Proceedings of ICONE 8
8th International Conference on Nuclear Engineering
April 2-6, 2000, Baltimore, MD USA

8792

APPLY RADIATION HEALTH EFFECTS DATA TO CONTRADICT AND OVERTURN RADIATION PROTECTION POLICIES AND RULES

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ABSTRACT

Low-dose, low-dose-rate, radiation enhances biological responses: for immune systems, enzymatic repair, physiological functions, and apoptotic removal of cellular damage, etc., enhancing biological capability and health, including prevention and removal of cancers and other diseases.

Low level radiation research has also shown no adverse effects in studies with the power to demonstrate such effects. And studies have shown beneficial biological and health effects in many substantial human biological and epidemiological studies, and animal experiments.

However, radiation protection policies and rules do not consider such valid data. They use data that are: 1. Not relevant. 2. Poor, and therefore sufficiently ambiguous to enable claims that “the linear model is not precluded.” 3. Misrepresented and manipulated, that falsify science research and reporting.

Since radiation protection interests strongly influence radiation research funding, science and science policy, the conduct of research and reporting of results, they ignore and suppress the data and the policy implications of contradictory results.

In some cases, scientific data are misrepresented and falsified. Scientific misconduct investigations are warranted for some results by radiation protection-funded scientists.

Research must document, and apply, these data to clinical applications. Unfortunately, U.S. Department of Energy and other radiation-protection committed research fails to address these essential biology and medicine objectives. Therefore, research and data assessments must be conducted by independent researchers and organizations that do not depend on radiation protection-controlled funding, directed to address the health and medical science.

The U.S. National Institutes of Health (NIH) Study Section on Radiation Research must be disbanded. Biological and health research applying radiation should be considered in the relevant biology and medicine research areas.

Research is needed by organizations whose primary interest is in providing cost-effective treatment of patients.

Independent assessment of the data must incorporate the scientists and analysts that have documented for decades that radiation health effects data is not, can not be, “linear.”

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Government agency rule-makings must be made accountable. Current proceedings promulgate decisions that are unaccountable to the public and 'stakeholders.' Radiation health effects 'facts,' conclusions, and recommendations, are promulgated by "advisors" in secret. They, and their staffs, are a "self-selected" group that depend on, and are rewarded by, radiation protection agencies, including funding to establish academic credentials. They fail to consider data and recommendations from the knowledgeable science, scientists, and analysts. Their decisions are then "accepted" by the agencies, that claim they are not subject to appeal for 'arbitrary and capricious' decisions. This premise, however, is subject to court challenge.

In addition we must: Defer current research and "cleanup" programs (those without significant interim public risk). Redirect research to organizations committed to credible biology, health and medicine, independent of radiation protection policies. Test/confirm the data that show health benefits. Conduct research on optimum doses and delivery modalities. 'Reengineer' radiation technologies that are made most cost-prohibitive by extreme radiation protection requirements. Investigate studies and scientists that misrepresent data for "scientific misconduct."

INTRODUCTION

Low-dose, low-dose-rate, radiation has been proven to enhance biological responses that are at all degraded. This is especially true for the immune system, for enzymatic repair of DNA damage, for physiological functions of cells and tissues, and apoptotic removal of damaged cells. These functions are shown to enhance biological capability and health. The effects of these enhancements include prevention and removal of cancers and other diseases.

Such capabilities have succeeded in eliminating some cancers, and other diseases.

Radiation protection policy fails to consider such valid data. It relies on data that is poor, and therefore sufficiently ambiguous to enable claims that "the linear model is not precluded;" and on data and analyses that are misrepresented and manipulated, thereby falsifying the science research and reporting. Scientific misconduct investigations are warranted for some results promulgated by radiation protection-funded scientists, including review committee participants.

Research to document, and apply these data to clinical applications, can be readily achieved. In current medical applications, less definitive data is routinely applied to conduct biomedical research and clinical trials.

Unfortunately, the U.S. Department of Energy, and many other radiation protection-funded research programs fail to address the essential biology, health, and medical objectives.

Numerous studies show that LDR prevents and reduces cancer and other diseases. Numerous studies show that immune system, enzymatic repair, physiological, and apoptotic repair/removal functions, tumor-suppression genes and proteins, and related cellular communications, are enhanced.

These results can be readily confirmed if conducted by researchers committed to understanding the underlying role of radiation in health and medicine. Radiation research journals and their peer-reviewers, dominated by radiation-protection-funded scientists, constrain publication of results that contradict radiation protection objectives.

It is necessary to engage research by organizations whose primary interest is in providing cost-effective health and successful treatment of diseases for patients.

Independent assessment of the data must incorporate the scientists and analysts that have documented for decades that radiation health effects data is not, can not be, "linear."

Revised government agency rule-makings must be conducted to be accountable for their substantive radiation health effects conclusions. Current proceedings promulgate decisions that are structured to be

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unaccountable. The factual bases, conclusions, and recommendations, on radiation health effects are promulgated by “advisors” in secret proceedings.

The advisors and committee members are a “self-selected” group of individuals that depend on, and are rewarded by, the government radiation protection agencies. This includes providing the funding necessary to establish academic credentials.

The staffs of this group also depend on funds from the government agencies. They are also “self-selected” by the radiation protection interests.

Such review bodies and committees fail to even acknowledge, much less substantively respond to, data and recommendations from the knowledgeable and credible science, scientists and analysts. Their decisions are considered to not be subject to the process of appeals for ‘arbitrary and capricious’ agency decisions. This premise, however, is subject to challenge in the courts, despite the Congressional initiative to defeat the ruling by the Supreme Court that the National Academy of Sciences is subject to the Federal Advisory Committee Act (FACA).

EARLY HEALTH PHYSICS OBJECTIVES BIAS THE SCIENTIFIC DATA

In a March 1996 meeting at the U.S. Nuclear Regulatory Commission (NRC), Charles Willis of the NRC stated, as reported in the transcript (ACRS/ACNW):

“...it's clear to many of us that we are not seeing the predicted ill effects at low doses, as has been pointed out to you.

“I personally came to this hormesis observation fairly late in the game. It wasn't until 1958 that I was working with the laboratory [Note: Oak Ridge] situation where we were doing experiments with below background levels of radiation, taking the potassium-40 out and seeing what the effects would be on the cellular level when we saw that the cells looked good but they didn't function. So we couldn't publish the results, another ill effect of the paradigm about the linear hypothesis.”

Potassium was separated at Oak Ridge for radiobiology experiments. Dr. Willis confirms that radiation research, funded for radiation protection objectives, supported the LNT by suppressing contrary scientific data, and that this activity dates back to the 1950's. Animal studies using separated potassium were also conducted. They have been stated to have “done poorly” but they recovered when the extracted K-40 or natural potassium was added.

Such potential bias in radiation protection-based research and results should be confirmed or refuted.

