The Harmful and Fraudulent Basis for the LNT Assumption

3

I do not hesitate to say that the LNT is the greatest scientific scandal of the twentieth century (Gunnar Walinder)

3.1 A Scientific Scandal of the Last Two Centuries

New technology and ideas can be difficult to implement. Critics of Captain Edward J. Smith of the RMS *Titanic* were fast to point out that his poor handling of wireless messages deprived Smith of vital information concerning navigation of the ship in an ice field. However, wireless technology was relatively new in 1912, and most officers of passenger ships in the North Atlantic had not considered the implications of enhanced communication capabilities that the wireless offered. Smith did not appreciate how wireless gave him the opportunity to look over the horizon and anticipate danger before it came into view. He shared this shortcoming with nearly all of his colleagues [1].

This is not a claim that can today be made for radiation hormesis. Every regulatory agency in the world, other than France, bases their policies on the LNT, in spite of the massive published scientific literature that has clearly pushed far beyond the factual horizon to demonstrate thresholds and the beneficial effects of low-dose ionizing radiation. The linear no-threshold (LNT) assumption is a dogma constructed of untruths, artful dodges, and blind faith. The LNT paradigm does not fit the facts but holds political sway for the time being. The LNT has the political power for now to ridicule, ostracize, censor, and ignore the hormesis message and the facts that underlie its contention. This is the corruption mythology of the harmful effects of low-dose ionizing radiation that costs enormous resources in money and the quality and quantity of lives. Folk today are more worried about legal and political

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Table 3.1 Contrasted characteristics of science and pseudoscience [2]

Science	Pseudoscience
Evidence obtained via experimentation informs beliefs; belief in a claim is withheld if evidence is not available; relies on entire body of evidence	Beliefs are formed first and evidence is sought to support; relies on credulity; disconfirming evidence is rejected to preserve belief
Makes conservative and tentative claims based on evidence; beliefs change with new evidence; open-mined	Makes sensational claims without evidence; rejects new evidence against belief; close-minded
Uses precise terminology to aid understanding and independent verification; rejects unverifiable claims	Uses vague language and jargon to avoid criticism and inhibit verification; accepts unverified claims
Knows, understands, and applies the rules of logic with body of evidence to make claims	Uses logical fallacies and cherry-picks evidence to make claims
Treats critics as colleagues and values criticism from a community of scientists; engages in honest debate	Does not value criticism and condemns dissent; works in isolation and dishonestly engages in debate

liabilities than they are in science-based truth. The result is a politicalized pseudoscience wound around the LNT[1] (Table 3.1).

The Merriam-Webster dictionary defines "phobia" as an exaggerated, inexplicable, and illogical fear. The result of fear is anxiety and avoidance [3]. The LNT has a wide-ranging impact on radiology, nuclear power, "dirty" bombs, nuclear waste disposal, food irradiation, home radon, and diagnostic and nuclear medicine. The societal cost of radiophobia and fear mongering is exorbitant, and those that continue to promote it stand the most to gain; just follow the money. The cost of implementation and carrying out radiation regulations does not improve plant safety or personal health; it actually costs tens of thousands of lives annually in the USA alone.

> Smoke detectors should not cross state lines according to radiation dose regulations.

[1] The ICRP, NCRP, UNSCEAR, BEAR-BEIR Reports and IAEA are national and international funded radiation protection agencies with select committees and government officials, who nearly all promote the LNT as a radiation protection model. Proponents of radiation thresholds and hormesis are not appointed to scientific committees no matter how qualified they may be. Regulators claim their findings cannot be reviewed and changed. Some of the research that has refuted the LNT and was prematurely terminated includes studies of background radiation, CHR radium dial painters, Nuclear Shipyard Workers, AEC/DOE high-dose workers, Manhattan Project dose workers, radiation deficiency studies and most recently, DOE low dose radiation studies. All showed clear evidence of radiation thresholds and hormesis. Dr. Noel Metting, director of the DOE low dose radiation program, was fired in 2014 for her challenge to the LNT; she was reinstate after appeal. Metting was just another example of what happens to a scientist who objects to the LNT inside of "closed" science venues. Critics of the LNT are readily ignored with no debate. Debate challenges are avoided. Critics of the LNT risk science careers, grants and appointments by gov't agencies. Radiation protection officials routinely suppress science objections. The nuclear industry does not assess data, does not do research, does not review scientific data, but does profit to the tune of 100's billions dollars per year from public funds used for radiation protection and useless 'clean-up' and waste disposal based upon the LNT

Deep fear of nuclear radiation is widespread, yet research on radiation's biological effects finds that the level of alarm far exceeds the actual danger. This "radiophobia" has roots in the fear of nuclear weapons, but has been significantly reinforced and inflamed by accidents at nuclear power plants. Radiophobia does far more harm to human health than the radiation released by nuclear accidents. In some cases, the harm results from disaster response. The influence of radiophobia on society's energy choices poses great additional dangers [4].

Radiation protection scientists knew in 1934 what level of radiation was harmful and what level was safe. In 1956, the US National Academy of Sciences (NAS) adopted the LNT assumption from an evaluation of genomic risks due to ionizing radiation, based in large part on the fraudulent studies by Mueller on mutations in fruit flies. In 1958, the National Council on Radiation Protection and Measurements (NCRP) generalized the LNT assumption to somatic cells and cancer risk assessment [5]. The LNT is pragmatic and not based on biological concepts or mechanistic biological research. Most of low-dose mechanistic research at low radiation doses confirms the presence of thresholds and hormesis [6] (Fig. 3.1).

It was the leading physicists of that time responsible for invention of nuclear weapons that instilled an exaggerated fear of small doses irradiating healthy tissues, during the Cold War period of massive testing of nuclear weapons. Dr. KZ Morgan (1907–1999) was a pioneer in radiation protection beginning with the Manhattan Project. He founded the Health Physics Society (1955) and the *Health Physics* journal (1958). During World War II, Morgan believed in a radiation dose threshold but

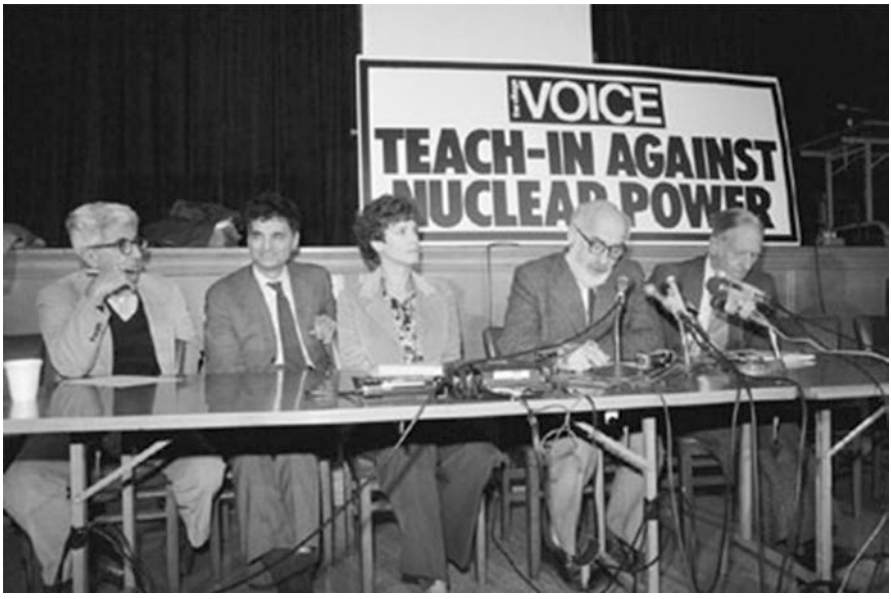

Fig. 3.1 Antinuclear advocates speaking in May 1979 at New York's Riverside Church (from *left*: Barry Commoner, Ralph Nader, unknown lady, John Gofman, and KZ Morgan) [7]

later reversed himself and became a firm believer in the LNT. He ignored the clear thresholds in radium dial painters and in Japanese A-bomb survivors and aligned himself with antinuclear activists who made absurd statements about the risks of radiation. Morgan could not give any good evidence for the LNT because it was theoretically impossible to do so [7].

John Gofman, an M.D. and nuclear physicist, was a graduate student of Glenn Seaborg at the University of California, Berkeley, from 1939 to 1943 working with cyclotrons. Gofman put a rat into a canister within a cyclotron and found it dead when he removed it later. He thought it had been killed by radiation, when in fact it had simply suffocated. The lab director, John Lawrence (1903–1991), wanted students to fear radiation and did not correct his misconceptions. Gofman (1918–2007) later wrote in his book, *Nuclear Witnesses: Insiders Speak Out*: It is not a question anymore. Radiation produces cancer, and the evidence is good all the way down at the lowest level [8].

Antinuclear activist organizations promoting radiophobia use blatant distortions. Fear mongering by antinuclear organizations such as Greenpeace has spread throughout the world. Greenpeace uses the words "birth defects, cancer, and nuclear power" in rapid succession over and over without establishing any scientific links, hoping that the repetition will become a mantra in place of the truth in the minds of its hearers. Sternglass in the 1960s predicted thousands of dead babies in the USA due to nuclear weapons testing fallout. Take this comment by a Korean organization: Relying on nuclear plants is like playing Russian roulette: the bullet-bearing chamber will come up eventually. It takes very little exposure to radiation to be fatal; the only difference between Hiroshima and Chernobyl is that in the first case hundreds of thousands of people died instantaneously and in the second, an even larger number will die of cancer over a longer, more painful period of time [9]. A 2009 review of Chernobyl finds that the earlier estimate of 50,000 deaths should be doubled to 100,000 [10]. Today, documented cases of radiation-related mortality from any cause from low-dose Chernobyl fallout are hard to come by. Is a little radiation really bad for you [11]?

