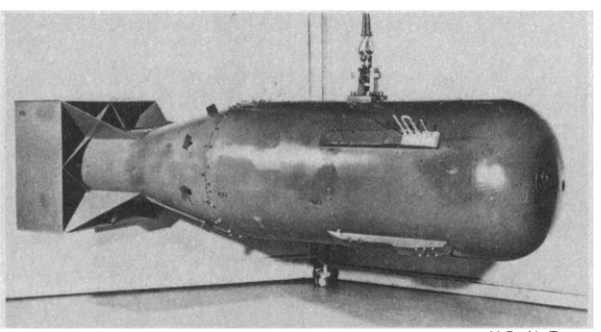
New A-Bomb Studies Alter Radiation Estimates

The basis of 15 years of radiation research may be in error; radiation toxicity may be understated

Some of the most important data on the effects of nuclear radiation on humans may be wrong, according to new research being done at the Lawrence Livermore weapons laboratory in California and the Oak Ridge National Laboratory in Tennessee. The new findings are far from welcome, as one consultant in this work says, for all the revisions "are moving in the wrong direction"—a direction that will worry the advocates of nuclear power. Government physicists have recalculated the data on the radiation fields created by the atomic blasts at Hiroshima and Nagasaki and produced some unexpected results. Their statistics show that most of the cancer caused by those bombs came from low LET gamma rays,* suggesting that this common type of radiation is more hazardous than had been assumed before.

The impetus for the revision comes primarily from Livermore, where physicists William Loewe and Edgar Mendelsohn last year used a computer to reconstruct the two explosions. Their findings are being checked and complemented by a group at Oak Ridge led by George Kerr. He began work on a similar project in 1977, shelved it, and then returned to the task in earnest when Loewe's data became known. Dean Kaul of Science Applications, Inc., in Chicago also carried out some early calculations that sparked interest in the issue. Kerr, Kaul, and Jess Marcum of Research and Development Associates in Santa Monica, California, have been funded by the Defense Nuclear Agency to explore the problem and check some of the old assumptions which have not yet been reexamined.

Although they differ in some of the details they stress, all of these scientists agree that the accepted figures for high LET (neutron) radiation at Hiroshima are grossly overstated. For example, the neutron radiation at a distance of 1180 meters from the epicenter of the blast appears to have been overestimated by a factor of 6 to 10. Since the effects on human health remain the same, one must conclude that the gamma rays were more toxic than had been thought.



U.S. Air Force

Did it produce neutrons or mostly gamma rays?

Duplicate of the bomb that hit Hiroshima

If this research proves correct—and it has survived a few peer challenges already—it will necessitate the rewriting of many basic documents on the hazards of radiation, including the chief attempt to define such risks published in 1980 by the National Academy of Sciences. That study, the work of the Committee on the Biological Effects of Ionizing Radiation (the BEIR report), was fraught with controversy on this very question.

Although much of the BEIR report was released to the press in May 1979, the Academy decided to recall and rewrite it because of dissension among the authors. Some of them, led by Columbia University biophysicist Harald Rossi, argued that the paper overstated the cancer-causing effects of low LET radiation. Their arguments leaned heavily on Japanese data and particularly on the thesis that many of the cancers in Hiroshima were produced by high LET neutron radiation.

Using the old Hiroshima radiation data as evidence, Rossi argued that the BEIR committee should lower the cancer risk estimates published in an earlier BEIR report in 1972. Instead, the committee raised the risk estimates. Rossi considered this an alarmist move and withdrew his support from the document. In the end, the Academy felt compelled to write a report that effectively split the difference between Rossi's point of view and that of his chief adversary, the committee chairman, Edward Radford, an epidemiologist at the University of Pittsburgh. The risk estimates in the final report of July 1980 were not as high as Radford argued they should be nor even as high as those in the 1972 report. Neither Radford nor Rossi endorsed the document.

Rossi concedes that the Livermore calculations may do away with the evidence for his theory that neutrons were responsible for the high cancer incidence in Hiroshima. But he does not expect to alter his general view that the hazards of radiation are exaggerated. Radford, in contrast, says the new Hiroshima data vindicate his position and invalidate Rossi's. Furthermore, Radford considers the BEIR 1980 report obsolete and expects that the probabilities it gives for the risk of dying of cancer after exposure to gamma radiation will be doubled. Likewise, he thinks the probabilities for contracting any form of cancer after irradiation will be quadrupled.