The organisms in potassium without K-40 were biologically deficient. This is consistent with the case with organisms that have been shielded from background radiation in numerous and wide variety of experiments

For example, organisms grown on glass slides were repeatedly found to grow differently. It was eventually found that those grown on slides with lower thorium content were deficient. The LNT precludes this “accident” from being known in the light of the accidental discovery of penicillin. But, it will be known. And those who suppressed the knowledge will also be known.

Supplemental radiation above natural background, stimulate these organisms. They demonstrate enhanced growth and increased mean lifespans. Such results have been consistently and extensively confirmed.

These and equivalent experiences confirm that data that contradict the LNT have not been adequately considered by radiation protection agencies and scientists. In addition, many scientists who have been interested in conducting such research, and in publishing such results, were constrained in their efforts.

Such experience was reported by Dr. Jake Spalding of Los Alamos to Senator Pete Domenici. (1999)

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Such experience was also reported by Prof. Dr. Gunnar Walinder about UNSCEAR in his 1995 book, stating also: **"I do not hesitate to say that the LNT is the greatest scientific scandal of the 20th Century."** (1996)

Animals with 'whole' immune systems and not living in a pathogen-free environment showed an increase in average lifespan and lower adverse health effects, with no adverse effects at doses below 10's to 1000's of rads. Dr. Egon Lorenz of the National Cancer Institute reported in Manhattan Project records that mice **"were irradiated with 4.4, 1.1, 0.11, and 0.044 r per 24-hr day. .. Male mice conceived and living continuously under exposure to 4.4 r/24-hr day up to total doses of over 2000 r are comparable with non-irradiated mice as far as weight, coat, and activity are concerned. Mammary tumor incidence is not significantly changed in mice exposed for 10-15 months to doses ranging from 4.4 to 0.44 r per 24-hr day"** and subsequent generations living **"under exposure of 1.1 and 0.11 r per 24-hr day show no damage to chromosomes as evidenced by the raising of 5 to 6 generations with normal litter size and an apparently normal life span."**(1954)

Notwithstanding this reality, by 1950 he states: **"It is well known that absorption of ionizing radiation by tissues is connected with damage, no matter how small the dose"** in a study that showed longer lifespans than controls in whole mice exposed to chronic radiation at 0.11 r/day, or about 40 r/year.(1950)

Marshall Brucer, M.D., states with respect to the Manhattan Project: **"Their first experiment, raising mice in an atmosphere of uranium dust, showed exposed mice lived longer than controls. They set up an arbitrary Maximum Permissible Dose (MPD) after proving that mice in radiation fields ten times the MPD lived longer than controls."** He states that after WWII about 20 articles per year mentioned hormetic effects, but **"Health Physicists soon learned that their livelihood depended on scaring the pants off Congress…Every Genetics budget meeting opened its request for funds with an anti-nuclear litany. …during the 1960s and 1970s about 40 articles/year described hormesis. In 1963 the AEC repeatedly confirmed lower mortality in guinea pigs, rats, and mice irradiated at low dose. In 1964 the cows exposed to about 150 rads after the Trinity A-bomb in 1946 were quietly euthenized because of extreme old age. In 1981 T. Luckey revived a very obvious radiation hormesis. *No* experimental evidence of damage at low doses existed; self-serving extrapolations from high dose-data dominated health physics."** (1990)

In the May 1961 Journal of the American Medical Association (JAMA), Dr. Hugh Henry, then at Oak Ridge, reported on all low-dose studies (defined as 'to about 1 rad per day'!) that the results show consistent life-lengthening vs. neither life-shortening, nor genetic effects.

He reports on early animal studies that had hormetic effects from internal doses, e.g., for U and Pu injections and feeding of U compounds, and for external γ- and x-radiation. Life-lengthening was regularly found, and radiologists and others with relatively high doses had no adverse health effects. He concludes: **"The preponderance of data better supports the hypothesis that low chronic exposures result in an increased longevity than it supports the opposite hypothesis of decreased longevity... Increased vitality at low exposures to materials that are toxic at high exposures is a well-recognized phenomenon."**

Voluminous, credible, peer-reviewed scientific literature data exists. Dr. T.D. Luckey, Prof. Emeritus of the U. Missouri School of Medicine presents a great deal of that literature, with more than 2,000 references.(1980,1991)'

In 1996, DOE investigated allegations about the now-accepted fact that the Oak Ridge mega-mouse studies presented false data on genetic effects starting in 1951. They under-reported the numbers of

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mutations in the control animals. International programs have abandoned the mouse data, and are assessing genetic effects of radiation for potential effects on genetic diseases, an effect never before indicated.

The Oak Ridge geneticist and statistician who had the access and expertise to analyze the original data and identified these deficiencies, a member of UNSCEAR, also alleged that the misrepresentations of the data seemed to have been intentional. This allegation was rejected by Oak Ridge. However, the other instances of failing to report scientific data indicate possible confirmation of practices of misrepresenting research in the 1950s. U.S. NRC and DOE, and the Congress, should formally inquire about these allegations, and whether contrary data were adequately considered in reviews and research results, and support for research.

In 1971, following the Federal Appeals Court "Calvert Cliffs decision," that the AEC Environmental Impact Statement was inadequate, the AEC contracted for the "Argonne Radiological Impact Program" to improve the basis to assess low level radiation health effects. Dr. Norman Frigerio analyzed U.S. cancer rates by state average background radiation doses; and applied the LNT models which were found to contradict the LNT, with consistently lower cancer rates in high-background states (since consistently confirmed). (1973) In 1973, although contracted by AEC itself to address the regulatory issues of low level radiation effects in response to a court action, AEC and radiation science policy interests terminated the study, and the results were not published.

This study was presented at a 1976 IAEA Conference on natural radioactivity. (Frigerio and Stowe, 1976) Dr. Walinder reports that these results were suppressed in UNSCEAR 1977. (1995) They were similarly arbitrarily dismissed in BEIR III 1980, with no scientific inquiry. Total populations with significant dose differences are the ideal test of the LNT, but analysis is suppressed. The AEC termination of the Argonne program should be investigated.

The program plan was to continue, to obtain more accurate radiation dose data, to apply the analysis at the more definitive correlation at the county level. The result was expected to confirm the preliminary inverse correlation results. Dr. Frigerio and others stated that this was the reason the study was terminated. These results have been confirmed in analysis of EPA radiation data of high vs the low background radiation states.

Conferences on natural background radiation consistently report the lack of health effects, and even beneficial effects, in high-background exposed populations. The high background whole body radiation doses shows no adverse health effects in a stable Chinese peasant population of about 70,000 living for generations in high radiation areas. The radioactivity source in high background areas are millions of times greater than the radioactivity allowed to be released from nuclear facilities or nuclear waste sites, at massive public cost.

