Extract from *Creating the New World; stories and images from the dawn of the atomic age*, by Theodore Rockwell, 2002, 2003, 1st Books Library, Bloomington Indiana, pp 150 – 176

Chapter 7, The Great LNT Scandal

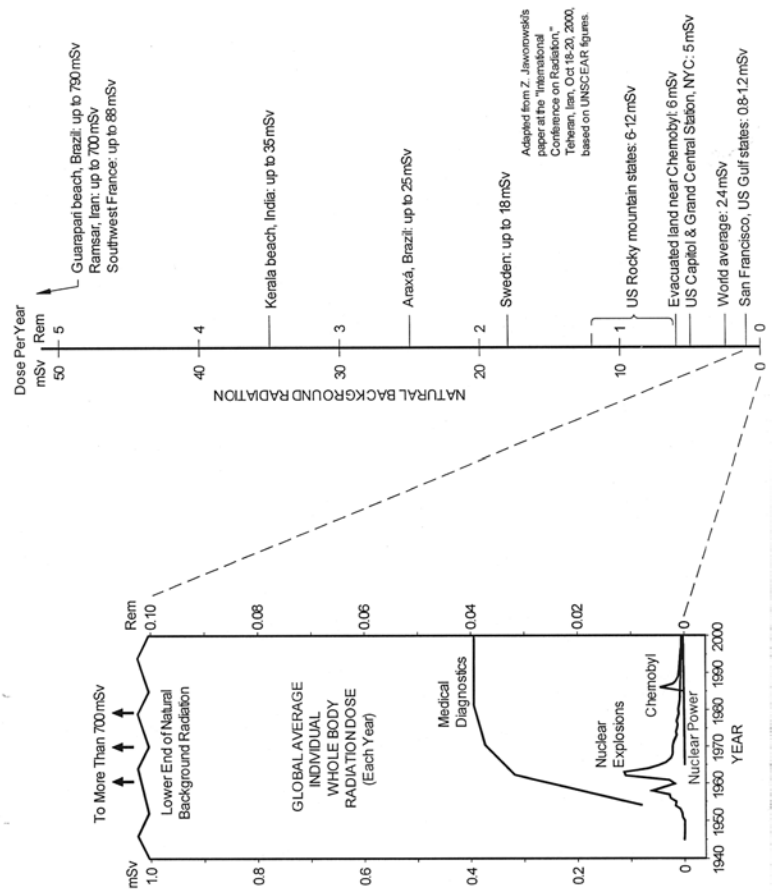

Figure 7.1 Sources of Radiation: The figure on the LEFT shows the average radiation dose we get each year from various sources, in Rem, the American unit, and in the metric unit, mSv. The radiation from nuclear power and its associated operations (including the Three Mile Island meltdown) hardly shows up. Fallout from the reactor accident at Chernobyl peaked, then declined. Fallout from testing nuclear weapons was larger, but it has also subsided. Medical diagnostics: dental and other x rays, radioisotope tests, CATscans (not counting the large radiation doses given to burn out tumors) are the largest. At the very top, we enter the lowest levels of natural radiation background. The highest natural background levels would be several hundred feet off the top of the paper!

So on the RIGHT, we have a reduced scale, going from 0 to 50 mSv per year. The numbers on the first chart are now all squeezed in between 0 and 1. The world average is 2.4. Some rooms in the US Capitol building are over 5. Places in Sweden are 18, parts of southwestern France are 88. And there are places in Iran that are over 700! These are places where generations of people have lived healthy long lives. USEPA says 0.04 mSv per year is too high!

I do not hesitate to say that this is
the greatest scientific scandal of the century
— Prof. Gunnar Walinder, Former Chair, Swedish Radiobiology Society

LNT: The Linear No-Threshold model, a postulated relationship between the amount of ionizing radiation striking a person and the resulting detrimental health effects. The model says that the damage is linearly proportional to the radiation dose down to zero dose, and that no dose is small enough to be harmless. This model is the basis for all radiation protection regulations, standards and procedures. It was created for administrative simplicity and is flatly contradicted by a vast body of credible scientific data and theory.

7. The Great LNT Scandal

While we were designing, building and testing the first reactor shielding installations, we didn't think much about the biological process of how radiation interacts with living organisms. We didn't have to. There was plenty of evidence that *high* levels of radiation could be harmful. And there was wide agreement that the permissible levels set by radiation protection standards were conservative. In fact, we know more about the biological effects of radiation than about most other biological hazards we face, such as the toxicity of fumes from kitchen grills and industrial smokestacks and trace toxicants in our food and drinking water. We found we could meet these conservative standards. There was no reason for confusion or conflict on the subject. But that happy situation did not last.

After I left Naval Reactors in 1964 and began to see a broader view of the nuclear enterprise, I became aware of a situation that had been building up for some time. A number of critics were questioning the adequacy of the protection standards. Much of this questioning was simply anti-nuclear rhetoric with little attempt to justify it scientifically. But subtler minds began to build a scientific rationale. They argued: Suppose an individual shows no immediate harm from a radiation dose, but then decades later comes down with cancer. How do we know that the cancer was not caused or abetted by the earlier radiation dose? Since 30 to 40%

of all persons get cancer at some time in their lives, this question is a troublesome one.

The Effects of Radiation on People

The most important question concerning the effects of radiation on people is: Is radiation always harmful, no matter how little we get? To answer this, let us look first at how radiation interacts with the body, quoting from Sheldon Novick's anti-nuclear book *The Careless Atom:*

> When one of these particles or rays goes crashing through some material, it collides violently with atoms and molecules along the way… In the delicately balanced economy of the cell, this sudden disruption can be disastrous. The individual cell may die; it may recover. But if it does recover … after the passage of weeks, months or years, it may begin to proliferate wildly in the uncontrolled growth we call cancer. (page 105)

That certainly sounds dangerous. And twice as much radiation will affect twice as many cells. In view of this, how can anyone possibly argue that "a little more radiation won't hurt"?

The answer lies in the numbers. Remember Lucy in the Charles Schulz "Peanuts" comic strip? She wanted to get a good look at the stars, and in order to get as close as possible, she stood up on a little chair. Her logic is unassailable:

1. You can see things better if you get closer.
2. Standing on a chair gets you closer.

This is foolish only when you consider the numbers. Lucy could climb up on a table, or to the top of a ladder, but her distance from the stars would not change significantly. The distance to the stars is so great, and the length of the ladder is so short in comparison as to be insignificant.

