nor Libby's acceptance lecture mentioned Kamen and Ruben's work—in my opinion, a gross miscarriage of justice.

The radiocarbon method was soon recognized as a basic technique for determining dates within the last 70,000 years. It has been used to date archeological objects like linen wrappings from the Dead Sea Scrolls, bread from a house in Pompeii buried by volcanic ashes from the eruption of Vesuvius in A.D. 79, charcoal from a campsite at Stonehenge, and corncobs from a prehistoric cave in New Mexico. Of course, its most publicized and controversial application has been in dating the Shroud of Turin [11].

Kamen's Move to Biochemistry

During World War II Kamen continued his work at Berkeley on the separation of uranium isotopes for the atomic bomb (Manhattan Project) until July 1944, at which time he was abruptly dismissed with no explanation and ordered to leave the project immediately. With this sudden disappearance of his career prospects, he accepted a temporary position as test inspector at the Kaiser shipyards in Richmond, a city in the East Bay area of California. In Spring 1945 he obtained a position at Washington University in St. Louis where he remained until 1957, attaining international recognition for his work on bacterial photosynthesis, bacterial cytochromes, and the use of radioisotopic tracers in biological and biomedical research [12].

Today, when narrow specialization is the rule among scientists, it is instructive to learn how Kamen made the transition "from cyclotrons to cytochromes"—the title of the *Festschrift* honoring his retirement on his 65th birthday [13]. In his words,

I was propelled into biochemistry by the radioactive isotope business. I was one of the original workers on tracer metabolism studies. There was essentially no such field when I started. Little was known about intermediary metabolism so one can say that the revolution in biology began about 1950 with the first determination of the various metabolic pathways. Now we have a very complex metabolic map that didn't exist twenty years ago. The metabolic fate of practically every compound known has now been traced so that we've seen the creation of a whole new science that didn't even exist two decades ago.

The organic chemist would think of the ways that metabolism might take place, but the actual biological processes could be entirely different. We were starting essentially from scratch, and we had to keep an open mind about what was happening. We had to expect the unexpected; we first observed and then did our theorizing. For example, everyone thought that in photosynthesis the carbon dioxide went to glucose. Using labeled CO_2 we found no labeled glucose within the first ten minutes. Yet the textbooks still state: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$ [4].

Concerning the impact of his biochemical contributions, Kamen stated:

Although the discovery of carbon-14 was undoubtedly my greatest discovery, I think that the discovery of nitrogen fixation in photosynthetic bacteria, which we made in St. Louis, was a pretty important contribution. Before our work there were only a few agents thought capable of effecting nitrogen fixation, but after we showed that it occurred with hundreds of species of photosynthetic bacteria, it became obvious that it was a general reaction not confined to legumes or *Azotobacter*.

My favorite times were when I was working on cytochromes. A cytochrome is a heme protein that functions by electron transfer based on the reversible ferrous-ferric ion equilibrium. Iron is the central atom, and the protein determines the potential.

The general or comparative biochemistry of cytochrome C is essentially my invention. Cytochrome C has been investigated about as intensively as any protein with the possible exception of hemoglobin and heme proteins. Almost every time a new method of looking at structure and function is discovered, it turns out that the investigators started out with cytochrome C. But it's always mitochondrial cytochrome C, and they find out a lot about mitochondrial cytochrome C by looking at cytochrome C outside the mitochondria. So we have a whole Pandora's box of cytochrome C's, which vary quite amazingly in details of structure but still have the same function—the general function being electron transfer. So the definition of cytochrome has been broadened considerably since we started work in 1950 [4].

Kamen linked his first and second careers as follows:

I'm very fortunate in having made discoveries that have changed science and have affected people's lives in general. Carbon-14 has had a great impact on archeology, anthropology, medicine, and other fields. Its biggest impact is on biochemical tracer work because we can devise various enzyme inhibitors, and once we know the enzymatic pathway, we know what molecules to design to block enzymes. That's the basic question in medical therapy and in curing diseases [7b].

Kamen's Problems with the U.S. Government

In 1947 newspapers in front-page stories, based on handouts and leaks from the House Un-American Activities Committee (HUAC), claimed that some Manhattan Project scientists had been part of espionage rings working for the USSR. Among these was Kamen, whose reputation was badly damaged before he had a chance to appear at a hearing to defend himself. After an abortive suicide attempt, made during the throes of depression, he decided to contest the charges and not to abandon his fight until he had won ultimate vindication.

