ford, and the Kremlin—we learn the least about the last one. As George Orwell once said, it takes more imagination than intellect to understand the Soviets.

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A Radiochemist and His Times

Radiant Science, Dark Politics. A Memoir of the Nuclear Age. MARTIN D. KAMEN. University of California Press, Berkeley, 1985. xii, 348 pp. + plates. $19.95.

Martin Kamen, extrovert, scientist, musician, and discoverer of ^{14}C, has written an autobiography covering the years 1913 to 1954. During that period, and especially between 1937 and 1954, he lived life intensely and interacted with many leading figures of the time in nuclear physics, biochemistry, and music. He had enriching experiences when, as a member of Ernest Lawrence's Radiation Laboratory during its best years, he was one of the pioneers in the use of radioactive isotopes. Later, he endured persecution by the House Un-American Activities Committee and others.

Kamen, the only son of Russian immigrants, early demonstrated unusual talent as a musician. At age nine he played the violin in a concert. Later he switched to the viola, and one of his lifelong favorite pastimes has been playing chamber music. His talent was such that it led to association with some of the musical greats, including Isaac Stern.

"Don Cooksey took this snapshot of Franz N. D. Kurie outside Le Conte Hall, on the Berkeley campus of the University of California, early in 1937. Kurie is preparing to haul away a week's supply of cyclotron needs, easily contained in a child's wagon. Big Science had not yet come to the Rad Lab." [From *Radiant Science, Dark Politics*]

Kamen received his B.S. and Ph.D. degrees at the University of Chicago, where he majored in physical chemistry. He completed his doctorate in the depression year of 1936, and he used part of a small accumulation of savings to travel to Berkeley to visit Lawrence's laboratory. Since he was a cheerful extrovert and a needed chemist in a physics laboratory, he was permitted to work without compensation for some months. He was then made a paid member of the staff at the princely salary of $1200 a year (no nonsense about a nine-month basis). In addition to serving as part of the crew of the cyclotron, his duties included preparing samples of ^{32}P and other radioisotopes for use on campus and elsewhere. He established a close relationship with Samuel Ruben of the chemistry department, and they conducted a large series of studies on photosynthesis using the 21-minute radioactivity of ^{11}C.

Among the many scientific activities in which Kamen participated, the most significant was the discovery in 1940 of ^{14}C. This radioisotope has been of enormous importance in advances in modern biology. Kamen and others had seen evidence of the probable existence of ^{14}C as early as 1936. For example, cloud-chamber observations of the irradiation of nitrogen with neutrons revealed tracks interpretable as $^{14}N + n \rightarrow {}^{14}C + p$. Moreover, experience from the bombardment of many elements with deuterons made it seem very likely that the reaction of $^{13}C + d \rightarrow {}^{14}C + p$ would occur. However, the abundance of ^{13}C in natural carbon is only about 1 percent, and when a bombardment of moderate duration was conducted no carbon radioactivity was detected.

One day in October 1939, Ernest Lawrence summoned Kamen to his office. Lawrence was in an unusual state of irritation because of statements by Harold Urey concerning the limited value of radioactive tracers. Urey pointed out that only short-lived radioactive isotopes of carbon, nitrogen, and oxygen had been discovered. None had been found in hydrogen. In contrast, Urey had developed means of separating the stable isotopes of those elements and this already had led to important biomedical discoveries. Lawrence was dependent on foundation support for his existing and future cyclotrons. He very much needed the discovery of ^{14}C. When Kamen told him that long, intense bombardments might be required, Lawrence quickly told him that the search for long-lived radioisotopes of biological significance had an extremely high priority. Kamen proceeded to carry on a tremendous program of bombardments culminating in an exhausting 72-hour effort. This produced enough ^{14}C for quick, unequivocal identification by Ruben and Kamen. Later, Kamen found that neutron irradiation of NH_4NO_3 was a much better approach to obtaining good yields of ^{14}C.

A chapter of the book is devoted to an assessment of Ernest Lawrence and Robert Oppenheimer and the relationship between them. Kamen had innumerable contacts with both. He was drawn into Oppenheimer's orbit soon after his arrival in Berkeley. Kamen states, "I had much in common with Oppenheimer. We came from very similar cultural backgrounds, and we were both firstborn sons of Jewish families, with all the pressure for achievement that implied. We both had received an intensive education in classics and humanist literature. I was thus drawn to Oppie from the moment I met him, and I could appreciate his strengths, as well as his failings." In another passage he states, "Oppie—highly cerebral and introspective, by turns arrogant and charming—was continually plagued by a sense of insecurity. He possessed extraordinary analytic powers but little manual ability. E.O.L. [Lawrence]—less cerebral and highly intuitive—showed practically no self-doubt and remarkable mechanical skills. They shared a common drive to be center stage." In this chapter and scattered throughout the book is additional information bearing on the eventual estrangement of the two great scientists.