Scientific American used to be known for accurate reporting on science and not for published fiction and propaganda. *Scientific American* in the June 2013 issue had an article entitled *Radioactive Danger Lurks in the Trees*. They reported that one million eventual deaths will result from deposited Chernobyl fallout due to a possible forest fire of so-called "contaminated" trees. The author believed that the risk of cancer after such a fire was 170 per 100,000 women and 18 per 100,000 men. A 2012 article in *Scientific American* says there is deadly radiation even associated with lightning strikes from the clouds [12]. The wildlife in Chernobyl evacuated zones are thriving in what is supposed to be an ecologic radiation death zone. Wildlife thrive in low-dose radiation, while only humans are supposed to be hurt by radiation. Where is the consistency of reporting facts?

The LNT assumption is based on seriously flawed and misleading epidemiological studies often conducted using phantom increased cancer risk for low-radiation doses.

The construction of a castle built upon the white cliffs of Dover was initiated by Roman conquerors and largely completed in the eleventh century by King Edward and King John. Tunnels were carved out of the rock below the castle during an invasion by Napoleon and enlarged during World War II. Vice admiral Ramsey used the tunnels of Dover as his command post to oversee the rescue at Dunkirk in 1940 and the invasion of Normandy in 1944. The tunnels were used as a secure command post in case of nuclear war with Russia and then abandoned in the 1970s. The reason was the fear of minimal radioactivity seeping into the tunnels with water from radioactive fallout.

The silliness continues today. On May 5, 2016, a spike of radiation was detected miles from the high-level nuclear waste tanks on Hanford, Washington. The EPA attributed the brief radiation to natural background radon emanation from the ground near a detector. Washington State Rep. Gerry Pollet called this meaningless spike a disaster that would result in 2102 additional fatal cancers for every 10,000 adults. This silly math and misuse of collective dose and the LNT by a Hanford agitator and politician were meant to scare, not educate, the public [13]. The latest in unbelievable science comes from Finland. The authors claim to have detected an increase in leukemia in a genetic subset of children aged 2–7 at a background dose difference of only 1 mSv [14].

An expansive, ever controlling government wants to take advantage of people's fears by promulgating regulations restricting exposure to ionizing radiation. Antinuclear NGOs thrive on fear. This radiophobia provides political power and lots of money to antinuclear activists, politicians, career radiation protectionists, and a long list of entrepreneurs who move "contaminated" soil from one place to another (even putting it into glass) and for the radon exterminator to relieve you of your own household radon gas you need for optimum health.

> There are great herds of elk and caribou in the Canadian artic. They survive in the winter by digging into the snow and eating large amounts of lichens. The lichens contain significant amounts of polonium-210 from the decay of uranium. According to the Chalk River Nuclear Laboratory in Canada, the animals typically receive an annual dose of about 1 Gy. The animal herds are not decreasing in number nor dying of cancer. Instead, they are thriving (Jerry Cuttler, S.A.R.I.).

Fear of radiation has served the political interests of countries that already possessed nuclear weapons, particularly the USA and U.S.S.R. The nuclear test ban treaty prohibited atmospheric and ocean testing; later treaties prohibited all nuclear weapons tests. However, all countries did not sign it. The idea that low-dose radiation was beneficial was anathema to their political interests. Instead they emphasized the supposed terrible cost to life from the infinitesimally small doses received by the northern hemisphere from test fallout while ignoring the higher doses received directly downwind in towns and cities of their own countries. The

hypocrisy was monumental by all sides; however, the radiation doses received by "downwinders" were beneficial.

People had good reason to worry about nuclear war. A book written in 1987 described updating of US military plans to launch a first strike war on the U.S.S.R. [15].

> The most insidious opposition comes from the radiation safety experts whose salaries, research funding, and bureaucracy depend on the status quo. They adhere to ALARA as if it were the Hippocratic Oath of their profession. According to Upton Sinclair, it is difficult to get a man to understand something when his salary depends on his not understanding it [16].

This led to political opposition to all things nuclear, including nuclear power plants. There are powerful political and vested interests in opposition to radiation hormesis today in spite of an overwhelming published literature to the contrary [17]. Not all officials believed in the LNT. George Kistiakowsky was President Eisenhower's science advisor and a former nuclear scientist who was a participant in the Manhattan Project; he believed that the use of the LNT was totally arbitrary. In his 1976 book, *A Scientist at the White House*, which he wrote in his diary in 1960 on being exposed to the idea of the LNT by the Federal Radiation Council, Kistiakowsky said: "… a linear relation between dose and effect … I still believe is entirely unnecessary for the definition of the current radiation guidelines, since they are pulled out of thin air without any knowledge on which to base them."

Critical thinking was suspended by decision makers for political agendas. The result has been an endless filing of lawsuits. Many people have thought they lived under the shadow of disease and death for decades, only because of radiophobia. Daniel Miles, who lived in St. George, Utah, in his 2008 book *The Phantom Fallout-Induced Cancer Epidemic in Southwestern Utah: Downwinders Deluded and Waiting to Die*, describes the inhabitants who called themselves downwinders and sued for their cancers. Follow the money! There are still people making claims that their "illnesses" are the result of having lived downwind of the Trinity test, even though they weren't actually "downwind" at the time of the test. Dr. Reginald Gotchy measured 700 people living near the Three Mile Island nuclear reactor accident a few months after the accident that happened on March 28, 1979 and found no increase in radionuclides. The increased radiation dose to two million people living around the plant was only 14 μGy [18]. Because we can't absolutely prove that there is no connection between their "illnesses" and radiation, radiation takes the fall. And once "victims" obtain an out-of-court financial settlement, a precedent has been set. There's no way to get the cows back in the barn. Follow the money!

A sad recent example is the US Nuclear Regulatory Commission (NRC) who granted the Vermont Yankee Nuclear Power Plant a 20-year extension of their operating license in 2011 that would keep it running until 2032. A miniscule leak of tritium from the plant, the radiophobia of the public, and the high costs of radiation

protection regulations caused the operating company to shut down a perfectly working 40-year-old plant. However, the NRC will say nothing because of politics. The Vermont Department of Health limits are 20 mrem per year. The NRC limits radiation doses for the general public to 100 mrem per year (1 mSv = 100 mrem). The EPA limit is 25 mrem per year from radioactivity in air, water, and soil. In comparison, the natural radiation background is 300 mrem per year in Vermont. The highest natural radiation levels found in the world are in Ramsar, Iran, where several thousand citizens live free from any adverse radiation effects at dose rates that are orders of magnitude greater than seen with the Vermont Yankee Plant.

Not surprisingly, radiation protectors often act in their own self-interest. Probably 90% of those employed in radiation protection are involved with "protecting" nuclear workers and the public from cumulative annual doses <100 mGy. Applying a threshold and the hormesis model would eliminate their careers. Most academics and physicians are not well informed about hormesis [19] (Table 3.2).

The whole sad story of dishonesty and misinformation and even fraud continues by radiation protection agencies and governments who want to keep the people of the world in fear of ionizing radiation [21]. The deadly outcomes resulting from radiophobia reactions have resulted in literally thousands that perished or had their livelihood destroyed due to irrational decisions to evacuate areas of low radiation levels. Michael Stabin of Vanderbilt University calls the LNT a "stupid bastard," which is not intended as a "low class slur" but a statement of fact.

A 1958 paper published in the *British Medical Journal* by Dr. Alice Stewart, *A Survey of Childhood Malignancies*, became one of the seminal influences for the LNT-based connection between low-dose X-rays during pregnancy and increased leukemia frequency in offspring. Stewart claimed an increased risk of leukemia for in utero exposures of 1–2-rad X-rays [22]. Several subsequent publications clearly showed that the human fetus exposed to doses less than 100 mGy (100 mGy = 10 rad) did not have an increased risk of leukemia or of any cancer [23]. This did not stop

Table 3.2 The supposedly ten most radioactive places on earth [20]

Ranking	Description
1	Fukushima, Japan, tsunami and nuclear reactor accident
2	Chernobyl, Ukraine, nuclear reactor accident
3	Mailuu-Suu, Kyrgyzstan, uranium mining and processing site
4	Polygon, Kazakhstan, nuclear weapons testing site and city of Semipalatinsk
5	Siberian underground liquid and solid waste storage facility and reprocessing plant at Tomsk
6	Sellafield, UK, Pu production facility for nuclear weapons
7	Pu production facility at Mayak and Techa River in Southern Ural Mountains of Russia
8	Coast of Somalia. Illegal burial of nuclear waste
9	Mediterranean Sea. Illegal dumping of radioactive waste
10	Hanford, WA, Pu supplier for most US nuclear weapons. Large mass liquid and solid nuclear waste

Stewart from becoming a spokesperson for antinuclear groups and an advocate of the LNT. Many studies have been carried out on the offspring of A-bomb survivors. These include birth defects (malformations, stillbirths, and newborn deaths), sex ratios, chromosome aberrations, blood-protein mutations, and minisatellite DNA mutations. None of these studies found any evidence for genetic effects resulting from parental exposures to radiation [24]. A recent study of women workers at Mayak, Russia, exposed in utero to γ-rays and plutonium found no risk of cancer in offspring [25].

Prof. Dr. Gunnar Walinder, former head of the Swedish Radiobiology Society and a preeminent Swedish radiation scientist, wrote about the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) in his 1995 book; he stated bluntly: "I do not hesitate to say that the LNT is the greatest scientific scandal of the 20th Century." Walinder wondered if radiation protection had become a health hazard. He believed that the LNT assumption was a primitive and unscientific idea. UNSCEAR, which had later changed its view on the LNT, expected no radiation-related health effects from Fukushima. There are 192 references to radiation hormesis in Annex B of UNSCEAR (1994) along with several thousand references in Luckey's books, which list the good, bad, and ugly from either listening to or ignoring evidence for radiation hormesis [26].

> A one-time dose of 400 adult aspirins can cause the death of one person. However, a group of 400 persons each taking one aspirin does not mean that one will die [27].

