Martin D. Kamen: An Interview with a Nuclear and Biochemical Pioneer

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Abstract: Martin D. Kamen (born in Chicago on August 27, 1913), codiscoverer of carbon-14 and a Nobel Prize-caliber nuclear scientist and biochemist whose life is replete with triumph and tragedy, discusses his life, career, and views of science, education, and politics in this wide-ranging interview, which is prefaced with and followed by a brief summary of his life, including his education, work on the Manhattan Project, his unexplained dismissal from this classified war work, his ultimate vindication from unjustified accusations of disloyalty, and his "second career" in biochemistry.

Born on August 27, 1913, as the only son of the Russian–Jewish immigrants Harry and Goldie (née Achber) Kamenetsky in Toronto, Canada, where his mother was visiting relatives, Menachem (Martin) David Kamen was an early pioneer in nuclear science best known as the codiscoverer of carbon-14, the long-lived radioisotope that not only revolutionized tracer methodology and still plays an essential role in the elucidation of biological mechanisms [1–4] but also added a new weapon to the arsenal of archaeological dating [5, 6], the most celebrated instance of which among the general public was the dating of the Shroud of Turin [7]. A precocious student and child prodigy on the violin (He was often greeted with the question, "How's young Heifetz today?" which contributed to his fear of being in the limelight [2]), he grew up in Chicago and matriculated as an English major at the University of Chicago in 1930, but soon switched his major to chemistry. In 1933 and 1936 he earned his bachelor's (*cum laude*) and doctor's degrees, respectively, the latter for research on nuclear chemistry under the supervision of William Draper Harkins [8].

In 1937 Kamen used his meager savings to travel to Ernest O. Lawrence's [9] Radiation Laboratory at the University of California, Berkeley, where he worked without salary for several months before he obtained a staff position as a minority chemist among a majority of physicists. In addition to working on the preparation of radioisotopes, he carried out numerous studies of photosynthesis with Samuel Ruben, with whom, on February 27, 1940, he discovered carbon-14 [10]. Because of Ruben's concern with departmental politics and obtaining tenure, Kamen allowed his friend to list his name first on the article [11], and thus Kamen's contribution to one of the major discoveries in nuclear science was minimized. Although Willard F. Libby received the 1960 Nobel Prize in chemistry "for developing radio carbon dating techniques," unfortunately, Kamen, the actual discoverer of carbon-14, was never recognized in this manner (Ruben's accidental death in 1943 precluded a joint award).

Kamen continued to work as a group leader on the Manhattan Project at Berkeley on the separation of uranium isotopes for the atomic bomb until July, 1944, when he was abruptly dismissed without explanation and ordered to leave the project immediately. After a temporary position as a test inspector at the Kaiser shipyards in Richmond, California, in the Spring of 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 radioactive isotopes in biological and biomedical research.

In 1947 headlines inspired by handouts and leaks from the House Un-American Activities Committee appeared in newspapers throughout the United States claiming that certain Manhattan Project scientists, including Kamen, had been part of espionage rings working for the Soviet Union. While in the throes of depression, Kamen made an abortive attempt at suicide, after which he resolved not to abandon his fight until he was vindicated. Finally, in 1955, in "a victory unprecedented in the annals of journalism," Kamen won a libel suit against archconservative Colonel Robert R. McCormick's *Chicago Tribune* and a similar suit against the *Washington Times-Herald.* Although he received numerous invitations to lecture at foreign institutions, his passport was withdrawn by the State Department in 1948 and was not reissued until 1955, following his successful lawsuit against Secretary of State John Foster Dulles.

Beginning in 1957, Kamen helped Nathan Kaplan found the graduate department of biochemistry at Brandeis University. Beginning in 1961, he helped Roger Revelle and a handful of colleagues to create the new University of California, San Diego campus at La Jolla, where he was Professor of Biochemistry from 1961 to 1974. He was also Professor of Chemistry at the University of Southern California from 1975 to 1978. A member of the National Academy of Sciences, the American Academy of Arts and Sciences, and the American Philosophical Society, he is the recipient of numerous awards and honors, including the American Chemical Society's Award for Applications of Nuclear Chemistry (1963), the Charles F. Kettering Research Award of the American Society of Plant Physiologists (1968), the Merck Award of the American Society of Biological Chemists, the Einstein Award of the World Cultural Council, the John Scott Award of the City of Philadelphia (1989), the Enrico Fermi Award (1996), and honorary doctorates from the University of Chicago and the Sorbonne (both 1969). As David M. Kiefer has pointed out [3], in view of Kamen's problems with the government, his receipt of the Fermi award, administered by the U. S. Department of Energy, "the successor to the federal agency

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Figure 1. Martin D. Kamen (photograph by Martin Schweig Studios, St. Louis, Missouri, Reproduced by permission).

responsible for the atom bomb, is, to say the least, ironic." He sums up his resigned response to the tragedy in his life with the humorous Viennese adage that he is fond of quoting, "Things are hopeless but not serious" [2]. Now retired from teaching, Kamen currently resides in Montecito, California.

Kauffman: Martin, we've been corresponding for years on one topic or another—first, about my work on your late mentor William Draper Harkins [8]; second, about my review of your autobiography [12]; and third, about the Borodin biography, which you critically read and for which you so kindly wrote the introduction [13]. It's really a great pleasure for my wife Laurie and me to meet you at last and for me to interview you for *The Chemical Educator*. I'm sure that our readers will look forward to learning what you have to say about a multitude of scientific and educational topics.

Since you've already reviewed the first four decades of your exciting and multifaceted life in *Radiant Science*, *Dark Politics* [12], I suppose we can omit the usual biographical data and plunge *in medias res*. Why did you choose chemistry as a career?