RADON - MISREPRESENTING THE DATA

In the 1980s, Dr. Bernard Cohen personally undertook natural background radiation studies similar to that terminated by the AEC in 1973 (and by ERDA/DOE and NRC). He tested the LNT using the significant lung cancer data vs. variations in residential radon. Initially, he found that lung cancer in the high radon area of Cumberland County PA was lower than the Pennsylvania average, and documented many other studies that found similar results. (1987)

Radon data did not exist at the county level. So Dr. Cohen obtained radon measurements in the 10 counties with the lowest, and the 10 with the highest, lung cancer rates. He found that radon levels were consistently higher in the counties with low lung cancer rates. (1989) This was then also found in the 100 counties in which university physics departments supported his effort to obtain residential radon measurements.

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Dr. Cohen then succeeded in measuring radon in 272,000 homes in the most populated U.S. counties. These data also consistently found inverse results, in dozens of independent studies of, e.g., 'all-rural' counties, 'all urban' counties, etc. (1995) Dr. Graham Colditz of Harvard, a world-renowned epidemiologist, contributed to an interim analysis of the data by counties. He confirmed the validity of the epidemiological analysis of these data. (Cohen and Colditz, 1994) Dr. Cohen also acquired all EPA and state radon data. These data also showed an inverse relationship.

In the full data set, the inverse correlation exceeds 20 standard deviations vs. BEIR IV predictions. The chance of error is equivalent to all the electrons in the universe. Any confounding factor must be: much greater than smoking; inversely correlated with radon; and unrecognized. This is inconceivable, except for only one postulate: radon doses at normal background levels stimulate lung tissue functions to protect against lung cancer.

Radiation protection interests ignore these confirmed results by alleging that "they are ecological studies," with no scientific basis to refute the data. No valid scientific criticism of Dr. Cohen's results has been documented, although general rationalizations of why one study might not be valid have been argued; but there is no basis to conclude that all of dozens of such studies are consistently in error. Yet radiation protection interests use these unfounded statements to misrepresent that these data have been refuted, and to constrain publication of confirmatory studies.

Dr. Kenneth Bogen at LLNL independently used 1950-1954 lung cancer mortality for women of ages 40-80 and 60-80 (who had smoked little), by county with EPA county environmental (not residential) radon data. He also confirmed the inverse correlation between lung cancer and radon. Dr. Bogen's biological model applies cellular response data to show that the inverse relationship is consistent with known biological responses. (1996, 1998)'

Prof. Dr. Werner Schuttmann, of the former East Germany, and Prof. Dr. Klaus Becker of Berlin Germany, documented research results that show that women in the very high radon uranium mining areas of Saxony, who have negligible smoking, have significantly lower lung cancer rates than women in lower radon areas. (1997) The Health Physics Journal denied publication due to comments by reviewers with the non-scientific statements that 'this is just another ecological study, and everyone knows that Dr. Cohen's studies are erroneous.'(Becker, 1998)

LNT supporters erroneously claim that "case-control" studies are "better." However, the accuracy of such case-control studies is completely dependent on knowing the individual doses. This is true in most case-control studies where doses/exposures are measured and controlled. However, in most radon case-control studies, individual doses are poorly known. Residential radon measurements are used. Therefore, "dose groups" are only statistical estimates, without knowing individual doses. But with small numbers combined with uncertainty of the correlation, there are wide errors. Unlike large population studies, case-control can not produce accurate or replicable dose-response results. In fact, the nature of statistics provides statistical power in large ecological studies. They apply rigorous statistics that more accurately represent mean doses vs. lung cancer rates.

In addition, the uncertain doses in most radon case-control studies produces much greater bias in the higher-dose region. The high-dose group is likely to include persons that have low-doses, while it is unlikely that the low-dose group will have persons with high-doses. Therefore, the high-dose group will have a bias toward excess cancers that are shown to result from low radon exposures. In addition, case-control studies do not adequately address cases in the very low-radon regions where the well-documented effects in Dr. Cohen's data, and other more definitive population studies, demonstrate that increased lung cancer is expressed.

It has been shown that the case-control studies do not contradict the results reported by Dr. Cohen and others with the dose regions and statistical errors produced by the case-control studies.

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Finally, Drs. Fritz Seiler and Joe Alvarez show that a "dose-response model" specifying "confounding factors" is necessary to determine a risk (e.g., the lung cancer risk from radon) when using a small representative population to produce a substantive basis to apply it to a large population. In that case, a "model," with any "confounding factors" must correct for systemic errors in applying the specific small-population data to the whole population. However, they show that for Dr. Cohen's results, as confirmed by others, show the actual relationship for the whole U.S. population. Therefore, a precise "model" and any "confounding factors" are irrelevant to "predict" the relationship to the whole population. EPA, and BEIR IV and VI, substantially misrepresent the data on the risk of residential radon for lung cancer in the U.S., and the world.

RADIUM DIAL PAINTERS AND OTHER RADIUM-CONTAMINATED PERSONS

In 1974, the preeminent radium health effects researcher Dr. Robley Evans of MIT rigorously demonstrated in an article in the Health Physics Journal (1974) that BEIR (1972) had misrepresented the data on the health effects of radium to produce a "linear no-threshold" result from extremely non-linear data. On his 1970 retirement, the Center for Human Radiobiology (CHR) was established at Argonne.

In 1981, an international conference reported that in then thousands of cases worldwide, there were still no cases of bone cancer or nasal carcinoma from ingestion of less than 250 uCi of Ra-226, producing an estimated dose of 1000 rad to the bone. The report was published in 1983. Dr. Evans stated in the "Invited Summary" of the conference: (1983):

"The studies of the radium cases during the past dozen years...has continued to show no radiogenic tumors, or other effects, in hundreds of persons whose effective initial body burden was less than about 50 uCi of Ra-226, and whose cumulative skeletal average dose is less than about 1000 rad." In 1983 DOE initiated termination of this program that had been established for the life of the dial painters, with more than 1000 cases still alive. (It may be that this message was received by the Radiation Effects Research Foundation that was established to follow the Japanese A-bomb survivors for life.)

It is significant that systemic intake of 50 uCi Ra-226 is about 125,000 times the annual ingestion at the EPA 5 pCi/l drinking water limits. Reductions in these limits are even being proposed to require greater public water supply expenditures under EPA program control. However, a moderate reduction in the limit by a factor of 4 would essentially eliminate the need for monitoring for radium and significant unnecessary costs, and still provide a safety margin of more than 30,000 to a person who drinks 1.1 liters per day of that water.