How does this apply to radiation? First, we must realize that the body sloughs off billions of dead cells every day in its continuous process of renewal. We don't assume that a pine tree is dying just because we see lots of dead needles under it. We know that dead needles are a natural byproduct of normal pine tree growth. There are many more cells in a human body than needles on a pine tree. And 98% of the atoms that make up these cells are replaced each year by atoms from the food we eat and the air we breathe. So before we worry about those cells damaged by radiation, we should ask how the number killed by radiation compares with those routinely killed in this natural process of metabolism and regeneration.

The scientific evidence is clear: for every cell killed by natural background radiation, millions are killed by this natural process of bodily renewal. But what about the damaged cells *not* killed? Isn't that where cancer comes from? No. The fact is that only one in ten million human cancers is caused by radiation, natural or man-made. The odds against one of those damaged cells leading to cancer is estimated to be about one in 10^{24}. (That's a one with twenty-four zeroes after it!)

The LNT Model

To be conservative, an *administrative* decision was made in the early days of nuclear energy to assume that at low doses, radiation continues to be harmful in proportion to the dose, all the way down to zero. This is shown by the dashed straight line labeled "LNT" (for "Linear No Threshold") in Figure 7.2. This is the origin of the idea that "no amount of radiation is harmless." There has never been any scientific basis for this assumption. It was mentioned by the International Commission on Radiological Protection (ICRP) in 1960 and recommended by ICRP in 1972. But this concept leads to the silly notion of *collective dose*: if 1,000 rem can kill one person, then one rem to each of 1,000 people is supposed to cause one fatality (somewhere) and so will 1 millirem to each of a million people. We don't make that sort of assumption for any other substance, and its use in radiation protection is scientifically indefensible. We know that if no one gets a harmful dose, then no one is harmed.

Even the data on high-level radiation doses have some conservative biases. The laboratory data on irradiated mice are invalidated to some extent by the fact that mice are known to be more sensitive, and differently sensitive, to radiation than humans. And we are beginning to recognize that the inbred mice and rats used for laboratory tests have vulnerable immune systems. Tests run on wild chipmunks show much less damage from radiation than tests on laboratory animals. Moreover, there is recent research showing that laboratory animals fed *ad lib*, that is rats and mice allowed to eat all they want, become obese and further weakened. Their life spans and their incidence of cancer are dramatically higher than for animals fed in a controlled manner.

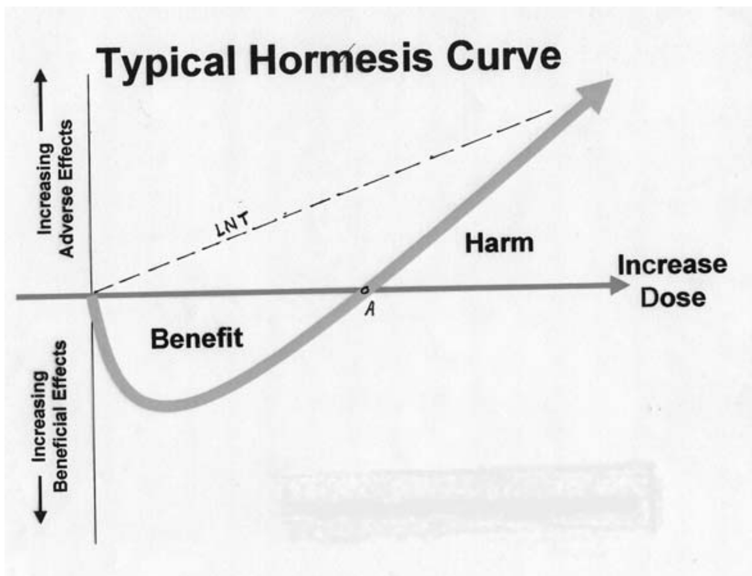

Figure 7.2 Biological Effects on Typical "Toxins" (Including Radiation)

In addition, radiation received rapidly from an atomic bomb or from irradiation tests in a laboratory, is much more toxic than radiation received more slowly, allowing time for the body to heal. Dr. Lauriston S. Taylor, one of the great radiation protection pioneers, notes that if people are exposed to 350 to 400 rems in a short burst, about half of them would die within 30 days. "By contrast," he writes, "the same dose administered uniformly over a year's time could pass unnoticed by most exposed persons." This should not surprise us; we know that a large bottle of pills (such as aspirin) taken one a day might be beneficial, whereas gulping them all down at once could kill us.

No Hiding Place Down Here

We can't look at how things would be without any radiation, because that situation does not exist—not on this earth, or in outer space, as far as we've explored it. There is no place we can go to get away from radiation. God's good green earth is in fact a naturally radioactive atomic waste dump, composed of the waste products of all the radioactive processes that produced the sun and light the stars. Our soil is naturally radioactive, and so are the oceans. The center of the earth is still molten because of the heat generated by this natural radioactivity, without which our planet would be cold and lifeless. Cosmic rays from beyond the galaxy bombard us from above; naturally radioactive potassium, carbon, rubidium, tritium, uranium, thorium, and their many radioactive decay products irradiate us from below. Our very blood and bones are radioactive, with half-lives up to a billion years (that is, it takes a billion years for their radioactivity to decay to half, and another billion years to decay to half of that). This situation began before the arrival of humans on earth and has nothing to do with our nuclear power activities. In fact, there is evidence that radioactivity is essential to life as we know it. Figure 7.3 compares some of the sources of radiation that confront us in everyday living. It shows that even making pessimistic assumptions about nuclear reactors, the radiation originating with nuclear power is tiny compared with the radiation from natural sources.

