



September 24, 2001

Dear Dr. Jameson,

Thank you for the opportunity to comment on consideration of three forms of ionizing radiation for listing as reasonably anticipated or known human carcinogens in the Eleventh Edition of the Report on Carcinogens.

Following are summaries of studies investigating effects on human and cell populations from gamma-rays, x-rays, and neutrons. Evidence exists that all forms of ionizing radiation are carcinogenic, not just the ones you have chosen for investigation. Alpha and beta particles also cause cancer and we strongly recommend that you list these radiation types as known carcinogens. We will formally submit references on this point at a later time. Due to the tragedies of September 11, research facilities have been difficult to access or simply unavailable. We would like additional time to comment which we believe to be available based on our phone conversation earlier last week. Therefore, we will add further comments concerning gamma, x-rays and neutrons. Where possible, we include not only the reference of the studies, but the studies themselves.

Significant numbers of people are exposed to all ionizing radiation types. While many humans are subjected to gamma-rays, x-rays, and neutrons from medical diagnosis and treatments, these exposures end with the patient and the patient's family. In addition to minimizing medical exposures, we must recognize and curtail the daily environmental contamination which exposes us to additional and long-lasting radiation doses. Ionizing radiation is spewed daily from the entire nuclear fuel chain including nuclear reactor operations such as at reprocessing facilities and power reactors and weapons fabrication facilities. Workers and members of the public are being exposed continually and over generations as a result of release of man-made radionuclides to our environment which do not simply vanish conveniently with the current generation. Many of the studies summarized and referenced here consider human disease in and around such facilities.

Ionizing radiation causes cancer. This is not disputed and while we welcome the NTP consideration to list these carcinogens, we also think it is about time. Throughout the scientific literature, there are statements like 'there is not safe dose of radiation', 'there is no dose of radiation below which a negative effect is not seen', "the well-recognized role played by ionizing radiation in the development of certain other forms of malignant diseases can be extended to include carcinoma of the breast...(MacKenzie, 1965)", radiation is a general carcinogen. (Please see our sheet of compiled quotes from eminent scientists and researchers on the dangers of even low levels of ionizing radiation). More importantly, the human and cell data illustrated by scientific studies support the fact that ionizing radiation causes cancer. Further, a low dose of radiation does not diminish the risk involved. Some studies show that lower doses actually pose more danger per unit dose than higher doses. Since NTP is only considering whether something is a potential or known carcinogen and is not considering dose or risk, we have not compared the low-dose risk and high-dose risk of cancer causation. However, it is important to note that low-doses of the radiation types in question have been linked with cancer and, further, these doses are within the range of doses not just to workers, but to members of the general public as well. These members include unborn and young children who studies have found are particularly susceptible to radiation.

Not only do these studies show that ionizing radiation causes cancer, many are starting to reveal the cellular mechanisms that allow this to happen at both the cellular and the organism level. Some studies indicate the ability of ionizing radiation to cause genomic instability which leads to cancer in future generations of both cells and humans; in the case of some cell cultures, the actual radiation dose was not delivered to the precursor of the damaged cells, but only to neighboring cells.

Evidence for carcinogenicity of X-RAYS

Human

*1) Court Brown, W.M., Richard Doll. "Mortality from Cancer and Other Causes after Radiotherapy for Ankylosing Spondylitis. *BMJ* 1965,2. 1327-1332. AND FOLLOW-UP:

2) Weiss HA, Darby SC, Fearn T, Doll R. "Leukemia mortality after X-ray treatment for ankylosing spondylitis" *Radiat Res* 1995 Apr;142(1):1-11

Population: Patients treated for Ankylosing Spondylitis with x-rays.

Follow up-time: 5-25 years based on patients; disease end point: Death

Total deaths from Cancers expected 133.25; Deaths observed: 267

Aplastic Anemia: .51 expected; 15 Observed

Leukaemia: 5.48 expected; 52 Observed

Other cancers of irradiated sites: expected: 127.27; 200 observed

The researchers estimate that "...in an average follow-up period of 13 years after first treatment the excess deaths from leukaemia and from other cancers arising in heavily irradiated tissues, which can be attributed to the effects of ionizing radiations, were 4 per 1,000 patients and 6 per 1,000 patients respectively."

"There is, however, no known factor other than radiotherapy which could account for an increase in so many different types...It remains a possibility, however, until a sufficient series of observations have been made on patients treated by other methods."

And as a follow-up study in 1995 concludes:

"Leukemia mortality has been studied in 14,767 adult ankylosing spondylitis diagnosed between 1935 and 1957 in the United Kingdom, of whom 13,914 patients received X-ray treatment. By 1 January 1992, there were 60 leukemia deaths among irradiated patients, almost treble that expected from national rates.