In the 1990s, follow-up after "another decade" confirmed these results. Dr. Robert Thomas, a long-time radiobiology researcher at LANL, a program manager at DOE, and the last Program Director of the Center for Human Radiobiology at Argonne to close the program, showed that the log-normal distribution of cancers projected a threshold of 400 rad without even considering the total absence of cancers in the large population with doses below 1000 rad. (1994) Dr. Constantine Maletskos, working with Dr. Evans and others similarly established that such a threshold was valid. (1994) Further analysis by Dr. Robert Rowland, former Director of the CHR, has more conclusively determined that a threshold exists. (1997) He states: **"Today we have a population of 2383 cases for whom we have reliable body content measurements... All 64 bone sarcoma cases occurred in the 264 cases with more than 10 Gy, while no sarcomas appeared in the 2119 radium cases with less than 10 Gy."**

To contradict these objective results, as used to misrepresent the actual data in BEIR IV, Drs. Charles Mays and Raymond Lloyd selected a first wide low-dose group range that included no cancers, and a second wide dose-group range that included the lowest dose with cancer, to manufacture a "linear" result.

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In the Federal Register in 1991, the EPA responded to a recommendation by its Science Advisory Board that they apply the radium dial-painter health effects data to establish radium limits in water, by stating (1991):

'EPA policy… is to assess cancer risks from ionizing radiation as a linear response. Therefore, use of the dial painter data requires either deriving a linear risk coefficient from significantly non-linear exposure-response data, or abandoning EPA policy and SAB/RAC advice in this case.'

Simply, science is irrelevant to the campaign to mislead the public about the hazards of radium, and radiation generally.

FDA achieved control of radiation from Congress using the notorious 1932 death of Philadelphia industrialist and socialite Eben Byers from a massive overdose of radium ingested in large quantities over 3 years, creating public fear. Byers did not die of cancer. Bone necrosis led to removal of his jaw and other interventions that put a gruesome image on the radiation effects. But FDA did not then assess the dose effects to the thousands of persons who had also used radium and other radiation sources; or acknowledge that Byers had been the victim of the equivalent of a drug overdose. The amount of radium that Eben Byers ingested daily is about 2,000,000 times EPA limits, based on drinking 1 liter/day at 5 pCi/l. The threshold for latent bone cancers from ingesting radium by the dial painters is more than 125,000 times the annual limits from drinking water at 5 pCi/l.

Following this, Dr. Edna Johnson and others suppressed well-known data on the stimulatory effects of low doses of ionizing radiation, especially, a 1937 NAS report, to claim that "radiation is harmful."

OCCUPATIONAL STUDIES: NO ADVERSE EFFECTS - MISREPRESENTED

The Nuclear Shipyard Workers Study (NSWS) funded by DOE was not reported. This 10-year, $10 million study of 39,004 nuclear workers (NW) carefully matched with 33,352 non-nuclear workers (NNW), from a population of 108,000 NW in a total population of about 700,000 workers, was completed in 1987. (Cameron, 1992) It was not published. After some pressure, DOE released a contractor's report, with a press release, in 1991. (Matanoski, 1991)

These radiation workers were exposed to external Co-60. They had good dosimetry and records in a program controlled by Admiral Hyman Rickover. They had limited confounding work experience. But this data was kept out of BEIR V (1990) stating that the NSWS was not published, even though the NSWS Technical Advisory Panel Chairman and BEIR V Chairman was the same person, Dr. Arthur Upton. However, BEIR V used other non-published sources, as such reports have always used when it suits them, as in the draft NCRP SC1-6 report, also chaired by Dr. Upton.

In the summary, the NSWS reports that the high-dose NW mortality rate was 0.76 that of NNW.

Of special interest is the fact that the summary report did not include "all cancer" mortality, since this is a most common factor, and of most interest in any such study. However, Dr. Myron Pollycove examined the detailed tables in the report and documented that the "all cancer" mortality in the detailed tables is also statistically-significantly lower than the NNW! The suppression of these results calls into question the scientific integrity of this study, and potential allegations of "scientific misconduct."

After long negotiations, Dr. Genevieve Matanoski, the Principle Investigator, received a continuing substantial contract from DOE in 1994, and retired as Head of Epidemiology at Johns Hopkins. Now, more than 5 years later (more than 12 years since completion of the original study), no papers have been published. There is no report to Congress, the shipyard workers, radiation protection agencies, or the public. There is substantial concern about the integrity of the data.

Further, this most definitive NW study was not included in a study of "all" U.S., U.K., and Canadian nuclear workers, contracted by DOE with the International Association for Research on Cancer (IARC,

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1996). The IARC included only 95,000 US, UK, and Canadian NW, with generally poor dosimetry and substantial confounding factors data, while suppressing the much more definitive NSWS.

IARC misrepresents its own data to claim that these results support the LNT. This IARC study, using only the weaker early NW data, was proclaimed as a definitive study, with a public relations campaign before the data was published to claim that it is the "best evidence of the linear dose-response to low doses." (This may be true, to the extent that it states, yet again, that no evidence exists for a low-dose linear dose-response).

This claim rests on one cancer, leukemia (absent chronic lymphocytic leukemia). There are 119 deaths in a total of 15,825 deaths, and one data point in the small high-dose group at ">40 cSv" that shows only 6 Observed deaths vs. 2.3 Expected deaths. The 116 leukemia deaths below 40 cSv show no excess leukemia. The IARC "analysis" discounts this data, and data points below the controls values (by a one-tailed p-test). They are able to produce a "trend analysis" in which the 6 vs. 2.3 deaths data point alone causes a positive slope. This data is then made to seem statistically valid by applying Monte Carlo modeling of 5000 trials. This manipulated data is used to support the LNT. This is highly questionable, as either science or policy-making, or ethics.

The IARC (with ICRP, NCRP, and other radiation protection organizations) public relations campaign widely disseminated these conclusions before the data were reported. Once the data was published, reviewers found that the data do not support the claims. The NCRP and others know this fact. Actually, as Dr. Luckey has shown, the actual data of the workers in this study demonstrate a hormetic effect, consistent with many other NW vs. NNW dose-response studies. (1997a, 1997b) With small numbers of cases in dozens of specific cancers, it is more surprising that no other cancers reflect the 1 in 20 possibility of exceeding the normal range of statistical significance.

Dr. Warren Sinclair, President emeritus of NCRP and controlling influence of NCRP, ICRP, UNSCEAR, and National Research Council/Board of Radiation Effects Research (BRER), however misrepresents the IARC report as "vindicating" the LNTH. Not only does this misrepresent the data, such a conclusion is contradicted by the lack of health effects in millions of people exposed to moderate doses, that are often much more well defined, especially from medical workers and patients, and from high-dose natural background radiation sources.

However, the NCRP and radiation protection interests claim that this is "the best study" to confirm that the LNT is valid. The ICRP/NCRP/BRER group would not use it so consistently if there were any obviously better studies to support the LNT hypothesis. On that basis alone, the LNT can be seen as refuted.

Dr. Luckey summarized the major NW vs. NNW studies. He shows that the NW have much lower cancer in 7 million person-years of exposure, and notes that, as with other natural nutrients, supplementation of deficiencies in human health are warranted. (1997b) This data further indicates the need to confirm the beneficial effects. Unfortunately, such research objectives are not supported (are constrained) by the radiation protection interests.