Kamen: I entered chemistry because of the Depression. I needed to find some way I could make a living.

Kauffman: But you had been a violin *Wunderkind,* and everyone expected you to become a musician. Why didn't you pursue music as a career?

Kamen: Because there weren't any openings for musicians in Chicago during the Depression. Since there were no jobs, there was nothing to do but stay in school.

Kauffman: Didn't you enter the University of Chicago as an English major?

Kamen: Yes. I was looking for something, but I didn't know exactly what. I had a very strong grounding in the classics so I thought I'd take up English. Science was the last thing on my mind. In fact, I designed my academic program to get rid of the science requirements as fast as possible and to get on with the business of learning some languages and eventually becoming a teacher—in the classics and in English.

Kauffman: So during the Depression at least you could teach even though you wouldn't make any big money.

Kamen: Right. It was a way to make a living—and I could probably still play music on the side.

Kauffman: Why chemistry rather than another science?

Kamen: Well, in a magazine my father saw an advertisement for International Correspondence Schools that promised "Be a chemist and make millions." He said, "Why don't you become a chemist?" So I said, "Okay, I'll try chemistry."

Kauffman: It seems that, beginning with Abraham and Sarah, Jewish parents have encouraged their kids to get an education. Did your being the only son in a Jewish immigrant family have an effect on your educational plans?

Kamen: Yes, there were great expectations. I was expected to be a professional of some sort—a doctor or something that would be highly respectable—something in a learned profession. When I showed that I was a very good scholar (I was always first in the class.), I was even considered possible rabbinical material, a scholar in some religious sense.

Kauffman: Why would a Jewish family feel that way?

Kamen: I think 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.

Kauffman: Was this the same in the old country?

Kamen: Yes, they transferred their traditions to America

Kauffman: Were their aspirations intellectual or artistic?

Kamen: Both, but the question was always "Can you make a living at it?"

Kauffman: Were there any professors who were especially influential in your education?

Kamen: Once I got into chemistry, I was mostly influenced by Arthur C. Lunn, a mathematician and musician who never got the credit he deserved. Sam Weissman and I attended his lectures, which were enthralling and in which he integrated everything into one gorgeous whole. Lunn invented quantum mechanics five years before anyone else. In the early 1920s his paper describing this was rejected by the editor of the *Physical Review*, and Lunn became discouraged, retired into his shell, and never published again. He had a complete theory of isomerism in which he generalized everything in one paper. It was incomprehensible to chemists because he took all the chemistry out of it; he just dealt with numbers, permutations, and combinations. Lunn was the only one who had intellectual contact with me at the University of Chicago.

Kauffman: What about Professor Harkins, your thesis advisor?

Figure 2. Kamen's relatives and friends on Chicago's South Side, 1921, photograph taken by his father, a professional photographer. His mother is standing (center), his father is seated to her right. Seated to his father's right and left are 9-year-old Martin (squinting in dread of the photo flash) and his 2-year-old sister Lillian, respectively.

Kamen: I never saw Harkins during my research or learned anything from him. I learned from books on my own. After I wrote the article [14] that served as my dissertation, Harkins added his name as senior author. I chose Harkins because I wanted to work with David M. Gans, who was Harkins' boy Friday and who was exploited by him. I really liked and admired Dave. He was very conscientious, a good lecturer, and his lectures were of great interest to his students. Simon Freed also had a great influence on me. I also chose Harkins because he was a senior professor, and, as his student, I would have a better chance of getting a job.

Kauffman: Did you prefer experiment over theory at that time?

Kamen: I prefer experiment to theory in general, but I didn't like organic chemistry at all.

Kauffman: Despite the fact that one of your hobbies is cooking?

Kamen: Yes, I'm a gourmet cook; so was [Gioacchino] Rossini.

Kauffman: What's your specialty?

Kamen: I mostly work on salads and pasta. Meats take too much time.

Kauffman: My wife is amused when I use a graduate to measure the ingredients when I mix drinks [15]. Are you a "scientific" cook?

Kamen: Not at all. I never measure anything.

Kauffman: Back to your education, what were your major interests?

Kamen: I was generally interested in mathematics, especially anything with a mathematical background.

Kauffman: Okay, why didn't you go into mathematics?

Kamen: Because I couldn't make a living in mathematics. I was fascinated by chemistry, but I was interested in mathematics too.

Kauffman: Was there any particular experience that hooked you on chemistry—like Ira Remsen and his boyhood experiment of dissolving copper in nitric acid [16]?

Kamen: No, it was just the more mathematical aspects of chemistry—measuring critical constants and solubilities and working with Henry's and Raoult's laws—things like that.

Kauffman: Why did you decide to go to the University of Chicago?

Kamen: It had a good reputation, and I could live and eat at home—money problems again.

Kauffman: And how did you happen to wind up in Berkeley?

Kamen: Mostly because I was chasing a girlfriend, Virginia A. Actually, I was interested in learning about the cyclotron and since Virginia had gone to Berkeley, I thought I'd go out there. So I spent the winter [of 1936–37] earning money as a photographer until I had enough to get on a train and go west. I had sixty bucks in my pocket, which kept me going for six months. Of course, when I got to Berkeley, it turned out that Virginia had found another boyfriend. In addition, I had a sore throat, and that's when I went over to Lawrence's lab and found they were just getting together to find out about deuteron activation in various elements. I got bismuth and thallium, which was all that was left since everybody had taken everything else.

Kauffman: Of your various contributions to chemistry, which do you think has had the greatest impact?

Kamen: Carbon-14 has undoubtedly had the biggest impact, but 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 affecting 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. 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.

Kauffman: What exactly is a cytochrome?

Kamen: It's 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.

