ORGANIZING AND APPLYING THE EXTENSIVE DATA THAT CONTRADICT THE LNT

James B. Muckerheide
Mass. State Nuclear Engineer
President, Radiation, Science, and Health, Inc.
Co-Director, the Center for Nuclear Technology and Society at WPI
Worcester Polytechnic Institute, 100 Institute Road,
Worcester, MA 01609
781-444-8319, Fax 781-449-6464
Email: muckerheide@mediaone.net, rad-sci-health@wpi.edu

ABSTRACT

The identification, and organization, of radiation health effects data, is needed to effectively apply the large body of relevant, valid, scientific data. The existing data are being organized to provide an initial basis to undertake the necessary credible, rigorous, technical review needed to reassess the bases produced by ICRP, NCRP and BEIR Committees that ignore substantial data to characterize low level radiation as a hazard. Such a reassessment and reexamination of the bases for regulation has been called for by the NRC Advisory Committee on Nuclear Waste[1].

The Radiation, Science, and Health, data source document provides extensive relevant data[2]. It incorporates the contributions of many independent, knowledgeable, radiation scientists and public policy analysts, working in the public interest. This "Data Document" is being updated to incorporate additional significant data from existing and developing scientific sources.

The data is organized by exposed population. Human populations are: the Japanese atomic bomb survivors, occupationally exposed, medically exposed, radium dial painters and other radium-burden populations, and populations exposed to weapons and facility releases, and natural radiation sources, including radon. Data are also presented from animal studies; cellular and molecular biology studies, and biological modeling studies.

The document includes BEIR V data that document the lack of health effects[3]. Data will also be included from the few studies that are claimed to support the linear model, which are insubstantial and unconfirmed, or substantially misrepresented. This includes the occupational exposure study by IARC[4] that misrepresents its own data[5,6,7], and the mega-mouse studies at Oak Ridge National Laboratory that misrepresented the data[8.9], back to the 1950's. Unreported programs and studies are also being identified, including animal and cellular studies with potassium from which the radioactive K-40 had been removed[10], the $10Million, 10-year study of the Nuclear Shipyard Workers completed in 1987[11,12,13], and others.

Research programs are identified that indicate the lack of adverse effects at low to moderate doses, and beneficial effects to significant populations, that have been terminated or not funded to assess substantial epidemiological and biological data of significant populations. Such programs include the Center for Human Radiobiology, established to follow the radium dial painters and other radium populations for their lifetimes[14,15,16], the study of the "high-dose" AEC/DOE workers at Oak Ridge[17], and others.

Current radiation science and radiation protection policies are contrary to the scientific evidence. They have been characterized within the knowledgeable biology and radiation science community as they "disagree with modern oncology,"[18] are "without scientific foundation,"[19]

"an immoral use of our scientific heritage,"[20] and "the greatest scientific scandal of the 20th Century."[21]

These policies cause direct public costs of US$ 100s Billions, to limit radioactivity to levels that are below 0.1% of the variation in natural background radiation, which varies by more than a factor of 10^{22}. No more than a few percent of such expenditures contribute any public health and safety benefits. Such wasted expenditures are especially significant and immoral in economically constrained societies, with significant real health needs. Indirect costs of the loss of public benefits from nuclear and radiation technologies are much greater.

INTRODUCTION

This summarizes the document, "Low Level Radiation Health Effects: Compiling the Data", by Radiation, Science & Health, Inc. This data is not considered by the international radiation protection policy bodies and responsible government agencies. These institutions arbitrarily presume that low level radiation causes adverse health effects, linearly to zero dose, and cumulatively, with little dose-rate effect, to support costly radiation protection objectives. These conclusions are contradicted by data on radiation health effects, and are contrary to current knowledge of biology and carcinogenesis.

FRAMEWORK: RADIOACTIVITY, RADIATION PROTECTION, AND COST CONFLICTS

A century of radiation biology data, and cellular and molecular biology data, show that no excess adverse health effects exist, nor can exist, from low dose radiation. They show substantial data on the existence of non-linear and biopositive responses, including health benefits; and they show that populations, and animal studies, exposed to low levels of natural background radiation, and at levels below natural background levels, produce adverse health effects[23-25]. Nevertheless, radiation protection policies establish limits that are at levels that are less than 0.1% of just the variation in natural radioactivity levels[26]. Natural radioactivity levels vary by more than a factor of 10, producing annual doses from less than 1 mSv (100 mrem) to more than 100 mSv (1,000 mrem), with some local areas exceeding 500 mSv (5,000 mrem)[26]. Yet radiation protection limits address levels of 0.01 mSv (1 mrem), 0.04 mSv (4 mrem), 0.1 mSv (10 mrem), 0.15 mSv (15 mrem), 0.25 mSv (25 mrem), and higher[27].

The control or reduction of such levels, which are trivial and far below the 'noise' within the large variations in background radioactivity, can obviously provide no public health benefit. Such limits cause direct public costs of US$ 100s Billions, of which no more than a few percent contribute any public health benefits. In addition, indirect costs of suppressing the benefits of radiation applications to public health and welfare, are much greater than the direct costs. Many research programs and proposals to investigate and confirm evidence contrary to the linear no-threshold hypothesis have not been supported by radiation protection policy institutions that control health effects science research funding.

THE EVIDENCE CONTRADICTS AND REFUTES THE LINEAR NO-THRESHOLD HYPOTHESIS (LNTH).