BEIR V 1990

It is important to consider that BEIR V primarily relies on the RERF Japanese survivor studies. (1990) Six other primary studies are identified as "used for model fitting" (p. 162-3). These studies are claimed to support the LNT. However, even these few studies have substantial contradictory evidence that BEIR V does not address.

Some have internal contrary data. Some are criticized in the literature. For some, other equivalent populations show contradictory results. And stronger studies of other populations produce contrary results.

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In some cases, arbitrary non-scientific statements dismiss contradictory data without justification. Some populations, especially medically-exposed persons, have greater doses than those that BEIR V identifies as “data sets used for model fitting,” but they are not included in the BEIR analysis, as they are now not included in the draft NCRP SC1-6 report. Many do not have high-dose effects to project a straight line to zero dose.

Finally, some significantly exposed populations, especially medically-exposed populations, of potential significance to assessing radiation health effects, are not studied by the radiation protection interests, e.g., natural background radiation populations, and persons who use and work at radium and radon spas.

Japanese Survivors Study

The Radiation Effects Research Foundation (RERF) Japanese survivor data at low doses have been substantially questioned, without resolution. This is especially true since DOE’s arbitrary reassignment of RERF from the National Academy of Sciences to a DOE-recruited and selected investigator at Columbia University.

Many independent studies of the RERF data contradict RERF analyses, even when limited to using the RERF's own processed data in the absence of access to the raw data. Even BEIR V consultants were unable to obtain the data to undertake an independent analysis.

Even then, some RERF data show more evidence of hormetic effects than adverse effects at low doses. However, critical analyses are not considered by radiation protection interests in BEIR V, or Draft NCRP Report SC1-6.

Certainly however, in the first instance, the conditions of doses to persons exposed directly to an atomic bomb, and confounding factors of survivors, both before and after the bombing, are of no significance to the assessment of the health effects of chronic low-dose exposures to environmental contamination.

Use of the RERF results for the assessment of health effects is well known to be inappropriate because the exposure does not apply to radiation protection for workers and the public exposed to chronic and highly fractionated and low dose-rate radiation, especially for extreme costly cleanup and decommissioning standards. Virtually all analysts, including the RERF researchers, as expressed at the Nov 1997 IAEA conference in Seville, have stated that the instantaneous gamma and neutron atomic-bomb-exposed population is not relevant to the assessment of effects for low-dose rate and low-dose exposures.

In his book, Dr. Walinder also reports on the “expectation” of UNSCEAR members that the RERF data would be manipulated to produce ‘expected’ results that support the LNT. (1995)

It is also common that BEIR V states that there are no adverse effects below a high dose, but then presumes a dose-response of a straight line to zero dose. For example, for colon cancer, BEIR states that: in the atomic-bomb survivors there is no excess cancer **“evident in doses below about 1.0 Gy.”** However, the linear model is then applied down to zero dose. This presumes an effect to less than 0.0001 Gy to support a radiation protection policy that even 0.00001 Gy should not be ignored in assessing collective dose and regulatory controls (e.g., NCRP 121, 1995).

Relative to significant populations with good dosimetry and relatively unconfounded results, for example, among medical patients and practitioners; the Japanese survivor results are both highly questionable and largely meaningless to the assessment of low-dose, low-dose-rate radiation health effects for radiation protection policies. They do indicate some agreement with high-dose-rate exposure results in animals and humans that have demonstrated beneficial effects at low to moderate doses.

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FLUOROSCOPY OF WOMEN WITH TB: BREAST CANCER - MISREPRESENTED

The Canadian fluoroscopy study is the second highest exposed group listed in the BEIR data sets "used for fitting the data". As noted, this study explicitly misrepresents it own data to report a linear dose-response in the literature and BEIR V. This figure has been published elsewhere in the literature and is contained in the RSH "Data Document" (Muckerheide, 1998), in the 1995 Nuclear News article, (Muckerheide, 1995) that are specifically referenced in the draft NCRP report.

Below about 30 cGy there is a highly statistically significant reduction in breast cancer by 1/3 in the largest group with a mean dose of 15 cGy, 2.7 standard deviations below zero risk. This equates to 10,000 fewer cancers in 1 million women at 15 cGy, instead of the false statement that 900 excess cancers are expected. This is consistent with other evidence of reduced breast cancer from low-dose radiation exposure, e.g., Makinodan. (1992) A straight line is projected from the high-dose data through zero. This forces a linear relationship despite the data. (This is consistent with the misrepresentation of data in many studies.)

Nevertheless, BEIR V also applied this false straight line in its report, which is presumably the reason to use this study at all. More substantial studies that fail to show adverse effects that can be claimed to support the LNT are not included. NCRP members continued to claim that this study supports the LNT in 1995 and 1996, using this widely known false straight line to zero. An inquiry is needed to establish whether the authors intended to report the data inaccurately.

In 1996 an 'update' was published by Dr. Geoffrey Howe, the second author of the original study. (1996) (DOE recruited Dr. Howe to Columbia University, and reassigned the RERF study from the National Academy of Sciences. DOE's initiative was defeated.) Howe claimed that the data now fail to show the hormetic effect identified in the original study.

However, the large low-dose groups are collapsed to one low-dose group of 1-49 cGy, obfuscating the data from the largest patient groups at 15 cGy (10-19 cGy) and 25 cGy (20-29 cGy) and 0-9 cGy, the largest group, 30-39 cGy, and 40-59 cGy.) When challenged on this conclusion at a meeting at the National Academy of Sciences in 1997, Dr. Howe stated only that the low-dose groups were "not informative" and responded similarly at a meeting at Chalk River. However, the low-dose groups had the largest number of cases, with the smallest errors.

The draft NCRP report states that this later paper "refutes" the 1989 study, even though the problem of "lumping" the data has been repeatedly identified. The NCRP also states that this is confirmed by a later paper by Howe (identified as "1998, in press") but does not provide any explanation or scientific basis for this conclusion. The NCRP Report makes this uninformative dismissive statement, to this most significant study (even according to BEIR V, chaired by the same Chairman), which has been extensively assessed and referenced by scientists that question the LNT. It has even been actively suppressed in 1994 UNSCEAR Appendix B, as described by Dr. Pollycove. (1996) However, the NCRP report is filled with voluminous data of limited or no applicability to assess adverse health effects, or even biological effects in whole organisms, to support the LNT.)

Note also that Dr. Howe also published an analysis of lung cancer in these women. (1995) They have significantly lower lung cancer at doses below about 2 Gy (200 rad) than the low-dose group. This is consistent with many other studies, as specifically presented by Drs. Harald Rossi, a member of BEIR and ICRP, and Marco Zaider, who reviewed all relevant data. They found that lung cancer is lower in groups that are exposed to low to moderate doses, from x-rays and other sources. (1997)

BENEFICIAL EFFECTS: EVIDENCE NOT CONSIDERED, AND SUPPRESSED

The data on beneficial effects, including such uses of radiation in the first half of the century, have not been studied or considered. The health and medical benefits of patients that receive significant low and

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moderate exposures are not considered, as with the Canadian fluoroscopy breast cancer study. In order to assess low-dose effects, all studies should analyze the dose range below the level at which adverse effects are demonstrated.

