In Memoriam

Martin D. Kamen, Whose Discovery of ^{14}C Changed Plant Biology as Well as Archaeology

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On August 27, 2018, Martin Kamen would have been 105 years old; we celebrate his life and work here. Many of us remember him fondly as a brilliant, engaging, friendly, cheerful person, one with a wide range of talents, and one who always had a spark of originality. His talents as a musician (top viola player and child prodigy in music), a writer (par excellence), and a topmost scientist are known to many of us. We think he should have received the Nobel Prize for his discovery of long-lived carbon-14, first described in 1940 (Ruben and Kamen, 1940). Use of ^{14}C has led not only to the discovery of the path of carbon fixation in photosynthesis (the Calvin–Benson cycle, 1961 Nobel Prize to Melvin Calvin; see Benson, 2002), but also to a revolution in archaeology in dating materials of ancient times (1960 Nobel Prize to Willard Libby), including the Shroud of Turin. See Figure 1 for a portrait of Martin Kamen.

Figure 1. Portrait of Martin Kamen. (Kamen, 1989; photo provided by Martin Kamen to Govindjee)

Menachem Nathan Kamenetsky (Martin David Kamen) was born August 27, 1913, to Aaron (later Harry) and Goldie (Achber) Kamenetsky (later Kamen) in Toronto, Ontario, where Martin's mother had gone from Chicago to visit relatives. Martin grew up in Chicago. As a child, he was a voracious reader and read, at the age of 8, Tolstoy's *War and Peace*. He attended Hyde Park High School, graduating in 1930.

In his youth, he was interested primarily in music. He entered the University of Chicago to study English but switched quickly to chemistry, obtaining a BS (cum laude) in 1933 with a focus on physical chemistry. He then did graduate work in nuclear chemistry at the same university, receiving his doctorate in 1936 under William Draper Harkins. (The exciting drama involved in his PhD Prelims is best described in Kamen, 1985.)

In 1937, he went to work with Ernest O. Lawrence for postdoctoral research at the Radiation Laboratory, University of California, Berkeley (UC Berkeley). It was there that his fascination with photosynthesis began, and he, with the help of others, used carbon-11 (half-life of 21 minutes; see Ruben et al., 1939) for his research. Although the cyclotron could make a lot of that isotope, it was a frustrating experience because ^{11}C disappeared so quickly. This gave Martin an incentive to work almost day and night to make long-lived ^{14}C. Together with Sam Ruben, he achieved this in 1940. (And, yes, on the day they made ^{14}C, Kamen was returning home in the early hours wearing a dirty lab coat and with messy hair and was mistaken for a murderer. He had to spend the night in jail and was released the next morning when UC Berkeley vouched for him.)

The lifetime of ^{14}C was calculated to be ~5,000 years (it is 5,730 years; see also Iowa State University, 2011). During 1940–1943, there was great excitement as Kamen was making huge quantities of ^{14}C for use in biology and chemistry (working for the Manhattan Project). During this period, a very important experiment using oxygen-18 water proved that the oxygen evolved in photosynthesis came from water, not CO_2 (Ruben et al., 1941). This discovery challenged the earlier views of Nobel laureates Richard Wilstätter and Otto Warburg, who had said that O_2 came from CO_2, not H_2O.

The years that followed were a sad period for Martin, perhaps caused by his passion for music. He was part of a circle of highly talented musicians in the Bay Area,

which led him to meet a member of the Soviet Consulate to talk about music (and about a possible cure for leukemia) at a dinner given by the violinist Isaac Stern. Yes, the Soviets were our allies, but not for nuclear weapons. It seems that the exchange of music notes between the two was mistaken by FBI agents sitting close by as the passing of atomic secrets. Kamen was immediately fired from the Lawrence Lab at UC Berkeley, with no notice or chance of appeal or hearing. He could not get any academic job and finally ended up working as an inspector in a San Francisco shipyard. Indeed, it was a shock—a violent one—for one whose discovery deserved, in our opinion, the Nobel Prize.