Oppenheimer and Kamen shared a

Martin Kamen "with Sol Spiegelman (right) at Cold Spring Harbor in 1947, attending a conference on cytoplasmic inheritance. Photographer unknown. Much interest was excited by our work on phosphate turnover in yeast. This provided some evidence for the existence of genetic copies of nuclear genes, which we called plasmagenes." [From *Radiant Science, Dark Politics*] proclivity to liberal causes which contributed to problems that both later endured. One evening in October 1940, Kamen attended a meeting at Oppenheimer's home. The matter under discussion was innocuous enough, but the Radiation Laboratory was already engaged in defense work. A security agent attended the meeting. Thereafter and for at least 13 years Kamen was under surveillance. Very soon Ernest Lawrence and his staff were engaged in an effort to develop equipment for large-scale electromagnetic separation of uranium isotopes. The project led to the erection of a huge plant at Oak Ridge, Tennessee. Kamen was, of course, familiar with what was going on. The situation called for great discretion concerning contacts and conversation. Kamen, the extrovert, was monitored in conversations that he considered to be innocent but that led to a growing dossier. In his activities away from the laboratory, he associated with Russian sympathizers and ultimately dined with two Russians who were on the Soviet Union's consular staff. In July 1944, he was ordered to leave the uranium project immediately. The Army had concluded that he was too much of a security risk. For about nine months, Kamen could find work only in a shipyard. However, in the spring of 1945 he obtained a position at Washington University in St. Louis, where for the next 12 years he exercised national and international leadership in the use of radioactive isotopes in bacteriological and biomedical research.

In 1948, the House Un-American Activities Committee obtained widespread publicity for itself by implying that Kamen had been part of a spy ring working for the Russians. For the next six years Kamen was in many battles, including a successful libel suit against the Chicago *Times* and a successful fight to obtain a U.S. passport. In spite of the nerve-wracking distractions, he was able to be a productive scientist.

Kamen has written a highly readable book, of interest to scientists and comprehensible to a general readership. In spite of, or perhaps because of, the trauma and triumphs that he has experienced, he writes with remarkable objectivity. His analysis of Lawrence and Oppenheimer is particularly insightful. If there is to be a criticism of the book it is that the author did not devote more space to sketches of the many scientists and musicians who were his friends and colleagues.

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On Technological Catastrophe

Normal Accidents. Living with High-Risk Technologies. CHARLES PERROW. Basic Books, New York, 1984. x, 386 pp., illus. $21.95.

This book examines the ways in which complex technological systems fail. Its author, Charles Perrow, argues that we may be intrinsically unable to safely build and manage and maintain our most modern technologies. We can no longer assume that new technologies offer social gains, since their "side effects" may prove catastrophic.

Perrow examines the catastrophic potential of the new technologies through a detailed study of past accidents. He examines nuclear reactor failures, airplane crashes, accidents at sea, dam failures, and problems in controlling nuclear weapons. He suggests that accidents are most likely to happen when the subsystems of a technical complex are "tightly coupled." Thus, for example, in a nuclear reactor the close coupling of water and air pressure lines can lead to a leak of water into the latter if a valve fails to hold or close. Similarly, though the clean and irradiated systems of the reactor are separated, a punctured tube may dump water from the latter to the former. Then, as happened at the Ginna Nuclear Reactor, a sensor, detecting the drop in pressure in the irradiated system, may pump more water through it, thus pushing more water into the clean system. Perrow suggests that when subsystems share pipes, valves, and feedlines while feedback mechanisms automatically control key processes unexpected but normal accidents will occur.

Though Perrow examines the technical causes of accidents in great detail, he analyzes as well some of the ways in which operators create or shape the structure of an accident. Thus for example he shows that ship collisions at sea are not abrupt. Rather, and most remarkably, ships snake toward each other as if they were intending to crash. Through a careful study of investigative transcripts, Perrow suggests that captains in such accidents get a fix on the course of the oncoming ship and simply do not change their minds, despite continuing contradictory evidence. Thus in one case a ship captain on the Chesapeake Bay believed he was following rather than approaching the ship he ultimately collided with. His "mental map" was rigid. Perrow argues that operators frequently ignore alarms and signals because they have malfunctioned in the past.

Perrow's study of the normal accident thus provides a rich framework for the study of ergonomics and accidents. But does he prove his central thesis? How "normal" are these accidents really? Are their dynamics primarily embedded in the complexity of tightly coupled subsystems, or do they fundamentally reflect problems of social organization, work design, management systems, and worker competence? Perrow waxes philosophical. "Man's reach has always exceeded his grasp (and that goes for women too). It should be so. But we might begin to learn that of all the glorious possibilities out there to reach for, some are going to be beyond our grasp in catastrophic ways" (p. 11). Yet many of his stories are about the inadequacy of the grasp itself, about negligent managers, incompetent operators, short-sighted owners, and disorganized social systems.

Consider the fire and explosion at the Flixborough chemical plant. Twenty-eight employees were killed and 36 were injured. As Perrow notes, managers discovered a leak from one of the five reactors and rushed to refit the plant to bypass the disabled reactor. But they did not inspect the other four, they jerry-rigged a scaffolding to support a 20-inch pipe, and they violated industry and manufacturer's recommendations in assembling their bypass piping. Perrow acknowledges that "fairly gross negligence and incompetence seem to account for this accident, but I would resist this conclusion" (p. 111). But why? Perrow's pessimistic supposition that a "fair degree of negligence and incompetence [is to] be expected in human affairs" makes his argument tautological. Only if we expect so little of social organization are such accidents "normal."

Consider nuclear reactors. The quality assurance division in many utilities, the division that watches out for safety problems, has low status and is frequently ineffective. Craft workers dislike the di-