In the early 1950s, long-term radiation health effects, were largely unknown, despite extensive evidence of, and research on, short-term health and medical benefits of low-dose radiation. Prudent, very conservative assumptions were made to produce initial criteria, or policy, primarily for use in limiting exposures to radiation workers. Normally in technical development, as research and development is completed, and knowledge of the subject grows,

the original assumptions are reduced in number and the criteria therefore become less conservative. Radiation protection policy is a major exception to this rule.

The LNTH is based on presumptions, from early assumptions for administrative purposes, that:

1. Health effects documented at high-doses and high-dose-rates can be projected to zero with no threshold, even though contradicted by voluminous data and scientific evidence, by scientific principles, and biological data; and
2. Each radiation "hit" that damages DNA contributes directly to the possibility that the cell will develop cancer, even though low dose radiation DNA damage is insignificant compared to normal oxidative DNA damage, which is 10 million times greater than average background radiation, i.e., at about 3 mSv/year (300 mrem/year)[25].

These presumptions lead to the concept of collective dose. This results in adding units that are concentrations, which is scientifically invalid[28]. Insignificant doses to individuals are therefore multiplied by large populations to predict health effects, equivalent to predicting: If 5 persons die in each group of 10 persons given 100 aspirins each, giving one aspirin each to 1000 persons will result in 5 deaths. The radiation protection policy that ignores dose rate effects data is equivalent to predicting that:

If taking 100 aspirin has a 50% probability to cause death, 1 aspirin per day for 100 days also has a 50% probability of causing death. The current presumption of applying a "dose-rate factor" predicts that: for a dose-rate factor of 2, there is therefore a 25% probability of causing death. This is equally fallacious. These presumptions further led to the policy of "as low as reasonably achievable" (ALARA), which today essentially requires not only that all regulations be met, but must then be exceeded as dictated by that ambiguous term, "reasonable".

The biological plausibility of these presumptions are refuted by:

1. The large body of world-wide radiation health effects data accumulated for over 50 years. Stimulatory biological effects and beneficial health effects exist in plants, animals and humans from low- to moderate-dose radiation exposures[2,23,24]. The positive immune response has prevented, and cured, cancer and other diseases[29-32]
2. Current knowledge of cellular and molecular biology. Cellular protection and DNA repair mechanisms accommodate the high rate of normal oxidative DNA damage events at 10 million times the damage rate of background radiation. And, radiation stimulates both DNA damage prevention, e.g., production of anti-oxidants, and essential DNA and cellular repair mechanisms, e.g., repair enzymes, p53 production, and apoptosis[25,28-34].
3. Current knowledge of cancer development. Multi-stage, iterative, biological processes preclude a linear cancer response to linear damage, as shown in biological models[35-37].

The data sources are from low and moderately high exposures to[2,23,24,38,39]:

1. Human populations from epidemiological and clinical studies: Early radiation workers, including medical practitioners, medical patients; the Japanese atomic bomb survivors, radium dial painters and other radium workers; and high natural background radiation exposures, including workers and residents in radon spa areas, and others. These studies consistently refute the hypothesis that low- to moderate-dose exposures cause harm, and do demonstrate that such exposures can provide health benefits.

2. Animal and plant populations exposed to high doses. Mammal populations exposed to more than 80 generations at moderate doses. These studies show no significant adverse health effects, but do provide voluminous evidence of beneficial health effects, even though radiation protection policy constrains such research and reporting of the data.
3. Biological research - in radiobiology, genetic and cancer research, and molecular biology: DNA and cellular damage from radiation is insignificant in the normal rate of metabolic cellular and DNA damage, and stimulates both damage repair mechanisms and immune functions, producing biopositive effects. This makes the LNTH biologically impossible.

DATA EXISTS AT THE DOSES AND POPULATIONS TO ESTABLISH THAT NO ADVERSE EFFECTS EXIST.

Contrary to radiation protection policy statements that the requisite data and knowledge do not exist in the low-dose region of interest, hundreds of scientifically valid studies exist in the peer-reviewed literature at low- to moderate-doses that fail to support, and directly contradict, the LNTH[2,23,24,38,39]. This evidence is frequently unstated, and even misrepresented, in the published papers[4,7,40,41]. The scientific data on exposed populations, and of biological research, are consistent with stimulation of biopositive biological and health responses to many stimuli, including pharmacological and physical stressors, from toxic metals to heat and exercise[42-45]. Plant and animal populations consistently find beneficial responses to low to moderate radiation doses[2,23,24,46,47].

Such beneficial responses are not seen in cells that do not have complete immune systems, and do not have the cellular communication and functional capability that is susceptible to positive stimulation and repair, nor in animals that are bred for tumorigenesis (without a complete immune system; nor in those kept in germ-free environments that provide no immune challenge)[23,24]. These are laboratory artifacts that do not represent whole organism responses and health significance results. Other studies fail to consider controls that die prematurely, and even include low-dose animals with the controls to "improve the statistics" relative to reporting high dose adverse effects[23].

THE RSH "DATA DOCUMENT" SUMMARIZES THE EXISTING EVIDENCE.

1. The Japanese atomic bomb survivors

The study of this population has limited scientific and public policy application to setting radiation protection policies for chronic and low-dose radiation.