The biological evidence that organisms in below-normal radiation background demonstrated adverse health effects has also not been considered, or even confirmed and evaluated. But more importantly, the data on many organisms that have demonstrated beneficial effects from supplemental radiation, including the prevention and elimination of cancer and other diseases, is not considered.

The extensive evidence of the stimulation of immune responses is not considered, including the many documented sources in Appendix B of the UNSCEAR 1994 report. (1994) Such research has led directly to successful treatment of some cancers by stimulating the immune system using low-dose radiation (both alone and in combination with traditional high dose cancer therapy). Such results have been reported by Dr. Hattori (1994, 1997) from the work of Dr. Sakamoto and Miyamoto (Sakamoto et al, 1987; Miyamoto and Sakamoto, 1987; Sakamoto, 1996; and Sakamoto, et al, 1997), and Dr. Takai (1991) in Japan, and others. As noted by Dr. Hattori, funding for this research is constrained by radiation protection interests that prevent such government medical research.

Low-dose total body irradiation (TBI) and half body irradiation (HBI) has successfully treated and prevented some cancers. That breast cancer and other cancers may be prevented or treated should be data to be investigated. Suppressing this data maintains high costs to the public for radiation protection control of radioactivity sources that are far below natural radioactivity levels. There $100s billions that can provide no public health benefit in environmental cleanup alone. However, there may be even greater costs: to women with breast cancer, and to millions of others with cancers and other diseases that may be readily preventable or treatable at low cost, with inconsequential ‘side effects,’ by low-dose radiation.

Also, research is constrained on the millions of persons who have used radium and radon balneology for health and medical applications throughout the world. Such research as has been supported is not considered in establishing radiation protection policy, as with the radium dial-painters and others with high radium burdens. The positive medical results of such practices are also not considered. These constraints are to the great cost and detriment of the public in resolving the role of radiation and health.

CELLULAR AND MOLECULAR BIOLOGY: STIMULATING HEALTH BENEFITS

The biological justification claimed for the Linear Non-Threshold (LNT) model is that a single ionizing photon or particle can damage DNA in a cell that can lead to cancer. But an adult body is impacted by about 15,000 nuclear rays or particles every second – over a billion such events every day – from natural sources.

But each day the DNA in each cell loses ~5000 purine bases because the body’s normal heat breaks their linkages to deoxyribose. More damage is caused by normal cell division and DNA replication. But the most damage – a million DNA nucleotides in each cell damaged each day – is caused by free radicals created in the normal process of metabolism resulting from routine eating and breathing and the stress of heat and exercise. Radiation causes more double breaks per event in the DNA than metabolism does, and these are harder to repair than single breaks. But even with this difference, the mutations (unrepaired or misrepaired damage) from metabolism outnumber those caused by natural radiation ten-million-fold. (Billen, 1990)

There are a large variety of anti-oxidants that prevent damage, enzymes that continually repair damaged nucleotides in DNA, and removal processes to eliminate those it cannot repair. (Varmus and Weinberg, 1993) Even high-level radiation adds only a few more mutations to the millions that are occurring from metabolism.

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The effect of low-level radiation that is not strong enough to degrade the body's tissue repair capacity is suggested by how the body reacts to low levels of other potential toxins. When small quantities of disease bacteria or toxic metals are taken into the body, the result is to stimulate the immune system. One effect is that subsequent attacks by this toxin, in larger amounts, are more effectively countered. Radiation works just the same way. Numerous studies have shown that low-dose radiation enhances immune functions, enzymatic repair capabilities, and removal functions, and shown that cellular and DNA repair mechanisms are stimulated.

This improved immune response affects the entire spectrum of metabolic damage. Therefore, if and when the body's defenses are degraded, low-dose radiation improves the protection, repair and removal of damaged DNA and cells. Low-level natural background radiation, and organisms and animals at sub-ambient radiation levels consistently show higher cancer rates and other physiological deficiencies. They recover when returned to normal background radiation or are provided supplemental radiation from external sources.

Therapeutically, the work in Japan, and in the U.S., have shown that 10-15 cGy full-body or half-body x-ray doses, delivered in 1-2 minutes, several days apart, stimulate the body's defense mechanisms. Specific immune responses were sufficiently definitive in animal studies to justify clinical trials for cancer suppression. The patients were generally far-advanced cases, therefore not ideal candidates for immune function stimulation. However, individual cases were successful, and a long-term clinical trial on non-Hodgkin's lymphoma patients has confirmed that the low-dose group substantially outlived the controls at 5 years and 10 years.

New initiatives are underway to establish the role of radiation in health rather than to maintain the constraints of committees and research committed solely to radiation protection. More is needed.

However, existing voluminous radiobiology and epidemiology data provide sufficient bases to refute the LNT, to find that low-dose radiation does not constitute a public health hazard, and to determine that it is beneficial. Directed research is necessary to better understand the precise mechanisms, and to quantify the various levels and conditions at which these benefits exist; and to more precisely establish the levels and conditions at which human exposure can be considered safe. But those levels are at least many multiples of average natural background radiation for chronic exposure

CONCLUSIONS

Voluminous, credible, peer-reviewed studies have demonstrated health benefits in response to low-level radiation in the 58 years since the Manhattan Project studies that refuted the LNT, and many more going back more than 100 years.

NO substantial, confirmed, studies in hundreds of studies in which the LNT dose-response would be readily demonstrated if it were valid, demonstrate the LNT – in low, moderate, and even in relatively high-dose populations.

However, these data are systematically ignored, and actively suppressed, by radiation protection interests that control radiation science policy, science funding, and reviews. Research has been terminated, publication has been constrained, reviews have ignored and misrepresented data, etc.

The "LNT hypothesis" is a fiction. It is maintained by a closed, biased, interest group at massive public cost, as taxpayers, electric ratepayers, and medically-insured; and to the extreme detriment of future generations as from resultant constraints on the human benefits of nuclear technologies.

Radiation protection limits have been 'ratcheted' to levels that obtain public funds to address radiation sources that are less than 1% of the variation in natural background radiation.

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Therefore, trillions of dollars world-wide are being extracted from the public on the basis of LNT-justified radiation protection policies. These policies mislead the public to believe and support these expenditures as protecting public health.