Kauffman: To return to your times at the Berkeley Radiation Lab, can you tell us about the state of the art in nuclear science at that time?

Kamen: Most of the radioactivity then was confined to the naturally radioactive radium, thorium, and uranium series. There were few radioactive isotopes of the lighter elements from hydrogen to lead, although some were beginning to be made by neutron activation. Deuterons and neutrons from the cyclotron created a quantum leap by a factor of thousands.

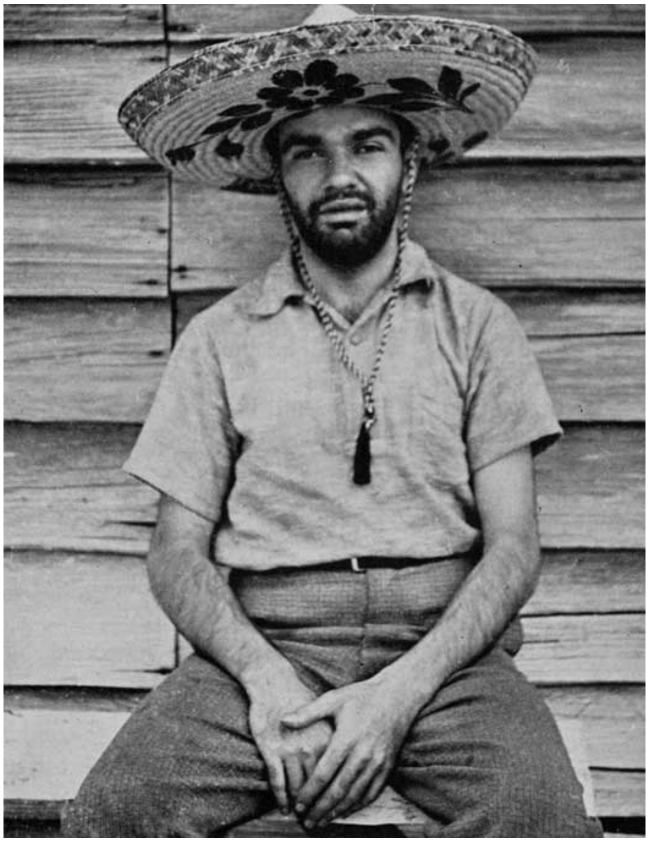

Figure 3. Kamen with beard and sombrero, showing the effects of a week in the wilds, summer, 1938. (Photograph by his friend and colleague Don Cooksey, a scientist in Lawrence's group.). The picture was passed around at a party on July 31, 1940 in Di Biasi's restaurant in Albany, California to commemorate the discovery of carbon-14 and other notable scientific events of 1940–1941, where it was signed by co-workers and wives, including Nobel laureates, Lawrence, Luis Alvarez, and Edwin M. McMillan.

During the decade of very rapid development, from 1935 to 1945, almost the whole isotope table was constructed.

At the time that I began, the state of the art was essentially zero. The techniques were all based on the use of weakly radioactive sources. The Geiger counter was considered a work of art; very few people knew how to make one that would work. The electroscope was then the instrument of choice, but soon tremendous developments were made in counting circuits. The same thing happened in medicine, and the development of complicated electronics and the CAT scan began. A decade counter didn't exist until about 1939; there was no 1 to 10, 10 to 100, etc., just digital counters with 1, 2, 4, 8, etc.

Developments then came in a flood—just as we needed more sensitive apparatus. In spectrometers, for instance, only a very few persons—you could count them on the fingers of your hands—could run a mass spectrometer back in 1935–36. In fact, for quite a while this was the bottleneck in using stable isotopes in biological research and why Lawrence assigned Sam Ruben and me the job of finding carbon-14 or any long-lived activity in that part of the periodic table. It was much easier to use a Geiger counter than a mass spec. That's why radioactive carbon-14, which we were using, was so much better than stable carbon-13, which Harold Urey and his co-workers were using at Columbia. Now you can buy spectrometers, and they're used by the thousands. Of course, before 1940, carbon-14 was unknown, yet in a remarkably short time it became as common as table salt, thanks to the nuclear reactor.

Kauffman: You've discussed the discovery and early history of carbon-14 [1], but what can you tell us about the tragic death of Sam Ruben, the codiscoverer of this radioisotope?

Kamen: Sam was a young kid badly driven in a department where everyone wanted to get tenure. He was competing with a whole bunch of other guys so he had this mania; he drove himself day and night, and he finally got killed because he was in a hurry and didn't take adequate precautions. He was assigned a very dull research problem—the persistence of phosgene on beaches, how long it took to dissipate. In October of 1943, anxious to finish the project, he had not slept for several days, and while driving home from the Marin beaches, he fell asleep at the wheel, his car went off the road, and he broke his right hand. Instead of getting some rest during the weekend, he returned to the lab early Monday morning and tried to transfer some phosgene to his vacuum line. Rather than delegate this operation to one of his subordinates, he awkwardly worked with his left hand, cracked a vial of phosgene, and was dead the next day. It was a tragic case. He left behind a wife and three kids.

Kauffman: Considering your escapades with radioisotopes, I expected you to glow in the dark What safety precautions were taken back in those early days?

Kamen: There wasn't much concern about safety then. Safety lags behind everything else because everybody's too busy to worry about it. Health physics was a science that didn't exist then, yet within a decade it became a big industry, and they were even granting degrees in it. Determining a safe dose, which was qualitative up to that time, became quantitative. There were very little data on beta- and gamma-rays, although there was considerable experience about alpha-rays, obtained, for instance, from the workers painting luminous watch dials. It was known that heavy metals seek out bone marrow. We already knew that radio-lead went to the bone and radio-iodine to the thyroid. The fact that suddenly a whole spectrum of radioisotopes, each with its own chemistry, for example, calcium, strontium, sodium, and whatnot, meant that we had to know where in the body they concentrated and how they were distributed. So there was a whole new blossoming of work on the clinical aspects of the use of radioisotopes, and clinical uses for them began to develop. Since then, there have been all kinds of developments to carry through enrichments and selective deposition in radiation therapy.