This population was exposed to near-instantaneous radiation of atomic bomb detonation, and has enormous confounding factors of personal conditions, and the effects and contaminations of war-time life, bomb effects, and follow-up conditions. Individual exposures are largely unknown, with radiation dose estimates that are known to be in substantial error, especially due to uncertainty in the neutron dose in Hiroshima. The "control" population was in the area following the bombing and so exposed to the fallout. The dose to these persons is claimed to be less than 0.5 cGy, but fallout doses have been estimated to be 20-50cGy. Therefore the Japanese survivor health effects are of minimal value to the knowledge of radiation dose-response for radiation protection purposes.

Unlike most government-funded studies, the Radiation Effects Research Foundation (RERF) data is not available to reviewers. This includes analysts for the taxpayer-funded BEIR reports. Recent US DOE attempts to establish control over the RERF provides further uncertainty in the results, following DOE defunding and closing of the Center for Human

Radiobiology while more than 1000 of the study population was still alive; and its failure to publish the results of the 10-year (1978-87), $10 million, Nuclear Shipyard Worker Study that contradicts the LNTH, and to which $millions more were committed by DOE in 1994, still without publication.

However, notwithstanding these limitations, Dr. Sohei Kondo[48] and others report on the processed RERF data[48], plus independent analyses[50-52], that adverse health effects in this population are limited to persons exposed to high radiation doses. In the population of about 75,000 persons followed for 40 years, with about 21,000 total deaths through 1985, there were about 500 cancers more than expected vs. the "control population". However, there are approximately 600 excess cancers in the population near-instantly exposed to more than about 200 cGy, and approximately 100 fewer cancers for persons exposed to less than about 20 cGy[48]. Kondo reports that those who were exposed to 1-9 cGy appear to have lower death rates from leukemia[48]; and Dr. Sadao Hattori reports that about 8 cGy is the optimum dose for the suppression of leukemia in these survivors[49].

The BEIR V reports that the Life Span Study indicates no significant increases for leukemia below 0.4 cGy[3], yet in typical fashion applies a linear result to presume effects down to zero dose. Dr. T.D. Luckey finds several discrepancies in the low-dose use of the LNTH as it applies to leukemia mortality[24], and shows that the data better fit the hormesis model. Dr. Myron Pollycove shows similar results for leukemia and non-cancer relative risk[6]. Mathematical analyses by Drs. Joseph Alvarez and Fritz Seiler also demonstrate discrepancies in the LNTH, and that non-linear models much better fit the data and show clear beneficial effects[50]. The data find no increases, and statistically significant decreases, in non-cancer health effects below the estimated 200 cGy dose[48].

Adverse effects on the unborn children have a documented threshold of about 50 cGy[3]. Below that threshold, Dr. Jaworowski reports on positive effects[54]. There are no genetic effects in approximately 90,000 children and grandchildren of the highly exposed survivors who have parental exposures in the range of 30-60 cGy[48]. Kondo[48] and others[3,6,51,52] report on studies that show that the lifetime data for the Nagasaki population (that has better dose data, but a smaller population than Hiroshima), the exposed population has longer life than the controls for all groups greater than 55 years of age.

2. Nuclear Reactor Facility Exposed Populations

No credible scientific studies demonstrate adverse low-dose radiation effects to nuclear workers. Early nuclear facility workers were significantly exposed. However, many early workers were also exposed to other chemicals and adverse stress and physical conditions, and exposures to contaminants prior to US AEC work before, during and after WWII. These workers generally had poor radiation dosimetry, and poor radiation protection practices. Presumably, since exposure to chemicals in the industrial workplace is claimed to be a significant contributor to human cancer, this group would be expected to have higher cancer rates than the general population. Such is not the case.

Only the shipyard workers on US Navy nuclear ships have moderately significant radiation doses in a moderately large population with high quality dosimetry and limited confounding effects from chemical exposures and other work conditions. The 10-year, US$ 10 million study of the shipyard workers undertaken in 1978, was completed in 1987. The nuclear workers were compared to a well-matched case-control shipyard non-nuclear worker group[56]. These workers show significantly reduced total mortality. The US DOE funded this study. The study was not published in the scientific literature. It was only released by DOE under pressure as a contractor report, with a 2-page press release, in 1991. These results have still not been formally reported in the literature, although substantial funding and data analysis continues.

Although Dr. Arthur Upton was Chairman of the Technical Advisory Panel (TAP) for this study, and he chaired the BEIR V Committee, this study was not included in BEIR V (though other unpublished work was included). Professor Emeritus Dr. John Cameron reported on this study and states: "The most significant and surprising finding of the NSWS research was that the nuclear workers with the greatest radiation exposure, a cumulative lifetime occupational dose-equivalent of 5 mSv or more, had a standardized mortality rate (SMR) of deaths from all causes of only 0.76 that for their age and sex in the general population, while the non-nuclear workers had an SMR of 1.0[12-13]." Professor Emeritus Myron Pollycove states: " The nuclear worker groups had a lower death rate from all causes, leukemia, and LHC than the non-nuclear workers[6]."

Professor Emeritus Dr. T.D. Luckey reports on information from nine studies with nuclear workers and bomb test observers totalling 13 million person-years[56]. The results show the exposed worker cancer mortality rate to be 65.6% of that of carefully selected control populations. Studies of the "high-dose" groups in the US and in the UK, including the cleanup workers following the 1957 Windscale fire, demonstrate that no excess cancers exist in these most significant populations1[7,57].