There were 86,611 survivors of the Japanese A-bomb detonations. Of those who died of cancer for the next 50 years, the number of solid cancers and leukemia deaths attributed to radiation was 480 and 93, respectively, amounting to less than 1% of those initially killed by blast and thermal effects [28]. UNSCEAR (1958) reported an incidence of leukemia in Japanese A-bomb survivors that was three times lower than in controls at a dose of 20 mGy and with a threshold of 500 mGy. Many other studies have shown evidence for radiation hormesis in the Japanese A-bomb survivors [29, 30] (Chap. 2).

UNSCEAR calculated in 1993 a collective dose for the entire world's population of 650,000,000 man-Gy truncated for 50 years; they also calculated 100,000 man-Gy for nuclear testing and 600,000 man-Gy for Chernobyl fallout. The tiny individual doses are harmless or beneficial. Only utilization of the LNT would make such foolishness sound scientific.

Abel Gonzalez of the ICRP attempted to take a middle political position on the LNT. According to Gonzalez, the LNT model yields speculative, unproven, undetectable, and phantom numbers. Nevertheless, he finds the LNT model to be prudent for radiological protection. Gonzalez states that:

> While prudent for radiological protection, the LNT model is not universally accepted as biological truth, and its influence and inappropriate use to attribute health effects to low dose exposure situations is often ignored. Speculative, unproven, undetectable, and "phantom" numbers are obtained by multiplying the nominal risk coefficients by an estimate of the collective dose received by a huge number of individuals theoretically incurring very tiny doses that are hypothesized from radioactive substances released into the environment [31].

NCRP-136 wrote:

> 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 decrease. However today, neither ICRP nor NRCP promulgates radiation dose regulations that take into account the benefits of low-dose radiation but continues to remain "prudent." (Fig. 3.2).

There is a socio-technical vanity and arrogance concerning the unreality of the LNT. The LNT has little to do with science but of the profit motive for the thousands of businesses that depend on radiophobia for their profitability. They depend on hypothetically exaggerated radiation hazards. The EPA facilitates this fear of radiation by published false estimates of annual number of Americans who will die

Fig. 3.2 Abel Gonzalez, ICRP Vice-Chairman from 2008 to 2013

View of nuclear wastes [50].

Fig. 3.3 View of nuclear wastes [33]

from cancer following exposure to radon in their homes. EPA exposure limits are orders of magnitude below levels where there is evidence of harm. The regulations cost hundreds of billions a year and accomplish nothing in radiation protection while preventing radiation that protects against cancer and other diseases [32] (Fig. 3.3).

Nations of the world spend hundreds of billions of dollars a year to maintain ridiculous radiation standards. For example, Poland spent billions of dollars on their first nuclear power plant only to have it abandoned due to politically motivated radiophobia by using the LNT to determine cancer risk. There is a near total fear of radiation in Germany causing a green energy focus and the abandonment of nuclear energy. Billions of dollars are spent each year by poor countries for phantom radiation protection; these resources could be used in much better ways to save lives [34]. Using present radiation protection regulations in the USA, it is estimated to cost 2.5 billion dollars to save one human life from so-called dangerous exposure. In contrast, it takes <$100 to save a life by immunization against a variety of communicable diseases.

Editors of major medical journals (*Lancet* and the *New England Journal of Medicine*) regularly publish papers that arrive at false conclusions about the risk of radiation.

The enormous social fear and media frenzy surrounding the release of radioactivity from the damaged Fukushima Daiichi NPP led to careful reexamination of the facts. Radiation hormesis is an excellent remedy for this affliction, and it is perhaps for this reason that this has been ignored and discredited over the past half century [35]. Today, people worry about dirty bombs, frantic evacuations, suicides, abortions, psychosomatic disorders, increased drug and alcohol use due to despair, and permanent abandonment of their home and properties from low-level radioactive contamination.

The first Earth Day, in 1970, was celebrated after a wave of environmentalism swept the nation. Many give credit to Rachel Carson's 1962 book, *Silent Spring*, which popularized the notion of large-scale chemical pollution, for igniting the movement. The enthusiasm spawned by Earth Day soon gave us brand-new regulatory agencies such as the Environmental Protection Agency. The "linear model" assumes that just a single molecule of a carcinogen or a single ionization from an X-ray can induce cancer. The linear model is rigid, absolute, and wrong. The resulting environmental regulations are having a negative impact, not only on societal costs but on our health as well (Calabrese. 2016 (go-nuclear.org)).

Radiophobia causes misappropriation of often precious resources to accommodate pseudo-dangers or made-up dangers; causes massive psychological damage in affected populations leading to depression, suicide, abortion, and unneeded stress; causes overspending on limited resources that could be used for more efficient and better purposes; and causes the avoidance of effective medical procedures such as low-dose radiation therapy (Bill Sacks, S.A.R.I.).

The grand total of the wealth and jobs created by the application of radiation technology in the USA is 420 billion dollars and 4.4 million jobs (Alan Waltar, S.A.R.I.). There have been no new nuclear power plants built in the USA since 1974. Ultralow limits have delayed and prevented the construction of new nuclear power plants, added billions to the cost of refurbishing old reactors and Superfund cleanup sites such as Hanford, and scared residents of Nevada from opening of the Yucca Mountain nuclear waste repository site. John Shanahan and the website, *Go Nuclear*, have contacts with thousands of professionals in nuclear energy and nuclear medicine in 111 countries. He believed that we need a new Earth Day dedicated to righting the past deceptions and correcting the ongoing errors in environmental regulation. It should be one that acknowledges our adaptive responses to what, in high doses, can cause cancer, but, in low doses, can improve our well-being [36]. Most members in the media and in the general public seem to believe that humans normally live lives free of natural background ionizing radiation. As a result, regulatory agencies only limit anthropogenic sources of exposures to radiation as being harmful, ignoring high doses from natural sources. Organizations like NAS and BEAR accept fraudulent, uncritical, unquestioning, and blind-faith rules put out by regulatory agencies and the scientific community [37].

3.2 The Scan that Cures

According to the *Book of Exodus*, a man who assaults another must pay a physician to heal the wounds. The thirteenth-century medieval physician and philosopher Nachmanides interprets this to mean that physicians require permission to heal, for without the warrant to treat, physicians might hesitate to treat patients . . . "in that

there is an element of danger in every medical procedure. That which heals one may kill another." This 800-year-old warning seems self-evident [38]. One should bear humility and avoid the arrogance of a know-it-all attitude when dealing with harm and benefit scenarios from CT scans. Even so, CT scans seem to be "The Scan That Cures." [39]. Diagnostic imaging is critical to effective therapy and saving and prolonging lives. Many epidemiological studies claim there is an increased risk of cancer associated with the low-dose radiation received during imaging, believing that view is the real health risk [40].

There were about 60 million CT scans in 2007 and 2008 in the USA, including four million children [41, 42]. Brenner and Hall estimated that up to 2% of cancers in the USA are attributed to CT scans. An iodine-based dye (injected) or barium solution (oral) may be administered as a contrast agent prior to CT scan to improve image quality. Severe anaphylactic reaction may occasionally occur, even to the point of being life threatening. Brenner and Hall do not address this risk in their analysis but only risk from X-ray exposure. The mean (± SD) cumulative dose from imaging procedures per patient per year is 2.4 ± 6.0 mGy; of this dose, 75% is due to CT and nuclear imaging [43]. The average dose from an abdominal-pelvic CT scan is the same as 100–250 chest X-rays [44]. There are many who want to decrease the dose received from a CT scan. The New York University Department of Radiology in 2016 was awarded an NIH grant of $3 million to work toward reducing the radiation dose from CT scans by as much as 90%.

> The general public's perception of the risks from CT scan radiation exceeds reality. Parents should agree to scans for their children with absolutely no worry or concern [45].

Computed tomography (CT) scan and computerized axial tomography (CAT) scan are procedures in which cross-sectional images (X-rays taken from many different angles) of structures of the body are created. Information is processed through a computer forming a three-dimensional image called a tomogram. The 3-D imaging makes CT scans more informative than chest X-rays. An X-ray source emitting an energy of 60–80 kv is used to make CT images. The scan time is very short, from 0.5 to 1.0 s. A higher CT radiation dose provides a higher image resolution with improved diagnostic reliability. Today, a chest X-ray gives 0.1 mGy, a chest CT gives 8 mGy, and a whole-body CT gives 10 mGy. In 2003, a chest X-ray gave 0.25 mGy and a whole-body CT gave 60 mGy. The difference in radiation dose between a chest X-ray and chest CT is today about 100-fold. Despite the apparent large dose differences, all fall in the hormetic zone.

Fear of ionizing radiation occurs in strange and unexpected places. In the midst of a combat zone, one of the concerns of a highly experienced and courageous physician is this fear. Mack Easty is a retired Army Lieutenant Colonel MD. Mack volunteered for a full year (2010–2011) tour of duty with a combat battalion

stationed in Kandahar Province, Afghanistan, just before his retirement. On one two-day patrol there were several IED (improvised explosive device) detonations. All the casualties received CT imaging, many with multiple scans with and without contrast media in Afghanistan hospitals and after transfer to medical facilities in Germany and Walter Reed Hospital. The typical CT scan is ubiquitous in combat casualties, each delivering a radiation dose of 10–20 mGy.

Mack wrote this to me in November 2011:

> I had always been taught that any amount of radiation incurs a cancer risk, especially CT scans since the radiation doses are 'massive'. As an emergency physician, I've ordered a lot of CT scans, but have always vowed to avoid them myself...I've always been taught that radiation exposures are additive and the lifetime cumulative dose determines ultimate risk...I was with a light infantry battalion and went on all the air assault missions. The guys with the worst injuries pretty much got scanned from head to toe when they made it to Kandahar … We flew 12 casualties (on this mission) and I figured out a lot of them were going to get scanned. I'm guessing these situations aren't things that Brenner and Hall [41] ever think about.