Trying to Minimize Your Radiation Exposure

If you are really concerned about reducing the amount of radiation your body receives, you might try to find a place to live where the natural radiation level is lower. You'd have to avoid flying and skiing and stay away from Colorado; in each case, the thinner atmosphere lets in more cosmic rays from space. (At sea level, the air shields cosmic rays as effectively as twelve feet of concrete.) Also stay away from parts of New England where the granite soil contains a lot of uranium. And parts of Florida, which has phosphate rock (used to make fertilizer) that is also quite radioactive due to its uranium content. And the fertile Piedmont Plain section of America has a high radon level. And the water in Wisconsin has radium in it. Don't live in a stone or a brick house; these also emit natural radiation. And don't sleep with anyone; the natural radiation from another body (either sex) is yet another radiation source. But most of us will choose to live without such precautions, believing (correctly) that such low levels of radiation pose no real hazard.

Every day, over 300 billion of our body's cells are struck by radiation from these natural sources. Natural radiation causes 70 million DNA-damaging events in each of us every year. This is for a typical environment. There are places in the world where people have lived healthily for countless generations with natural radiation over a hundred times greater than other places, and they thus get correspondingly more initial cell damage. About 12 million Americans get more than 1,000 mrem per year to the lungs, and about 2 million of these get more than 2,000 mrem per year just from radon. But they show no harmful effects from this. On the contrary, detailed studies have shown that they generally live at least as long and are healthier than people who live in locations with much lower radiation levels.

Hormesis: the Beneficial Effects of Radiation

To many people, the idea that radiation could be good for you lies somewhere between the absurd and the insidious. It reminds them of the 1960s joke about the tobacco companies deciding to fight the Surgeon General's report with advertisements proclaiming: *Cancer is Good For You*. But in fact, there is solid scientific evidence that small quantities of radiation are beneficial—perhaps even necessary—to health.

This idea that toxic materials are beneficial at low doses is not new, nor is it confined to radiation. The proto-scientist Paracelsus stated it clearly in 1540: "Nothing is poisonous, but the dose makes it so." This principle is called *hormesis*, from the Greek word to stimulate. It refers to the fact that tolerable challenges to any organism stimulate the immune system and strengthen the organism. Any fight you win makes you stronger. Toxicologists E. J. Calabrese and E. A. Baldwin stated in the authoritative journal *Nature*: "The hormetic model is not an exception to the rule--it is the rule." (Feb 13, 2003) It would be anomalous if radiation behaved differently.

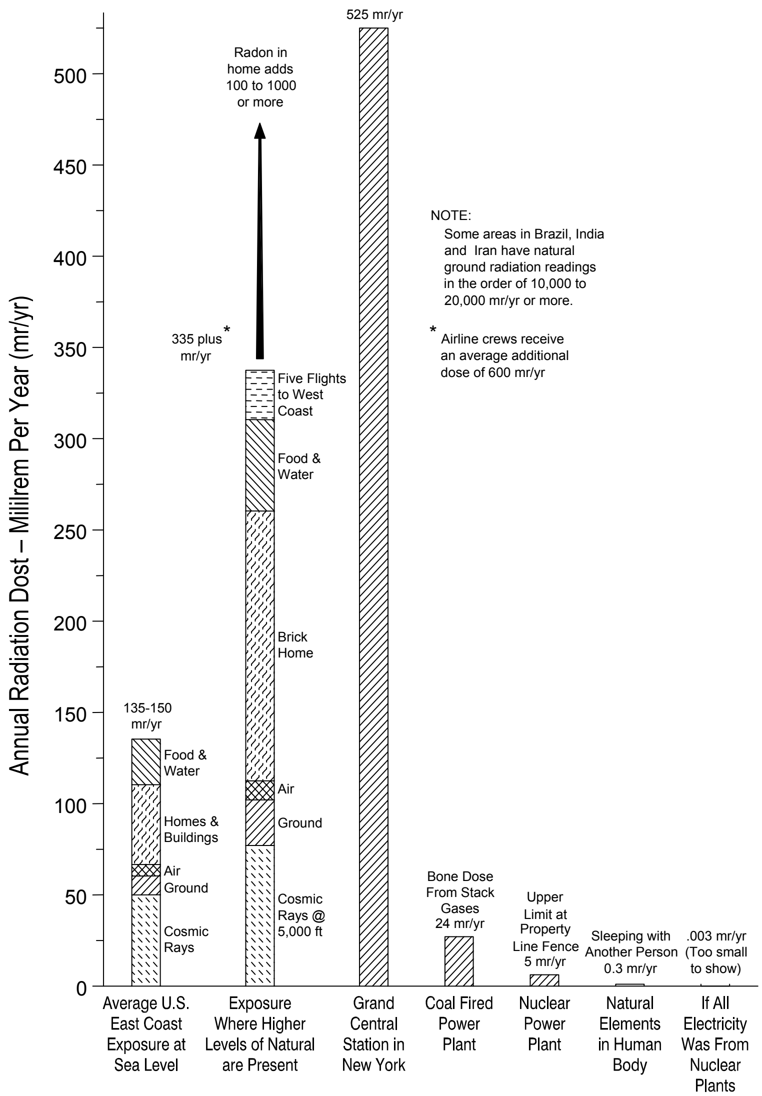

Figure 7.3 Some everyday radiation sources (*Hoke*)

Over forty years ago, Dr. Hugh Henry summarized for the *Journal of the American Medical Association* (vol. 176, p. 671, 1961) some of the Oak Ridge studies. His conclusions are clear:

> A significant and growing amount of experimental information indicates that the overall effects of chronic exposure (at low levels) are not harmful…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.

T. D. Luckey, Chairman Emeritus of the Department of Biochemistry of the University of Missouri School of Medicine, published a book on "Hormesis" (CRC Press, 1980) devoted entirely to the beneficial effects of low-level radiation, citing 1,269 research reports, and followed with another book (CRC Press, 1991) similarly titled, citing 1,018 references. The abstract of his recent summary of the situation (*Radiation Protection Management*, vol. 15, p. 19, 1997) states:

> Exposed nuclear workers and military observers of atmospheric atomic bomb tests with carefully selected control populations provide 13 million person-years of experience with low-dose radiation. These carefully monitored studies show conclusively that low doses of ionizing radiation reduce premature cancer mortality in humans. When person-years were used to obtain a weighted average, the cancer mortality rate of exposed persons was only 65.9% that of unexposed controls.