One thought is that Martin, being a brilliant thinker, had earlier interpreted some results of a colleague at Oak Ridge as if his sample had been exposed to a radiation source. Existence of such a facility at Oak Ridge was then a secret, and the colleague was investigated for leaking information. It is considered highly likely that the FBI was already watching him.

Martin was rescued, only after World War II ended, when the physicist Arthur Holly Compton (Nobel laureate, 1927), then chancellor of Washington University in St. Louis, hired Martin for a tenured professorship in the medical school and supported him in many ways. Martin was charged with overseeing the university cyclotron. During this period, Martin visited Robert (Bob) Emerson (1903–1959) at the University of Illinois at Urbana–Champaign, where he also met Robert (Robin) Hill, who was visiting Emerson's laboratory. Martin came to learn from Bob Emerson how to do specific measurements in photosynthesis (see Figure 2).

Figure 2. Martin Kamen (extreme right), next to Robert (Bob) Emerson, A. Stanley Holt (discoverer of chlorophyll d structure), and Robert (Robin) Hill (discoverer of the Hill reaction and cytochrome f), visiting Emerson's lab. (Photo taken in 1952; from Kamen, 1985, facing p. 213)

Martin's later research dealt with mechanisms of photosynthesis in bacteria and with bacterial cytochromes. He made an important discovery in 1949 with Howard Gest, who studied photoproduction of hydrogen (Gest and Kamen, 1949) and the ability of a photosynthetic bacterium to fix nitrogen (Kamen and Gest, 1949). These findings led to a new way of looking at the physiological capabilities of anoxygenic photosynthetic bacteria (see Gest et al., 1950; Ludden and Roberts, 2002). In addition, the work on the discovery of a cytochrome with Leo Vernon (Vernon and Kamen, 1954) was very important for understanding the mechanism of bacterial photosynthesis. Figures 3 and 4 show Martin in his lab at Washington University in St. Louis.

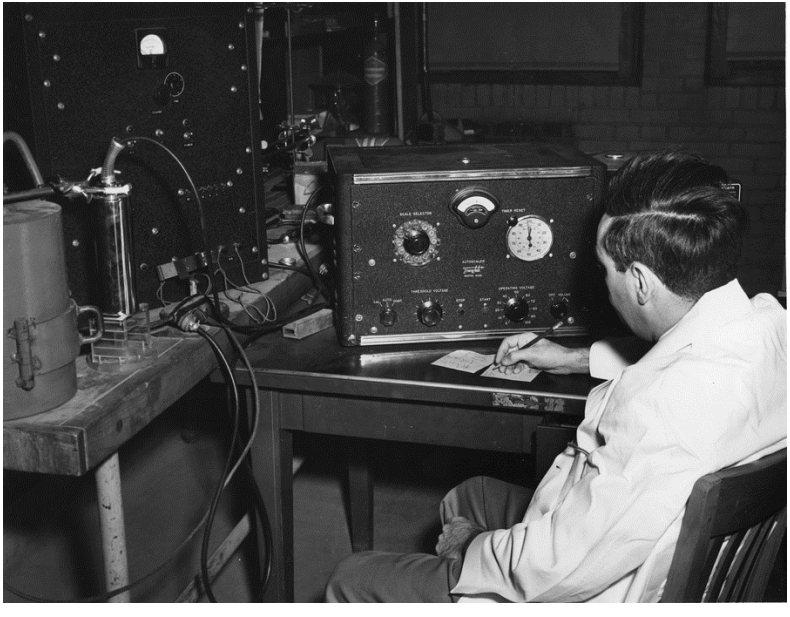

Figure 3. Martin Kamen (then associate professor of chemistry at Washington University and chemist at the Mallinckrodt Institute) sitting in front of an instrument to record radioactivity from various materials. At the extreme left is a lead-shielded container (~600 lb) in which radioisotopes were delivered from Oak Ridge, Tennessee. Also seen are various types of Geiger counters to record the presence of radioactive materials. (Photo taken in 1950; courtesy of Washington University Photographic Services Collection, Washington University Libraries, Department of Special Collections)