The recent, significant, DOE-funded study used to claim the existence of adverse worker health effects is the International Association for Research on Cancer (IARC) combining the UK, US, and Canada nuclear worker studies[4]. The study found no association between low-dose radiation and adverse health effectsor even a beneficial effect[56]. However, this study of approximately 95,000 workers did not include the most significant and most scientifically definitive study of the US nuclear shipyard workers, completed in 1987 and funded also by DOE, of approximately 700,000 workers, with analysis of data on 35,000 nuclear workers, plus 35,000 matched controls. In this study, the IARC analysis reported only on a "test for linear trend". From a single data point for only one cancer, leukemia, with 6 deaths vs 2.3 expected (in 238 deaths in workers exposed to more than 40 cGy with no excess in any other cancer), there was no increase with dose in the 113 leukemia deaths in the workers exposed to doses less than 40 cGy. The IARC study misrepresents this data to claim that a linear trend is demonstrated.[5,6,7] This result was widely announced in a media campaign in scientific, trade, and public press long before the study data were made available for peer review, reporting that a "linear dose response" from low-level radiation was found in nuclear workers.

3. Medically-exposed Populations

Practitioners and patients in radiology and nuclear medicine have received significant doses compared to natural background or nuclear workers. Radiologists in practice before 1925 were exposed to very high doses, including many with World War I experience with wounded military personnel in which case loads, x-ray equipment, and "hands-on" x-ray practices led to very high doses. Marie Curie practiced at the front lines in France with her "radiologic cars", and trained hundreds of radiologists, receiving very high doses in the process[59]. Early radiologists, many with WWI experience, were claimed to have excess cancers and leukemia in 1950s studies. Even these reports at these high doses are substantially uncertain[60]. However, Nobel Laureate Dr. Rosalyn Yalow reports[59] on a study by Dr. Peter Smith and Sir Richard Doll in 1981 that radiologists starting practice since 1921, with rudimentary radiation protection practices, with mean doses estimated at about 500 cSv, have no excess cancer or leukemia compared to other medical practitioners[61]. Dr. Yalow reports also on US Army personnel that in WWII, 6500 radiologic technicians had an estimated 50 rem in training, with 24 months median service and that a 29-year follow-up found no increased malignancies compared to army medical, laboratory, and pharmacy technicians[59,62].

In a study by the US National Cancer Institute of the more than 100,000 U.S. female radiologic technicians certified since 1926, more than 500 eligible breast cancer cases had a mean of follow-up of 29 years; however, no association was found for breast cancer to experience in radiotherapy, radioisotopes, or fluoroscopy, nor to personal fluoroscopy or multifilm procedures[63].

Medical patients receive significant radiation doses, with poor to good dosimetry. Early patients have demonstrated adverse long-term health effects from high doses. However, there are millions of procedures with moderate exposures every year subject to prospective studies. Some historical records enable credible followup. Radiation protection interests fail to undertake credible research on these most significant populations.

Hyperthyroid patients treated with I-131 received an estimated 10 cSv whole-body/bone dose. Of 22,000 patients treated by I-131 vs 12,000 treated by other means, primarily surgery, there is no leukemia increase[59,64]. This is contrary to BEIR V LNTH predictions that leukemia would more than double[3]. No excess thyroid cancer is found from diagnostic I-131 use (mean thyroid doses estimated to be 50 cGy) for patients that were not suspected of having thyroid cancer[59]. In fact, these patients have a significant reduction in thyroid cancer.

Studies of significant x-ray exposures and leukemia incidence are also negative[65]. Yalow reports on one such study based on competent records of exposures up to 300 cSv from normal x-ray practices over many years[59,66]. Yalow reported also on the extent of the evidence that doses at the level of moderate medical exposures, which are very much higher than radiation protection limits, are not implicated in adverse health effects[59].

In the case of high doses from multiple fluoroscopies to female tuberculosis patients, data at doses below 30 cSv indicate highly significant reductions in breast cancer, although the report projects a straight line from higher dose data, simply dividing all excess cancers by total dose to claim an excess of breast cancer, ignoring and contradicting its own data[5,6,67]. A more recent report obfuscates this relationship[40,68].

Stimulation of the immune system by ionizing radiation, based on animal studies[30,31] using 10-15 fractions of 10-15 cGy each over 3 weeks, is successfully treating and suppressing the reappearance of cancer and non-Hodgkins lymphoma in the hospital of Tohoku University[32].

Human fertility has been found to be improved by x-ray exposure, confirming research studies in animal populations[24]. In addition, female sterility was successfully treated by x-rays to the ovaries, with lower than normal genetic effects to the children or grandchildren.[69]. Lower genetic malformations and cancer are found following 1 cGy doses[24].

4. Radium-burden Population

In decades of study of the radium dial painters and others with internal radium, there is no case of bone cancer or nasal sarcoma in the population with less than about 1000 cGy doses. Recent analysis confirms these conclusions reached at MIT by Dr. Robley Evans in the 1960s[70], followed by more comprehensive reviews in studies at the Center for Human Radiobiology at Argonne National Laboratory reported in an international conference in 1981, published in 1983[71]. (In the US, these studies were then terminated by DOE starting in 1983, although more than 1000 subjects remained alive.)

Recent follow-up data and analyses by Dr. Constantine Maletskos, working with Evans, reports an estimated threshold of 1100 cGy[72]; by Dr. Otto Raabe who reports a threshold of about 1000 cGy[73]; and by Dr. Robert Thomas, who reports that a log-normal projection of just the homogeneous group of female dial painter cases, ignoring the fact of thousands of cases with no cancers, projects to a minimum threshold of about 400 cGy[14,15]. Recent work indicates that the doses to these populations were underestimated with corrections that confirm the threshold, but work to scientifically study this data is not supported[16]. Direct exposures to external gamma

radiation from daily work with luminous compounds on studio bench tops, while sitting for many hours per day, is a highly significant but unquantifiable contributor to radiation exposure to the upper torso and head in considering the potential risks from low level radiation[74].

