

"continues to spend about \$5 billion a year on nuclear weapons design, testing, and production." Actually, the United States stopped testing nuclear weapons several years ago, and the Clinton Administration stopped production of nuclear weapons. It is true, however, that the Energy Department continues to maintain spending on the stockpile stewardship program, which maintains the integrity and safety of existing nuclear warheads.

The discussion of health effects, including the effects of low levels of radiation and the toxicity of many chemicals, is balanced and valuable. Several chapters cover the environmental and health hazards associated with the production of nuclear weapons.

They review the information known at the time on the U.S. government's radiation experiments on humans. Since then, the commission chartered by Energy Secretary O'Leary has published its detailed report, which verifies and expands on information in the book.

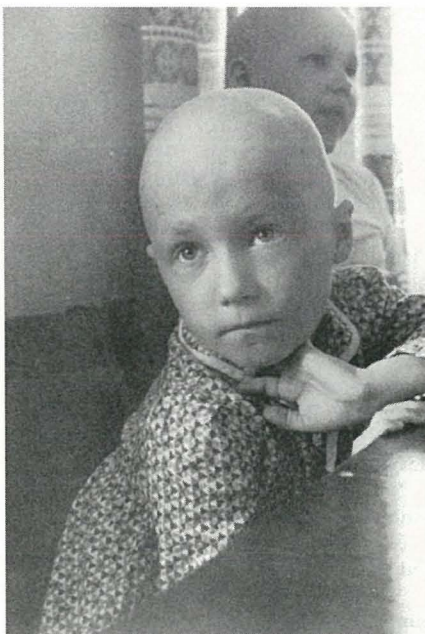
In discussing uranium mining and milling, the authors point out that the United States and the Soviet Union did not adequately respond to early evidence of radiation hazards to underground miners. They are harshly critical of inaction to ventilate uranium mines. The extensive discussion of mill tailings mentions that tailings produce radon but does not discuss the health risks of that radon (which are small).

They note that Canada is a major supplier of uranium and that operating Canadian mines has led to "local water supplies ... contaminated with radium—at three to four times the drinking water standard." They discuss the effects on Australian, South African and Namibian miners.

In the discussion of health effects in the former Soviet Union, they use the available information, but warn against accepting Soviet data at face value, citing "cover-ups" of accidents and pressures "to falsify health outcome records by not reporting radiation-related diseases."

The book goes into substantial detail on seven weapons facilities in the United States: Fernald, Hanford, the Nevada Nuclear Test Site, Oak Ridge, Pantex, Rocky Flats and Savannah River. Here, the authors' description of a particular plant in Oak Ridge notes that:

Draft estimates published in 1993 for upper-bound releases to the air from the X-10 facility appear to be far too high.... The immense range and release estimates for the X-10 reactor and associated chemical processing illustrates the nature of uncertainties confronting serious analyses of what actually happened in terms of doses and health effects as a result of nuclear weapons production. The main prob-



Leukemia patient at Chelyabinsk, 1991. From *Nuclear Wastelands*.

lems relate to secrecy, inadequate documentation, and the difficulties of reconstructing day-to-day events that took place decades ago.

This statement notwithstanding, I think the authors selectively used all the references showing increases in cancer for plant workers in nearby sites but cited few studies that disputed those. Where they do include contradictory statements, the authors criticize them as having weaknesses. For example, "of the studies that have been conducted around weapons facilities, none has provided clear evidence for increased disease risk, although it is inappropriate to use these analyses as evidence for no risk." A more balanced review has since been published by Cardis *et al.* (*Radiation Research* 142:117–132. 1995).

The authors conclude:

Findings of excess cancers in workers and off-site populations have been noted in many epidemiological studies....while in others they have not been detected. In general, it is difficult to determine the validity of these studies in the face of serious problems with the quality and the completeness of the data .... It is also impossible at present to estimate the disease burden due to community exposures to non-radioactive chemical pollution emitted by industries associated with nuclear weapons.... In sum, from the data that are available on environmental releases, discharges, accidents, and radiation doses and the current state of knowledge regarding the risks posed by exposure to radiation, it appears likely

that health effects have been experienced on a significant scale. Continuing health risks will persist for decades.