Almost all nuclear medicine developed during the last thirty-five years. Now it's a big business—a medical specialty like surgery or obstetrics—and entire faculties of medical schools are devoted to it. Yet, it didn't exist when we started in 1945.

Kauffman: What was the most dangerous or stupid thing that you did in the lab? Did you see any of the effects of this radiation?

Kamen: I remember making radioactive sodium for a hospital. At that time we didn't have an external target so we had to bombard the sodium inside the cyclotron where there wasn't any cooling. So we had to deposit the sodium in a "cold finger" while pouring on liquid air. A million volts and a few microamperes in the beam created heat like an oxyacetylene

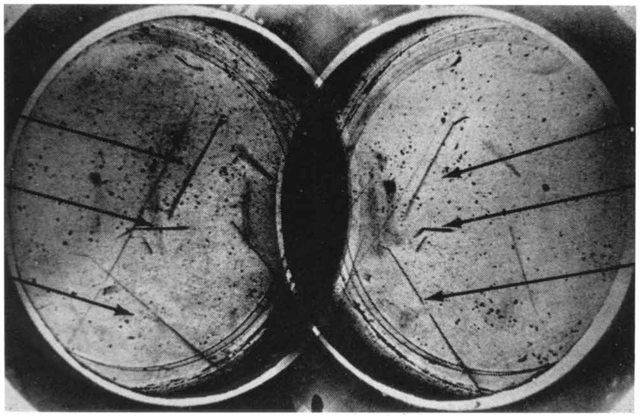

Figure 4. Two views, taken from different angles to give a stereoscopic projection to show production of carbon-14 visualized in a cloud chamber, only extant photographs, taken by Kamen and physicist Franz N. D. Kurie.

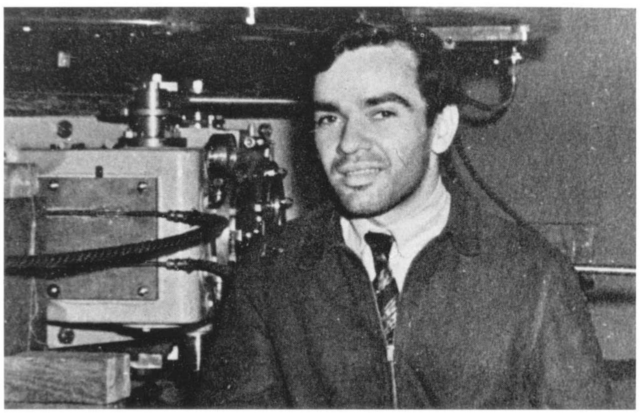

Figure 5. Kamen at probe port and target chamber of 60-inch cyclotron at Donner laboratory, early 1941. His 3-day growth of beard was typical of his many hours without sleep. (Photograph by Don Cooksey.)

torch. All the neutrons from the deuteron reaction of sodium were coming out and bombarding us—my colleague, the physicist, Jack Livingood, and I took turns at the cyclotron. We each got about a hundred daily doses of neutrons in ten minutes.

As a matter of fact, there were far fewer accidents than you might imagine. I must have been the most irradiated guy in the world, and I certainly was the most active at one time. I was the Radiation Lab chemist, and I did try to avoid excessive doses. You know we constructed all kinds of remote control apparatus, but I found it was handier to work quickly than to work with the handicap of awkward remote control. You either minimize the time or the exposure. It's the product of the two that's important so it was easier for us just to work fast. Sometimes there would be accidents, and the stuff would fall on the floor. Then you'd take a jackhammer, rip out the concrete, and haul it away. These problems haven't really been solved yet. They're still with us. The disposal of radioactive waste is a real concern in nuclear energy.

Kauffman: What do you think is the future for nuclear power?

Kamen: I don't know because I haven't studied the economics of it. But, if the problem of waste disposal can be handled, it's the most efficient way of getting energy. I mean fusion, not fission.

Kauffman: How do you feel about nuclear fission?

Kamen: If you're in the Sahara and have no other way of getting energy, it's not a bad way to do it. But it has to be carefully engineered and handled by experts. I know of no nuclear power plant engineered so that there can't be accidents, and it's not like handling a coal-fired or steam-powered factory. Here, if a valve leaks or something goes wrong, as it's bound to do, it's no big deal, but if a valve leaks in a nuclear plant, you get Chernobyl—you get radiation that lasts for thousands of years, and the long-term effects of radioactivity are unknown. So I'd prefer not to see nuclear fission used at all unless it's used with special care and the persons using it are not just ordinary technicians but persons trained to know what they're doing.

Kauffman: So Chernobyl could happen here?

Kamen: Yes, it's going to happen again. Of course, the effects aren't understood until the accidents happen. Nothing terrible has happened here yet, but the Chernobyl disaster practically ruined the sheep industry in Western Britain and Scotland. That sort of thing is going to happen if you've got a lot of radioactivity around. I don't know anyone who's devised a factory with valves and seals that don't leak. In a nuclear plant valves and seals must be 100% leak-proof, not 99.999%.

I would say the future of these plants is not only economically unfeasible but also not ready from an engineering standpoint. But we have lots of them going right now. The operators are taking a calculated risk, but nothing can be done about it. However, the opposition is also not well informed. We should make a very thorough examination of all alternative sources of energy before using nuclear fission. And then, it should be used only as a last resort and only in a small capacity.