Dr. Kondo reviewed the data and reported on the beneficial effects demonstrated in all-cause mortality in the early decades following exposure, and in non-cancer effects, in US and UK populations[48]. The absence of leukemia or other potential radiogenic cancers and health effects to this population, highly exposed to both external and internal radiation, contradicts the LNTH. Implications of the increased longevity of these early workers has been noted, but competent work has not been supported.

5. Nuclear Weapons and Facilities Releases

Participants in atomic weapons tests have demonstrated no adverse health effects. National Academy of Sciences studies of more than 46,000 participants in 5 major atomic bomb tests, completed in 1985, found no adverse effects[59,75]. There were excess leukemias in one test with relatively few observers. But, of the 10 leukemias reported, only one of them affected an observer who was exposed to more than 3 cSv. In another test with few observers, there were fewer than expected leukemias. Dr. Yalow notes that this is typical in small-numbers statistics, and no excess leukemias exist in the total exposed population.

An NAS report on 40,000 military participants in the July, 1946 Operation Crossroads, including one detonated below the water that greatly increased radioactive contamination, found. total mortality slightly higher than controls. However, cancer death is not increased, nor is any other cause of death potentially associated with radiation. The average dose was estimated to be 6 rem (cSv). There is also no increase found associated with groups with the higher doses[76].

Fallout from the 1954 Bravo nuclear weapons test affected the Marshall Islanders, and fishermen on the "Lucky Dragon" fishing vessel. Ash stuck to the skin and caused significant burns. In the high-dose group in the Marshall Islanders there was an excess of thyroid nodules[48]. The 23 "Lucky Dragon" fishermen were exposed to roughly 200 rad (cGy) to 670 rad (cGy). The person exposed to an estimated 670 rad (cGy) died 206 days after the event. All others, monitored for 24 years, showed no associated adverse health effects. At 21 years, one died of ascites caused by cirrhosis. No cancers were observed[48,77].

No excess cancers are found in the public in Utah exposed to above-ground atomic bomb test fallout[3]. In a study of British bomb tests, although the participants had significantly more leukemias and multiple myelomas, there was no association with the type or degree of radiation exposure[78].

In Russia, Prof. Dr. Zbigniew Jaworoski reports that 10,000 people were evacuated from a 1957 thermal explosion of nuclear materials in the Urals. In the 7,852 people studied for 30 years, tumors in the 496 mSv group were found to be 28% lower, in the 120 mSv group 39% lower, and in the 40 mSv group 27% lower in the exposed population than in the nonirradiated control population from the same region[79].

Dr. Alan Brodsky reports: "The Chernobyl accident has been estimated in an appendix of the 1988 UNSCEAR report to produce a collective dose equivalent of 0.6 million personSv (60 million person-rem), mostly in the former Soviet States and Europe. Thirty percent of this collective dose has been delivered in the first year following this 1986 accident, and the remainder will be delivered in the tens of years after the accident. This collective dose (in the first year) is about 2 percent of the annual natural background collective dose to the world population[80].

Professor Jaworowski states: "Unexpected results were obtained in one of the best studies in human genetics carried out in Hungary before and after the Chernobyl accident. Several serious congenital anomalies occurred after the Chernobyl accident with lower frequency than

before the accident."[79] Professor Jaworowski also states: "Eleven years that passed since the Chernobyl catastrophe are more than enough for realistic assessment of its early and late health effects. The fatalities of the Chernobyl accident caused by ionizing radiation, are 28 victims who succumbed to accute radiation sickness. Three more persons died during the first few weeks due to non-radiation factors of the catastrophe. Thus, the total of the early victims amounts to 31 persons. Over the next ten years 3 children died due to thyroid cancers[81]."

Dr. Shantyr et al report on a study of the Chernobyl accident: "In the five-year age groups cancer morbidity of the emergency workers makes no statistically significant differences with that of the male populations of Russia and St. Petersburg. No evidence of an association between radiation dose and cancer morbidity was observed[82]." Dr. Roger Berry monitors the health effects of high-dose UK workers. He states: "The Windscale fire cohort show a similar deficit of cancer deaths against expectation[57]."

6. Natural Background Radioactivity

Natural background radioactivity is by far the largest source of exposure to ionizing radiation. Further, background radiation varies by a factor of about 100. Significant populations are exposed to differences of factors up to about 10 locally[59,83]. Populations with significant radiation dose differences consistently find either statistically significant lower cancer rates in the more highly exposed groups, or no effects in populations that are poorly differentiated, in direct conflict with the LNTH. There are no adverse effects in 2 large, stable, comparable populations in China, that have typically lived in the areas for 6 generations, with a factor of 3 difference in radiation dose[84].

A preliminary AEC analysis of external radiation dose and national cancer data by states in the U.S., with rigorous statistical analysis to test various linear models, found that the "high background states", with 3 times higher doses than the low background states, and twice the national average, have consistently and significantly lower cancer rates, with analysis of readily identifiable confounding factors[85]. This study at state-average data levels was preliminary to plans for more comprehensive studies of cancer and radiation at county or other population group levels. However this AEC contract to support environmental assessment was then terminated, and the work unpublished, by AEC and later by DOE. Subsequent analyses with later U.S. average dose and cancer data has confirmed these results[24,87,88].

