NATIONAL ASSOCIATION
OF ATOMIC VETERANS

WASHINGTON OFFICE • SUITE 606, 236 MASSACHUSETTS AVENUE, N.E., WASHINGTON, D.C. 20002 • (202) 543-7711

PREPARED STATEMENT OF

GLENN H. ALCALAY

NAAV SCIENTIFIC AND MEDICAL ADVISOR

TO THE

HOUSE COMMITTEE ON VETERANS' AFFAIRS

MAY 24, 1983

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE:

It has been nearly four years since this Committee convened for hearings to investigate matters pertaining to the health and well-being of the approximately 250,000 ex-servicemen who partook in above-ground nuclear weapons experiments between 1945 and 1962. Since the time of the last hearing in 1979, many critical factors have emerged which have direct bearing on the question of the relationship between exposure to ionizing radiation and adverse health effects, especially in relation to those effects which have a latency period of several decades and beyond.

One of the most important discoveries in recent years centers around the interpretation of Japanese A-bomb studies. Most of the national and international scientific bodies conducting radiation research rely almost exclusively on these Japanese data, including the National Academy of Science's Biological

Effects of Ionizing Radiation (BEIR-3) Committee, as well as the Interagency Task Force on Ionizing Radiation, which the Veteran's Administration relies upon.

Another important development since the last Committee hearing is the finding by the Centers for Disease Control that ex-servicemen who witnessed the SMOKY atomic test in 1957 have a three to four-fold increase of leukemia as well as a ten-fold increase of a rare form of bone marrow disease similar to leukemia.

Finally, evidence has been mounting since the last hearing which suggests that low-level ionizing radiation--the type of radiation many of our former veterans were exposed to--causes many degenerative diseases besides cancer and thyroid nodules, including chromosome changes which can lead to sterility and birth defects among the children of atomic veterans. All of these aforementioned current scientific discoveries shall be expanded upon in the following sections.

CONTROVERSY OVER JAPANESE A-BOMB DATA

According to researchers at the Lawrence Livermore weapons laboratory in California and the Oak Ridge National Laboratory, some of the most important data on the effects of ionizing radiation on humans may be wrong. In an article in the May 22nd, 1981 issue of Science, a consultant who is working on this research said that the dose revisions "are moving in the wrong direction"--a direction that will cause great concern among the advocates of nuclear energy.

The importance of this new finding is that it completely changes the scheme of radiation doses which the Japanese bomb survivors are supposed to have received, especially in Hiroshima. The new research has revealed that most of the cancer caused by the atomic bombs came from gamma rays--and not from fast neutrons--suggesting that gamma radiation is much more hazardous than was previously believed. The film badges worn by some atomic veterans recorded only gamma radiation.

David Auton, a physicist in the office of target and damage assessment of the Defense Nuclear Agency (DNA)--and who accompanied General Harry Griffith at the April 6th Senate hearing--has stated his concern about the new findings with the Japanese A-bomb studies. In an interview in the May 22nd, 1981 Science, Auton stated, "The implications are far reaching for health regulation and nuclear power in this country in general."

More recently, Dr. Edward Radford, professor of environmental epidemiology at the University of Pittsburgh and former chairman of the BEIR-3 Committee, has sharply criticized the Japanese studies which serve as the basis for the National Academy of Science's BEIR-3 report. In a March 18th, 1983 New York Times article entitled "Health Expert Finds Hazard of Radiation Worse Than Feared," Radford said that the new research on the Japanese A-bomb victims shows that the radiation damage was ten times worse than previously indicated.

In conjunction with these recent developments in radiation studies, it should be noted that since at least 1978 the federal

government has admitted that there is no known safe dose of ionizing radiation, no "threshold" level. This admission is found in a Nuclear Regulatory Commission document (July 31, 1978, SECY-78-415, Policy Session Item from Robert B. Minogue, Office of Standards Development) which urges that the term "permissible dose" be discontinued because it has been misinterpreted to mean "safe." Minogue, the author of this document, states that "Considerations of the linear hypothesis indicate that some risk is associated with any dose of radiation, however small."

