FEAR OF RADIATION IS KILLING PEOPLE AND ENDANGERING THE PLANET TOO

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ABSTRACT

We are permitting tens of thousands of real people to die needlessly each year because some people fear that the alternative might pose a hazard to hypothetical people from postulated events that have never happened. The real people are dying from food poisoning, from inhaling particulate matter from coal-fired power plants, from avoiding mammograms, x-rays, MRIs, and other life-saving technologies, from unwillingness to use smoke-detectors containing radioactivity, and many other such fears. In addition, the planet is threatened by global warming, acid rain, smog, toxic runoff, and shortages of drinking water. Use of nuclear technologies could ameliorate all these problems, but many people are afraid because we have told them that even the tiniest amounts of radiation are hazardous. This is simply not true, and we should start saying so. In fact, there is considerable evidence that therapeutic doses of low-level ionizing radiation would be beneficial for most people.

BACKGROUND

When it became clear, in the wake of the war-time atomic bomb program, that many thousands of people would be working with radiation in a wide variety of military and civilian activities, radiation specialists developed radiation protection standards based on experience obtained with x-ray operators since World War I, in the Manhattan Project experiments with animals, and from the results of the surviving populace of Hiroshima and Nagasaki. These standards were set to provide sufficient margin below the levels found to be harmful, and were to be simple and straightforward enough to be used by persons not trained in the fundamentals of radiobiology.

There was no question that high-level radiation could cause immediate physiological effects. The uncertainty was whether radiation levels too low to create immediate symptoms could cause delayed effects such an genetic damage or cancer to show up decades later. The decision in the early 1950s was, for administrative simplicity, to assume that the harmful health effects of radiation decreased linearly with radiation dose, all the way down to zero health effect at zero radiation, with no radiation threshold below which we could say there was no significant hazard. This was called the Linear No-Threshold or LNT model. Fortunately, as data came in on the third generation of A-Bomb survivors it became clear that there was absolutely no detectable inherited radiation damage, and the additional cancer incidence from low-level radiation was too small to detect, whether zero, positive or negative.

For high-level radiation, providing adequate radiation protection standards, instrumentation and procedures was straightforward, and radiation protection people then turned their attention to the subtleties of the low end of the radiation scale. These people were called “health physicists”; they tended to be either physicians or physicists; they were seldom biologists. Thus they were not always sensitive to some of the problems that started to arise. First, the bomb data were from people irradiated at a very high dose rate—“in a flash.” To assume that biological damage caused by such a dose was quantitatively equal to a chronic dose—one received slowly over months or years—was questionable. It argued, in effect, that if a person took one aspirin tablet a week for 100 weeks, it would be just as deadly as taking 100 aspirin tablets all at one sitting—which is clearly ridiculous. At low dose rates, damage has a chance to repair and heal.

In addition to error introduced by ignoring dose rate, another confounding factor had crept in. In considering genetic damage, some people worried that if large numbers of people were irradiated at a level that caused no individual to be harmed, there might still be damage to the gene pool that would add up to degrade future generations. So they created the notion of "collective dose". They said that if large numbers of people are irradiated, you should add up the individual doses to get a collective dose for the group. When it became clear from the bomb data that even at high dose rates, there was no detectable inherited damage, the idea of collective dose was nevertheless retained and applied to cancer, where it made no sense at all. The collective dose concept says in effect that if we give a hundred million people one aspirin each, then, based on the datum that the lethal dose for aspirin is (say) 100 tablets, one million people in this group will die. You could go around and question them one by one, and they will tell you they feel fine, but the risk protectors will insist that a million deaths will be due to those aspirins. But deaths don't occur to populations; they occur to individuals. Does anyone really believe that people will become sick and die just because they are surrounded by other aspirin-takers? Or that 30,000 people will die from harmless levels of fallout from the Chernobyl accident, just because such a calculation "predicts" it?

IMPLICATIONS OF THE LNT MODEL

As the government began to grapple with the disposal of radioactive waste from the weapons program, the LNT and collective dose policies imposed a huge burden. Natural radioactivity was suddenly seen as a public health hazard. To illustrate the absurdity of this situation, let me give a few examples of the application of the LNT calculation to some routine situations:

- Natural uranium, thorium and radon are considered hazardous, requiring regulation;

- 100,000 deaths each year are calculated to result from routine medical use of x-rays;
- Natural radiation background is claimed responsible for 650,000 deaths per year;
- Air travel supposedly causes 510 radiation deaths; and, most clearly absurd:
- If each person in the world ate one Brazil nut, its natural radioactivity would cause 250 deaths.

Of course, we know this is not the case. In fact, persons living in naturally high radiation areas show no deleterious effects and in many cases are actually healthier.