How you choose to analyze data often biases your conclusions. Epidemiologists like Brenner and Hall believe that all radiation is bad for you. This logically leads them to the use of a simple positive straight line without a threshold to represent the entire dose–response curve for cancer and radiation dose. Over 80 million Americans received a CT scan in 2011; the probability of receiving a CT scan was greater than one in ten. Brenner and Hall, using a simplistic LNT model, concluded that CT scans will be responsible for 1.5–2.0% of all cancers seen in the country [41]. Mack Easty was trained from publications by Brenner and Hall. Mack, as an emergency physician, needed to make sure to convey these "facts" to his patients before ordering these studies. There is no credible study, and it is a fantasy to support the contention that routine CT scans will cause future cancers [46, 47]. In fact, there is no epidemiologic study that has demonstrated adverse effects of radiation at doses less than about 100 mGy [6, 48].

The soldiers in the field are blest by the best medical care in the world. They are blest to be alive because of men like Mack Easty and accompanying medics. The casualties also receive a "hidden" blessing. The small doses of radiation they receive from CT scans stimulate a physiological phenomenon called radiation hormesis or benefit that enhances their healing and helps to prevent a wide variety of inflammatory and proliferative diseases in the future. Low-dose radiation is not harmful but is beneficial [6]. There is abundant scientific evidence that low-dose radiation exposures such as received by CT scans will reduce, not increase, cancer risks [46]. Mack Easty has been a member of S.A.R.I. for the last few years.

I was a professor at Korea Advanced Institute of Science and Technology (KAIST) in the Nuclear and Quantum Engineering Department in Daejeon, Korea, from 2004 to 2010. Korea obtains 40% of its electricity from nuclear power. During that time I made several presentations about the benefits of ionizing radiation. I was the keynote speaker at the annual meeting of the Korean Radiation Protection Society. I spoke at Seoul National University, Korean Nuclear Society, two nuclear

institutes in Daejeon, at KAIST, and in international meetings in Beijing and Hiroshima. The message was always the same. Low-dose radiation is good for you. Get as much as you can. If you smoke cigarettes, get an annual whole-body CT scan to limit your lung cancer risk [49]. I was probably entertaining but did not seem to make many converts.

The FDA even recommends that smokers and ex-smokers should get an annual CT scan to early detect life-threatening lung cancers. A $250 million study carried out over 5 years by the National Cancer Institute (NCI) showed I was right. Annual CT screening for lung cancer reduced lung cancer mortality in current and former heavy smokers by 20%. Also unexpectedly, annual CT screening cuts all-cause mortality by 7%. These results published in the November 2011 issue of *Radiology* triggered not an increased emphasis on causation but an early halt to the trial after the scan's benefits became obvious. The researchers assumed the benefits were due to the ability to detect tumors early when they are smaller and more treatable. This is a big issue since 220,500 new cases are diagnosed in the USA each year claiming 157,000 lives annually. Interestingly, screening studies with standard chest X-rays have not shown a screening benefit. The radiation dose from a standard chest X-ray is up to 100 times less than for a typical CT scan. The study involved 53,500 current and former heavy smokers (> one pack a day for at least 30 years) who were randomized to undergo either helical CT or a chest X-ray. By October 2010, 354 of those receiving CT scans had died from lung cancer versus 442 deaths for those receiving chest X-rays; the difference was 20.3% drop in mortality rates [50, 51]. The authors mistakenly attributed the differences to a screening effect without collaborating data rather than to radiation hormesis. Even so, a research team member, Dr. David Naidich, called the results stunning. The paper expresses angst over potential later cancers resulting from CT scans but completely ignores the possibility of radiation hormesis decreasing cancer risk.

Benefits of low-dose radiation are not only for cancer prevention but for prevention and treatment of a wide variety of other diseases that have significant pathological inflammatory components. The number of lives that could be saved, improved, and prolonged by low-dose radiation is enormous.

There is no evidence that CT scans increase the risk of cancer, in children or adults [46, 52]. Yet the experts contradictorily advocate the use of lower doses of radiation for needed CT scans as a "prudent" approach, thereby conflating the actual prudence of confining medical procedures to those that are clinically indicated by limiting radiation exposures that are clinically indicated [53]. Thus, apparently afraid to wander too far out on a limb in the face of the dominating and intimidating, but erroneous, belief in LNT, they undermine their own messages of reassurance, leaving patients and/or their parents confused as to whether there is risk or not. The number of excess cancer deaths in the USA due to CT scans has been estimated to be 29,000 per year, a figure that is patently false. There should be less than expected cancer deaths not more from CT scans. The LNT model has contributed to a widely held perception that radiation does more harm than good for patients who depend on advanced imaging to obtain correct diagnoses. Concerns over low doses of radiation from CT and X-ray scans are not only misguided but may lead to more deaths

from missed or delayed diagnosis than would supposedly be derived from radiation exposure.

In 2016, a Fox Chase Cancer Center researcher (Mohan Doss, S.A.R.I.) evaluating atomic bomb survivor data concluded that there should be no concern regarding low-dose radiation exposures to children and cancer risk from pediatric CT scans. The data on the long-term health effects of the survivors of the atomic bombings of Hiroshima and Nagasaki is generally regarded as the most important data for estimating health effects of radiation. Doss recommends the discontinuation of ALARA. We should not continue this campaign, but rather, we should educate the public to help alleviate their concerns. The ALARA principle can lead to issues with the quality of the images produced and can produce nondiagnostic scans, which can lead to a missed or incorrect diagnosis [52] (Fig. 3.4).

The use of fluoroscopic X-ray monitoring during the treatment of tuberculosis was common between 1920 and 1960. Typically, each dose was in the range of 10–100 mGy, and exposures occurred as frequently as every 2–3 weeks for 3–5 years. No significant increase in breast cancer was noted up to cumulative doses of 500 mGy [6]. The Canadian fluoroscopy study contains the second largest group listed in BEIR V and has good dosimetry documentation. Below a cumulative dose of 300 mGy, there is a highly statistically significant decrease in breast cancer. Miller wrote: The data was most consistent with a linear dose-response relationship … Our additive model of lifetime risk predicts that exposure

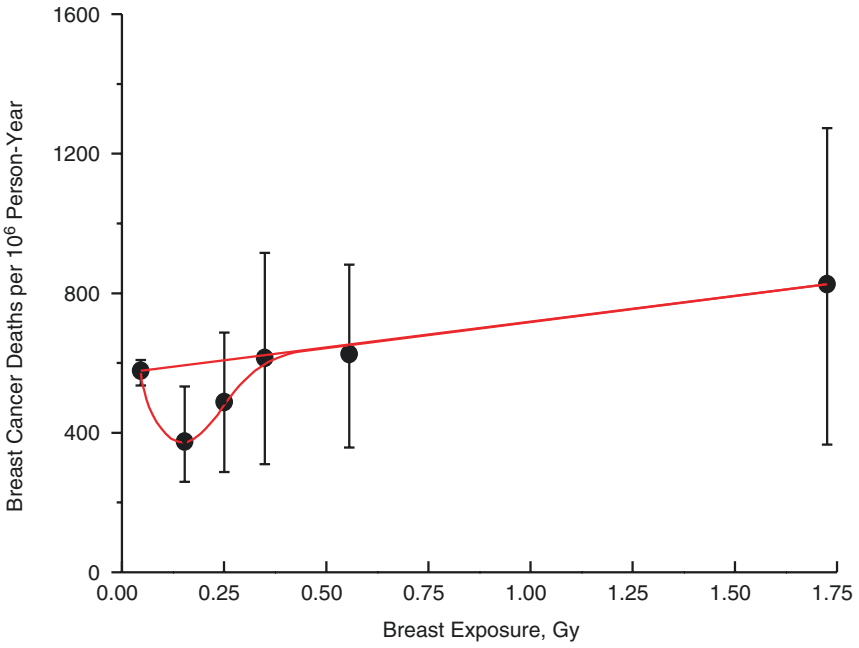

Fig. 3.4 Breast cancer mortality in Canadian tuberculosis patients given periodic fluoroscopic examinations. Figure redrawn from Miller et al. [54]

to 1 cGy at the age of 40 increases the number of deaths from breast cancer by 42 per million women [54]. Miller estimated an excess of 900 cases of breast cancer in a million women using the LNT assumption, [54] while Makinodan predicted 10,000 fewer cancers than expected in a million unexposed woman, using the same data [55]. Miller misrepresented the data to force fit an LNT response. BEIR V followed by applying a false straight line in its report; BEIR does not include any substantial studies that show the adverse effects claimed with the use of the LNT. In 1995 and 1996, NCRP continued to support the LNT assumption using this well-known straight line to zero [56]. An "update" study was published by Howe in 1996 [57]. Howe claims that the study does not show evidence of radiation hormesis. Howe graphically presents this conclusion by combining the four lowest dose groups into one group, thereby eliminating all evidence of hormesis. When challenged at the1997 National Academy of Sciences meeting in 1997, Howe said that the low-dose groups were "not informative." These low-dose groups in the Canadian breast cancer study had the largest number of cases with the smallest error bars. Subsequently, the NCRP SC 1-6 draft stated that the paper by Howe "refutes" the 1989 study [56].

Later Howe published a paper on lung cancer in the same Canadian women being treated for tuberculosis. The women had significantly lower lung cancers at cumulative doses below 2 Gy [58]. This radiation hormesis response was similar to many findings by other investigators [6, 49, 59]. The risk of childhood cancer was studied in a cohort of 92,957 children who had been examined with diagnostic X-rays in a large German hospital during 1976–2003. Newly diagnosed cancers occurring between 1980 and 2006 were determined through record linkage to the German Childhood Cancer Registry. No increase in cancer risk with diagnostic radiation was observed [60]. The low-dose radiation of medical imaging provides no pathway to poor health, whereas the LNT and ALARA most certainly do [61].