THE CALDWELL "SMOKY" STUDY AND DR. ALICE STEWART'S RESEARCH

The most significant piece of scientific research to date is the government-sponsored Centers for Disease Control study of the 1957 SMOKY test participants by Dr. Glyn Caldwell. The Caldwell study is the only scientific study we have so far which has investigated a particular nuclear test, and the finding of this study has shown a statistically significant incidence rate of leukemia. In addition, an alarmingly high incidence rate of a very rare form of bone marrow disease similar to leukemia--polycythemia vera (PV)--has been identified among the SMOKY participants in conjunction with the leukemia finding. Both of these diseases are closely associated with exposure to ionizing radiation.

In the past month, a British epidemiologist has made the startling discovery that an abnormally high incidence of leukemia and other reticuloendothelial system (RES) neoplasms has occurred among British ex-servicemen who participated in nuclear weapons

tests at Christmas Island in the South Pacific between 1957 and 1958. Writing in the April 9th, 1983 issue of the British journal Lancet, Dr. Alice Stewart states that she would have expected to find 17 cases of RES disease among the approximately 8,000 atomic veterans who served at Christmas Island. From a preliminary sample of only 330 returned questionnaires from the group of 8,000, Dr. Stewart has located 27 cases of RES disease thus far--a finding that suggests a dramatic incidence rate of RES disease in this population exposed to ionizing radiation. This recent finding by Stewart is a significant piece of the enigmatic puzzle surrounding the atomic veterans issue, and we shall be monitoring the progress of these British researchers as they attempt to unravel a portion of Cold War history by use of statistical techniques. Moreover, Stewart and her co-researchers in England are getting the full support of the scientific community in that country, as exemplified by the following statement which appears in the April 9th Lancet, and which was underwritten by a wide array of British scientists:

> The servicemen present at the nuclear test explosions constitute a uniquely large sample of healthy young men who were at risk of exposure to ionising radiation and among whom there now appears to be evidence of radiation related effects. To examine as fully as possible their subsequent medical histories, access to a complete nominal roll of the total group of exposed persons is required, together with full disclosure of what is known about radiation exposure of the men on duty during these tests. We urge that an independent academic body be asked to conduct a full investigation into the morbidity, mortality, and perhaps genetic effects in these men, and given the means to do so.

RADIATION EXPOSURE AND DEGENERATIVE DISEASES

In a 1975 study of physician radiologists (American Journal of Epidemiology, Vol. 101, No. 3, pp. 199-210), Matanoski, et al., found a significantly higher cancer and leukemia incidence rate among those physician specialists who were accidentally exposed to x-rays during treatment. This finding is important because x-rays are very similar to gamma rays, one of the types of radiation atomic veterans were exposed to.

In addition to cancer and leukemia, radiologists in the study by Matanoski developed a plethora of diseases having statistical significance, including diabetes, cardiovascular disease, stroke, and hypertension. Interestingly, Matanoski noted an age-related gradient in relation to the incidence of disease: there were more diseases among older radiologists than among younger radiologists. This, says Matanoski, is probably due to refinements in the x-ray procedure over the decades.

In another interesting and quite relevant study, Elkeles (Journal of the American Geriatrics Society, 1977, Vol. XXV, No. 4, pp. 179-82) discovered a close relationship between atherosclerosis and ingestion of alpha particles. Atherosclerosis is a form of arteriosclerosis in which fatty substances deposit in the inner walls of the arteries and can lead to cardiovascular disease and heart problems. The significance of the Elkeles study is that it demonstrates a significant causal link between ingestion of alpha radiation and cardiovascular disease. This is especially important in light of the fact that an untold number of the 250,000 atomic veterans

ingested and inhaled varying quantities of alpha particles during the atmospheric nuclear weapons tests. What is particularly worrisome is the fact that because film badges were designed to **only** record external gamma (and x-) radiation, the internal absorption of alpha (along with beta, neutron, and gamma-emitters) may have been significant. The study by Elkeles would certainly warrant an investigation into the possibility that alpha particle ingestion may be responsible for an excess number of cardiovascular diseases among atomic veterans, especially in view of our preliminary findings which indicate an abnormally high incidence rate of heart problems among our atomic veteran members.