The importance of the new research is that it completely changes the scheme of radiation doses that people are supposed to have received in Japan, particularly in Hiroshima. Until now, it was thought that the Hiroshima blast was unique in that it produced a large field of fast neutrons, a high LET form of radiation. Neutron radiation is considered more dangerous than low LET radiation, a category that includes x-rays, electrons, and gamma rays. Its singular presence in Hiroshima was said to make the cancer risk found there anomalous. Most of the radiation people encounter is not of this kind. The wastes from nuclear reactors, for example, emit gamma rays. Thus, a

*The terms "low LET" and "high LET" (for linear energy transfer) refer to the physical quality of the ray. Low LET radiation loses relatively little energy as it travels along its course, and includes electrons, gamma rays, and x-rays. High LET radiation loses energy more rapidly as it travels, and includes beams of neutrons and protons.

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number of scientists have always considered Hiroshima a special, high-risk case, and in studying the peacetime hazards of radiation, they have discounted some of the cancer data from that city.

As it happens, the cancer mortality data from Hiroshima are the most valuable in the world. Unlike the data from Nagasaki, they are abundant enough to reveal a clear relationship between doses of radiation received and ill effects. That relationship is defined by a linear equation: an increase in dose above the natural background radiation correlates with a proportional increase in ill effects. The pattern suggests that any increase in radiation, no matter how small, directly increases the risk of getting cancer. The mortality data from Nagasaki are sketchier, making them susceptible to a variety of interpretations. The significant point is that if the new bomb calculations are accurate, the data from Nagasaki and Hiroshima can be combined and treated as a single, coherent pattern of response to low LET radiation. It is too early to say precisely what that pattern will look like, because now the doses must be recalculated for each radiation victim. But most of the researchers who spoke to *Science* said the new data would probably increase the risk estimates for gamma radiation.

Radford, an advocate of this point of view, claims that the argument over Hiroshima and its mortality data has been a distraction from the main body of scientific evidence. He says the 1980 BEIR report miscalculated in emphasizing mortality data so heavily, for death certificates do not give a very accurate reading of the number of cancers or even cancer deaths in a community. Radford thinks it was a mistake to pay so much attention to Rossi's theory about deaths in Hiroshima, for he claims the theory is contradicted by "90 percent" of the epidemiological data on record. He is pleased that the Hiroshima data may now look consistent with all the rest.

"The implications are far reaching for health regulation and nuclear power in this country in general," says David Auton, a physicist in the office of target and damage assessment of the Defense Nuclear Agency. His office is funding the research at Oak Ridge that may confirm the new dose estimates. As he describes the situation, the health physics community faces a nasty dilemma, if the new bomb data are accurate. On one hand, the standard-setters may adhere to Rossi's principle, which maintains that many of the cancers produced in Hiroshima were caused by fast neutrons. But the number of neutrons thought to have been present is now so small that one must account for their effects by increasing the estimate of their potency. The resultant killing power of neutrons is "incredible," Auton says. Industrial safety rules would have to be revised, reducing exposure limits for neutron radiation to one-tenth of the present limits. For critical jobs, companies would have to employ ten times as many people.

On the other hand, the health physics community may abandon the Rossi principle and conclude that nearly all the cancers in Hiroshima were produced by gamma rays, not neutrons. That news will not be welcome either.

Auton wishes frankly that someone else were funding this research, which he thinks is important for future health and energy policy. His office is doing it because "nobody else was interested." The controversy has been brewing for at least 4 years, for that is how long it has been since a government consultant first raised serious questions about the validity of the Hiroshima data. According to Auton, however, it was just 5 months ago that he was approached by Harold Wyckoff, chairman of a special committee assigned to study this question for the National Council on Radiation Protection and Measurements. It is a private organization that collects and publishes radiation risk information. Since no other agency would fund the research, Auton says, he agreed to have the Defense Department pick up the tab for work being done at Oak Ridge, and thus come up with some answers for Wyckoff. The funding began about a month ago.

"This work is of marginal interest to us and we really can't afford to spend very much money studying civil effects," Auton says, but it is important to resolve the uncertainties. It might make more sense for the Department of Energy or the Nuclear Regulatory Commission to pay for this work, and "the electric power people really should be interested," according to Auton. It is important that the new research be credible. Auton agrees that it would be best if the sponsor were an independent group not associated with the weapons program or the nuclear industry.

U.S. Air Force

Hiroshima, 1945

Some concrete buildings survived the blast.

Arthur Upton, the former director of the National Cancer Institute and an expert in radiobiology, has followed this controversy closely since he learned of the new bomb data last fall. It is an important issue, he says, and should be the subject of more research, sponsored by a neutral scientific organization such as the joint U.S.–Japanese Radiation Effects Research Foundation. If the new dose estimates are correct, Upton says, "I am not sure one can substantiate the Rossi thesis." It may remain important for radiobiology, for there are differences in the way that plants and animals respond in the laboratory to high and low LET radiation. Upton agrees with Radford that the new data greatly strengthen the argument that there is no "safe" level of exposure to radiation, in that every incremental bit of exposure increases the chances of injury.