3.3 Chernobyl and Fukushima

James Muckerheide (1942–2014) spent the later part of his life trying to tell the truth about the health effects of low-dose radiation [56]. Most in government agencies throughout the world have failed to listen to James and many others. An expansive government may want to take advantage of people's fears by promulgating regulations. This is a clear and demanding problem in radiation protection. The LNT assumption is extremely simple to understand by the public and to apply in radiation risk estimates. The LNT is responsible for the radiophobia following the Chernobyl (1986) and Fukushima (2011) nuclear accidents. The accidents created an atmosphere of dread and panic by adjacent populations who had been taught that there is no safe radiation dose. Tens of thousands of cancer cases were predicted in the general population around Chernobyl [62]; no cancers or other clinical medical issues were found associated with Chernobyl radiation [27]. The incidents resulted in the loss of thousands of lives not from radiation-induced

cancer but from fear of radiation. The people of Russia and Japan would have greatly benefited by listening to the advice of James Muckerheide [56].

Kofi Annan (former United Nations Secretary-General) predicted in 2000 that three million children would require treatment because of Chernobyl, and many would die prematurely. Poor people in South America would not consume free powdered milk given by European relief agencies because they feared it was contaminated by radioactivity from Chernobyl. All these false views are the simple result of believing that even the smallest radiation exposure was harmful to health.

> We have quite a gap between scientific realities where not a single death from radiation has occurred and psychological trauma causing over 1000 deaths from the Fukushima accident (Wade Allison, S.A.R.I.).

The Chernobyl plant in northern Ukraine was a 1 GW nuclear power reactor. The Chernobyl accident happened on April 26, 1986 at the nuclear power plant in Pripyat, Ukraine[2]. The Chernobyl reactor exploded and the graphite core burned; it was about as bad as you can get. The accident was the worst nuclear power plant accident since the advent of nuclear power nearly 60 years ago. There followed a total meltdown of the reactor core, which, associated with burning graphite, produced a large, radioactive, aerosol emission for several days. The accident released 100 times more radiation than the Hiroshima A-bomb in 1945 and much more radiation than released into the environment from the Fukushima reactors. The explosion at Chernobyl went through the roof of the Reactor 4 building, spreading a radioactive cloud over areas as far away as Spain and Scandinavian countries. It also led to the relocation of 350,000 persons in Belarus and Ukraine and left an area of 100,000 square kilometers "uninhabitable." Needlessly, it may remain that way for generations to come. The results of radiophobia were untold numbers of abortions, suicides, and panic evacuation deaths.

> There were 134 cases of persons at Chernobyl that had acute radiation syndrome; of these 31 died within a few weeks. Of the 103 high-dose, long-term survivors, only 19 had died by 18 years later, mostly from cardiac disease and liver cirrhosis, often in men associated with cigarette smoking and alcoholism. Andrei Tarmozian, a 25-year-old fireman at Chernobyl in 1986, was successfully treated by a US physician, Dr. Robert Gale, for high-radiation exposure. Tarmozian survived but died at age 50, not of cancer, but from cirrhosis of the liver associated with alcoholism. Tarmozian believed that vodka protected him against the carcinogenic effects of radiation.

[2] The author was attending an IAEA conference in Vienna, Austria, at that time. The conference was about radiological hazards associated with nuclear power plant accidents.

Psychological disorders occurred in millions of people in Russia as a result of radiophobia associated with Chernobyl fallout. It was the most significant health effect observed, all because of the LNT. The Russian government evacuated and relocated 270,000 people; had they stayed they would have received from 1986 to 1995 a cumulative dose of between 6 and 60 mGy. Their mean ten-year cumulative dose from background radiation would have been 150 mGy. The Chernobyl evacuees would have received an additional 160–210 mGy had they stayed. Many places in the world experience much greater annual natural doses than these, up to 200 mGy per year. None has an increase in cancer rates. The background dose rate in Colorado is 6 mGy per year which would give a cumulative 10-year dose of 60 mGy; in Ramsar, Iran, it would have been 2000 mGy.

Mikhail Gorbachev believed that the Chernobyl accident was perhaps the real cause of the economic collapse of the U.S.S.R. One could now imagine much more clearly what might happen if a nuclear bomb exploded …one S-18 rocket could contain a hundred Chernobyl's (quoted by Jaworowski [63]). The enormous political, economic, social, and psychological impact of the Chernobyl accident was due to the irrational fear of ionizing radiation. Nuclear power is the cleanest, safest, and nearly inexhaustible supply of energy in the world. Nearly four million people living in Russia live in "contaminated" areas, receiving doses of >15 mGy. These people were declared to be "victims." They were much more victims of radiophobia [64]. According to the IAEA and other sources, from 100,000 to 200,000 abortions were performed following Chernobyl throughout Europe because of fear and the advice of physicians [65–68]; these unborn children were the ultimate victims.

UNSCEAR, the Chernobyl Forum, and many Russian and former U.S.S.R scientists believe that more than 800,000 excess deaths had resulted from Chernobyl during 1987–2004 [69]. Marvin Goldman in 1987 estimated that 53,400 people would die of radiation-induced cancer from Chernobyl fallout over the next 50 years [70]. In reality, the fatality rate per GWe-year at Chernobyl was nearly 50 times less than fatalities in hydroelectric plants [63]. Radioactive cleanup workers or "liquidators" worked in a 30-km^2 "high-" dose zone in 1986–1987. Workers were sent home when their cumulative dose reached 100 mGy to be replaced by new workers. The expected increase in cancer among these workers based on the LNT was 0.6% or about 1200 cases (BEIR 2006). The observed cancer mortality rate for the next 20 years was about 20% less than in an unexposed control population [71]. There were less than expected deaths and birth defects in populations exposed to Chernobyl fallout than seen in unexposed control populations [6, 63, 72]. Even people living in Bryansk district (the most contaminated area in Russia with a mean cumulative dose of 40 mGy) had a 17% decrease in cancer incidence [73]. Today, one can attend the "Chernobyl Festival" where for $200 you can take a tour of the reactor and enjoy a dinner. Those who travel today will feel like they are entering a nature paradise. In this area around the surrounding reactor, there are once again wolves and Przewalski's horses, European bison, and lynx which all have free range in the flourishing forests.

LNT advocates consistently proclaimed an increased risk of cancer whenever the epidemiological numbers are positive while hypocritically ignoring any negative number that indicated a benefit. The affected countries were very keen to exaggerate

the medical and environmental consequences of Chernobyl fallout because of potential western investments in future studies and aid. Research money and outside aid would dry up if their studies demonstrated benefits from ionizing radiation. Because the LNT hypothesis is very well established, and because many strong radiation protection organizations are in place, scientists and government officials are reluctant to seriously consider the implications of radiation hormesis phenomenon, which has very important public health consequences. The cost in lives and money in implementing current radiation guidelines is enormous, while the "benefit" to our health may be negative with not less but more cancer [74].

At 15:37 on March 11, 2011, a tsunami wall of water engulfed the Japanese eastern coastline, including three nuclear power reactors at Fukushima. There were about 20,000 Japanese who died from the Tohoku and resultant tsunami. No one died from direct effects of ionizing radiation (Fig. 3.5).

The operator of the stricken Fukushima Daiichi Nuclear Power Plant revealed that 600 tons of reactor fuel melted during the disaster, with the exact location of the highly radioactive blobs remaining a mystery [75]. Radiophobia covered up the real impact of the tsunami on Fukushima refugees. The only things we learned that were helpful from Fukushima are that emergency generators and cooling water pumps should be placed further up the hill and that earthquake zones are hazardous (Wade Allison, S.A.R.I.). According to the World Nuclear Association (2016), UNSCEAR (2013, 2016), and IAEA (2015), there have been no deaths from radiation sickness or any other health effect from Fukushima fallout nor are health effects likely to be detected in the future in either a nuclear plant employee or in those living nearby the facility [76].

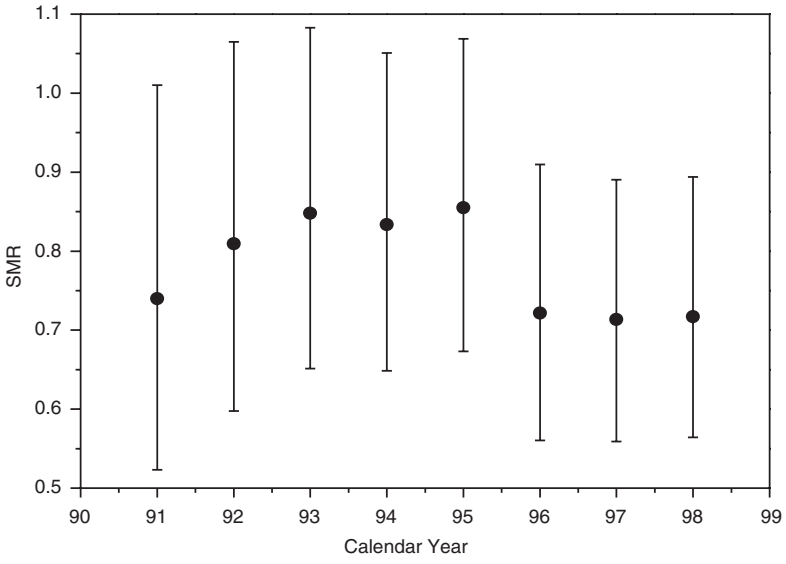

Fig. 3.5 SMR for all-cancer mortality in Chernobyl liquidators [71]. An SMR = 1.0 is expected for a similar unexposed population

Fukushima radiation levels following the 2011 nuclear power reactor accident were less than several natural, high-radiation background areas. Radiation doses received during the first year to those living in a 20-km radius were 20 mGy; 169 nuclear reactor personnel received doses of >100 mGy, mostly by inhalation (6 staff received >250 mGy and 136 received 100–250 mGy) [78]. A recent paper found that Fukushima individual radiation doses were by a factor of 4 smaller than earlier doses employed by the Japanese government [79].

The number of evacuees initially totaled 328,903 that was reduced to 263,392 as of February 13, 2014, nearly 3 years after the tsunami. Of the 132,500 Fukushima residents, about 70% experienced mental and physical disorders. Long-term refugee life spawned suicide, divorce, separation of family members, migration and settlement outside the evacuation zone, and mental illness. No one was killed by radiation alone. However, more than 1000 people died from radiophobia induced by the LNT [24].