In a report issued by the International Atomic Energy Agency (IAEA) in 1978, a Japanese researcher has noted a major finding concerning cardiovascular disease among Hiroshima females. Writing in the "Proceedings of a Symposium on Late Biological Effects of Ionizing Radiation" (Volume I, Vienna, March 13-17, 1978), Dr. H. Kato has discovered a dose-response phenomenon with respect to cardiovascular disease in Hiroshima females: The rate of cardiovascular disease among the Hiroshima A-bomb survivors increases with dose of radiation. This is a truly significant finding in two regards: (1) Japanese women typically have a relatively low incidence rate of cardiovascular disease in the unexposed population, and (2) The new findings from the Hiroshima studies suggests that gamma radiation was responsible for more of the damage than was previously considered.

CHROMOSOME ABERRATIONS AND POSSIBLE GENETIC EFECTS OF RADIATION

Several studies among exposed populations have strongly suggested a direct link between exposure to ionizing radiation and chromosome and genetic damage.

As early as 1925 reports began to surface about the ill-effects associated with the ingestion of radium and other radioactive materials among the women who were formerly employed as luminous-dial painters. In a February 12th, 1966 issue of the British Medical Journal, J.T. Boyd, et al., concluded that there was a linear dose-response between the intake of radium and chromosome abnormality among the radium-dial painters.

Likewise, a linear dose-response between exposure to ionizing radiation and chromosome aberration was noted among former dockyard workers who handled radioactive substances. In an article in Nature ("Radiation-Induced Chromosome Aberrations in Nuclear-Dockyard Workers," Volume 277, February 15, 1979, pp. 531-34), H.J. Bates, et al. studied a group of workers who were exposed to neutron and gamma radiation during the refueling of nuclear reactors. His research indicates that most exposures were below the internationally accepted maximum permissible level of 5 rem per year, and that there was a significant incidence of chromosome aberration in peripheral blood lymphocytes ten years after their exposure.

In the 26-Year medical follow-up study of the Marshall Islanders who were exposed to radioactive fallout, researchers for the Brookhaven National Laboratory have discovered that at least 50% of the exposed Marshallese have manifested a rare form

of chromosome aberration which is attributable to their radiation exposure. Conard et al. (1980, BNL 51261) has stated that this finding is consistent with the Japanese A-Bomb data. Of profound importance is the discovery that a higher incidence of chromosomal aberration occurs among the Marshallese group exposed to low-level radiation as opposed to the higher dose group. This same phenomenon occurs with respect to the incidence of thyroid cancer among the exposed Marshallese, whereby the lower dose group (i.e., Utirik Atoll) has a significantly higher ratio of thyroid malignancies than the higher dose group (i.e., Rongelap Atoll). This major finding among the Marshallese suggests that at higher doses of ionizing radiation the impacted cells are destroyed, whereas at lower doses the cells are merely maimed and/or maligned, and may be spared for a later malignancy or chromosomal change. This suggests that low-level ionizing radiation may be far more deleterious to human health than was previously believed, and it is this type of radiation dose the majority of the atomic veterans received during the above-ground testing period.

SUGGESTIONS TO THE COMMITTEE REGARDING A HEALTH SURVEY

Based upon the forgoing testimony, it appears that the possible adverse health effects associated with exposure to ionizing radiation--and especially at low doses--may constitute a far more serious health problem than was previously assumed. Moreover, as the scientific and medical evidence continues to filter in concerning health effects beyond cancers and leukemia,

in particular cardiovascular disease and chromosomal changes with the possibility of birth defects among the offspring of exposed populations, it seems appropriate to expand the focus of radiation-induced injuries.