One of the curious aspects of this research is the manner in which it was published. The record serves as a compelling argument for declassifying as much as possible of what is done at government labs, for many of the assumptions in this case might have been challenged sooner had the underlying data been available for scrutiny.

The Rosetta stone of Japanese radiation dosimetry is known as T65D, which stands for tentative dose estimates compiled in 1965. The figures were assembled by physicist John Auxier of Oak

Ridge in a painstaking analysis of measurements made during and after the Japanese blasts, interviews with the bombardiers, and a test explosion in the Nevada desert. Some of his work was classified because it described in detail the makeup and radioactive output of the Little Boy (Hiroshima) and Fat Man (Nagasaki) bombs. Auxier's methods of computing the doses, which underlie 15 years of research on health effects in Japan, were never described in detail. In 1977, however, the government published a quasi-technical narrative by Auxier (*Ichiban*, Energy Research and Development Administration, TID 27080) giving some additional information on Auxier's methods.

As questions about these figures arose in the late 1970's, the National Council on Radiation Protection (NCRP) asked Auxier to justify his estimates with more supporting information. After working on this project for several months, Auxier explained that he could not reproduce all the data because some had been lost. He explained to *Science* that when Oak Ridge was reorganized in 1972, he was moved from one place to another, and his old classified files were left behind in his laboratory. Auxier says that the records division at Oak Ridge made a mistake in shipping the files: the valuable data were sent to the shredder.

The NCRP continued to ask for confirmation of the T65D numbers because they had become important in the debate on the hazards of radiation and because new data were becoming available. In 1976, the Los Alamos Scientific Laboratory in New Mexico, a weapons design center, released an estimate of the radioactive output of the Hiroshima bomb for the first time. The figures were not published, but given in a private letter to C. P. Knowles of Research and Development Associates, who was trying to help the Defense Nuclear Agency pin down the precise explosive power of the Fat Man bomb. This is one of the key uncertainties in the record; some say the blast equaled the power of 12.5 kilotons of TNT, and others say it may have been as potent as 15 kilotons. Several people in the weapons and biophysics community soon obtained copies of the letter, including Kerr at Oak Ridge and Kaul at Science Applications. Using the new data and computer techniques not available when Auxier did his research, Kaul and Kerr in separate projects came up with numbers that were at odds with the T65D results.

Kerr's laboratory is the best equipped and best funded for this expensive computer work, Kaul says, and for that reason it has been given the primary responsibility for reviewing the old numbers. Kerr's task is complicated by the fact that he is in a sense Auxier's successor at Oak Ridge and works just down the hall from this senior official whose work he has been asked to review.

Auxier, meanwhile, says that his data are the best available, not likely to be changed much by the work of latter-day

Technology Transfer Reappraised

Transfer of technology from industrialized countries to developing countries emerged in the 1970's as a highly charged issue in the so-called North-South dialogue. Less-developed countries protested that control of technology by the industrialized North keeps them in a state of technological dependence.

A report* just issued by the Organization for Economic Cooperation and Development (OECD) in Paris questions major assumptions on which the technology transfer debate has been conducted. It argues that technology transfer has been mutually beneficial for industrialized and for developing countries, or at least some of them.

The report notes that technology transfer has helped a group of "industrializing" developing countries to participate, on stronger terms, in the world trading system. These include Brazil, Mexico, South Korea, Taiwan, Hong Kong, and Singapore.

The report's main challenge to the notion of technological dependence is its assertion that "technological monopolies are temporary," that change is propelled by a "technology cycle." New technology introduced in one country is transferred under tight control first to other developed countries and then to less-developed countries. As licensing and sale of the technology spreads, it becomes standardized.

Proof that this process is working is seen in the rise in imports by industrial countries of manufactured goods from developing countries. Moreover, some industrializing countries are themselves exporting technology, mostly in the form of turnkey plants and equipment.

Feedback from technology transfer also affects industrial countries. The impact has been most conspicuous in the decline of traditional industries, notably clothing, footwear, and light manufacturing, that have faced offshore competition. Loss of jobs has created a protectionist backlash that includes criticism of technology transfer. But, says the report, technology transfer has benefited the United States and other OECD countries by creating export markets for their capital-goods industries during a period of slow growth.

By focusing on the industrializing countries, the report offers a selective view of the problems facing developing countries. It does note in passing that for the poorest countries, the cost of imported oil, trade deficits, and foreign debt make the outlook bleak. Even for the industrializing countries, the burden of energy costs, deficits, and debt have "led to pessimism regarding future financing of development."

The report was prepared by the staff of OECD, which is essentially a club of governments of western industrial nations plus Japan. OECD serves as a data gathering and intergovernmental policy-planning organization. It is, therefore, not surprising that the report assesses technology transfer mainly from the sellers' point of view.