The solid curve in Figure 7.2 shows the biological effects of most toxic substances, such as lead, mercury, arsenic, copper, selenium, manganese, chromium, etc. Radiation seems to act the same way. Below zero on the damage scale there is negative damage—that is, benefit. Damage can be in the form of increased cancer incidence, decreased longevity, etc. From zero radiation (above background) to the point A, the body has a radiation deficiency and would benefit from more radiation. For radiation doses above A, there is damage—more and more damage as the dose increases. The natural radiation background is generally in the beneficial region, i.e., nearly all of us could benefit by more radiation.

A great deal of research shows that the beneficial effect of small doses results from the toxic material acting like a vaccine, stimulating the body's anti-mutagenic defenses. These defenses work to prevent damage, to repair damage, and to remove damaged cells from the system so they can't go on to become cancers. Laboratory tests show that low-dose radiation stimulates each and every one of these cancer-fighting defense processes. *This enhancement of the body's defense processes is not limited to the occasional cell damaged by radiation. It works on all cells, including the 10 million times larger number damaged by normal metabolism. So the net result is to decrease the number of persistent mutant cells that lead to cancer*.

The science is very clear on this. But at the time of my writing, this important fact has not yet been taken into account in setting radiation policy. I'll come back to that in a moment.

Selenium is a good example of a poison acting beneficially. It is considered highly toxic. Cattle, horses and sheep grazing in selenium-rich soil lose their hair, their appetites, become paralyzed, and die. Yet a selenium *deficiency* causes other problems, including an increased susceptibility to cancer and congestive heart failure. Serious illness and multiple deaths among grazing animals has been traced to a deficiency of selenium in the soil. The minimum intake recommended to maintain health is about one ten-thousandth of a gram per day. And a gram is only one twenty-eighth of an ounce. Yet somewhere between three and five ten-thousandths of a gram is considered an upper safe limit. Luckily, we have a much greater tolerable operating range.

During the past fifty years we have accumulated lots of data on low-level radiation. This work generally confirms the solid curve of Figure 7.2 and refutes the linear assumption (marked "LNT"). It shows there is a threshold—somewhere between 20 and 100 rem per year—below which there are no detrimental health effects from radiation, and below 20 rem the organism may actually suffer from a radiation deficiency. More research is needed to determine optimum radiation doses and dose rates, and to explore the variation with different kinds of cancer. But this is not the kind of work that can currently get funding from the radiation protection funding sources.

The conclusions stated above come from international teams of scientists and physicians studying: 1) Hiroshima and Nagasaki survivors; 2) occupational exposure among radiologists and atomic energy and weapons workers in the U.S., the U.K., Canada, and the former U.S.S.R.; 3) medical patients receiving radiation therapy; 4) persons who ingested radium during the days when radium was used to make luminescent dials; 5) miners working in uranium mines; 6) U.S and British troops participating in atomic bomb tests; 7) persons living in high-level natural radiation backgrounds; 8) and laboratory tests on plants and animals.

If current regulatory policy and practices were changed to reflect the scientific evidence—that small amounts of radiation can be beneficial rather than harmful—this would have a very significant impact on radiation protection and environmental clean-up planning for the immediate future and for the long-range. And it could significantly reduce much of the fear that surrounds the very word radiation in many people's minds.

Low-dose x rays have been used for nearly a century to treat local infection and avert the need for amputation. The radiation is too weak to kill the bacteria, but it stimulates the immune system to do the job. When sulfa and other "wonder drugs" were introduced, these became the treatment of choice, although they are much less effective. Clinical tests were run at Harvard in 1976 to successfully treat cancer with whole-body x rays, and Sakamoto and others in Japan researched the process in more detail and reported further successful treatments.

When a colleague of mine, E. J. Bauser, contracted an "incurable" cancer, he volunteered to take the treatment. His primary physician formally terminated their relationship warning that the radiation would kill him. The treatment gave substantial improvement with no detectable side effects, though as with chemotherapy further treatments were required as the condition returned. As of this writing, 11 years after his original "terminal" diagnosis, he has been unable to find a therapist willing to give further radiation treatments. He is told, “Chemo is the recommended treatment.” But at age 85, he dreads the prospect of the debilitating effects of further chemotherapy.

Is Ionizing Radiation Essential to Life?

We’ve seen that low doses of radiation are beneficial to life. What if we were to reduce radiation levels to below the natural background? How would an organism respond to that? There were hints as to what the answer would be when active marine life was found near hot underwater jets, thriving deep in the sea, far below the reach of life-supporting sunlight. These areas are also high-radiation zones because of the natural radioactivity flushed up with the jets. Lacking sunlight, these flourishing biota may derive their energy from the radioactivity. But no money is available to investigate such an exciting possibility.

A number of experiments have been done with plants and mice and other animals that were not only shielded from external radiation, but in the case of mice, were fed special food whose radioactive potassium isotope was depleted, greatly reducing their bodies’ natural radioactivity. The organisms looked normal but failed to function properly. When radiation was restored, they returned to normal functioning. Again, these studies have not been properly written up and followed up on since they contradict rather than support official LNT doctrine that all radiation must be harmful.

Radon: “The Silent Killer in Your Home”

High doses of radon are said to cause lung cancer. Therefore, based on the linear no-threshold (LNT) model, regulatory bodies claim that natural radon levels in homes present a risk of lung cancer. The BEIR-VI report, “Health Effects of Exposure to Radon,” by a special committee of the National Research Council, concluded: “the estimated 15,400 to 21,800 deaths attributed to radon … constitute an important public-health problem.” (I won’t comment on their implication of three-figure precision in an estimated range that varies by over 40%.)

Let's look at the data. Figure 7.4 shows the number of lung cancer deaths at various levels of radon as reported by Dr. Bernard Cohen. The figure is based on actual radon measurements in homes and number of lung cancer deaths in counties in which over 90% of Americans live. This is the actual population to which radon regulations apply. The dashed line shows the LNT "prediction" of lung cancer deaths for this same population. The data make clear that, within the range of radon levels measured, the number of lung cancer deaths *decreases* as radon levels increase. It does not increase, as the EPA and the National Research Council reports claim.