Studies of lung cancer and other cancer rates as a function of high radon exposures find a lower cancer rate in high radon areas, or no effect in studies of poorly differentiated populations. The most comprehensive and scientifically rigorous study of radon effects and the LNTH has been developed for over 10 years produced by Professor Emeritus Bernard Cohen at U. Pittsburgh, incorporating more than 350,000 home radon data measurements and cancer data from 1792 counties, using 1601 counties to avaoid 'retirement' states, including about 90% of the U.S. population[89-98]. This study and responses to all criticisms, demonstrates that the LNTH can not be valid[97,99-100]. Analysis by leading epidemiologist Dr. Graham Colditz at Harvard University establishes the validity of the biostatistics in the population analysis[96]. Drs. Fritz Seiler and Joseph Alvarez also document the case that the data on the whole population define the valid dose-response relationship, superceeding the question of a 'model' and what ever confounding factors may exist[101].

Populations in radon spa areas, for example, in the area of Misasa Japan, find lower cancer rates in the higher radon source area[49,102]. Smaller populations with larger dose differences include Kerala India at about 4 times average background, Guarapari Brazil, about 6 times, and Ramsar Iran, about 10 times background[83]. These populations all find no adverse effects from background radiation[24,103-105] To the contrary, "The people of Kerala have a higher fertility rate with the fewest neonatal deaths than any other state of India[24]" Dr. Kondo states:

"The negative correlations of home radon levels with lung cancer rates ... are based on ecological studies on groups of people; they can be taken as strong evidence against the validity of non-threshold hypothesis that is adopted for the assessment of radiation risk by the EPA and corresponding agencies in many other countries of the world.[49]."

Many case-control studies have been applied to residential radon health effects. Such studies are generally too small, with small differences in radon levels, and unable to correlate home radon measurements with radon lung dose, to be adequate as a case-control study. An exception is in Shenyang China where women live in much more constrained and comparable residential conditions than women elsewhere. Radon was measured in each house for 1 year, with detectors in the living room and the bedroom. An odds ratio of 0.7 was found, contradicting the BEIR-IV LNTH projection of 1.8 for high vs low exposures[49,106]. Another more substantial case-control study in Finland found essentially no effect for indoor radon concentrations over approximately an order of magnitude, again contradicting the LNTH[107].

7. Animal and Plant Biology

Hundreds of scientifically valid studies of animal and plant populations have demonstrated that low level radiation produces beneficial biological and health effects, or no effects[23]. No substantial or reproducible studies that could demonstrate adverse effects have been produced. The LNTH can not be supported, and is demonstrated to be invalid, by such consistent radiation health effects data as has been able to be published. Dr. Luckey, Professor and Chairman Emeritus of the Department of Biochemistry at the U. Missouri School of Medicine, has summarized more than 2000 studies that demonstrate beneficial effects from "whole-body" doses, not including beneficial effects from organ doses[23,24].

The work during and following the Manhattan Project, by Egon Lorenz of the National Cancer Institute, and many others at AEC-supported national laboratories and universities, report on beneficial effects: lower cancer rates, increased mean life span, increased growth rates, increased size and weight, and increased fertility and reproduction, and reduced mutations, along with many enhanced physiological and biological functions[58,108,109]. Studies that fail to demonstrate beneficial effects are largely the result of using hybrid animals with deficient immune systems, keeping animals germ-free, and even studies that discard controls with early mortality[24]. The physiological responses in animals and plants are shown to be equivalent to the effect of many natural elements and compounds that are essential nutrients at low levels and toxic at high levels.

Dr. Luckey reports that: "The beneficial effect of low dose irradiation was discovered 100 years ago at the University of Missouri. Professor W. Shrader (1896) inoculated Guinea pigs with diphtheria bacillus. Unexposed controls died within 24 hours. When animals were exposed to X rays before inoculation, they survived[23]," and "The statistically significant results of Lorenz have been confirmed in several studies. The well-designed and executed experiments of Donaldson (1964), Bonham (1990), and Hershberger (1978) leave little doubt that chronic exposure of young animals to low doses of ionizing radiation increases the growth rate. Exposure to acute doses is less pertinent; however, such data add evidence to the concept of radiation hormesis. A chronologic perspective of radiation hormesis in growth suggests this is a general phenomenon.[24]." Dr. Harold Boxenbaum reports that: "Further support that radiation produces longevity hormesis is supplied... (I)n this case, the data deal with chipmunks living in the wild. The animals were live-trapped, irradiated with either a single-dose of 200 or 400 Roentgens gamma-radiation, except for controls, and then returned to the wild. It is readily apparent that gamma-radiation exposure, within the dose-range utilized, enhanced longevity[108]."

In mammals, some population studies replicate the beneficial effects of low level radiation doses, while none show detrimental effects consistent with the LNTH. However, many

studies did not include the dose range of interest due to the radiation protection establishment requirements to assess higher doses for purposes of radiation protection standards. Since there was general knowledge of beneficial effects at lower doses, it was easy to avoid both the dose ranges of interest and to perform studies with animals that would not have full immune competence to enable a general beneficial response.