Leukemia mortality was not increased among unirradiated patients. Among those irradiated, the ratio of observed to expected deaths for leukemia other than chronic lymphocytic leukemia was greatest in the period 1-5 years after the first treatment (ratio = 11.01, 95% confidence 5.26-20.98) and decreased to 1.87 (95% confidence interval 0.94-3.36) in the 25+ year period."

3) Dr. John Gofman, M.D. Ph.D, Egan O'Connor, ed. *Radiation from Medical Procedures in the Pathogenesis of Cancer and Ischemic Heart Disease: Dose-Response Studies with Physicians per 100,000 Population*. CNR Book Division, 1999.

* an Introductory chapter will be provided.

Using the number of physicians per 100,000 people in the nine census regions Dr. Gofman has demonstrated strong support for medical irradiation as "a highly important cause (probably the principal cause) of cancer mortality in the United States during the Twentieth Century."

In his monograph, Dr. Gofman uses a 1988 and 1993 UNSCEAR (United National Committee on the Effects of Atomic Radiation) report to support his physician- per-population method. The report states "...a good correlation was shown to exist between the number of x-ray examinations per unit of population and the number of physicians per unit of population."

The percentages of the death-rates from all cancer caused by medical radiation (i.e., the percentage would be absent if medical radiation were absent): females 50% , 1988; males 74%, 1988.

*4) Knox, E.G., A.M. Stewart, et al. Prenatal Irradiation and Childhood Cancer. *Journal of The Society for Radiological Protection*. 1987; 7(4).

Population: 14,759 geographically matched and birth-date- matched case/control pairs of children who died of cancer in England, Wales and Scotland.

The pre-natal radiation relative risk of childhood cancer between the ages of 4 and 7 years is 2.11.

Time span: From 1950-79 about 7 percent of all childhood cancers, and 8 percent of those with onset between the ages of 4 and 7 years were caused by x-ray examinations.

Disease end point: Death

*5) Population: 50,000 female breast cancer patients. There was doubling of lung cancer risk for those who chose radiation therapy versus other methods of treatment. No dose or delivery information. Treatment was from 1973-1986. (*WSJ*, May 14, 1993). Unfortunately, we could not find the published study referenced in the *Journal* article.

6) Gofman, M.D., Ph.D, John W. *PREVENTING BREAST CANCER: The story of a Major, Proven, Preventable Cause of This Disease*. 1996.

The author of this 450 page review of breast cancer studies concludes that about three-quarters of recent and current breast cancer incidence is caused by earlier exposure to ionizing radiation, primarily from medical procedures (x-rays). For a complete list of references and the complete book please see <http://www.ratical.org/radiation/CNR/PBC/contents.html>.

Cell Studies

*1) Waldren, C, et al. "Measurement of low levels of x-ray mutagenesis in relation to human disease." *Proc. Natl. Acad. Sci. USA* 1986. 83.

Mammalian cells used. Caffeine synergism found to double the mutagenic yield of x-rays on certain cell components. X rays create a high level (about 94%) of complex genetic lesions. Complex lesions are harder to repair and can lead to many somatic cell disease endpoints including cancer. Additionally, at lower doses there is a higher mutational efficiency than at higher doses; this observation runs counter to expected results.

Evidence for carcinogenicity of NEUTRONS

Cell

*1) Ponnaiya, M. N. et al. "Induction of Chromosomal Instability in Human Mammary Cells by Neutrons and Gamma Rays". *Radiation Research* 147, 1997, 288-294.

Cells: human mammary cells irradiated with 0.43 MeV neutrons

Result: Neutron irradiated cells showed cell aberrations greater than controls consistently between 5 to 40 population doublings post irradiation.

*2) Harper, K., et al. "Delayed appearance of radiation-induced mutations at the Hprt locus in murine hemopoietic cells". *Experimental Hematology* 25: 263-269 (1997)

Mouse bone marrow cells irradiated with Californium-252. Note that the researchers also performed this experiment on mouse cells with no spontaneous incidence of leukemia or particular susceptibility to radiation-induced leukemia. The result was a 2-3 fold increase in mutations 14-15 cell divisions after neutron irradiation. (please also note much the same conclusions are shown for x-rays in this study)

Conclusions: Following x- and neutron radiation of cells researchers found an increase of radiation-induced genomic instability in descendants of these cells. The type of instability created may contribute in the accumulation of mutations necessary for tumor progression. The authors conclude by saying "The causal link between ionizing radiation and cancers has long been established (ref. Given), although little is known about the mechanisms involved."