Many people living in Tokyo did voluntary evacuations, among them members of the French embassy and many Americans. The Japanese government had forcibly and unjustifiably removed and relocated over a 1000 elderly people outside of Fukushima, similar to the relocation of American Japanese along the Pacific coast of the USA to inland "camps" in 1942. The relocation had substantial social impact: loss of homes, employment, community support and social ostracization, and isolation because of supposed radioactive contamination. As around Chernobyl there were a rash of suicides, alcoholism, and manifestations of PTSD. Stress-induced deaths in Fukushima were greater in number than from 2011 natural causes. Psychological consequences of low-dose radiation exposure may result in depression, post-traumatic stress disorder, chronic anxiety, sleep disturbance, severe headaches, alcoholism, intense anger, despair, and suicide. Societal risk was aggravated by radiophobia which is an emotional reaction that considers radiation as being unsafe no matter how low is the dose.

The Japanese government panicked and evacuated a hospital intensive care unit, taking them to a high school where many died. There were suicides among residents of nursing homes. Had the evacuees stayed home, their cumulative exposure over 4 years, in the limited and small areas of most intensely radioactive locations, would have been about 70 mGy—roughly comparable to receiving a high-resolution whole-body diagnostic scan each year. Most of the other evacuees would have received much less, about 4 mGy/y. Recently, Mohan Doss and two other researchers, Carol S. Marcus of Harbor-UCLA Medical Center in Los Angeles and Mark L. Miller of Sandia National Laboratories in Albuquerque, petitioned the Nuclear Regulatory Commission to revise its rules to avoid overreactions to what are nonexistent threats.

Nuclear Japan is a documentary film directed by Hiroyuki Kawai, a 70-year-old lawyer and filmmaker with a remarkable record of winning very high-profile cases, and elucidated the controversial issue of the nuclear power industry in Japan. The film takes you back to a few hours after the earthquake on March 11 to the shore of Namie Township, 7 km north of Fukushima No.1 nuclear power plant. The local fire brigade in Namie was desperately searching for missing persons swept away by the

disastrous tsunami. However, the next morning on March 12, the question starts to rise for the possible dissemination of radioactive material. The Japanese government consequently declares the area within 10 km from the Fukushima Daiichi Nuclear Power Plant as an evacuation zone. As a result, the fire brigade in Namie Township was forced to give up the search for tsunami victims. A month after the earthquake, the search for missing persons resumed. During the search, more than 180 bodies were found along the shore of Namie Township. If it weren't for the nuclear accident, most of those lives could have been saved [80].

Of the 17,000 killed in Japan by the tsunami and over a 1000 by the stress of emergency evacuation from Fukushima region, none has died from excess radiation exposure nor are expected from radiation-induced cancer or any other disease. Total voluntary and nonvoluntary relocations in Japan were initially estimated at 500,000. Why do much of the media misread the Fukushima meltdown and mention that no one has died of radiation exposure and no one is expected to die from it? Fukushima foolish evacuation did great harm to the elderly due to a nonexistent radiation threat emergency evacuation around the Fukushima Daiichi Nuclear Power Plants; this has been reported by the Japanese Recovery Agency.

The claims of radiation-induced disaster are mind-boggling. Dr. Gordon McDonald, executive director for research at the Koinonia Institute, claims that Japan's radiation is poisoning America. He believes that released Cs-137 from the Fukushima accident is having catastrophic effects on sea stars, killer whales, sockeye salmon, and other oceanic creatures. Even people who should know better have espoused outrageously inaccurate views. YouTube videos portray zombies following the Fukushima contamination. Yale University professor Charles Perrow warned that even humanity could be threatened for thousands of years by radioactivity from Japan. Canadian scientist, David Suzuki said: Fukushima is the most terrifying situation I can imagine. You have a government that is in total collusion with TEPCO, the energy company. They're lying through their teeth … It's bye-bye Japan and everybody on the west coast of North America should evacuate.

Several sailors serving on the aircraft carrier *Ronald Reagan* have sued the Japanese government for cancers and other diseases that have appeared among them since being exposed to radioactivity from the Fukushima nuclear accident. Radiophobia is good for lawyers. On February 10, 2014, several US naval personnel serving in the Navy off the coast of Fukushima, Japan, filed a billion dollar lawsuit against Tokyo Electric Power Company (TEPCO), claiming that they knew they were in danger of suffering from the toxic radiological exposure caused by the failure of the Fukushima Daiichi Nuclear Power Plant nuclear reactors. The exposures on the nuclear-powered aircraft carrier were a very small fraction of normal background exposures (<0.2 mGy).

In overreaction, the Japanese government is preparing to store the surface soil with a Cs-137 content of 100 Bq/kg, or about the radioactive content of the human body due to naturally occurring K-40 and C-14. The Fukushima cleanup costs by 2016 amounted to 42 billion dollars. Essentially, none of this herculean effort is needed. The radiotoxicity of naturally occurring U-238 and Th-232 and their daughter products Ra-226 and Po-210 is over 1000 times greater than for Cs-137.

Cesium-137 content found in tuna caught off the California coast was tenfold higher than found in tuna caught pre-Fukushima. The author of the "expose" failed to mention that even this "high" radioactivity is 30-fold lower than naturally occurring potassium-40 in tuna or that the radiation dose to tuna is also much higher for naturally occurring polonium-210 than for radio-cesium. On November 17, 2016, a United Nations panel found no evidence of increased cancer caused by the Fukushima reactor accident.

3.4 Statistical and Observational Malfeasance

We are suffering from a crisis of over-certainty, placing faith in meaningless statistical analyses and invalidated models, while packaging the old as new [81]. Bobby Scott (S.A.R.I.) writes of harm linked to biological-mechanisms-devoid, radiation-phobia-promoting LNT model whose use is currently justified based on seriously flawed and misleading epidemiological studies conducted by LNT profiteers that create phantom increased cancer risk for low radiation doses. Calabrese writes of abusive, falsified research used to promote the LNT [37, 82–84]. Cuttler writes of politicized science to promote the LNT [5]. "Science" today uses seriously flawed methodology that could have disastrous results [85].

Much of the scientific literature, perhaps half, may simply be untrue: Afflicted by studies with small sample sizes, tiny effects, invalid exploratory analyses, and flagrant conflicts of interest, together with an obsession for pursuing fashionable trends of dubious importance, science has taken a turn toward darkness. In their quest for telling a compelling story, scientists too often sculpt data to fit their preferred theory of the world. No one is incentivized to be right. Instead, scientists are incentivized to be productive and innovative. Our love of "significance" pollutes the literature with many a statistical fairy tale. We reject important confirmations. And individual scientists, including their most senior leaders, do little to alter a research culture that occasionally veers close to misconduct [16, 86].

> Torture numbers and they'll confess to anything (Mark Miller, S.A.R.I.).

Epidemiology studies can be a dream scenario for environmentalists, because they require no science (Robert Hargraves, S.A.R.I.). A case in point is the myriad numbers of positive and negative epidemiology studies published with respect to food consumption and cancer [87]. This demonstrates that for many epidemiology study designs, the claims in the conclusion may be as likely to be wrong as to be right. There is also a bias for publishing positive results, even though negative results are just as informative. This makes it more likely that incorrect results will end up being published, especially if they fit the researcher's preconceived notions. Preference may also be given to epidemiological studies with the highest quality of methodology and interpretation, regardless of the results and level of statistical manipulation [88, 89].

Most patients lack basic knowledge about the risks of radiation exposure from X-rays and other diagnostic imaging tests [90]. Physicians are told what to believe. Dr. Mack Easty, an emergency room physician, writes: You have my full sympathy. If you think it's tough and crazy being an emergency physician, you can only imagine how trying it is to convey accurate information to patients as a radiation oncologist. And the board exams remain rife with this overly simplified—or downright inaccurate—nonsense, or else we cannot get or maintain board certification [91].

The impact of the LNT assumption is enormous with respect to avoidance of radiation exposure to prevent and treat diseases, as well as in medical imaging technologies, costs of implementing radioprotection guidelines, radiological terrorism, and the development of improved nuclear reactors for electrical power generation. Falsely vilifying radiation hormesis, in the absence of actual confirmatory data and in apparent ignorance, or at least neglect of much contrary observational and experimental data, and particularly without regard to the risks of being wrong, can be deadly. Yet the statistical limitations and manipulations of many epidemiological studies by LNTers on radiation risk determination and the use of "tricks" to hide radiation hormesis and its benefits are legion in the radiation sciences community. Data should be transparent. The obsession for controlling variables when the results show no effect or radiation hormesis seems designed to impress rather than inform. As a result, nice linear placements seem too good to be honest (Wade Allison, S.A.R.I.).

I think it is vital for us all to realize that there is still a role that paradigm blindness played in the early promotion of LNT in the 1940s and 1950s. Trapping by false paradigms is firmly *entangled* with deliberate distortion in ways that each reinforces the other. They are often inseparable. And since paradigm blindness can catch every one of us if we are not vigilant and open to learning from others, this is at least as important an aspect of the history of LNT as the deliberate distortion and lying. In short, paradigm blindness and deliberate lying both played, and continue to play, a role in the original creation and the continued maintenance of LNT, and it is important for us not to omit the former while concentrating only on the latter. The lessons may be even more profound in the former aspect, as they apply to all of us. The LNT-promoting radiation epidemiologists are trapped in the LNT paradigm, even if there may be a tendency on the part of some, or all, of them to fudge a little as they fool themselves (Bill Sacks, S.A.R.I.).

Everything should concern biology, including epidemiology. That is, there are biological mechanisms proposed for the observed results. There is a great problem with false paradigms, unfounded assumptions, and specious statistics in radiation science. All epidemiological studies that attempt to show causal correlation between low-dose radiation and low-dose-rate radiation and cancer incidence and cancer mortality are based upon hidden circular reasoning that "removes" the impact of hormesis by using the LNT assumption while failing to account for other radiation exposures, such as natural background, medical and therapeutic exposures, etc. exposures [92]. The LNT authors routinely conflate dose with dose rate and regard cumulative dose at low-dose rates as a meaningful risk factor. Risk estimates from radiation dose delivered in small packets over time are not additive for individuals

or even large populations. It is like saying if you ingest 100 aspirin at one time, it is lethal to one person, or if 100 persons take one aspirin, it would also be lethal to one person (Bill Sacks, S.A.R.I.).