WHY LOW-LEVEL RADIATION DOESN'T CAUSE CANCER

The biological justification claimed for the Linear Non-Threshold (LNT) model is that when a single ionizing photon or particle hits a living organism, DNA in the cell may be damaged. This may impair the cell's function and lead to cancer. But to understand the significance of this event, we have to look at the numbers of such events. The first consideration is that we all live in a sea of natural radioactivity—cosmic radiation pouring in from outer space and naturally-radioactive materials in our soil, building materials, food and water. The body cannot distinguish "man-made" radiation from "natural" radiation; in both cases the nuclear particles arise from the same processes and have the same characteristics. And our bodies are impacted by some 15,000 nuclear rays or particles every second—over a billion such events every day of our lives from these natural sources.

But our bodies face even greater challenges: About 5000 purine bases are lost daily from the DNA in each human cell because the body's normal heat breaks their linkages to deoxyribose. Even 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. Radiation causes more double breaks per event in the DNA than metabolism does, and these are harder to repair than single breaks; but even after making generous allowance for this difference, the mutations (unrepaired or misrepaired damage) from metabolism outnumber those caused by natural radiation by ten-million-fold.

The table below, from work in progress by Myron Pollycove, Ludwig Feinendegen, et al., summarizes these numbers for each of the body's 100 million million cells. Some ten billion free radicals are created each day in each cell, and about 1% if these are within striking distance of the DNA. These free radicals near the DNA are shown in the first row of the first column below. (There is no really comparable figure for radiation.) About 99% of these are gobbled up before they can cause any harm, and the remaining free radicals damage the DNA, as shown in the second row. The corresponding number of DNA alterations caused by background gamma (low LET) radiation is only 0.005 per day, or one DNA alteration every 200 days. About 99.99% of these alterations are repaired in the metabolic case, and about 1 in 500 in the radiation case (because of the greater difficulty in repairing the double breaks). Finally, about 99% of the damaged cells are removed, leaving 1% of the damaged cells to persist as mutations, as shown in the last row of the table.

Number of Events Occurring Daily in Each Cell of the Body:

	Metabolism	Radiation(100 mrad/yr)
Free radicals created near DNA	100,000,000	
DNA alterations	1,000,000 (1 in 100)	0.005

Un/misrepaired alterations	100 (1 in 10,000)	0.00001 (1 in 500)
Mutations: Persistent un/misrepaired	1 (1in100)	0.000,000,1 (1 in 100)
Ratio of mutations, metabolism to radiation:	**1 in 10,000,000**	

These facts raise two questions: first, how can any living organism withstand such an onslaught? How do any of us survive? The answer is that the body has a large variety of anti-oxydants that prevent damage, enzymes that continually scan the DNA to repair damaged nucleotides, and processes that remove those it cannot repair. The second question is: How does chronic exposure to high-level radiation harm an organism? Clearly, adding a few more mutations to the millions already occurring from metabolism is not significant. But high radiation levels can overwhelm the organism's normal biological functions and repair processes, and leave the organism damaged and vulnerable to the mechanisms that initiate and progress to cancer and other adverse consequences.

This raises another question: What is the effect of low-level radiation that is not intense enough to degrade the body's tissue repair capacity? The answer is suggested by how the body reacts to low levels of other potential toxins: when we inject small quantities of disease bacteria into the body, the result is to stimulate the immune system, so that subsequent attacks by this toxin, in larger amounts, are effectively countered. Some research indicates that radiation may work just the same way. Numerous studies (e.g. UNSCEAR 1994) have shown that DNA and cellular repair mechanisms are stimulated by low- to moderate-levels of radiation. Thus, tests on isolated tissue specimens with no supporting immune system are not fully protected. There are reports that organisms kept in a below-normal radiation background are affected adversely, and recover when returned to normal.

To summarize: our body temperature and normal eating and breathing cause millions of times more mutations in our bodies than the natural level of ionizing radiation. And the low-level radiation being regulated under current policy is as low as 1% of the natural radiation background we all live in. Scientific theory and data, as well as our actual experience, show that low-level radiation does not harm us.

RADIATION HORMESIS

Many people are astonished by claims that small amounts of radiation seem to be beneficial (an effect called "hormesis"). They demand extraordinary proof of such a surprising finding. But in fact it would be surprising if it were not so. Most physical insults to the body work that way. The medieval proto-scientist Paracelsus declared: "The dose makes the poison." We take supplemental vitamins and minerals to improve our health, knowing that at higher doses some of these same substances are toxic. That is also the basis for inoculation: small amounts of a disease culture are injected into the body and these stimulate the immune system. Many experiments show that radiation works the same way.

