degenerative diseases, including those with a clear hereditary cause, such as Huntington's disease, could result from a genetic or acquired abnormality in glutamate metabolism or in the glutamate sensitivity of certain neurons. Either situation could lead to the overstimulation and subsequent death of neurons. This model also raises the possibility that there are vulnerable subgroups within the population at large: a person with such a disease or the predisposition to it might be particularly susceptible to dietary excitotoxins.

Social Issues chair Wexler, whose own research is on Huntington's disease, says the major message from the round table is that more research is needed on the possible role of excitotoxins in neurological diseases. Since that role is as yet only speculative, Choi and others agree it does not presently provide a basis for regulatory action. But Wexler notes that since research might identify excitotoxin-containing foods that pose a threat to all or part of the population, regulatory agencies do need to be drawn into the process.

Hence the letter to the FDA, which is being drafted by Olney and consumer advocate attorney James Turner and must be approved by the board of councillors of the Society for Neuroscience before being sent. The letter will not take a position on glutamate or any other specific issue, Turner says, since no consensus exists as yet among members of the society. "We are looking on this as a friendly communication in which we're trying to bring [excitotoxin research] to the attention of the FDA and to point out that the Society [for Neuroscience] provides a resource to help work their way through this issue."

The FDA's Hattan told *Science* he agrees that the agency could benefit from better communication with those who are doing research on neurotoxins: "The FDA doesn't have the basic science resources immediately available to us to follow up on some of these [areas]. It would be useful to have principal investigators, when they have a critical mass of data, come to the FDA and talk to us about it."

Wexler hopes for more than merely opening an avenue of communication. She wants to get across a subtle message: that the FDA should listen more carefully to researchers whose funding comes from government grants. To Wexler, those supported by the food industry are caught in a potential conflict of interest that has clouded at least one debate—the one about glutamate. "The Society for Neuroscience has all these neuroscientists who are using tax dollars to do research," she says. "If the [regulatory] arm of the government doesn't pay any attention to their research findings, that makes no sense." ■ MARCIA BARINAGA

Academy Panel Raises Radiation Risk Estimate

What was once an extreme view becomes mainstream as statisticians recalculate the effects of the Japanese atomic blasts

THE MILLS OF the National Academy of Sciences may be slow, but they sometimes grind exceedingly fine. In December they produced a 421-page report* that pulverizes an argument made by a group of experts 10 years ago that the dangers of low-level radiation were being exaggerated.

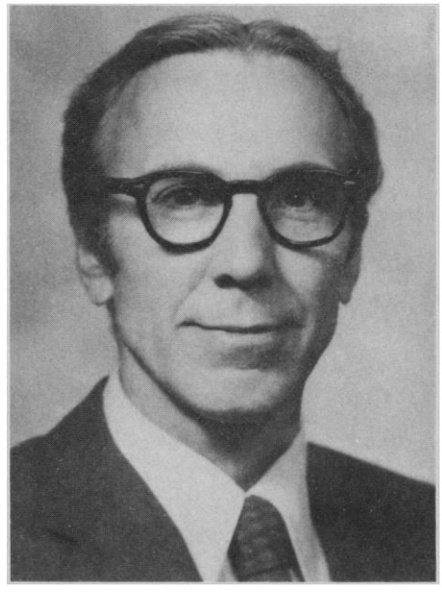
The new study concludes that the risks have been underestimated until now. Not only that, but it says that the likelihood of getting cancer after being exposed to a low dose of radiation is three to four times higher than that given in the earlier Academy report, which itself was denounced by some old hands at the time as alarmist. Thus, an evolving scientific understanding of health effects has made the alarmist viewpoint of the 1970s appear moderate today and it has given some former alarmists a chance to say "I told you so" about their predictions.

The person responsible for bringing this risk assessment to a soft landing—unlike the last one in 1979 which shattered on impact—is Arthur C. Upton, the unflappable chairman of the Academy's fifth committee on the Biological Effects of Ionizing Radiation (or BEIR V). Upton, who heads the Institute of Environmental Medicine at New York University, is scrupulously balanced in his presentation of these issues. This helps to explain why his group was able to reach a consensus while the last one, BEIR III of 1979–1980, broke into factions.