Kauffman: What about nuclear fusion?

Kamen: It will be fantastic. It uses a source with an infinite supply—water. But it won't be ready for quite some time.

Kauffman: In these days where narrow specialization is the rule, how did you manage to make the transition "from cyclotrons to cytochromes"—the title of the *Festschrift* honoring your retirement on your 65th birthday [17].

Kamen: 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 thirty 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 three 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:

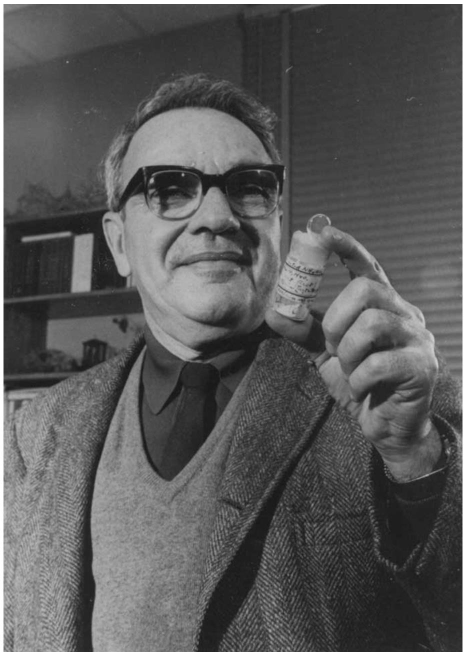

Figure 6. Kamen observing weighing bottle containing the original sample of carbon-14 ($Ba^{14}CO_3$), on the 40th anniversary of its discovery, 1980 (courtesy, Martin D. Kamen).

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Kauffman: In entering this new field was your previous training of any use?

Kamen: No, I went into it with absolutely no training that was of any help. I got all my training on the job.

Kauffman: Was funding for equipment, supplies, and assistance ever a problem for you?

Kamen: No, in the radioisotope work Lawrence provided everything, and the cytochrome work didn't require elaborate equipment. I also had grants so there were no problems with funding.

Kauffman: Were there any barriers to progress in your research?

Kamen: No barriers at all. I just had to change my own thinking and ideas.

Kauffman: What new tools are available that have been useful in your research?

Kamen: There's been a tremendous increase in all kinds of spectroscopy—NMR, EPR, etc.—during the last 20 to 25 years and every day there are new variations on these methods. The invention of new techniques is going on at a great rate that guarantees that progress will continue.

Kauffman: What do you look for in a young person who wants to work with you?

Kamen: I look for somebody who wants to work and who doesn't sit around; I like people who are self-starters, who are curious, and who aren't particularly impressed with what's been done before.

Kauffman: Would you place these qualities above intellect?

Kamen: I'd place them alongside intellect. If you have an intellectual who's lazy, nothing happens. It's nice to have all these qualities, but very often a desire to work overcomes an intellectual handicap.

Kauffman: Over the years have you noticed any changes in the number of students wanting to do research?

Kamen: Well, the standard complaint now is that we're not getting enough interest in the sciences, that there's a falloff in the supply of potential researchers. There's no longer the incentive to go into science that there once was—either because science is viewed as bad and creates pollution and whatnot or because students see better possibilities for making money in other ways.

Kauffman: Do you feel that students are as good as they used to be?

Kamen: Yes, I think so, but they're probably not as well trained.

Kauffman: How about freshmen? I've found a marked deterioration in incentive in the last decade particularly. Most students expect everything handed to them on a silver platter.

Kamen: That's probably true of freshmen, but as you go up the line, the quality improves. Our graduate students were all good. In every generation a few percent want to work, while most students goof off, so the situation hasn't changed much.

Kauffman: Do you have any strong feelings about our current educational process?

Kamen: I think that education at the elementary and secondary levels are equally bad; there isn't enough incentive to have good teachers at those levels. Kids get turned off, and we're losing a lot of talent that would be available if we had more inspirational teachers. We make up for it at the college and graduate school levels. Kids arrive in college who can't read or write English, and in graduate school they still haven't corrected this deficiency, and that's a big handicap. Somehow, we get them over that in graduate education; a lot of remedial work is involved, and it's a tremendous waste of time. If teachers aren't educated, students aren't educated. It's a vicious cycle. We have people teaching who are primarily interested in getting teaching certificates, which require a certain number of courses in education. In other words, they're learning how to teach, not what to teach. I think it's more important to learn what to teach than how to teach, and I think that's where we're having trouble right now.

Kauffman: Do you think that raising salaries will help?

Kamen: No, I think you've got to get rid of the schools of education because that's where the trouble is, where the course requirements are made.

Kauffman: In recent years has support of your work by funding agencies been a problem?

Kamen: It began to be a problem just before I retired. The trouble was that the university had produced a tremendous number of researchers, but the research budget hadn't gone up so it was becoming harder and harder to get funds from a limited source, which was the federal government. A lot of good research, but also a lot of bad research, is getting done because the government spends lots of money on medical research. It's emotional. With NIH, funding is readily available only for research on cancer and similar dreaded diseases. There's also a repression of creativity because of paperwork and bureaucracy.

Kauffman: Do you perceive any dichotomy between teaching and research?

Kamen: No. In graduate work research is teaching and vice-versa. In undergraduate courses I think there's a dichotomy because a professor doing research can't be expected to spend much time being a teacher too. Teaching large classes at the

Figure 7. Kamen (right) and Charles D. Coryell (left), codiscoverer of promethium (element 61), at conference on isotopes and their applications, university of Wisconsin, Madison, late 1940s (photographer unknown).

elementary level takes a special person, who may not be a good researcher. It's incorrect to assume that because a person's a good researcher he's a good teacher and vice-versa. Sometimes he's both, sometimes he's neither.