In broad terms, what the report's authors say is occurring is a major restructuring of the international industrial system. For the industrial countries an "adaptive strategy" is counseled. With a two-way trade in industrial products now established, the North can retain its comparative advantage only by keeping its "innovatory capacity" at a high level. Pressure to transfer R & D activities to developing countries will build as their scientific infrastructures strengthen. The report borrows from Lewis Carroll to observe that industrial countries must "keep running to stay in the same place."—JOHN WALSH

**North/South Technology Transfers: The Adjustments Ahead*, Organization for Economic Cooperation and Development, Paris, 1981. $12.

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revisionists. His judgment is widely respected. As the grand old man in this field, he is in a position to influence funding decisions on new research. Auxier told *Science* there is no need for an independent review of the discrepancies between his data and Kerr's, expressing an opinion which may have made it difficult to get the present review started. Auton, the Defense Nuclear Agency official who makes the funding decisions, says that he has great respect for Auxier's work, a respect based as much on Auxier's standing in the community as on his ability to "drag out corroborative data."

Kerr has never published any of his work outside the laboratory, he says, because he prefers to be "timid" about it. Earlier controversies have taught him to move cautiously in matters as important as this, and he still thinks there could be some weaknesses in the new bomb data.

This stalemate existed for several years until the summer of 1980 when Loewe decided to rework the calculations. He started the project because the old Hiroshima data and Rossi's recent warnings about the potency of neutrons worried people in the lab. Livermore scientists are involved in weapons research and are frequently exposed to neutron radiation. They wanted to know more about the dangers. Loewe's investigation, completed last October, found both the Hiroshima data and Rossi's principle to be unsubstantiated. Loewe argues that there is no evidence showing that neutrons were present in significant quantities in Hiroshima.

Loewe, Kerr, Auxier, and others in this controversy will present their arguments at a meeting sponsored by the Radiation Research Society on 31 May in Minneapolis. Auton calls it "the beginning of an important dialogue," one which he probably will not be able to attend because the new Administration has reduced the bureaucracy's travel allowances. But Auton hopes the meeting will lead to a general and independent review of the issues. "If the weapons folks" make it a strictly internal project, he says, "I just have a concern that nobody will believe the results."

—ELIOT MARSHALL

Science Adviser Post Has Nominee in View

The job, turned down by several candidates, may now be offered to a man who is not a member of the science establishment

The choice of science adviser to President Reagan has been narrowed down to a single candidate: George A. (Jay) Keyworth, a 41-year-old physicist from the Los Alamos Scientific Laboratory. Although the job had not formally been offered to Keyworth as of this writing, Administration officials expect an announcement by the end of May, but caution that something could still go awry even at this late stage of the selection process.

When Keyworth's name came up as a potential candidate late in April, it drew a mixture of surprise and unease from the scientific establishment. The surprise stems from the fact that Keyworth is virtually unknown outside his field. And the unease is related to the fact that his candidacy was being vigorously supported by Edward Teller, the so-called "father of the hydrogen bomb," and Harold Agnew, president of General Atomics and former director of Los Alamos. Both are well known for their hawkish defense views.

Those who know Keyworth describe him as smart and personable. His research has been concerned mostly with nuclear structure and low-energy nuclear reactions, and for the past 3 years he has directed the physics division at Los Alamos. One scientific colleague, Arthur Kerman of MIT, describes Keyworth as "a very good scientist who is a lot broader than his background would indicate."

Outsider causes unease

Candidate George Keyworth

His background does not, however, include service on the usual round of government science committees. Hence he has little experience with federal science policy and has made few links to the scientific establishment. "He doesn't provide any channel between the national (scientific) community and the White House," complains one veteran of science and government affairs.

Such concerns are abruptly dismissed by Keyworth's supporters. Although he "lacks obvious credentials, that doesn't mean he will not do a superb job," says one. Agnew scoffs that "he has all the right credentials—all he doesn't have is 20 years membership in the club." In a telephone interview with *Science*, Agnew also said that he thinks much of the unease about Keyworth is simply due to the fact that he is an outsider—"If you get a bunch of chickens together and you put in a new rooster, they start clucking and running around," he remarks.

As for Keyworth's shortage of links to the scientific establishment, Agnew says that "defense will be the thrust of this Administration, and somebody who has the respect of the people in the defense labs is needed." He adds: "For the past four years, you have had a geologist in charge, and the defense community has suffered."

How did somebody from outside the traditional ranks of candidates for science adviser get selected? Keyworth says he was approached about the job early in April, and "it came as a surprise to me." The post was formally offered in March to Arthur Bueche, head of research and development at General Electric, but he was forced to turn it down for personal reasons. Several other people were subsequently sounded out about

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