BEIR V deals with low levels of penetrating radiation that impinge on humans from outside the body, essentially x-rays, neutrons, and gamma rays, which make up the bulk of the public threat that has concerned health officials in the past. A special study issued last year, BEIR IV, deals with a different problem that gets increasing attention these days—internal short-range "alpha" radiation primarily from radon gas. Thus, while BEIR IV has implications for clearing the air in homes and uranium mines, BEIR V has implications for policing man-made sources such as medical diagnostic machines and the nuclear industry.

Although BEIR V was not officially asked to comment on public safety, Upton said at a press conference that he expected there would be "some response" from regulatory authorities in the form of tighter standards. At least one activist group, the Nuclear Information and Resource Service of Washington, D.C., is already citing the new BEIR V data as it seeks to prevent federal deregulation of very low-level radioactive waste streams (emitting less than 10 millirem per year). Warren Sinclair, president of the National Council on Radiation Protection and Measurements, an industry advisory body, says that given the "pressure" of BEIR V, his council "might very well feel that now is the time" to reduce the maximum occupational exposure limit from 5 rem per year to something less.

Even so, perhaps in the interests of preserving calm, Upton takes a low-key approach to the implications of his report. "There has been no revolution in the assessment of risk, no frightening increase [in the perceived health effects]," Upton told an audience at the Academy on 19 December. But he said it is possible to be much more specific about the degree of risk now because there has been a tremendous improvement in three areas of analysis. The most

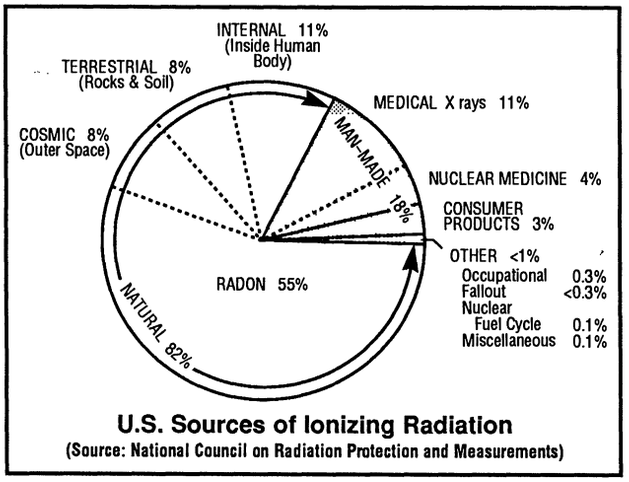


Unflappable chairman. *Arthur Upton's steady direction helped achieve a consensus.*

*"Health Effects of Exposure to Low Levels of Ionizing Radiation" (National Academy Press, Washington, D.C., 1990).

important is that researchers have been able to accumulate another decade of mortality data from Japan, where survivors of the Hiroshima and Nagasaki atom bomb attacks are watched closely for the aftereffects of the radiation they received in 1945. The other two changes are an improved calculation of the radiation released by the two bombs and a more sophisticated computer model of risk designed specifically for this report.

The shift began with the most tangible of all data: the body count. According to a committee member who helped write both reports, Jacob I. Fabrikant of the University of California at Berkeley, "More cancers are appearing than we predicted" in BEIR III.



Where the risk begins. *Most of the radiation hazard, as far as public health is concerned, comes from natural sources such as radon.*

Meanwhile, physicists were making huge changes in the estimates of the amount of radiation released in Hiroshima and Nagasaki. In the early 1980s, researchers at the Lawrence Livermore National Laboratory uncovered problems with calculations made in the 1960s of the amount of gamma rays and neutrons released when the bombs detonated. The more they looked, the more inaccuracies they found. In the end, the governments of Japan and the United States decided to pour several million dollars into a complete revision of the dose estimates.