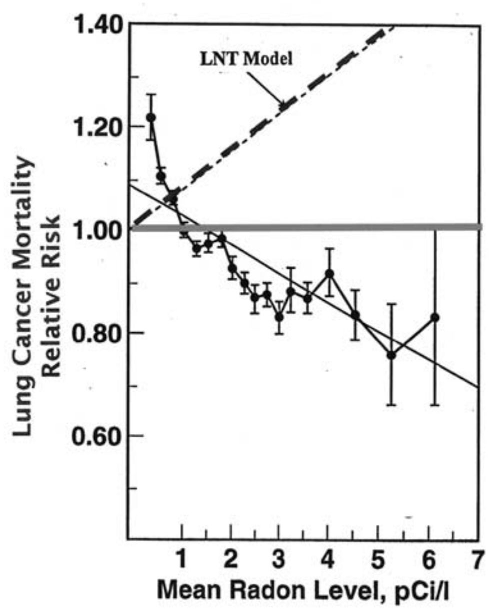

Figure 7.4 Cohen's lung cancer mortality data at various radon levels (*Cohen*)

Since this evidence differs from the LNT by twenty standard deviations, the policymakers have tried to ignore, obfuscate and disparage it. But their criticisms take the form of generic objections, which don't in fact apply to the actual case. For example, the BEIR-VI report on radon, on which the EPA regulations are based, relegates this evidence to its

Appendix G and doesn't even mention the many other studies that reach the same conclusion. Appendix G states:

> Potential confounding by smoking was addressed … The potential for confounding by sociodemographic factors or their correlates was explored by stratification on levels of 54 variables. Confounding by geography was assessed by stratification, and the sensitivity of the findings to outliers was examined. There was a strong negative association between 1970–1979 lung cancer mortality and the county-average radon concentrations; the association could not be explained by confounding. In interpreting this finding, Cohen proposes that the negative association implies failure of the linear non-threshold theory.

Sounds pretty convincing, doesn't it? Let's see what the body of the report says. The Executive Summary Conclusions states: "The carcinogenicity of radon is convincingly documented through epidemiological studies of underground miners, all showing a markedly increased risk of lung cancer." But miners are exposed to diesel fumes, silica and other mineral dusts, as well as higher radon levels than found in homes. Certainly all high-radon home-dwellers do not "show a markedly increase risk of lung cancer." The Conclusion concedes, "most of the radon-related deaths among smokers would not have occurred if the victims had not smoked."

But what about Cohen's data on actual people living in homes? This is not even mentioned in the entire 14-page, single-spaced Executive Summary. Nor is it discussed in the main body of the report. Going back to the 61-page Appendix G, we find that "ecological studies" (the type that Cohen and others performed using average radon measurements and average lung cancer data) are dismissed as follows:

> We conclude that ecological studies are noninformative for estimating risks posed by exposure to indoor radon or for evaluating a potential threshold exposure below which radon progency exposure would not be harmful.

So on what does the BEIR committee base its conclusion that 15,400 to 21,800 Americans die each year from radon? (See Figure 7.5.) Do you find that more convincing than Cohen's data? I sure don't!

Earlier in the appendix, a critic of Cohen's data states: "Most of us would not be willing to discard a useful theory (i.e., the LNT premise) on the basis of such a test." This turns on its head the classical scientific method of Sir John Popper and Richard Feynman, which requires that "a theory, however elegant" must be abandoned if it is contradicted by a single immutable fact. And here we have not just a single fact, not just the mass of radiation data, but everywhere else we look—toxicology, vaccinations, sunshine, exercise therapy—all exhibit the biphasic response: harmful at high levels, beneficial at low. In the case of radiation protection, that principle seems to be repeatedly overlooked.

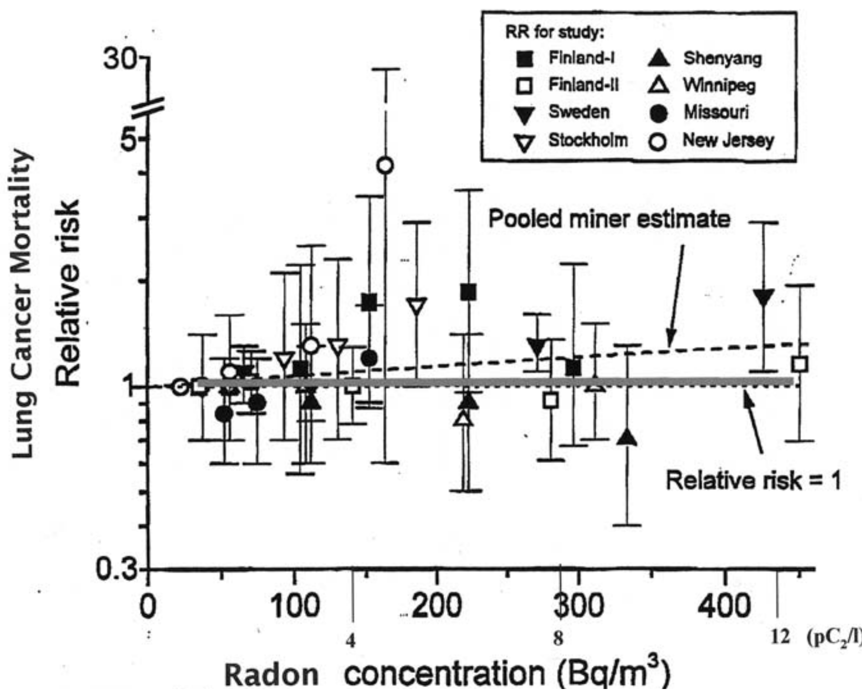

Figure 7.5 BEIR VI graph of lung cancer vs. radon levels. Note size of error bars (*National Academy Press*)

How Is Such a Discrepancy Maintained?

How do LNT advocates respond to the charge that the evidence does not support their premise? I am continually surprised at how little effort they make to state a scientific defense. For example, in the report NCRP-121, p.45, they state:

> *Few experimental studies*, and essentially *no human data,* can be said to prove or *even to provide direct support* for the concept … The *best* that can be said is that *most* studies do not provide quantitative data that, with statistical significance, contradict the concept.…It is *conceptually possible*, but with a *vanishingly small probability*, that any of these effects *could* result from the passage of a single charged particle, causing damage to DNA that *could* be expressed as a mutation or small deletion. It is a result of this type of reasoning that a linear nonthreshold dose-response relationship *cannot be excluded.* [Emphasis added.]