* On this topic, see also an overview by Prof. Eric Wright "Radiation-induced genomic instability: a brief overview" given at a symposium in 1999

Evidence for carcinogenicity of GAMMA RAYS

Human

*1) Wing, S. et al. "A Reevaluation of Cancer Incidence Near the Three Mile Island Nuclear Plant: The Collision of Evidence and Assumptions". *Environmental Health Perspectives*. 105 (1). 1997.

Population: General public exposed to external radiation from the Three Mile Island accident in 1979 in the path of the released radiation plumes. Estimated dose by use of cytogenetic analysis was 60-90 rads.

Endpoint: cancer incidence

Results: increases of two to ten times were seen in leukemia, lung cancer and all cancers.

*2) Wing, PhD et al. "Mortality Among Workers at Oak Ridge National Laboratory: Evidence of Radiation Effects in Follow-up Through 1984." *JAMA* 265 (11).

Population: White male employees of Oak Ridge National Laboratory, A Department of Energy facility in Tennessee.

Endpoint: all causes of death

Conclusions: Leukemia deaths were 63% higher than expected

*3) Gardner, M. J. et al. "Results of case-control study of leukaemia and lymphoma among young people near Sellafield nuclear plant in West Cumbria". *BMJ*. 300. 423-429. 1990.

Population: Children who were stricken with leukemia-lymphoma in the West Cumbria Health district, near the Sellafield nuclear reprocessing plant.

Endpoint: leukemia-lymphoma cases

Conclusions: The relative risk of leukemia/lymphoma among children with fathers working at Sellafield Nuclear Facility ranged from 2.44 to 6.42. "The raised incidence of leukemia, particularly , and non-Hodgkin's lymphoma among children near Sellafield was associated with paternal employment and recorded external dose of whole body penetrating radiation during work at the plant before conception."

--See also Viel, JF. "Incidence of Leukaemia in Young People Around the La Hague Nuclear Waste Reprocessing Plant: A Sensitivity Analysis". *Statistics in Medicine*. 14: 2459-2472 (1995).

This study finds an association between childhood leukemia (among residents) and the La Hauge reprocessing plant in France.

*4) Kneale, G.W., A.M. Stewart. "Childhood Cancers in the UK and their Relation to Background Radiation" in *Radiation and Health*. Ed. By R. Russell Jones and R. Southwood. 1987. John Wiley & Sons, Ltd.

Population: UK Children

Endpoint: Cancer deaths

Conclusion: The study concludes that the effects of terrestrial gamma radiation is stronger than prenatal x-rays. The effect is even more pronounced when combined with other sources of background radiation including weapons testing, emissions from nuclear power and other nuclear facilities, etc. The researchers conclude that external penetrating radiation is the principle causes of childhood cancer, causing 80% of all cancer deaths before 16 years of age.

*5) National Economic Council. *Occupational Illness Compensation for Department of Energy Contractor Personnel; Report of Task Group I DRAFT*. January 2000.

*6) Alvarez, R. "The Risks of Making Nuclear Weapons: A Review of the Health and Mortality Experience of U.S. Department of Energy Workers." For The Government Accountability Project. January 2000.

Two synopses, both culling information from studies investigating the link between cancer incidence and ionizing radiation exposure at United States weapons fabrication facilities run by the Department of

Energy. From Alvarez "All told, workers at fourteen DOE facilities were found to have increased risks of dying from various cancers and non malignant diseases."

Cell

*1) Morgan, W. F. et al. "REVIEW: Genomic Instability Induced by Ionizing Radiation". Radiation Research 146, 247-258 (1996).

For a good synthesis of ionizing radiation genomic instability studies, see (Morgan, et al. 1996).

One conclusion: "The loss of stability of the genome is becoming accepted as one of the most important aspects of carcinogenesis, and the numerous genetic changes associated with the cancer cell implicate genomic stability as contributing to the neoplastic phenotype."

Many studies summarized in this publication show genomic instability created by neutrons, x-rays and gamma rays.

An * indicates that a copy of this study will be provided

Cindy Folkers
Energy Future Project Coordinator
Nuclear Information & Resource Service

Brent Blackwelder
President
Friends of the Earth

Researchers and Studies which support the LNT or even stricter radiation standards

There are many reputable scientists who believe, based on their research, that there is no threshold for radiation damage to humans- no dose which is harmless. These are just a few of their words:

“There is no safe level of exposure and there is no dose of radiation so low that the risk of a malignancy is zero”—Dr. Karl Z. Morgan, dubbed the father of Health Physics.¹

“...there is no safe level of exposure to ionising radiation, and the search for quantifying such a safe level is in vain.”—Rosalie Bertell, PhD.²