Figure 4. Left to right: Herta Bregoff (graduate student), Martin Kamen, and Stanley Hanson (from Durham University, U.K.), Metabolism Laboratory, Mallinckrodt Institute of Radiology, Washington University Medical Center. (Photo taken in 1950; courtesy of Washington University Photographic Services Collection, Washington University Libraries, Department of Special Collections)

The worst happened to Martin in the early 1950s: his passport was canceled, and the *Chicago Tribune* declared, in front-page news, "Kamen, a Traitor." Martin suffered mentally, morally, and monetarily. As far as we know, the events were as follows. He had been invited to a symposium on isotopes in Paris and another symposium in Israel. While a travel agency was preparing his air tickets, U.S. federal agents, acting on orders from the State Department, canceled his passport. It was the beginning of the McCarthy Era. The support of President Compton of Washington University in St. Louis was unwavering and strong. In addition to the front-page title, the *Chicago Tribune* published, with pictures, unsubstantiated stories on Martin about his passing secret documents to Soviet agents. With time, many individuals and organizations (including the American

Civil Liberties Union and the Federation of American Scientists) came forward in his defense and support.

After seven years, the courts ruled in favor of Martin Kamen. It was a day of rejoicing when he had a new passport. Soon thereafter he served exceptionally well at two more universities, Brandeis University (1957–1961) and the University of California, San Diego (1961–1978). During this period, he also served as director of a laboratory in Gif-sur-Yvette, France (1967–1970), and taught at the University of Southern California (1974–1978). One of us (Govindjee) became closely associated with him in Gif-sur-Yvette, which resulted in the publication of a paper on the fluorescence characteristics of photosynthetic bacteria of different ages (deKlerk et al., 1969), not to mention visits to the best fish restaurants in Paris.

For a concise and complete picture of photosynthesis, à la Kamen, see Martin's elegant book *Primary Processes in Photosynthesis* (Kamen, 1963b), in which he used the pts scale for the negative log time (in seconds) of photosynthesis from a femtosecond (pts = 15) to a second (pts = 1). To get a complete and authentic picture of Martin Kamen, his life, and his achievements in chemistry, physics, biology, biochemistry, and medicine, we recommend Kamen's own descriptions of his life and work (Kamen, 1963a, 1985, 1986, 1989).

Kamen received many honorary degrees, including those from the University of Chicago, Washington University, University of Illinois, Brandeis University, University of Freiburg (Germany), and Weizmann Institute of Science (Israel). His awards include the ASPP Charles F. Kettering Award for excellence in photosynthesis (1968), the Merck Award of the American Society of Biological Chemists (1982), the Albert Einstein World Award of Science (1989), and the Enrico Fermi Award (1996). He was a member of the National Academy of Sciences, as well as the American Academy of Arts and Sciences and the American Philosophical Society.

Several articles have been written on Martin's work and life, including a Wikipedia article (https://en.wikipedia.org/wiki/Martin_Kamen); see also, for example, Arnold (2003), Doolittle (2004), and Kaufmann (2000, 2002). An outstanding review of a book published in Martin's honor was written by Sable (1983). See Figure 5 for a photograph of Martin Kamen taken in 2000 by his first graduate student, Howard Gest.

Figure 5. Photograph of Martin Kamen, taken by Howard Gest. (Photo taken in 2000; provided by Howard Gest to Govindjee)

We end this brief memorial to Martin Kamen with a quote from Leo Vernon (1985): "This is the Martin Kamen I know: kind, gentle, enthusiastic about life, creative, perceptive, and talkative. He has broad knowledge of atomic physics, music, biochemistry, politics, and baseball. He even knows who played first base for the Yankees after Lou Gehrig."

Acknowledgments

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