Studies have demonstrated beneficial effects of low level radiation in response to infection, as early as 1896, and to wound healing, and other adverse health conditions[24]. However, no generalized research was supported on such beneficial effects in order to establish the role of radiation in physiology, health and medicine. Beneficial effects in dissolving selected cancers and in non-Hodgkins lymphoma have been documented, but research on such potentially beneficial applications has again not been supported in the interest of radiation protection programs and costs.

Dr. H. Planel and associates at the Laboratoire de Biologie Medicale in France, and others, produced experiments in lower order animals, on the effect of both low- to moderate-exposure doses, and on suppression of natural background levels that consistently find that a continuum exists for stimulation by radiation, including detrimental effects from reducing radiation levels below normal background, with beneficial effects at higher doses up to a level at which the organisms demonstrate deleterious effects from very high doses[23,111-113]. In health and medical research such results lead to establishing the basis for vitamin and mineral and other supplements for nutrition and health. Support for such radiation research has not been provided.

In plants, Drs. Sheppard and Regitnig in Canada[114] Dr. Alexander Kuzin in Russia[115-117] and many others who produced results in Stimulation Newsletter[118] and even high school science projects, have demonstrated the stimulation of growth and reproduction by irradiation of seeds and seedlings over many decades. Dr. Kuzin and others have called for planning to implement irradiation programs to enhance food supplies1[115].

8. Cellular and Molecular Biology, Genetics, and Cancer Research

World renowned radiobiologist Dr. Gunnar Walinder of Sweden and others in biology state that research on cancer at the level of the cell and tumor in whole organisms has established that carcinogenesis is a complex, iterative, progression that precludes the biological plausibility of the LNTH as a plausible postulated stochastic "hit" to DNA that can progress to a cancer[25,119-121]. This research rejects the proposition that a single hit on DNA that causes either a single- or double-strand break, with a presumed constant repair error rate, can lead to cancer.

Biological evidence has established that 'whole' cell colonies and organisms have adaptive responses to radiation, for cells in which complex intracellular communications and responses are enabled, and for organisms in which immune responses are functional[33,45,49,109,122-124]. Dr. Kondo (1988) and others establish the biological evidence that 'altruistic cell suicide', apoptosis, which is absorbed without the necrosis and potential damage of cell killing, stimulates proliferation of healthy cells to replace a damaged cell, which eliminates injury[128]. Apoptosis is shown to be stimulated by radiation, and that the role of radiation at low doses that do not exceed the body's capability to function within the cell life-cycle, may be beneficial, if not essential in the process of cell repair.

Dr. James Trosko and others show that radiation damage effects can only initiate at levels that exceed normal levels of oxidative damage; and that responses are triggered by intracellular signal transduction mechanisms that are epigenetic, not genotoxic, in nature[120]. As such, radiation doses sufficiently high to contribute to cancer are not the result of a toxic insult, but triggered by a non-stochastic epigenetic process. When damage frequencies are within the background rate of metabolic processes, which are thousands to millions of times the natural radiation background rate, proliferation and adaptive functions in multi-cellular organisms

regulate damaged cells through sharing reductants for repair and by triggering apoptosis. Biologically, cancer can not be caused by radiation at low doses.

Drs. Myron Pollycove, Ludwig Feinendegen, and others report on work by Drs. Daniel Billen, John Ward and others that cellular and DNA repair mechanisms are complex functions of the effect of radiation on the stimulation of multiple repair mechanisms[25,129,130]. Research has demonstrated that radiation enhances known specific repair processes that control the repair effectiveness of both DNA and cellular damage events[131]. The work on the cell by Dr. Bruce Alberts, President of the National Academy of Sciences, and others, find that the normal metabolic and oxidative DNA damage events rate is extremely high[131]. The DNA damage rate of radiation due to natural background radiation is an insignificant fraction of the normal DNA damage rate. At many multiples of natural background radiation, these events remain insignificant contributors to DNA damage and mutation rates. However, at such levels, recent research led by Dr. Sadao Hattori in Japan[49,133], and Dr. Shu-Zheng Liu in China[33,122], and Drs. Sheldon Wolff[121] and Takashi Makinodan[134], and others, have confirmed that both DNA and cellular repair mechanisms are enhanced.

Dr. Takeo Ohnishi states, "The induction of p53 by low dose radiation may contribute to the prevention of cancer event, because there are thresholds in several kinds of radiation-induced cancer[135]." Drs. Yoshio Hosoi and Kiyohiko Sakamoto state, "TBI [total body irradiation] on mice with 15-20 cGy suppressed spontaneous lung metastasis significantly, and 15 cGy was the most effective dose[136]." Drs. Pollycove and Paperiello state, "The biological effect of radiation is not determined by the number of DNA mutations it creates, but by its effect on the body's protective processes. [emphasis theirs] At high levels, radiation supresses them; at low levels, it stimulates the DNA damage-control biosystem[137]."

Such molecular biology data establish that the LNT hypothesis is not biologically feasible, and that beneficial effects are biologically plausible. Combined with the extensive evidence of stimulation of biological processes and physiological functions, and the extensive evidence of biopositive effects on organisms, and the epidemiological evidence in significant populations, the need for changes in radiation science policy to recognize the scientific evidence, and to support and allow research to confirm this evidence in animal studies and in health applications and clinical studies, is established. The potential for human and environmental benefits is enormous.