In this regard, the National Association of Atomic Veterans recommends the following:

- That a comprehensive epidemiological and genetic survey be conducted of the 250,000 ex-military personnel exposed to ionizing radiation during above-ground nuclear tests between 1945 and 1962
- That this survey be conducted by a truly independent and non-governmental body, such as an academic body from a major university, in order to prevent an inherent conflict of interest when government-sponsored agencies collect and assess data, and then make policy decisions based upon data interpretation
- That NAAV assist with the initial establishment of the study protocol, and that NAAV have continual input and access to data and data collection
- That the epidemiological and genetic study be both a morbidity and mortality study
- That the study will include diseases other than cancer and leukemia, such as cardiovascular disease, neuro-muscular diseases, pre-mature aging, and other degenerative diseases
- And finally, that the proposed epidemiological and genetic survey raw data and results be submitted to various independent bodies for impartial peer review so that an objective and fair analysis of the study may be achieved

In conclusion, the National Association of Atomic Veterans is perplexed about the Veterans Administration's opposition

to the epidemiological and genetic study of atomic veterans and other veterans exposed to toxic substances during military service, as well as their offspring, as called for in Senator Alan Cranston's Senate Bill 11. Because no substantive data currently exists regarding the possibility of genetic and birth defects among the offspring of atomic veterans, NAAV finds it hard to believe that the Veterans Administration would go on record as opposing S. 11 which specifically calls for the first genetic study of atomic veterans and their offspring.

It is both ironic and unfortunate that the Associate Deputy Chief Medical Director of the Veterans Administration, Dr. Earl Brown, has stated at the April 6th Senate hearing that "No genetic effects exist among the offspring of atomic veterans." Not only is there no existing scientific evidence to support such a claim, but having the Veterans Administration oppose a genetic study (as outlined in S. 11) raises the most profound question about the intentions of the Agency mandated by Congress "To care for him who shall have borne the battle and for his widow, and his orphan."

Thank you.

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Letters to the Editor

CANCER FOLLOWING NUCLEAR WEAPONS TESTS

SIR,—In December, 1982, the BBC television programme *Nationwide* initiated a follow-up of men who had been involved in nuclear weapons testing in the South Pacific by inviting first-hand accounts from viewers. The programme also enlisted our help with the statistical analysis of reported illnesses and deaths.

The South Pacific tests — whose local base was Christmas Island — overlapped in time with other weapons tests. Thus, there were twelve tests in Western and South Australia between 1952 and 1957, and nine South Pacific tests between May, 1957, and November, 1958. The follow-up of the South Pacific population is far from complete but already there is evidence of an abnormally high incidence of leukaemia and other reticuloendothelial system (RES) neoplasms.

The number of British servicemen and civilians who witnessed the tests or helped with the removal of radioactive waste is not yet accurately known. However, we have provisionally estimated that 8000 of the 13 000 men who (according to an answer to a Parliamentary question on Feb 8, 1983[1]) took part in the whole series of twenty-one British tests were involved in the South Pacific tests. We are also assuming that these men had the same age distribution as all members of HM Forces serving overseas in 1957.[2] Hence, the figures for the overall size and age-distribution of the study population in table I.

TABLE I—PRESENT STATE OF THE FOLLOW-UP OF BRITISH SERVICEMEN WHO TOOK PART IN 1957–58 NUCLEAR WEAPONS TESTS

Age on Jan 1958	Expectations for South Pacific servicemen*: Age distribution†	All males	1958–82 deaths: All causes§	1958–82 deaths: All cancers¶	Present state of follow-up: All respondents	1958–82 deaths: All causes	1958–82 deaths: All cancers
[illegible]	[illegible]	1848	63	11·5	78	12	8
20–24	[illegible]	4008	192	35·1	136	25	18
25–29	[illegible]	776	56	13·1	25	13	10
30–34	[illegible]	480	57	14·9	28	14	9
[illegible]	[illegible]	416	81	22·0	47	20	17
[illegible]	[illegible]	296	91	25·6	15	7	5
[illegible]	[illegible]	120	55	15·1	1	1	1
50–54	[illegible]	56	36	9·1	—	—	—
Total	[illegible]	8000‡	633	146·4	330	92	69