Kauffman: Have you personally encountered any conflict between your own research and teaching activities?

Kamen: It sometimes happens. There might be an emergency in teaching when I couldn't spend much time in the lab or vice-versa. This problem doesn't arise in Europe where they make a distinction between teaching and research. There, the research faculty is not the same as the teaching faculty. Germany, for example, has its Max Planck Institutes. Here we put research and teaching activities under one roof. I feel strongly that the objectives of a research organization and a teaching organization are quite different, but there should be some contact between them. It's important for a researcher to lecture to undergraduates so they can see what research is like.

Kauffman: Martin, you've been a department chairman as well as a dean. What changes in the administration of chemistry departments do you think would improve faculty productivity and improve the quality of education?

Kamen: There should be some way of lessening the bureaucratic load. Faculty shouldn't be involved in any kind of paperwork or administrative stuff of any sort. Some specialist should take care of it. Professors are too valuable a resource to waste their time filling out forms. Also, no department should be very big. If it gets to more than about ten faculty members, it should be split.

Kauffman: How do you feel about staff meetings?

Kamen: They're a complete waste of time. Let the administrators work out the details and give the faculty veto power over their decisions. People who like to attend meetings are not usually very productive or creative.

Kauffman: To what extent do you think that your work has had an influence on our lives and health?

Kamen: 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.

Kauffman: So the old trial and error work is no more? No more Paul Ehrlich and 606?

Kamen: No, now you know what you want and you design it for that purpose. Drug houses do this now as a matter of routine, and every time they discover an antibiotic, it's not by accident.

Kauffman: No more serendipity? No more Alexander Fleming and penicillin?

Kamen: Accidental discoveries are still happening, but most research is carefully engineered and planned, and it's done by people in applied areas. About the only place where accidental discoveries still occur is in universities.

Kauffman: Do you feel that the scientist has a special responsibility above or beyond those of the average citizen?

Kamen: Since he has special knowledge in some areas, he should be able to transmit it as an expert to the public. For example, he should answer in an informed way technical questions involving pollution, what to do about it, and how to get rid of it. Or say the question arises in the courts as to what is a carcinogen. This is a legal problem. In the law there's no such thing as maybe—it's either yes or no. The public has to understand that in science it's always maybe. What are the chances that the sun will rise in the west tomorrow morning? Perhaps $1/10^{10}$, but not zero.

Kauffman: And so the Delaney clause, which was included in the Food Additives Amendment enacted by the U. S. Congress in 1958, authorized the Food and Drug Administration to prohibit the use of carcinogens in food but didn't take quantitative data and dosages into account when considering substances to be carcinogens.

Kamen: Right. That's why the Delaney clause was crazy.

Kauffman: Have you personally testified before administrative or political bodies concerned with energy or the environment?

Kamen: Only occasionally. During the energy crisis [of the 1970s] I was called in as an expert witness to give testimony to Congress on the possibility of using solar energy to replace oil and gas.

Kauffman: Outside of science what other activities have enriched your life?

Kamen: My music, of course. I play a lot of chamber music, and, as you know, I've been involved with a lot of musicians. I now enjoy it more than ever because I don't make a living at it. I can play what I want and with whom I want. I'm at a professional level. I don't have to practice, but I have fun doing it.

Kauffman: Are you playing in any orchestra at this point?

Kamen: Community orchestras, when they ask me, and occasional chamber music ensembles.

Kauffman: What are you playing these days—viola or violin?

Kamen: Viola. I stopped playing violin in 1930–31.

Kauffman: The only chemists that I know of who were also composers were Alexander Borodin, Georges Urbain, and Emil Votoček. Can you name some other chemists who are also musical performers?

Kamen: The list is endless. For starters there's Gerry Edelman, Rockefeller University, a violinist; Hugo Theorell,

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Figure 8. 1948 Cartoon during the House Un-American Activities Committee investigations.

the Swedish Nobel laureate biochemist, also a violinist; Kai Linderstrøm-Lang, the Danish biochemist, another violinist; John Postgate, the English microbiologist and jazz trumpeter; Jerry Meinwald, Cornell, a flautist; and Waldo Cohn, a cellist, who was the founder and conductor of the Oak Ridge Symphony.

Kauffman: Is this combination of scientific and musical talents more typically a European trait?

Kamen: Yes, it's unusual to find a cultured European intellectual who isn't also a musical performer.

Kauffman: I read your *Radiant Science* [12] with tears in my eyes, partly because of my empathy for the injustices and persecutions done to you but also because of the poignant emotion aroused by your prose. As a former English major, can you offer our readers some tips on writing?

Kamen: As you know, it's very difficult to be a writer. If you write well, you know the agony of writing. To turn a good sentence is a great thrill. Those who can't write think anything they write is good. They think it's easy.

Kauffman: Supposedly most scientists are notoriously poor writers. Is this true?

Kamen: Most scientists who are bad writers haven't had much specialized training. They're no better or worse than anyone else with a lack of background. It's been a common experience of people like me to rewrite theses because students are unable to spell.

Kauffman: But this is the fault of our educational system.

Kamen: Yes, unfortunately, it's not considered important to spell or write correctly.

Kauffman: What have been your primary activities since you retired?

Kamen: Mostly editing, consulting, and continuing with my music. I haven't done anything in the lab, but I've been seeing my former students a lot and talking with them about their experiments, helping them write some books. I travel a lot to chair symposia and meet former students in Scotland, Germany, England, Sweden, and Japan. Some of my students are now professors in Japan.

Kauffman: Has your son David followed in your footsteps?