Appropriate extreme corrective actions are needed:

1. **Defer massive site 'cleanup' programs** (those without significant interim public risk), pending an expedited preliminary independent review of any potential health benefits, to be led by persons not committed to the LNT, or with conflicts of interest in the funds and agencies that depend on the LNT. Court action may be needed in light of legal agreements on the basis that such agreements were fraudulently based.
2. **Direct radiation protection-funded-and-controlled research to health and medical research institutions** competent in biology and epidemiology. Apply LDR to clinical trials and life-saving interventions. Provide health stimulation data to medical interests and the public. Research the optimum radiation supplements and delivery modalities to prevent/cure cancer and other diseases, and to enhance general health. Apply the data that show: Radiation levels below natural background cause adverse health effects (by shielding, removal of K-40 from natural potassium, etc.). Epidemiological studies with significant, well-known, doses show low-dose results that contradict the LNT. Enhanced immune, enzymatic, physiological, and tumor-suppression in "immunologically whole" organisms, in animal experiments and in human patients, workers, etc. Study the Taiwan residents exposed to Co-60 contamination starting in 1982, with strong indications of much lower cancer rates than unexposed residents. Formal studies are suppressed by the radiation protection interests.).
3. **Apply "cleanup" funds to research to "reengineer" radiation technologies** anticipating standards that provide assured public health and with much more cost-effective applications to enhance public benefits.
4. **Initiate government agency rulemakings to incorporate radiation health effects data – made subject to public input and legal accountability.** (Undertake legal challenges to rules that have failed to adequately consider the scientific evidence.)
5. **Investigate science studies that misrepresent and suppress data for "scientific misconduct."** Include official reviews that fail to include all, and misrepresent, relevant data. Also, **identify the costs of defrauding the public** ($100s billions in direct costs that provide no public health benefit, and greater indirect costs for premature cancer deaths, and other adverse health consequences).

The indirect human, economic, and environmental costs of the constraints on radiation technologies are much greater than even the direct costs. Indirect costs apply to energy (in many forms, not just electricity), food and water irradiation, nuclear medicine, and industrial applications. They also include the current costs of suppressing human health and medical benefits.

Committed direct costs are likely to exceed one trillion dollars worldwide; indirect costs are greater.

The benefits of radiation technologies can substantially alleviate pending world conflicts over oil, food, water, and other resources. They can reduce environmental degradation.

Future world resource demands are driven by a population growing by the total US population every 3 years; combined with the rapidly growing expectations of individuals in the developing world. These needs can be met by applying cost-effective nuclear technologies, combined with reduced absolute first-

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world per capita resource requirements achieved by applying the advanced electronic and materials technologies.

Knowledgeable scientists and analysts are providing the extensive evidence on the data, and questioning the process of controlling research and results, and scientific reviews. This evidence, and these views, must be considered by public policy, science, and legal authorities. The request by U.S. Senator Pete Domenici to the U.S. General Accounting Office to assess the validity of the LNT is a good first step. Due in June 2000, this report must be followed up by the knowledgeable science, public policy, and legal authorities.

We must reorient radiobiology and radiation health effects expertise, and radiation technologies. We must develop the enormous opportunities to provide more cost-effective medical, technology, and environmental benefits to provide the enormous essential resources that can reduce potential world conflicts, for the world our grandchildren will inherit.

REFERENCES

ACRS/ACNW, 1996, U.S. NRC, Advisory Committee on Reactor Safeguards and Advisory Committee on Nuclear Waste Joint Subcommittee: 1st Meeting, Rockville, MD, (March 26).

Becker, K., 1998, personal communication.

BEIR V, 1990, "Health Effects of Exposure to Low Levels of Ionizing Radiation", Report of the Advisory Committee on the Biological Effects of Ionizing Radiations (BEIR Committee), National Academy of Sciences-National Research Council, Washington, D.C.

BEIR, 1972, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation". Report of the Advisory Committee on the Biological Effects of Ionizing Radiations (BEIR Committee). National Academy of Sciences-National Research Council, Washington, D.C.

Billen, D., 1990, "Spontaneous DNA Damage and Its Significance for the 'Negligible Dose' Controversy in Radiation Protection," *Radiation Research,* Vol. 124, pp 242-245.

Bishop, M., 1989, "Cancer," in Molecular Biology of the Cell, Bruce Alberts, J.D. et al., Eds., Chap. 21 pp. 1187-1218, Garland Pub.

Bogen, K. T., 1996, "A Cytodynamic Two-Stage Model that Predicts Radon Hormesis (Decreased, then Increased Lung-Cancer Risk vs. Exposure)," Preprint UCRL-JC-123219. Lawrence Livermore National Laboratory, Livermore, CA (40 p.,150 references).

Bogen, K. T., 1998, "Mechanistic Model Predicts a U-Shaped Relation of Radon Exposure to Lung Cancer Risk Reflected in Combined Occupational and U.S. Residential Data," BELLE Newsletter, 7: 2 (Nov).

Brucer, M., 1990, A Chronology of Nuclear Medicine, Heritage Publications, St. Louis.

Cameron, J. R., 1992, "The Good News about Low Level Radiation Exposure: Health Effects of Low Level Radiation in Shipyard Workers," Health Phys. Soc. Newsletter 20:9

Cardis E, Gilbert ES, Carpenter L, Howe G, Kato I, Armstrong BK, Beral V, Cowper G, Douglas A, Fix J, et al, 1996, "Effects of Low Doses and Low Dose Rates of External Ionizing Radiation: Cancer Mortality Among Nuclear Industry Workers in Three Countries," Radiat. Res.,145, 647

Cohen, B. L., 1987, "Tests of the Linear, No-Threshold Dose-Response Relationship for High-Let Radiation," Health Phys. 52:629.

Copyright © 2000 by ASME

Cohen, B. L., 1995, "Test of the Linear-No Threshold Theory Of Radiation Carcinogenesis For Inhaled Radon Decay Products," Health Phys., 68, pp157-174.

Cohen, B. L. and Colditz, G. A., 1994, "Tests of the Linear-No Threshold Theory for Lung Cancer Induced by Exposure To Radon," Environmental Res., 64:65.

Cohen, B..L., 1989, "Expected Indoor 222Rn Levels in Counties with Very High and Very Low Lung Cancer Rates," Health Phys. 57:897.

Evans, R. D., 1974, "Radium in Man," Health Physics, 27, pp 497-510

Evans, R. D., 1983, "Highlights of the Meeting - Invited Summary," In: Radiobiology of Radium and the Actinides In Man, Proc. of an Int'l Conf, Health Phys 44 (Supp 1), 571-573

Frigerio, N. and Stowe, R., 1976, "Carcinogenic and Genetic Hazard from Background Radiation," IAEA Symposium, Biological and Environmental Effects of Low Level Radiation, vol. 2, pp285-289, Vienna.

Frigerio, N., Eckerman, K. and Stowe, R., 1973, "Carcinogenic Hazard from Low-Level, Low-Rate Radiation, Part I," Rep. ANL/ES-26. Argonne Nat. Lab

Hattori, S. (1994) State of research and perspectives on radiation hormesis in Japan, Intern. J. Occup. Med. Toxicol., 3:pp203-217. See also BELLE Newlsetter Vol. 3, No.1.

Hattori, S., 1997 Interview, "Using low-dose radiation for cancer suppression and vitalization." 21st Century Science and Technology.