The leaders of the dosimetry revision at the Radiation Effects Research Foundation of Japan went to "incredible and unbelievable" lengths to ensure accuracy this time, Fabrikant says. For example, roof tiles from buildings at various distances from the epicenter of the blast were subjected to a new "thermal luminescence" examination to determine exactly how many gamma rays hit them on 6 and 9 August 1945. The results were double-checked by laboratories in several countries. The shielding provided by air, humidity, windows, walls, and roofs was recalculated. The doses received by the 95,000 survivors were individually reconstructed, taking into account whether the person was facing or turned away from the blast, and, if sideways, which side of the body was exposed. Today, researchers are intent on recalculating the radiation doses to the survivors' individual organs.

Although the new Japanese dosimetry reshuffled all the cards in the deck, it made two changes of broad significance. It eliminated neutrons from the picture almost entirely, meaning that gamma rays alone were responsible for most of the health effects. This greatly simplified and strengthened the association between low-level gamma radiation and cancer. In addition, it lowered the overall level of gamma rays in onr of the bombed cities by about a factor of 2, meaning that the gamma radiation must have been more potent than realized before.

When it came time to link these dose estimates together with the cancer data in a model that could be used to project effects at low doses, the BEIR V committee found that it could not fit the new information to old mathematical constructs. Even the models used as recently as 1988 by the United Nations Committee on the Effects of Atomic Radiation were unworkable. Instead, the committee turned to a new model developed by statisticians Dale Preston and Donald Pierce with a program they wrote.

David G. Hoel of the National Institute of Environmental Health Sciences, the committee member who led this mathematical subgroup, says, "We pretty much started de novo," tossing out all the equations that had been used before. The BEIR III committee, he says, used "lots of different models," including a linear-quadratic formula that assumes the effects are negligible at low doses and climb steeply at higher doses. Looking back on that effort, Hoel says, "The data didn't really fit the model." One can see at a glance that the solid tumors "are all clearly linear," fitting on a straight-line pattern of decreasing effect with decreasing dose. Hoel says: "There wasn't any suggestion that we should have a threshold value" for doses below which one would expect to see no detrimental effects. The leukemia effects, however, are best described by a linear-quadratic curve.

For individuals, BEIR V calculates risk in terms of many variables, including sex, age at exposure, time since exposure, dose rate, and so on. But for purposes of whole population exposures as might occur in a nuclear accident or during war, it provides a general lifetime risk factor for all types of cancer of 0.8% for a single exposure of 0.1 Sievert (10 rem). This means that in a population of 100,000 people exposed to 10 rem of radiation, roughly 21,000 would die of cancer, and probably 800 of those cancers could be blamed on radiation.

The BEIR V results seem to vindicate the chairman of the previous BEIR panel, Edward P. Radford, who fought bitterly with what he calls a "rump group" of his committee and ended up in a quarrelsome press conference at the Academy on 2 May 1979. He had wanted to use a simple linear model to express risks, extrapolating straight down from the highest dose-response patterns (which are well established) to the lowest dose effects. He also held out for the use of a "relative risk" model, which would have multiplied (rather than added) a risk factor with the normal cancer rate to express the effects of radiation.

But a group of six dissidents in the committee led by Harald Rossi of Columbia University argued that these measures would exaggerate the risks. They argued that the cancer effects at low doses are unknown and probably do not follow a straight line projected down from the high-dose effects. Rossi argued that the committee should not try to set a single risk factor under the threshold of 10 rad, below which he considered the risks negligible.

The factions carried their quarrel into the auditorium at the Academy and from there to the pages of scholarly journals. They never reached agreement. Behind the scenes, Fabrikant was asked to serve as chairman of a subgroup to clean up the mess. In 14 months he put together a final report—BEIR III—which included dissenting statements from Radford and Rossi.

Although Radford believes his position has been justified retroactively by BEIR V's decision to use a linear, no-threshold, relative risk model for solid tumors, Fabrikant disagrees. "That's Mickey Mouse," he says, "or more like Donald Duck. Radford quacks a lot. Don't pay attention to it." Radford has "a very singular concept that if you draw a straight line, all the dots fit on the line. He has no understanding of the complex aspects" of risk estimation, Fabrikant says. Furthermore, he argues that the data available to BEIR III in 1979 simply did not justify this approach. According to Fabrikant, it's like saying, "in the absence of data, I was clairvoyant. . . . We have done things in BEIR V that we couldn't conceivably have done before." ■ **ELIOT MARSHALL**