Kamen: No, he's not a scientist at all but a Chinese translator and scholar. He was formerly a staff member of the Taiwan National Museum, married a Chinese woman, has a son of his own, and is now working as a translator for the United Nations.

Kauffman: Are there any scientific areas that you feel are neglected?

Kamen: Well, if there are, nothing can be done about it. In the past molecular spectroscopy was "hot" for a while, but then it "cooled off," leaving lots of problems that have never been solved, but nobody cares; it's not important. In biochemistry there are lots of problems in metabolism that have more or less gone by the board because interest has shifted to molecular biology. There's always a residue of unsolved problems in any area, but no serious omissions.

Kauffman: So there are fashions and styles in science?

Kamen: Yes, G. N. Lewis said there are fads in science as in anything else. Right now, the fad is biotechnology—recombinant DNA, probes, monoclonal antibodies, and stuff like that. After a while, this will recede, and something else will come along to take its place.

Kauffman: Lately the lines of demarcation between disciplines have been disappearing. Is this desirable, and if so, can it be accelerated?

Kamen: It's just a natural evolution, and I'm not sure it needs to be speeded up. There were once sciences called zoology or botany, and now it's animal physiology or plant physiology. The broad, general systems are being split up to follow the expertise, which is only possible in a very limited area. There are very few generalists left. In Leonardo's or Goethe's time it was still possible for one guy to know everything that was known about science. There's no such thing as a general approach in science any longer. We know all the components, but we don't know the mechanism. For example, we really don't know how each heart cell expands or contracts to make the heart beat. Similarly, we don't know what vision is or hearing, or taste. There's still a great need for basic research on these fundamental phenomena.

Kauffman: If you were a 21-year-old university or college graduate today, what field would you choose for your career?

Kamen: I'd probably become involved in something concerned with molecular biology. It's no longer descriptive biology; it's essentially chemistry and physics. I'd probably enter an area where chemical and physical principles are applied to biological systems—like genetics.

Kauffman: Your security problems with the U.S. government and an irresponsible press during the McCarthy era and the early days of the Cold War will probably engender disbelief in the present generation. They'll find it difficult to believe that character assassinations of scientists on the basis of outright lies or the flimsiest of evidence could have been tolerated in a democracy. Your case is much less well known than the Oppenheimer case, yet, unlike Oppie, you eventually triumphed. How do you feel about the recent erosion of civil rights? Could your experience happen again?

Kamen: Yes, 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

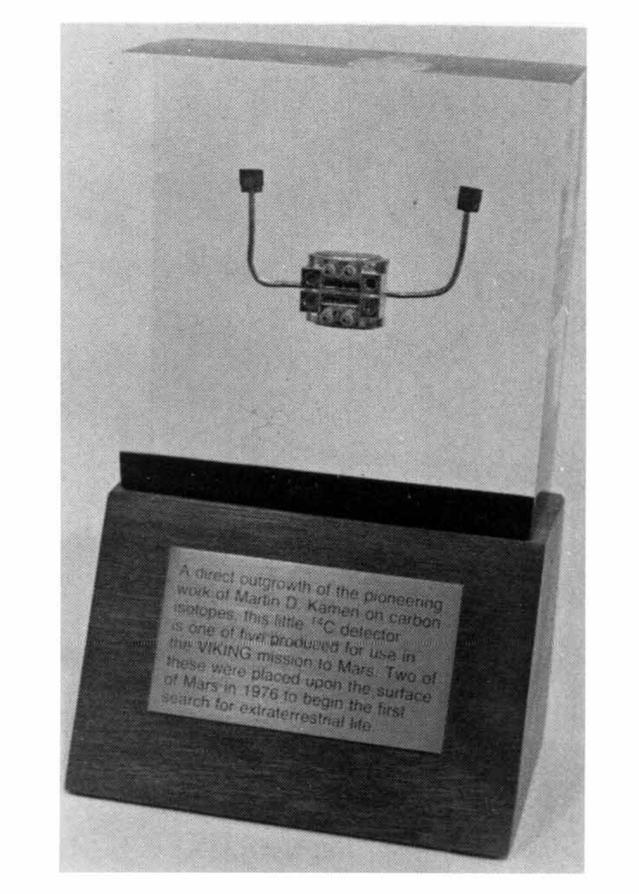

Figure 9. Momento presented to Kamen on his 65[th] birthday by Harold P. Klein, Director of Life Sciences, Ames Research Center: "a direct outgrowth of the pioneering work of Martin D. Kamen on carbon isotopes, this little ^{14}C detector is one of five produced for use in the VIKING mission to Mars. Two of these were placed upon the surface of Mars in 1976 to begin the first search for extraterrestial life." (Photograph by Maurice Lecovre).

Figure 10. Kamen's and Kauffman's logos.

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.

Kauffman: John Philpot Curran's "Eternal vigilance is the price of liberty."

Kamen: Exactly. Even Reagan himself recognized that bureaucrats have a tendency to make decisions that go beyond their power. Here, in *Radiant Science* (p 322), I quote him: "I am opposed to administrative agencies exercising powers that the Constitution assigns to Congress. Such agencies, no matter how well intentioned, cannot be allowed to govern by administrative fiat."

Kauffman: Tell me, Martin, if you had to do it all over again, would you handle your case differently?

Kamen: Whatever I did worked. It's a matter of luck whether you come out all right—entirely a matter of randomness. I'd get the best lawyer that I could find who was willing to take the case.

Kauffman: During our entire conversation, Laurie and I have been curious about that strange looking object on your table. What is it?

Kamen: This memento was presented to me on my 65th birthday by Harold P. Klein, Chief of the Biology Division of NASA's Ames Space Center. The inscription tells what it is.