Hattori, S., 1997, "State of Research and Perspective on Adaptive Response to Low Doses of Ionizing Radiation in Japan," In: Low Doses of Ionizing Radiation: Biological Effects and Regulatory Control, IAEA-TECDOC-976, IAEA-CN-67/126, pp402-405.

Henry, H. F., 1961, Is all nuclear radiation harmful?, J. Am. Med. Assoc., 176, 671.

Howe, G. R., 1995, "Lung Cancer Mortality Between 1950 and 1987 after Exposure to Fractionated Moderate-Dose-Rate Ionizing Radiation in the Canadian Fluoroscopy Cohort Study, and a Comparison with Mortality in the Atomic Bomb Survivors Study," Radiat. Res. 142, 295-304

Howe, G. R. and McLaughlin, J., 1996, "Breast Cancer Mortality Between 1950 And 1987 After Exposure To Fractionated Moderate-Dose-Rate Ionizing Radiation In The Canadian Fluoroscopy Cohort Study," Rad Res. 145:694

Lorenz, E., 1950, "Some Biologic Effects of Long-Continued Irradiation," Am. J. Roentgenol., 63, 176.

Lorenz, E., 1954,. Biological Effects of External Gamma Radiation, Part I, (R. E. Zirkle, ed.), McGraw-Hill, New York, p24.

Luckey, T. D., 1980 Hormesis with Ionizing Radiation, CRC Press, Boca Raton, FL. Also in Japanese, Soft Science, Inc., Tokyo.

Luckey, T. D., 1991, Radiation Hormesis, CRC Press, Boca Raton, FL.

Luckey, T. D., 1997a, "Ionizing Radiation Decreases Human Cancer Mortality Rates," In: Low Doses of Ionizing Radiation, Biological Effects and Regulatory Control, IAEA-TECDOC-976, IAEA-CN-67/64, pp227-230.

Luckey, T. D., 1997b, "Estimation of a Minimum Yearly Radiation Allowance (MYRA)," J. Clean Technol., Environ. Toxicol., & Occup. Med., Vol 6, No. 3, pp239-252.

Makinodan, T., 1992, "Cellular and Subcellular Alterations in Immune Cells Induced by Chronic, Intermittent Exposure In Vivo to Very Low Doses of Ionizing Radiation and its Ameliorating Effects on Progression of Autoimmune Disease and

 Copyright © 2000 by ASME

Mammary Tumor Growth," In: Low Dose Irradiation and Biological Defense Mechanisms, Sugahara, T., Sagan, L.A. and Aoyama, T. Eds., Elsevier Science Publishers, Amsterdam. 233-237.

Maletskos, C. J., 1994, "Radium in Man - 20 Years Later," ANS Transactions, vol 71, p. 33.

Matanoski, G.M. 1991 Health effects of low-level radiation in shipyard workers final report, June 1991, DOE, DE-AC02-79, EV10095.

Miyamoto, M. and Sakamoto, K., 1987, "Anti-Tumor Effect of Total Body Irradiation of Low Doses on WHT/Ht Mice," Jap. J. Cancer Clin. 33(10): 1211-1220

Muckerheide, J., 1995, "The Health Effects of Low Level Radiation Science, Data, and Corrective Actions," Nuclear News, 38, 11 (Sep).

Muckerheide, J., (Ed.), 1998, Low-Level Radiation Health Effects: Compiling the Data, also, Supplemental Data 1999, 2000 (in press), Radiation, Science, and Health, Needham MA Box 843, 02494

NCRP (1995) Principles and Application of Collective Dose in Radiation Protection. NCRP Report No. 121, National Council on Radiation Protection and Measurements, Bethesda. MD; 45.

Pollycove, M. (1996) "Positive health effects of low-level radiation....and why," University of California, San Francisco.

Pollycove, M., 1994, "Positive Health Effects of Low Level Radiation in Human Populations," In: Biological Effects of Low-Level Exposures, (BELLE) Calabrese, E. Ed. Lewis Publishers, Boca Raton, FL

Pollycove, M., 1997, "The Rise and Fall of the Linear No-Threshold (LNT) Theory of Radiation Carcinogenesis," American Physical Society Meeting, Physics and Society Forum, April 1997

Rossi, H. H., 1997, "Radiogenic Lung Cancer: The Effects of Low Doses of Low Linear Energy Transfer (LET) Radiation," Radiat. Environ. Biophys. 36:85-88

Rowland, R., 1997, "Bone Sarcoma in Humans Induced by Radium: A Threshold Response? In: Proc of the 27th Ann. Meeting, European Society for Radiation Biology, Radioprotection colloquies, 32,CI:331-338

Sakamoto, K. Myojin, M., Hosoi, Y., Ogawa, Y., Nemoto, K., Takai, Y., Kakuto, Y., Yamada, S., Watabe, N., 1997, "Fundamental and clinical studies on cancer control with total or upper half body irradiation." J. Jpn. Soc. Ther. Radiol. Oncol. 9:161-175.

Sakamoto, K., 1996, "Fundamental and Clinical Studies on Tumor Control," ANS Trans. 75: 404

Sakamoto, K., Miyamoto, M., Watabe, N. and Takai, Y., 1987, "The Effect of Low-Dose Total Body Irradiation on Tumor Control," Jap J. Cancer Clin., 33(13), 1633-1638; Jpn. J. Cancer Chemother 14(5), 1545-1549.

Schuttmann, W., and Becker, K., 1997, "Another Test for the LNT Hypothesis: Residential Radon in Saxony," to be pub'd.

Spalding, J., 1999, personal communication

Takai, Y., Ogawa, Y. Nemoto, K., Yamada, S. and Sakamoto, K., 1991, "Direct Anti-Tumor Effect of Low Dose Total (or Half) Body Irradiation and Changes of the Functional Subset of Peripheral Blood Lymphocytes in Non-Hodgkin's Lymphoma Patients after TBI (HBI), J. Jpn. Soc. Ther. Radiol. Oncol. 3: 9-18

Thomas, R., 1994, "The U.S. Radium Luminisers: A Case for a Policy of 'Below Regulatory Concern'." J. Radiol. Prot., 14, 2, pp 141-153.

U.S. EPA, 1991, Federal Register 56, (138), 33050-127.

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UNSCEAR, 1994, United Nations Scientific Committee on the Effects of Atomic Radiation, Annex B: Adaptive Responses to Radiation in Cells and Organisms, Document A/AC.82/R.542, 11 Mar 1994.

Varmus, H., and Weinberg, R.A., 1993, Genes and the Biology of Cancer, Scientific American Library, 153.

Walinder, G., 1995, Has Radiation Protection become a Health Hazard?, Karnkraftsakerhet & Utbildning AB (The Swedish Nuclear Training and Safety Center) Nykoping, Sweden.

Walinder, Gunnar (1996), personal correspondence.

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