In June 2001, after six years of study, report NCRP-136 recommended continued use of LNT but conceded (page 6):

> It is important to note that the rates of cancer in most populations exposed to low-level radiation have not been found to be detectably increased, and that in most cases the rates have appeared to be decreased.

With such a weak case, you would think that it would not be possible to maintain such a discrepancy between science and policy for several decades—nearly two human generations. In controversies outside the nuclear field, there are people advocating tightening of safety standards and others arguing that excessive regulation is costly and wasteful. These two forces tend to be resolved by a middle-of-the-road solution that is tolerable to both sides. But for nuclear power there has been no force for moderation because all parties (except consumers) have profited from the fruits of radiophobia. So we have neither a personal nor an institutional constituency for radiation reform.

Researchers, policymakers and regulators draw their incomes and their reputations by continually studying a problem that is said to be dangerous and mysterious. Industry benefits from having lucrative projects to create large, complex safety systems and by "decontaminating" and "remediating" trivially-radioactive sites and equipment. Efforts to show that such measures are unnecessary are met with warnings, "The Government has been nice to us; we don't want to disparage them."

Leo Tolstoy said it well in his 1901 book, *What is Art?*:

> I know that most men, even those who are clever and capable of understanding the most difficult scientific, mathematical or philosophical problems, can seldom discern even the most obvious truth if it be such as obliges them to admit the falsity of conclusions they have formed perhaps with much difficulty—conclusions of which they are proud, which they have taught to others, and on which they have built their lives.

How Can Radiation Protection Policy Be Changed?

To challenge this situation, James B. Muckerheide, State Nuclear Engineer for Massachusetts, and Co-Director of the Center for Nuclear Technology and Society at Worcester Polytechnic Institute, set up in 1995, an international not-for-profit organization of independent experts on radiation science and public policy and called it Radiation, Science & Health, Inc. (RSH). Its stated mission is: "To document the scientific data that contradict the linear model;" and "To advocate for revision of radiation science policies."

RSH has collected, evaluated, excerpted and published on its website, **http://cnts.wpi.edu/rsh/docs**, evidence refuting the LNT from several thousand papers. Muckerheide recruited respected senior scientists from all over the world who were retired or otherwise able to resist pressure from the radiation protection community. He asked me to be a founding officer and director, and I gladly accepted.

Muckerheide had already started in 1994, arranging special sessions at the annual meetings of the American Nuclear Society (ANS), where scientists could present their research data refuting the LNT, answer questions, and discuss the implications. Seventeen such sessions were held, and the many papers presented were made part of the ANS

Proceedings, available to the scientific community at large. In addition, RSH provided speakers for dozens of other technical meetings worldwide. It was becoming increasingly difficult for policymakers to claim they were not aware of evidence that warranted changing the policy.

We started with our professional society, the American Nuclear Society, and tried for five years to get a simple position statement that low-dose radiation was not hazardous, and thus, the LNT should not be used to set radiation standards for the low-level radiation that is relevant to nuclear facilities. One would expect a scientific society to be reasonably free of political concerns. But one of the members kept expressing concern that such a statement might imply that the National Council on Radiation Protection and Measurements (NCRP) was not doing its job.

The statement was blocked, and the objector was later appointed to the NCRP. Another, expressing concern in more generic terms, was then appointed to the ICRP (the international equivalent). After it was too late to help shape public opinion on a number of important issues, a lengthy but fairly good compromise statement was finally issued.

This is what I call "institutional scientific misconduct." We also ran into it with the Nuclear Regulatory Commission, the Department of Energy, the Environmental Protection Agency and the National Council on Radiation Protection and Measurements, who refused to properly consider the relevant data and winked at badly flawed reports that appeared to support their position. Cutting off research they didn't like and selecting like-minded individuals for their committees, they managed to sustain the status quo.

Scientific misconduct by some individual scientists was also discernible. Simple refusal to acknowledge beneficial effects was the most common. They wrote, for example, "(since) there is no reason to expect radiation to *decrease* cancer mortality" and went on to ignore such data or even to count all health effects as detrimental. They worked mostly at higher radiation levels and then stated that any effect or absence of effect at lower levels would be too small to observe, which is true only if you assume the LNT applies—a classical case of "begging the question."

The word got around that if researchers wanted funding, they should be counting dead mice, not looking for happy mice.

The prevalence of such conduct has become sufficiently blatant and widespread in the field that some formal scientific misconduct charges may have to be filed. These have been effective in other areas where a political agenda tends to erode scientific integrity.

Energy Secretary Says: “We’re Killing People”

When the Nuclear Regulatory Commission was formed in 1975, it was given full responsibility for regulating nuclear facilities. This left the new Department of Energy (DOE) free to promote and encourage the development of nuclear technology without any regulatory conflict. But that did not prevent DOE from stretching the LNT premise to state in a news release on June 3, 1997, that “after six years of study and analysis” it concluded that 23 people will be irradiated to death as a result of the trivial radiation doses from shielded shipping casks carrying radioactive waste across the country. There is no scientific basis for such a statement, and it raised baseless fear of fuel shipments.

Then, on July 15,1999, an official DOE news release had this ominous paragraph:

> **Radiation-Induced Cancers**. We estimate that over the next 30 years, there will be between 250 and 700 radiation-induced cancers among DOE contractor employees, of which about 60 percent will result in death…

But the worst was yet to come.

On January 29, 2000, Energy Secretary Bill Richardson released a bombshell. As reported in the *Wall Street Journal*, “After decades of denials, the government is conceding that since the dawn of the atomic age, workers making nuclear weapons have been exposed to radiation and chemicals that have produced cancer and early death.” Richardson was quoted as saying, “This is the first time that the government is acknowledging that people got cancer from radiation exposure in the plants… Justice has finally come; the government is for a change on their side and not against them.” The article ended by saying that these conclusions were all based on previous publicly available reports. "None of the research was done specifically for this study."

Since this conclusion contradicted every valid scientific study I'd seen, I called the Secretary's office and asked for a copy of the report on which the statement was based. I was told that the report was not available. So a formal request for the data was written by RSH on February 1, and the Assistant Secretary for Environment, Safety, and Health, David Michaels, wrote me to say that the report was prepared by the National Economic Council (that's right; by economists!) based on "studies previously dismissed." When the economists have concluded their efforts, "we anticipate a public robust discussion involving not only the issues raised in the report but also whatever recommendations come out regarding compensation for DOE workers."