All epidemiological studies that purport to show a monotonic causal correlation between low-dose and low-dose-rate radiation and cancer (incidence and/or mortality) are based on hidden circular reasoning that erases any hormetic zone and/or threshold. Analyses usually fail to account for natural background and medical exposures. We also show that many of the LNT authors routinely conflate (fuse, combine into one entity) dose with dose rate, apparently without understanding the difference.

Does the EPA really protect the public or does it protect the established worldwide radioprotection empire that costs hundreds of billions of dollars a year [93]? It is difficult to understand why the unscientific behavior in applying the LNT is tolerated. The LNT was cleverly created to be untestable using creative statistical analyses. The LNT is un-confirmable due to statistical signal and noise issues. However, the LNTers cannot refute radiation hormesis despite an ever growing and enormous published literature that confirms the truth of hormesis. Radiation protection specialists demand statistical significance from studies associated with radiation hormesis but refrain from the same statistical fidelity from studies that promote the LNT. Epidemiologists are more likely to report, and journal editors are more likely to accept positive findings than null findings. Thus, information in the literature on populations exposed to low doses of radiation may be slanted in favor of those studies that show higher risks than the conventional estimates, since those that show estimates consistent with the accepted values would not be seen as significant [94].

Epidemiological studies utilizing the LNT hypothesis to develop a risk model commonly employ inappropriate methodology such as giving excess statistical weight to high-dose regions where most cancers occur while ignoring the absence of cancers in low-dose regions, utilization of dose lagging, shifting the dose–response curve to the left, making small doses appear more harmful than they are, attributing reduction of cancer incidence at low doses to the healthy worker effect (HWE), ignoring the presence of thresholds, averaging over wide dose intervals so that nonlinearity is removed, and ignoring radiation exposures from medical and other sources [46].

Radiation epidemiologists often play the trick of using the wrong null hypothesis, since the LNT model is assumed to be the correct null hypothesis. Then they force the intercept of the fitted linear relationship to be 1.0. I think what would be revealing is to allow both the intercept and slope to be free parameters with uncertainty assigned to RR = 1. In many cases, the intercept obtained would be significantly different from RR = 1, indicating that the LNT model is inconsistent with the epidemiology data [95]. Also, limiting the data analysis to only low radiation doses could lead to a slope of zero (threshold model) or a negative slope (hormetic response). By not considering nonlinear responses, they are able to play a "slope constraint trick" whereby negative slopes (hormetic responses) were not allowed to exceed (i.e., be more negative) than the value "−1/maximum dose." With a U- or

J-shaped response, slopes on descending arms of the dose–response curve can approach negative infinity.

Other tricks used by epidemiologists are the use of "wasted dose" by lagging. Throwing away radiation dose is common with many research groups. The thrown away dose may have stimulated the body's natural defenses [96]. A 5-year lag means that 5 years of radiation dose is thrown away. This is not consistent with the LNT assumption which assumes that each unit of dose is equally capable of causing cancer. Another trick is averaging overdose groupings and incorporation of low-dose data which may show hormesis in a high-dose group or in the control group. This can be an "effective" means of "hiding" hormesis and a threshold. A third trick is to constrain the slope of the dose–response curve to always be positive, which readily supports the LNT assumption. This causes any low-dose data showing hormesis to simply be ignored [6, 97, 98].

The problem of random error caused by sampling variability is more important for low-dose than for high-dose studies. The major determinant of error is sample size and its distribution across exposure and disease categories. This comparison emphasizes the importance of considering sampling variability in assessing the results of low-dose studies. In most studies of low-dose effects, the standard error is larger than that for high-dose studies, even if the overall sample sizes were the same.

In general, systematic biases are also relatively more important for the objectives of low-dose studies than they are for those of high-dose studies. Because of the existence of more and larger populations exposed to low doses, low-dose studies are often ecological (correlational) or case-control studies rather than cohort studies. The ecological and case-control studies are particularly prone to bias in their design. Selection bias is a major potential problem in case-control studies: The major concern is over the appropriateness of the control group. This is a particular problem for those studies in a medical setting.

Information bias leading to misclassification of either exposure or disease status, if random, leads to underestimated risk. Confounding may be more important for low-dose than for high-dose studies. All research like this is bedeviled by "confounders"—differences between populations that must be accounted for. Some are fairly easy (older people and smokers naturally get more cancer), but there is always some statistical wiggle room. As with so many issues, what should be a scientific argument becomes rhetorical, with opposing interest groups looking at the data with just the right squint to resolve it according to their needs. They give no confidence intervals to show statistical significance. And this whole scare seems to be the result of data mining—if one looks hard enough for any unanticipated outcome at all, one is bound to find one or two statistical significance; this is not necessarily clinically significant. But the real question is whether such outlying outcomes are reproducible. This kind of research is truly junk science—the goal of which is to get funding to stay alive in a research-dependent job or to reinforce one's past contentions in which a reputation is invested, and not to discover actual reality (Bill Sacks, S.A.R.I.).

The dose and dose rate effectiveness factor (DDREF) was proposed by BEIR VII only for use with the LNT assumption. DDREF essentially reduces the slope of the

LNT function (for high-dose rate) to supposedly account for dose rate effects. What is generally not recognized is that application of the DDREF essentially removes the ability to demonstrate a threshold-type or hormetic-type response so that one is still left with the notion that any radiation dose no matter how small could cause cancer. The DDREF falsely ensures that the dose response at low doses will be linear with a positive slope and is therefore scientifically meaningless. With the LNT assumption, the quantitative analyses of dose responses for carcinogenesis use a DDREF of about 2 to extrapolate to low doses from effects induced by high doses.

The HWE is a "catch-all" term that is used irrespective of the extent or degree of benefit obtained within the workplace, to avoid invoking the other obvious scientific conclusion (i.e., there is a benefit from low-level radiation) [99]. The HWE is postulated by LNT proponents to explain undesirable epidemiological results, such as reduction in all-cause mortality and all-cause cancer in nuclear workers receiving low doses of radiation during their employment. LNTers do at least admit that these "benefits" are abundant, frequent, and real. The HWE assumption is that nuclear workers had to be healthier even when hired. I can tell you from personal experience as a Hanford worker (1966–1992) that this is not true. They might say that nuclear workers received better medical examinations [6]. Those that I received at Hanford were superficial.

HWE has been attributed to preemployment medical screening examinations and annual physicals. Medical screening prior to employment does not remove those who might develop cancer decades later. That does not stop proponents of the HWE from suggesting that the preemployment physical must unwittingly identify distant cancer victims [100]. No reduction in cancer mortality was found in those who received annual medical physicals compared to those who did not [101–103]. Thus, routine preemployment medical examinations do not eliminate cancer-susceptible individuals. Routine preemployment medical examinations did not eliminate cancer-susceptible IARC workers since no genetic tests were carried out [104]. In 2011, the rate of thyroid cancer diagnosis in South Korea was 15 times that observed in 1993. Yet thyroid cancer mortality was unchanged—the cause was overdiagnosis due to widespread thyroid cancer screening. Screening identifies thyroid abnormalities that do not need to be treated [105].

One must pose the difficult question of whether there is any serious evaluation of HWE or whether the HWE is in effect a "zombie science" not supported by medical evidence but used dogmatically to "eliminate" radiation hormesis as an explanation for decreased all-cause mortality and all cancer mortality in epidemiology studies [106]. HWE is of little or no consequence in interpreting data on cancer mortality, and the healthy worker effect is relatively weak [107].

We are bombarded with radiation from space, rocks, food, and water. Our Creator has provided us with ionizing radiation to make us healthy [108]. The same is true for nuclear workers. The average mortality of nuclear workers was substantially lower than in control groups; there was a lower mortality in nuclear workers who received lifetime doses of <100 mGy [48, 109]. SMR for cancer is lower in the IARC cohort of nuclear workers and should be considered as a hormetic effect, rather than an HWE as claimed by the IARC [110].

Nuclear workers employed in 154 facilities in 15 countries were examined. The annual radiation doses received by nuclear workers are small, with the maximum annual dose being 5.3 mGy and the mean lifetime working dose being 20 mGy [6, 111]. The paper just before Cardis et al. in the same volume and number of the *Radiation Research* journal contained the "raw" un-manipulated data for all-cause mortality and all-cause cancer. The mean and range for SMRs for all 15 countries were all-cause mortality 0.62 and all cancer mortality 0.74 [112]. Cardis did not assess the confounders of smoking or other occupational exposures in her analysis [111]. Cardis explained away the large decrease in mortality and cancer in the preceding paper by Vrijheid [112] as the healthy worker effect. Fornalski and Dobrzynski published an analysis for the study by Cardis, showing why the healthy worker effect cannot explain the reduced mortalities in nuclear workers [110]. A further discussion of the healthy worker effect was done by Sanders [6].

SMRs for cancer in two Canadian cohorts of 45,468 radiation-exposed workers [113]and 206,620 dental, medical, industrial, and nuclear power workers [114], as compared to the general Canadian population, and in comparison with SMRs for cancer for badged male workers at INEEL with zero dose or positive dose [115], all showed clear evidence of radiation hormesis. UK radiologists (1897–1920) had a noncancer SMR of 0.86 compared to all other male physicians. Noncancer mortality makes up ~80% of all mortality. Post-1955 radiologists had an all-cause SMR of 0.68 compared to non-radiologist, male physicians [67]. Cancer incidence was determined in 7417 patients with hyperthyroidism treated with ^{131}I in the UK. Cancer incidence was reduced in an "unhealthy" population. The whole-body dose from ^{131}I was 280 mGy [116].