*Including civilians; data from Atomic Weapons Research Establishments.
†See Registrar General's Statistical Review of England and Wales 1957 (HM [illegible]).
‡See text.
§Calculated from population calculated from 1961 and 1971 life-tables for England and Wales.
¶Calculated from quinquennial rates for England and Wales for period 1958–[illegible].

If these assumptions are correct then, although the number of respondents is, thus far, only 330, the number of deaths from leukaemia and other RES neoplasms is already much higher than would be expected if all 8000 men had been followed-up (table II). For 22 of the 27 RES neoplasms in table II there is inquest, pension tribunal, or death certificate confirmation of the cause of death. 13 other servicemen, still living, have reported RES neoplasms, and these include 3 leukaemias, 7 lymphomas, and 3 cases of polycythaemia vera. For all cases of RES neoplasms the records relating to the men's whereabouts in the 1950s include dates of arrival and departure from Christmas Island, service rank and number, and camp, ship, or squadron number.

TABLE II—CERTIFIED CANCER DEATHS (1958–82): OBSERVED AND EXPECTED NUMBERS BY SITE

Site (and ICD no)	Cancer deaths 1958–82: Ascertained†	Expected‡	Ratio
Digestive (150–159)	21	44·0	0·48
Respiratory (160–163)	11	51·9	0·21
Other solid (170–199)	10	33·3	0·30
RES neoplasms* (200–209)	27	17·2	1·57
Total (140–209)	69	146·4	0·47

*16 leukaemias, 9 lymphomas, 1 myeloma, and 1 polycythaemia vera.
†From 330 respondents.
‡From 8000 men.

For the men who died from causes other than RES neoplasms there was a history of aplastic anaemia in 3 cases, polycythaemia vera in 2, and lymphoma in 2. Finally, among the men who were under 25 years of age in 1958 (and therefore still in their 40s today), there are already 10 reported cases of cataract.

For the men with RES neoplasms the documentary evidence in support of the diagnosis and weapons test involvement is such that a major artefact can be confidently excluded. This leaves as possible explanations of the high incidence of these radiation-related cancers either: (*a*) far more men at risk than the 8000 we have allowed; (*b*) much higher radiation doses than has hitherto been supposed; (*c*) much higher cancer risks from small doses of radiation than has hitherto been supposed;[3] (*d*) exposure of the men to other causes of RES neoplasms, or (*e*) a combination of some or all of these factors.

Department of Social Medicine,
University of Birmingham,
Birmingham B15 2TH

E. G. KNOX
TOM SORAHAN
ALICE STEWART

SIR,—The figures presented in the above letter by Professor Knox, Dr Sorahan, and Dr Stewart, which refer to the men involved in the South Pacific tests during 1957–58, even on the most conservative estimates reveal a subsequent incidence of RES malignancies greatly in excess of the numbers expected on the basis of the relevant population statistics when analysed strictly in accordance with life-table methods. While, as Knox and his colleagues suggest, there may be causes other than radiation for the excess RES malignancies, the reported incidence of cataract, virtually unknown as a spontaneous occurrence among young men, is a strong indication that some of those involved had received radiation greatly in excess of a safe dose.

The servicemen present at the nuclear test explosions constitute a unique, large sample of healthy young men who were at risk of exposure to ionising radiation and among whom there now appears to be evidence of radiation-related effects. To examine as fully as possible their subsequent medical histories, access to a complete nominal roll of the total group of exposed personnel is required, together with full disclosure of what is known about radiation exposure of the men on duty during these tests. We urge that an independent authority should be asked to conduct a full investigation into the morbidity, mortality, and possible genetic effects in these men, and provide the means to do so.