No such public discussion ever took place. The industry and the scientific community were strangely silent. The Secretary told reporters that the responsible officials knew that workers were being killed, but they lied about it and covered it up for fifty years. Still no reporter queried the Secretary. Congress quickly passed a "Sense of Congress" statement declaring, "Since World War II federal nuclear activities have been explicitly recognized by the U.S. Government as an ultra-hazardous activity." No mention was made of the fact that all valid studies show that nuclear workers have *better* health, *less* cancer and *greater* longevity than other workers.

Most egregious was the unprovable and indefensible statement, "Furthermore, studies indicate that 98% of radiation-induced cancers within the DOE complex occur at dose level below existing maximum safe thresholds." Reading the transcript of the Congressional hearings, I saw not a single voice of doubt or question as the measure passed without objection. No one wanted to be seen as opposing handing out money to the "cold war heroes." Since no one can prove that an illness was caused by low-dose radiation—none has ever been detected—the decision as to compensation in each case will apparently be based on whether the illness *could have been caused* by radiation. The list of illnesses and symptoms that might possibly have such an origin grows almost daily, so the number of eligible beneficiaries increases correspondingly.

Shortly after the election of a new administration, Secretary Richardson accepted a position as Director of the anti-nuclear political action group Natural Resources Defense Council, who announced that they considered that he had been a good Energy Secretary.

We in RSH had had little response to our efforts to get working scientists to speak out on the discrepancy between data and policy. They saw our efforts as endangering their funding. "That's not how I get tenure for my people," was the response from an official of the National Cancer Institute when we asked for help in getting low-dose irradiation treatment for a patient with an "untreatable" blood cancer.

We appealed formally to appropriate organizations to investigate this gap between the policy and the science. We wrote detailed documented letters to the U.S. Department of Energy, the U.S. Nuclear Regulatory Commission, the U.S. Environmental Protection Agency, the advisory commissions and panels, and the congressional leaders who had expressed interest in nuclear technology.

None of this led to effective action until Senator Domenici asked the General Accounting Office to investigate it. For a year we worked hopefully with the director of that investigation, but the ensuing report was toothless. Virtually all the material we had provided was ignored. Senator Domenici arranged for the Department of Energy to undertake research to resolve the matter, but this money was diverted to a multimillion-dollar, 10-year program on genome functions and cell cultures, designed to yield no animal or human information in the foreseeable future. It was clear that more decisive action was needed.

Suing the U.S. Environmental Protection Agency (EPA)

About that time (March 2000), I received a call from Alan Pemberton, a lawyer from the prestigious firm of Covington & Burling, asking if he could use a paper I had written on the LNT issue. I discussed the problems we were having in reaching any resolution to that situation, and asked if his firm ever did any *pro bono* work (i.e. for free). He said, "Of course. We do quite a bit." I asked who in the firm made the decision to take a case on that basis, and he said, "I'm the chair of the pro bono committee."

"Have I got a deal for you!" I replied, and we talked about the possibility of approaching the LNT problem from a legal, rather than a purely scientific, standpoint. He responded positively and said he would check whether his firm could help us. In a week or so he returned with a big yes and turned me over to Kipp Coddington, one of their lawyers who also had an engineering background and was quite familiar with the radiation question and with EPA.

RSH's many discussions with Coddington were fruitful. He advised that we find a particular legal action that could be challenged, rather than seeking to challenge the overall philosophy. This made sense to us, and we found that the EPA had just proposed a rule on the permissible levels of radioactivity in "Primary Drinking Water." The proposed rule had a deadline for public comment of June 20, 2000, and by working diligently we were able to complete our comment, with a nearly foot-thick stack of legal and technical attachments, in time for me to load twenty copies of it into my van and carry them over to the EPA office an hour before the close of business on the last day.

The next step was to wait for EPA's response. EPA was under court order (unrelated to our action) to issue a final rule by the following November, so we knew that EPA could not delay its response for years, which often happens. The response, as expected, did not address our basic objection, namely that in using the LNT premise to establish permissible limits, EPA was "arbitrary and capricious" in ignoring the best peer-reviewed science that the law required it to use. The EPA rule set goals for each nuclide at zero and then required that operating levels be reduced as near zero as technologically feasible—a continually elusive target. So the next step was to petition the federal appeals court to review the rule (and hopefully send it back for revision).

On January 4, 2001, just 15 days before we were to file our petition with the court, I got an email from Coddington. I had over 40 previous emails and numerous phone calls from him on this case, but this one was different. Its message was simple:

> We cannot represent you in this matter for a variety of reasons that are too difficult to explain here but are unrelated to the merits of your case.

I was never able to determine why his firm had pulled out or who put the pressure on them. Neither Coddington nor Pemberton would answer my questions, and I was left to scramble for a lawyer to pick up the pieces. Luckily, John Ferguson, who worked with my engineering firm, MPR Associates, agreed to assign one of his lawyers, Mike Wigmore, to help us, and he took over filing the petition. I had previously met with lawyers from the American Water Works Association, the National Mining Association and the City of Waukesha (Wisconsin) Water Utility, each of whom had submitted sharply critical comments to EPA. Mining and water treatment operators saw that the rule would suddenly convert each of their small, local operations into federally controlled radiation handling facilities, with implications they could only begin to see. The mining association joined us in the suit, as did Waukesha, but the Water Works Association held back. Waukesha persuaded six other local water-treatment facilities to join in. And the Nuclear Energy Institute (NEI) also filed as petitioners at the last moment.

This last one surprised me, because I had spent two years trying to get NEI to join with RSH to challenge the LNT. Joe Colvin, NEI President, told me that he and his members did not think this was an issue that could be settled in the foreseeable future, and they were staying out of it. We had also approached the Joint Defense Group (JDG), the utility lawyers who work together to defend utilities being sued for radiation-induced injuries. They told us the insurance companies used to just settle these cases out of court without regard to the merits. So the utilities set up the JDG to fight them.