This paragraph captures both the objectivity and the bias of the book. Although the book is wordy and repetitious and lacks objectivity in some places, it is nevertheless a valuable reference. —*John Ahearne, Sigma Xi Center; formerly U.S. Nuclear Regulatory Commission*

**Dark Sun: The Making of the Hydrogen Bomb.** Richard Rhodes. 731 pp. Simon and Schuster, 1995. \$32.50 cloth, \$16.00 paper.

Named after the ominous application of isotopes of the sun's fuel, hydrogen, to make H-bombs, *Dark Sun* follows in the footsteps of its Pulitzer Prize-winning predecessor, *The Making of the Atomic Bomb*. It boldly and ambitiously covers the penetration of the Manhattan Project by the Soviet KGB, the U.S. hydrogen-bomb program, the Soviet atomic- and hydrogen-bomb programs, and the impact of nuclear weapons on some aspects of the Cold War.

Although the coverage of nuclear plotters Klaus Fuchs, Donald Maclean, Guy Burgess, Morris and Lona Cohen, Harry Gold, Julius and Ethel Rosenberg and David Greenglass occupies about one-fourth of the book, I found it both riveting to read and useful in explaining the dynamics of that episode of covert technology transfer. By narrowing the technological choices, Fuchs saved the Soviet Union perhaps one or two years in its quest for the atomic bomb, but he did not significantly aid the Soviet hydrogen-bomb program, since he did not know the Teller-Ulam trick that used absorbed radiation to implode hydrogen-bomb secondaries. Nevertheless, these stolen fruits motivated the Soviets to be prepared for crash funding the production of "eka-osmium 94" (plutonium) as the war in Europe ended. A review of these past thefts may also be relevant when considering non-proliferation regimes after the Cold War, when more technical secrets will undoubtedly be lost.

There have been many descriptions of the U.S. hydrogen bomb program, but Rhodes breaks new ground in his discussion of the transition from the "alarm-clock" design to the Teller-Ulam design and its application at the 1952 Mike test. The 60 pages that Rhodes dedicates to these technical discussions makes *Dark Sun* useful for interested scientists. Rhodes was guided through these technical intricacies by Chuck Hanson, the well-known researcher of the history and technology of nuclear weapons.

As a journalist-historian, Rhodes thrives on personal contacts with the par-



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ticipants to supplement archival sources. As one would expect, the details of the Soviet atomic- and hydrogen-bomb programs are incomplete, as source documents are not all available. Nevertheless, Rhodes has managed to lay out considerable detail on the Soviet bomb project and on the personalities of Soviet nuclear scientists. He writes about these events in a journalistic style, capturing the personal dynamics of Soviet scientists. There were Soviet counterparts for roles played by scientists in the West. For example, Igor Kurchatov (the "beard"), scientific director of the Soviet program, played a role similar to that of Robert Oppenheimer (the "pipe"), and both directors experienced reservations about their work when they observed its awesome consequences. Georgi Flerov initiated the Soviet dreams of nuclear prowess with his letter to Stalin, a role similar to that played by Leo Szilard with Einstein's letters to President Roosevelt. Andrei Sakharov, the Soviet discover of Teller-Ulam radiation compression, was also similar to Szilard in realizing that an unfettered nuclear arms race would doom us all.

The two nuclear-weapons programs are more similar than dissimilar, raising the more general issue of the technological imperative that captivates the basic drive to climb the scientific mountain. The quotations and descriptions of these landmark events kept this reader up beyond his bedtime. For those who wish more technical details of the Soviet program, I recommend *Making the Russian Bomb: From Stalin to Yeltsin* by T. Cochran, R. Norris and O. Bukharin (Westview Press, 1995).

Rhodes does not pontificate or sell hard conclusions in the more difficult historical areas of wisdom (for example, over the decision to drop the bomb). If I had to make the difficult choice between David Holloway's book, *Stalin and the Bomb* (Yale University Press, 1994), and Rhodes's *Dark Sun* for my general education students, I would choose Rhodes because of the technical details, such as the Mike test, and the development of the personalities of the players. Holloway may have a broader scope on some of the pithier historical issues, but I am thankful to both Rhodes and Holloway for helping us understand the nuclear world. There are many audiences for both of these books.—David Hafemeister, *Physics, California Polytechnic State University, San Luis Obispo*

### Clarification

In the review "Bibliographic Software" (*Software for Scientists*, July-August), it should have been noted that EndNote is available for Macintosh, Windows and DOS operating systems.