T.D. Luckey (Luckey 1997) lists numerous data from humans irradiated with low-level radiation that confirm results from animal studies and other research described in his two classical books on radiation hormesis (Luckey 1980, 1991). These human studies comprise 13 million person-years of low-level radiation with robust statistical consistency. They show the irradiated populations with lower cancer mortality than the unirradiated controls by the following ratios:

- U.S. Army bomb test observers: 77.4%
- Canadian bomb test observers and Chalk River clean-up crew: 87.5%
- U.S. nuclear weapons plant workers: 59.8%
- U.S. nuclear shipyard workers: 65%

- British energy and weapons workers: 28.3%
- Canadian atomic energy workers: 85.7%
- Los Alamos laboratory employees: 77%
- Observers at Operation Crossroads (Bikini bomb tests): 65.9%
- Additional data are given for persons injected with plutonium, fishermen irradiated from weapons fallout, and populations living in naturally high radiation areas. All show beneficial effects from low-level radiation. For explanation and qualification of the above figures, see the original report.

THE DESTRUCTIVE POWER OF FEAR

Fear of radiation can indeed kill people and hurt the planet. And fear keeps us from reaping the benefits that radiation technology can bring. For example:

- Doctors world-wide are concerned that many people avoid life-saving medical procedures such as mammograms, x-rays, and radiotherapy, out of unwarranted fear.
- 100,000 additional abortions took place in Europe during the year after the Chernobyl reactor accident terrified much of the world. Presumably these abortions were caused by a groundless fear of bearing "nuclear mutants," although the radiation level from the fallout was lower than the natural background in many places where people have lived healthily for generations.
- 33 million Americans are sickened and 9000 die each year from food contaminated with pathogens and parasites that could easily be killed by food irradiation. Moreover, irradiated food is always plainly marked and no one need eat it who chooses not to.
- Tens of thousands of Americans die from respiratory problems brought on by inhaling particulate pollution emitted by fossil-fueled power plants.

Nuclear plants produce virtually no atmospheric pollution. In fact, a coal-burning plant discharges more radioactivity than a nuclear plant.

- The planet is under siege from global-warming gases, acid rain, smog and other effluents from power plants and automobiles. Nuclear plants, and electric cars with batteries charged from such plants, could eliminate most of this problem.

Many such problems are amenable to solution through nuclear technology. (To argue, for example, that a planet three-quarters covered with water is facing a water shortage shows how deeply the fear of using nuclear energy has replaced common sense.) In addition to life-and-death issues, nuclear technology is involved in literally millions of applications, including tritium exit and airport signs, shrink-wrapping, and sterilizing everything from surgical instruments and bandages to cosmetics, condoms, tampons and vitamin pills. So the question of shutting down nuclear power involves much more than the fate of a few electric power stations.

RESPONSIBILITY OF SCIENTISTS

We in the nuclear community like to blame nuclear fear on technical illiteracy of the media, the public, the regulators and the politicians. But it is we, not Greenpeace or Ralph Nader, who created the China Syndrome, the Linear No-Threshold model, the notion of Collective Dose, and the idea of guaranteeing that we can protect nuclear wastes for a million years (while others casually dump into the environment mercury, lead, cadmium, arsenic, selenium and other toxins with infinite half-lives). We felt in the early days that we could meet even the most stringent requirements, and we never dreamed how far the what ifs would be pushed. Now we must call a halt and draw a line, beyond which we call nonsense by its right name. No one else can do this for us.

The anti-nuclear forces have convinced many people that they speak for the whole public, but polls show they do not. The positive PBS program “Nuclear Reaction” drew an almost-hysterical reaction from anti- nuclear professionals, but the studio reports that despite the efforts of detractors, the responses were favorable by a ratio of three to one. There are other similar examples. Irradiated food, for instance, has been offered for sale on occasion, and has met with high public acceptance, despite the scare campaigns of opponents. The point is that scientists need no longer assume that the public will jump down their throats if they discuss this issue honestly.

Scientists, engineers and technical managers in the nuclear field should first familiarize themselves with the molecular biology and the microdosimetry of radiation damage to organisms. The basic facts are simple and surprisingly reasonable. Once the basic radiobiology is understood, scientists should then discuss with other scientists and technologists and with their own managements the importance and urgency of evaluating this information and supporting any research needed to fill the gaps, and then incorporating it into public policy. Until management and institutions are committed to this viewpoint, there is no point in trying to convince the media or the public.

RADIATION, SCIENCE & HEALTH, INC.

Individual scientists, expressing the need to reconcile policy with biological theory and data, find that they are brushed aside as idiosyncratic voices from the fringe. Papers go unpublished, research proposals are turned down, and letters are unanswered. What is needed is a scientific voice that cannot be ignored, and a program to review the research, to rescue the ignored and the unpublished, and to correct the misinterpreted. What is needed is institutional clout. To this end, a not-for-profit, tax-deductible, organization has been established called Radiation, Science & Health, Inc. (RSH), a group of independent experts in radiation science newly formed to help focus and coordinate this effort. It is the purpose and continuing mission of RSH to organize, assess, and present applicable data and research programs that have been ignored or misrepresented under the current radiation policy, and to assure that such data and programs are adequately considered and supported by those setting radiation policy. Interested organizations and individual scientists, engineers and managers are encouraged to join in and support this effort.

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