Kauffman (reads)**:** "A direct outgrowth of the pioneering work of Martin D. Kamen on carbon isotopes, this little ^{14}C detector is one of five produced for use in the VIKING mission to Mars. Two of these were placed upon the surface of Mars in 1976 to begin the first search for extraterrestrial life." Where are the remaining two?

Kamen: They're in the Smithsonian Institution. It cost $2.5 million to make these five so I guess this one is worth half a million bucks.

Kauffman: It's the only one in a private living room. You must be very proud of it. To end this interview on a question of cosmic importance, I've always wondered what that little symbol is that you always write under your signature on letters. Is it some kind of secret occult sign?

Kamen: Do you know archy from *archy & mehitabel* [18]?

Kauffman: Of course. John F Baxter, my late thesis advisor, introduced me to Don Marquis' writings. I read *archy & mehitabel* to my daughters when they were kids. I have a tape of *a & m* with Eddie Bracken and Carol Channing, and we even christened our late mean-tempered Siamese cat "mehitabel."

Kamen: Well about forty years ago I started using the cockroach symbol—archy—in signing my letters. It gradually developed into a 6-1egged spider. Of course, I know that arachnids have eight legs. It's my logo, that's all.

Kauffman: The way that the Fiesers used cats in their books and the way I use an airplane for my signature. I'm sure your many friends, colleagues, and former students will be grateful for the explanation of this momentous mystery.

Epilogue

On the occasion of the 50[th] anniversary of the introduction of radiocarbon dating it seems appropriate to recount the circumstances surrounding the discovery of carbon-14, the long-lived radiosotope of the element that is central to living systems [1b]. In the autumn of 1939, Kamen's boss, Ernest Orlando Lawrence, who received the Nobel Prize in physics that year, assigned him the task of finding carbon-14 or any long-lived radioisotope in that portion of the periodic table because it was much easier to measure radioactivity with a common Geiger counter than to measure masses with a mass spectrometer, which at that time was a relatively rare instrument. At Columbia University 1934 Nobel chemistry laureate Harold Clayton Urey and his co-workers were then using the stable nonradioactive carbon-13 isotope, which required the use of a mass spectrometer, in competing with

Figure 11. Hazel o'Leary, U.S. Secretary of Energy, presents the 1996 Enrico Fermi Award (gold medal and $100,000) to Kamen, while sister, Lillian, and son, David, watch. (Courtesy, U. S. Department of Energy.)

Lawrence's group in a race to use isotopes as biological tracers.

Because the search for carbon-14 was a high-priority one, Lawrence offered Kamen his 37-inch and 60-inch cyclotrons as well as much time as he needed and help from whomever he wished. In September 1939, Kamen planned a research program involving every conceivable method for synthesizing long-lived isotopes of carbon, nitrogen, and oxygen (elements of atomic numbers 6, 7, and 8, respectively. By October 17 he was convinced that none of his planned alpha particle-induced reactions were feasible so during January 1940 he began to expose continuously a graphite probe target to collect stray deuterons in the internal beam of the 37-inch cyclotron as the most likely nuclear reaction to produce carbon-14:

$$^{12}C_6 + {}^{2}H_1 \rightarrow {}^{13}C_6 + {}^{1}H_1$$

$$^{13}C_6 + {}^{2}H_1 \rightarrow {}^{14}C_6 + {}^{1}H_1$$

Kamen worked at night, inserting the probe to intercept deuterons during night operation and then retracting it to allow others to use the cyclotron during the day. This process involved considerable radiation hazard, for each night he had to examine the intensely radioactive probe to ensure that some graphite still clung to the target surface. As he said in the above interview, "I must have been the most irradiated guy in the world."

During the last phase of the bombardment, Kamen stayed up three nights in a row, and the target accumulated a total exposure of 5600 microampere hours. Just before dawn on the morning of February 19, 1940, he removed the probe, scraped off the graphite, and left it in a weighing bottle on Samuel Ruben's desk. He related how on his way home, during a thunderstorm, "with eyes red-rimmed from lack of sleep, unsteady gait from weariness, and a three-day growth of beard, I was picked up by the police as a likely suspect for a mass murder perpetrated a few hours earlier somewhere in the East [San Francisco] Bay." Fortunately, when a witness to the crime failed to recognize him, he was released.

While Ruben processed the sample, Kamen had to remain at a distance and not handle anything since he was so contaminated from his contact with radioactivity. A week later they estimated the half-life of carbon-14 to be at least 1,000 years (The currently accepted value is 5.73×10^3 years.) and wrote a preliminary account of their discovery in a letter to *Physical Review* [11], and the rest, as they say, is history.

It might also be appropriate to mention here the cause of all of Kamen's problems with the federal government and the House Un-American Activities Committee. He eventually learned that all his troubles were exacerbated by an innocent dinner that he had with some Russians. A compassionate and gregarious man, Kamen had helped to obtain radioactive phosphorus-32 to treat an official with leukemia at the Russian Consulate in Seattle. To show his gratitude the Russian vice consul invited Kamen to dine with him at Bernstein's Fish Grotto, a popular San Francisco restaurant, where they were observed by U.S. military intelligence agents. The saga of Kamen's rise from humble beginnings to international scientific prominence and his triumph over such adversity with no trace of bitterness is an inspiring tribute to the human spirit.

Also, as a cautionary tale, Kamen's problems with the government recall a shameful period in American history when political expediency aroused the anti-intellectualism latent in our society and a hysterical tide of anti-Communism swept the nation. As Kamen states in the above interview such times could occur again. For those of us who lived through those times, it should remind us that undeserved harassments such as those that Kamen suffered could easily be repeated. As philosopher George Santayana shrewdly observed, "Those who cannot remember the past are condemned to repeat it."

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