9. Biological models

Current data from cellular and molecular biology is being reflected in models of biological processes and responses, and tumorigenesis. Simplified 2-stage models (representing the 3- to 6-stage cancer process) by Drs. Kenneth Bogen at LLNL[139,140], Tom Downs at U. Texas[142], Fleck et al1[142], Schollnberger et al[143], and others, reflect linear damage from radiation, but incorporating repair processes that include cell death by apoptosis along with wound repair. These models reflect the significant work being developed that establish the biological significance of the molecular and cellual mechanisms. Dr. K.-H. Weber performs unconstrained modeling to current biology data to reflect the dose-response relationship, rather than force data to a preordained model as is currently applied in radiation protection policy to support the linear model[144]. He finds non-linear results. Dr. Downs states that, "Almost without exception the dose-response models studied to date have focused on harmful effects. Current models thus have limited flexibility. Some contain mathematical restrictions prohibiting a decrease in response whenever there is an increase in dose. In such cases the existence of a threshold or of beneficial effects are excluded automatically from consideration[142]."

10. Nutrition and health

Drs. Luckey, Planel, and others, have produced research data that prove that a background radiation deficiency adversely effects microbes, plants and invertebrates[23,78,111-113]. This manifests as a deficiency in essential nutrients, comparable to responses of such organisms to deficiencies in essential vitamins and minerals. Such data is consistent with dose-response for such nutrients that affects all orders of biota, including humans. Confirmatory research on the role of radiation in health and nutrition, and on mammals, has not been supported by the radiation science establishment, even though: 1. substantial results can be produced at doses of interest for radiation protection; 2. such preliminary research would require less than 1% of funding for current radiation health effects studies (which provide limited, if any, significant results); and 3. the potential benefits to human health are great, along with possible elimination of large and unwarranted public costs for radiation protection, and unfounded public fear of radiation.

Dr. T.D. Luckey states (1996): "Ionizing Radiation as an Essential Agent: If ionizing radiation is an essential agent, most populations live in a partial radiation deficiency. Radiation hormesis would then be the alleviation of a partial radiation deficiency. This would make the dose-response curve for ionizing radiation comparable with that of several essential nutrients. Examples include vitamin A, thiamin, vitamin B6, calcium, iron and selenium. Individuals and populations who receive insufficient amounts of these essential nutrients are routinely supplemented with those nutrients. Supplementation with an essential agent present in insufficient amounts would explain the dramatic results following small increments in whole body exposures to chronic, low dose irradiation[78]."

The author and Dr. Theodore Rockwell state, "For some situations, there are available fatality figures. For example, about 10,000 people die each year, in the United States alone, from food poisoning, and the problem is growing in magnitude and complexity. The New England Journal of Medicine reported on May 29, 1997, and stated in an editorial, " 'We already have the means of virtually eliminating the problem - namely, irradiation. The use of ionizing radiation for food pasteurization has been extensively evaluated...' The 10,000 Americans who die each year from food poisoning are real persons, with names and families. They should not be sacrificed to save hypothetical persons, who are threatened only by baseless fears and a government policy that nourishes those fears[41,145]."

11. Costs

Radiation protection policy supports radiation protection committed to control radiation to negligible levels. This results in high public costs for negligible public health and safety benefits. Estimates for radioactivity "cleanup" and decommissioning exceed US$1 Trillion worldwide to meet standards that are far below levels of naturally-occurring radioactivity and natural radioactivity releases to the environment. Professor Emeritus radiobiologist Dr. Marvin Goldman, then President of the Health Physics Society, stated, "Are we really serious about investing about a trillion dollars to cleaning up our atomic backyard when in all likelihood very little credible health risk may be involved...?[146]"

In addition to identified "cleanup" costs, public costs for regulatory control to negligible levels, and for future facility "decommissioning", are similarly enormous. Dr. Klaus Becker asks, "How much of our rapidly decreasing funds can we afford to devote to the further reduction of potential risks which, if they exist at all, are so small that they could not be detected in decades of painstaking and expensive research efforts? Tens of billions of dollars are spent every year worldwide in decommissioning, redemption, or nuclear waste programs, which could obviously be used much more beneficially in other areas of public and individual health, in rich and even more so in poor countries[147]."

Professor Jaworowski states, "Each life hypothetically saved by implementing the U.S. Nuclear Regulatory Commission's regulations costs about $2.5 billion (Cohen 1992). Such spending is morally questionable. Studies of radiation hormesis suggest that such expenditures may be futile and actually have an adverse effect on the health of the population[79]."

The author has stated, "Recently, however, these radiation protection excesses have resulted in large incremental public costs, with even more proposed, with no accompanying public health benefit. Currently, these policies especially effect radioactive waste management and site decommissioning costs, to the benefit only of government bureaucracies and contractors. The immense costs incurred are reducing the viability and public benefits of many radiation and nuclear technology applications, and humanity is losing major advances and contributions to human health and well- being, without benefit to public health[5]."

Radiation protection policies cause further unwarranted public costs by promoting a public fear of radiation that provide incentives for government and private interests to apply alternatives that are more costly, provide lower public health and safety, are less effective, and have greater environmental costs. In medicine, energy, and industry, these policies have caused high public health and safety costs in addition to economic costs; with rapidly growing prospects for international conflicts over resources and environmental damage in the growing economies and populations of the 21st century.

CONCLUSION

Research policies must be committed to assess the biological role of ionizing radiation, of beneficial effects in health and medicine, and to confirm animal research and successful cancer treatment by the bio-positive stimulation of the immune response. This research must be undertaken by interests committed to biology and medical science, that are not committed to, or constrained by, radiation protection interests and funding.

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