Saint [illegible]
[illegible]
London

J. F. BIRAS
J. FIELDING
JOHN H. HUMPHREY

Westminster Hospital Medical School,
London

ALLAN JACOBS

St Bartholomew's Hospital
Medical College, London

PATRICK LINDOP

London

JOSEPH ROTBLAT

Middlesex Hospital Medical School,
London

JAMES A. THOMPSON

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'Lancet' letter backs A-test cancer theory

by PAUL LASHMAR

CLAIMS that British servicemen have died and suffered illnesses from being present at British nuclear tests in the 1950s and 1960s have been supported by evidence from a leading cancer expert.

Dr Alice Stewart, of the University of Birmingham, has established that 27 men from a sample of 330 veterans of atomic tests on Christmas Island in the late 1950s have died of cance of the blood-forming organs. This kind of cancer, which includes leukaemia, has a high incident rate among people exposed to substantial doses of radiation.

In a letter to the medical journal, the *Lancet*, published yesterday, Dr Stewart said that statistically she would have expected only 17 deaths from these cancers in the entire batch of 8,000 men who served on Christmas Island.

A group of British nuclear test veterans has formed an association to fight for compensation for men and the relatives of men who they say suffered as a result of being at the tests.

So far, the Ministry of Defence has maintained that no one suffered from the tests and has refused to pay pensions to men who claim they have suffered illnesses from being exposed to radiation. The ministry says that safety rules at the tests were 'stringently observed.'

In January, three days after a front-page article in THE OBSERVER highlighting the plight of the veterans, the Ministry of Defence announced it would organise a mortality survey of the 12,000 servicemen who had been at the tests at Monte Bello and Christmas Island and the Maralinga test range in Australia.

Dr Stewart's figures have been compiled from names given to her from letters from former servicemen written to BBC Nationwide and THE OBSERVER.

A second letter in yesterday's Lancet from a group of seven eminent doctors and professors, all experts on radiation and its effects, supports Dr Stewart's data and calls for a full independent inquiry.

One of the group, Dr Jack Fielding, Honorary Conant Haematologist at St Mary's Hospital, Paddington, described Dr Stewart's figures as 'amazing and unexpected.'

He said yesterday: 'It is clear that the sample of 330 are self-selecting but Dr Stewart has already found a much greater incident of cancer of the blood-forming organs than you would expect from the entire sample of 8,000 men.'

Dr Fielding is certain that many of the men have been exposed to radiation. 'What is also striking is the amount of additional evidence from the data that many of the men have been exposed to radiation. If you include those who died of other causes but had cancers like leukaemia and suffering from these cancers like leukaemia and include men still alive but suffering from these cancers you get 48 cases—15 per cent of the sample.

'Ten of the sample have cataracts, which in men of these ages are rare except for those exposed to radiation.'

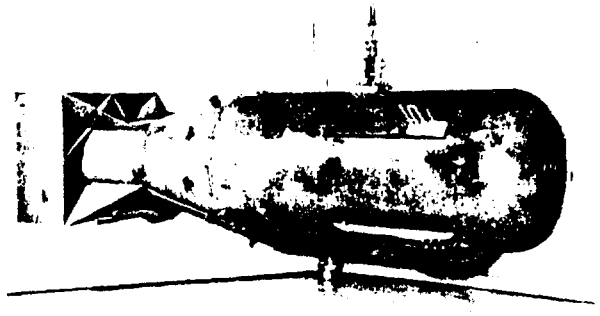
The seven doctors and professors want the ministry's survey to be turned over to an independent body and extended to cover servicemen who are living and to test the sons and daughters of veterans.

 [Science] vol 212 May 22 1981

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.



U.S. Air Force

Did it produce neutrons or mostly gamma rays?

Duplicate of the bomb that hit Hiroshima

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.

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. 512.

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

Outsider causes unease

Candidate George Keyworth

"a very good scientist who is a lot broader than his background would indicate."

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