Kamen later discovered that all his difficulties with the government stemmed from "a dinner he had with some Russians." He had met Soviet vice-consul, Gregory Kheifetz, and another official at a cocktail party given by the late violinist Isaac Stern, a close friend. Kheifetz asked Kamen for help in obtaining radioactive phosphorus-32 to treat an official at the Russian consulate in Seattle suffering from leukemia. Kamen, being a compassionate person, complied with the request. To demonstrate his gratitude, Kheifetz invited Kamen

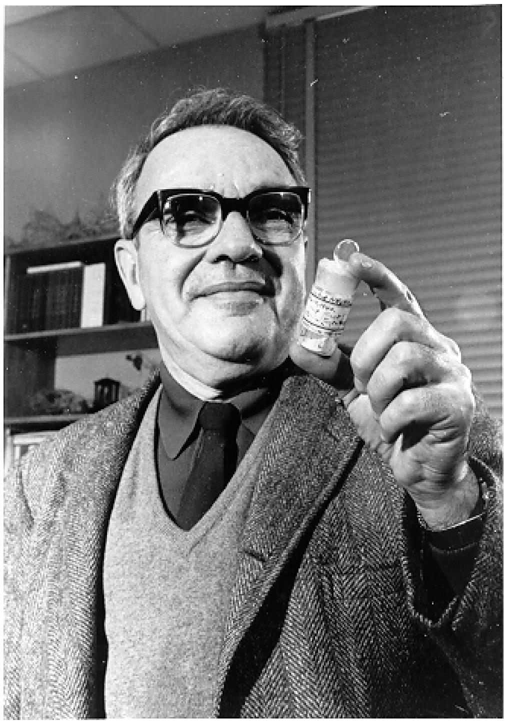

Figure 1. Martin D. Kamen observing the weighing bottle containing the original sample of carbon-14 ($Ba^{14}CO_3$), on the 40th anniversary of its discovery, 1980. Courtesy, Martin D. Kamen.

to an innocuous, convivial two-hour dinner with him and his successor at Bernstein's Fish Grotto, a popular San Francisco seafood restaurant, where they were observed by U.S. military intelligence agents.

For years Kamen continued his frustrating efforts to clear his name and at the same time to continue his scientific studies under conditions that would have daunted a less determined individual. Finally, in 1955, he won a libel suit against archconservative Colonel Robert R. McCormick's Chicago *Tribune* and a similar suit against the *Washington Times-Herald* in what was described as "a victory unprecedented in the annals of journalism." Kamen received many offers to lecture at foreign universities, but in 1948 the State Department withdrew his passport, which was not reissued until 1955, after his lawsuit against Secretary of State John Foster Dulles had succeeded.

Kamen's Later Years

In 1957 Kamen began to help establish the graduate department of biochemistry at Brandeis University in Waltham, Massachusetts, and in 1961 he helped create the University of California, San Diego campus at La Jolla, where he served as Professor of Biochemistry (1961–1974). He then became Professor of Chemistry at the University of Southern California (1975–1978). He continued to teach into his eighties, being one of six faculty members of the Oregon Institute of Science and Medicine, Cave Junction, Oregon. A scholar of wide and eclectic interests, he was concerned with historical and philosophical problems [14]. He donated his collected papers and articles to the Mandeville Special Collections Library of the Geisel Library, University of California, San Diego.

Kamen was a member of the National Academy of Sciences, the American Academy of Arts and Sciences, and the American Philosophical Society. His numerous awards include the American Chemical Society's Award for Applications of Nuclear Chemistry (1963), the American Society of Plant Physiologists' Charles F. Kettering Research Award (1968), the John Scott Medal of the City of Philadelphia (1988), the U.S. Department of Energy's Enrico Fermi Award (1996), and two honorary doctorates (University of Chicago and the Sorbonne, both 1969). He was a member of Israel's Weizmann Institute of Science Board of Governors.

Kamen's Legacy

The cautionary tale of Martin Kamen's rise from humble beginnings to international scientific prominence and his triumph over adversity is a tribute to the human spirit. It recalls a shameful period in American history when political expediency aroused the anti-intellectualism latent in society and a hysterical tide of anti-Communism swept the nation. For those too young to have experienced the McCarthy era and the early days of the Cold War, it will engender disbelief that such character assassinations of scientists on the basis of outright lies or the flimsiest of evidence could have been tolerated in a democracy. For those of us who lived through those times, it will remind us that such undeserved harassments could occur again.

In this post-September 11 era in which the present administration has used the unprecedented terrorist attacks on the World Trade Center and the Pentagon as a pretext for the increasing restriction of our civil liberties, Martin Kamen's warning is most timely:

> The HUAC [House Un-American Activities Committee] is a recurrent phenomenon of American history. Experiences like mine will doubtless happen over and over again. And there's always a tendency toward erosion of civil liberties when we're not watching the bureaucrats who will invade our rights whenever they can, to aggrandize themselves. That's why the founding fathers set up three independent branches of government—executive, legislative, and judicial—and a system of checks and balances so that a citizen always has some place to go to have a wrong rectified. The history of the United States has shown that one of the three branches is dominant at any given time and tries to lord it over the others. This system of checks and balances has worked pretty well in maintaining individual liberties, but you have to be on guard and watch the bureaucrats all the time [4].

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