Our suggestion to get at the root of the problem, to challenge the indefensible premise that low-dose radiation is harmful, met with indifference. They apparently see no reason to contest the present situation with its steady flow of cases.

What would it mean to win such a lawsuit? Would a judge settle a scientific question in court? I've been told that judges will not choose between opposing scientific viewpoints and say, "That one is better." But what I have seen judges do is to determine that an agency did not follow proper procedures in arriving at its scientific decisions and therefore, acted arbitrarily and capriciously. The matter would then be returned to the agency to be dealt with properly. For example, the EPA used the LNT premise to set a limit for chloroform in water. A judge ruled that no scientific basis had been cited for believing that chloroform acted that way. He struck down the ruling and remanded the matter to the agency for revision. In another case, involving the carcinogenicity of second-hand tobacco smoke, the Conclusion of the 90+ page five-year case stated:

> "EPA publicly committed to a conclusion before research had begun; excluded industry by violating the Act's procedural requirements; adjusted established procedure and scientific norms to validate the Agency's public conclusion; and aggressively utilized the Act's authority … to establish a de facto regulatory scheme."

The Court also noted that, in conducting its risk assessment:

> "EPA disregarded information and made findings on selective information; did not disseminate significant epidemiological information; deviated from its Risk Assessment Guidelines; failed to disclose important findings and reasoning; and left significant questions without answers."

On the basis of such history, we had hoped that the legal system might provide us what we were unable to get from the scientific community or the executive branch of the government: an unambiguous and unavoidable requirement to competently and objectively answer the question: Is low-dose radiation harmful? In this endeavor, we could silently pray with the bailiff: "God save the United States of America and this honorable court."

On February 25, 2003, the Court handed down its decision: "We conclude that … EPA complied with the requirements of the SDWA and the APA" (the applicable laws). Some of the petitioners are considering appealing to the U.S. Supreme Court. One told me he had already spent a million dollars on this case and appeal would probably cost another million. "But it will cost me $70 million to comply and make a nightmare out of running a little sewage plant," he complained. "And the idea that no one should challenge a federal agency is one this Supreme Court might want to jump on." Meanwhile, RSH is exploring amending the law, in which there was already some interest in Congress. I hope the next edition of this book will be able to report a happy ending to this saga.

Why Is This Important?

I found that most of the nuclear movers and shakers did not place the problem of low-dose radiation high on their priority list. They viewed our efforts to reform the situation as mildly commendable, like sending money to the Red Cross. But they considered the whole subject rather arcane and theoretical compared with other more urgent items confronting them. Why then do I consider it so important? What difference would winning this case make in the real world?

Nuclear operations, and specifically nuclear radiation, are widely viewed as presenting an unprecedented hazard to the human race—one we should not accept if there is any possible alternative. This is expressed many ways, but the underlying factor in each case is the argument that no amount of radiation is harmless. Thus, if there was any exposure to radiation, a worker who gets cancer concludes that radiation must be the cause. The law often agrees with him, and nuclear employers often pay off without questioning it.

LNT advocates who call themselves pro-nuclear claim there is no practical difference between saying that low-dose radiation poses no risk, and saying that the risk is less than other risks routinely accepted and therefore, should be tolerable. But this is, in fact, a black-and-white difference. Many people argue, and some courts agree with them, "it is not for *you* to say that *I* must accept an increased risk of cancer just because you find it tolerable. I say you have put me at risk without my consent, and I want compensation."

We don't apply the LNT philosophy to any other hazards. We don't ascribe deaths to the highly-toxic trace elements in our vitamin pills, such as selenium. In fact, we pay for them believing they are beneficial. The same reasoning should hold for radiation. We pay a high price for treating radiation differently.

Thousands of tons of nickel and other valuable metals used in the nuclear industry cannot be recycled because of trivial contamination. Families living near the burned-out Chernobyl nuclear plant are showing record levels of alcoholism, clinical depression and suicide because they can't return to their ancestral homes. They are told the land is "contaminated," although the radioactivity is generally lower than first-class real estate in Denver.

Japan has been forced to cut back and rethink its national commitment to nuclear power, because it recently experienced the worst nuclear accident in its history. This accident killed two factory workers at the uranium enrichment facility and "exposed over 600 members of the public to radiation." No one notes in repeated use of this phrase that the public radiation exposure was less than those individuals might encounter from variations in natural background and was too low to cause any detectable harm.

Some hospitals have had to close down their life-saving nuclear medicine facilities because of the burdensome regulations and uncertainty about accountability and disposal. Lives are lost because people have been warned away from treatments such as mammograms that involve radiation. Firefighters tell us that lives are lost because people won't buy smoke detectors with radioactive sources. Tens of thousands are said to die from respiratory illnesses caused by fossil-fueled power plants. Plans for fighting global warming and other ecological damage are distorted to exclude nuclear power, the most benign power source. "The waste problem" turns out in the end to be concern for reducing still further radiation levels that are already harmless.

Once the idea is established that any potential source of radiation must be treated as an extraordinary hazard, then spent fuel and other radioactive material become objects of terror—"mobile Chernobyls" in the words of the media. Although such shielded containers simply cannot hurt anyone, we are told that we must protect them from terrorist attacks and track them with extreme measures as they are trucked across the country. We are urged to ring nuclear facilities with extra guards and anti-aircraft batteries, even though it would be impossible to cause a release of radioactivity through any credible attack scenario on the reactor structure or the fuel storage pools that would create a serious public health hazard. This conclusion is described in a heavily documented, peer-reviewed pair of papers in *Science*, (September 20, 2002; January 10, 2003) that I co-authored with eighteen other Engineering Academicians. More life-threatening as well as more likely would be an attack on the chlorine storage tanks at a local water-works, an oil refinery, a natural gas pipeline, or even a neighborhood automobile filling station.

Even natural radiation that we have lived with healthily for countless generation is now characterized as hazardous, requiring government regulation and control.

While agreeing that low-level radiation is “probably harmless,” critics argue that “ALARA (reducing radiation ‘as low as reasonably achievable’) will always be good public policy.” But of course if we believe the scientific data, we must conclude that such policy is not only expensive, burdensome and unnecessary, it is counter-productive. It causes harm, not benefit. Until we understand that very important basic fact, we will always be fighting the radiation bogeyman to the detriment of the public welfare.