In 1940, several members of the US Committee on X-Ray and Radium Protection “proposed that the [radiation exposure] standard be lowered by a factor of five in response to the accumulating evidence that ANY amount of radiation, no matter how small, can cause genetic damage, injuring future generations.” Gioacchino Failla argued against the lowering of the standards saying that “if genetic damage were to be a consideration for standard-setters, then logically no radiation exposure should be allowed.”³

“...the human epidemiological evidence establishes—by any reasonable standard of proof—that there is no safe dose or dose-rate...the safe-dose hypothesis is not merely implausible—it is disproven.” Dr. J.W. Gofman⁴

“One thing we should take from this (1991 study of Oak Ridge weapons workers by Steve Wing, et al.) is that there isn’t any safe level of radiation exposure...” Dr. Carl Shy⁵.

“The reanalysis (of Hanford worker data) provides no support for the idea that...there is reduced cancer effectiveness of radiation at low dose levels...” Drs. G.W. Kneale and A. Stewart⁶.

“There is evidence that single tracks of all types of ionizing radiation can induce a variety of damage including DNA double-strand breaks which are believed to be critical lesions in radiation exposure. There is also a body of experimental evidence that argues against an error-free DNA repair system operating at low doses of ionizing radiation that might result in a dose threshold for the induction of gene and chromosomal mutations.” MP Little and CR Muirhead.⁷

“An important feature of alpha irradiation is that, no matter how low the total dose to the whole body, a substantial dose of radiation (approx. .5 Gy) is delivered to an individual cell if it is traversed by a single alpha particle.” E Wright⁸.

The U.S.

Committee on the Biological Effects of Ionizing Radiations concludes that, despite some evidence of a partial repair mechanism, recent low-dose radiation data "do not contradict the hypothesis, at least with respect to cancer induction and hereditary genetic effects, that the frequency of such effects increases with low-level radiation as a linear, non-threshold function of the dose." (National Research Council BEIR V 1990)

Works Cited:

- 1... "Cancer and low level ionizing radiation" *The Bulletin of the Atomic Scientists*. September 1978.
- 2.... *No Immediate Danger? Prognosis for a Radioactive Earth*. Women's Educational Press, Toronto, Ontario. 1985: 45. isbn 0-88961-092-4
- 3 Caufield, Catherine. *Multiple Exposures: Chronicles of the Radiation Age*. Harper and Row, New York. 1989: 48. isbn 0-06-015900-6.
- 4... *Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis*. Committee for Nuclear Responsibility, Inc. 1990:18-16, 18-18. Isbn 0-932682-89-8.
- 5 Garloch, Karen. "Repeated low radiation doses hike leukemia risk, UNC study finds." *The Charlotte Observer*. Wednesday, March 20, 1991.
- 6 ... "Reanalysis of Hanford Data: 1944-1986 Deaths." *American Journal of Industrial Medicine*. 23:371-389 (1993).
- 7... "Curvilinearity in the Dose-Response Curve for Cancer in Japanese Atomic Bomb Survivors." *Environmental Health Perspectives*. 105 (6): 1505. (1997)
- 8... "Chromosomal instability in the descendants of unirradiated surviving cells after alpha particle irradiation." *Proc. Natl. Acad. Sci. USA*. 95: 5730 (1998).

The following are additional studies are not quoted above:

Epidemiology:

Stewart, A.M., et al. "Radiation Exposures of Hanford Workers Dying from Cancer and Other Causes." *Health Physics*. Nov (1977).

Stewart, A.M, et al. "Delayed Effects of A-bomb radiation: a review of recent mortality rates and risk estimates for five-year survivors." *Journal Epidemiology and Community Health*. 36(2):80-6 (1982).

Morgenstern, H., et al. "Epidemiologic Study to Determine Possible Adverse Effects to Rocketdyne/Atomic International Workers from Exposure to Ionizing Radiation" Report by the UCLA School of Public Health. September, 1997.

Wing S., et al. "Mortality Among Workers at Oak Ridge National Laboratory." *JAMA*, 26 (11):1397 (1991)

Cell studies:

Lorimore S. A., et. al. "Chromosomal Instability in the descendants of unirradiated surviving cells after alpha particle irradiation." *Proc. Natl. Acad. Sci. USA*. 95: 5730-5733 (1998). (Eric Wright is co-author)

Kadhim M. A., et al. "Transmission of chromosomal instability after plutonium alpha particle irradiation." *Nature*. 355:738 (1992). (Eric Wright is co-author)

Many more published studies (especially cell studies) and entire books show scientific evidence for the tightening of radiation standards in order to adequately protect human health. Those listed above are in no way wholly representative, but merely provided as reference.