SMR values for all-cause mortality and all-malignant neoplasms mortality were significantly less in the US shipyard workers, who had received cumulative doses that ranged from 5 to 400 mGy than for nonnuclear workers who worked at the same facility and received the same medical care and screening [117, 118]. The 28,000 nuclear shipyard workers had a death rate from all causes that was 24% lower than did the 32,000 age-matched and job-matched unexposed shipyard workers. The Department of Energy news release about the study did not mention that the deaths from all causes of the nuclear workers were 16 standard deviations lower than for the controls [119–121] (Fig. 3.6).

A comprehensive study of nuclear workers at the Idaho National Engineering and Environmental Laboratory (INEEL), previously known as the Idaho National Laboratory (INL), was published not in the open peer-reviewed literature but as an "in-house" DOE/NIOSH publication. The study compared the SMR for all-cause mortality and all cancer mortality in badged workers (those who had received a measured radiation dose of ionizing radiation from the site's facilities) to those who were also badged and worked at the same facility but received zero dose. All cohorts received the same medical care [115].

All-cause mortality and all cancer mortality were significantly less in badged workers with a positive dose than in badged workers with zero dose. INEEL badged workers with a positive dose had significantly less cirrhosis of the liver even though they experienced a significantly higher frequency of alcoholism. This indicates that

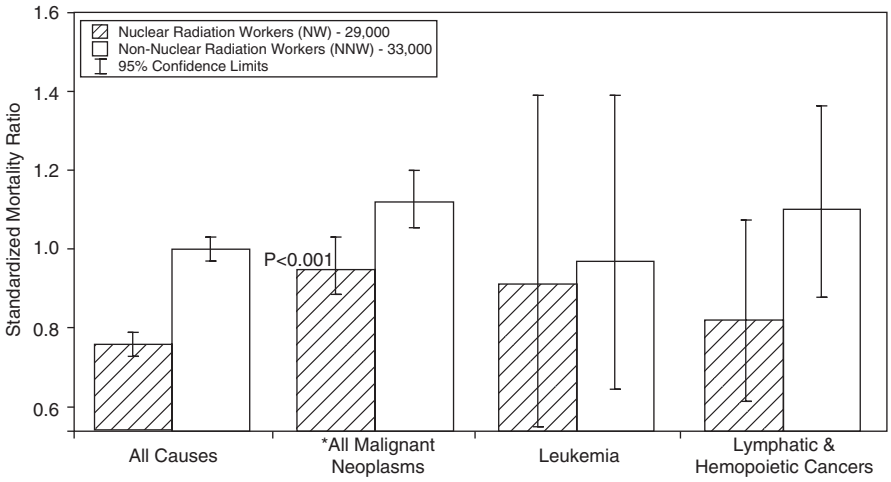

Fig. 3.6 SMR ratios for selected causes of death among nuclear and nonnuclear shipyard workers who received the same level of medical care [117, 118]

low-dose radiation protected the liver from damage due to alcohol consumption. Noncancer cardiovascular, respiratory, and GI diseases along with cancer of the respiratory and GI tract were all significantly less in badged workers with a positive dose than in badged workers with zero dose. The one exception is for myeloma which was significantly greater in workers with a positive dose. Though myeloma cases are few in number, this association has also been seen in other studies of nuclear workers, such as the Hanford site in WA. The epidemiological study design and subsequent results eliminated the so-called healthy worker effect as being the cause for significantly different observations among the two badged groups, since all workers received the same medical care. The obvious conclusion is that radiation hormesis accounted for these significant differences in health of INEEL workers. The failure to publish this work, along with failure to publish in a timely manner the nuclear shipyard worker study and radium dial painter study because of potential "political" implications, is a sad tale of academic intimidation and data suppression (Table 3.3).

Prior to the late 1990s, EPA's cancer risk assessment guidelines (CRAGs) required sufficient evidence of a cause-and-effect relationship in humans before a substance could be classified as a "known human carcinogen." However, by the late 1990s, EPA decided to classify substances as known human carcinogens without sufficient epidemiological evidence to support such a decision. As a result, EPA invented bogus human carcinogens such as dioxin, formaldehyde, and trichloroethylene. Using similar LNT methodology, it was relatively easy for the EPA to classify radon and low-dose ionizing radiations as human carcinogens.

It is probably only a matter of time before we witness the next event in which large numbers of people are exposed to ionizing radiation as a different threat has come to fore from intentional releases of radioactivity resulting in low-dose

Table 3.3 SMRs for all-cause mortality in males badged with zero dose or positive dose at INEEL [*$p < 0.05$] [115]

Cause of death	SMR badged-zero dose	SMR badged-positive dose	Ratio: positive dose/zero dose
All cause	0.96	0.86*	0.90
Diabetes mellitus	1.28	1.09	0.85
Alcoholism	**0.20**	**0.70***	**3.50**
Cirrhosis of the liver	**0.85**	**0.59***	**0.69**
Diseases of the CNS	1.32	0.92	0.70
Diseases of the heart	0.87	0.83*	0.95
Diseases of the circulatory system	0.98	0.81*	0.83
Diseases of the respiratory system	1.05	0.81*	0.77
Diseases of the GI system	0.95	0.69*	0.73
Diseases of the genitourinary system	0.85	0.79	0.93
Diseases of the blood-forming organs	0.69	0.65	0.94
All cancer	1.14	1.01*	0.89

exposure to a large population [122]. The only method for calculating the long-term so-called "stochastic" adverse health consequences of a radiation exposure is by using the LNT assumption. A stochastic system is one that is unpredictable due to the influence of a random variable. The system is randomly determined but maybe statistically analyzed but not precisely predicted. The process must be analyzed using probability theory. Epidemiologists speak of "stochastic deaths," those they predict will happen in the future because of radiation or some other risk. With no names attached to the numbers, they remain an abstraction. The millions of lives benefiting by low-dose radiation are not an abstraction but real.

The LNT assumption is widely accepted by the general public. However, the scientific validity of this model has never been proven and has been seriously questioned and debated for many decades. The absence of scientific consensus has been officially acknowledged, including by the US Congress Office of Technology Assessment [123]. Numerous studies (experimental, epidemiological, and ecological) have shown that low doses of ionizing radiation are beneficial to health [6]. The LNT assumption was adopted by the NAS in 1956 for the political purpose of creating radiophobia to impede the continuing development and testing of nuclear weapons. The LNT assumption was used to predict the risk of cancer for the very low doses associated with test fallout, even though no one had demonstrated an increased risk in epidemiological studies [124]. The NAS has misled the American public about cancer risk from ionizing radiation ever since. Truthful evidence needs to reach the public writing in clear plain language in order to lessen FUD (fear, uncertainty, doubt) about radiation risks. Science often does not drive regulations or funding decisions. Public opinion developed and manipulated by politicians can be

much more important. Few care that health risks are overestimated. They only care if risk is underestimated (Tony Brooks, S.A.R.I.).

> What might be the cost reduction and health benefit if people were allowed exposures up to 100 mGy/year?

There are serious ethical issues associated with the use of the LNT assumption. They are associated with social and medical destruction in Chernobyl and Fukushima, self-interest, economic incentives, human biases, and political pressures. Proponents claim "to be on the safe side" regarding nuclear hazards regardless of the economic or human costs. At stake are the hundreds of billions of dollars spent for "safety" around nuclear power plants and for waste storage. The extremely harmful episodes of public panic that accompany rare radiation release events such as Fukushima and Chernobyl make the projected costs for next-generation nuclear power plants to be enormous.

The ICRP 2013 Symposium in Abu Dhabi did not make any major changes in radiological protection regulations from those given in 2007. The 2007 regulations were similar to those made in 1990 by the ICRP. The ridiculously low-dose regulations do nothing to protect the public. According to the ICRP, public exposure from planned situations will not exceed 0.3 mGy per year from waste management operations, and no more than 0.1 mGy in a year for the public exposed to such operations. The occupational exposure dose limit is 20 mGy per year. The general public exposure is not more than 1 mGy per year. Below 100 mGy per year, however, no increased cancer incidence has been detected, either because it doesn't exist or because the numbers are so low that any signal gets lost in the epidemiological noise [125].

The ICRP wishes to address limitations of epidemiological studies (particularly when they appear to demonstrate radiation hormesis). The ICRP documents are of great length and even greater verbosity making them virtually useless and almost incomprehensible for informing the public. The ICRP and their adherents, such as BEIR VII, use misapplication of atomic bomb survivor Life Span Study (LSS) data like a mantra. Their analyses ignore low-dose exposures up to 100–200 mGy, to which nearly half of the survivor population received. BEIR VII was supposed to be devoted to doses <100 mGy; yet 90% of their relevant reports are devoted to much higher-dose studies.

The ICRP uses the LNT and LSS data to generate scary but false publications affecting public opinion. The current ICRP radiation dose restrictions are absurd. If the "no-threshold" part of the LNT assumption is taken seriously, and an exposed population experiences as much as a 0.5% increase in cancer risk, it simply cannot be detected. The LNT assumption operates on the unprovable assumption that the cancer deaths exist, even if the increase is too small to detect, and that therefore "no level of radiation is safe," and every extra mGy is a public health hazard. Once the LNT is explicitly discarded, we can move on to regulations that reflect only discernible, measurable medical effects. Those living in Mississippi receive 2 mGy per

year from natural radiation, while those living in Colorado receive 7 mGy per year. Utilizing the ICRP's train of thought, it would be dangerous to move from Mississippi to Colorado. Never mind that epidemiological studies clearly show that the cancer rate mortality in Colorado is 30% less than in Mississippi after correcting for confounding factors. LNTers claim they err on the safe side. They stubbornly continue to claim a relationship with any dose of radiation and potential harm. This is not just a benign difference in scientific opinion, but the radiophobia that results from application of the LNT assumption is a national security and health problem. The LNT assumption is extremely simple to teach as a fact to the public who mostly remain ignorant of the benefits of low-dose radiation.

LNT religious culture relies on emotional arguments propped up by the precautionary principle of "better to be safe than sorry." This is a powerful argument that has successfully been used by epidemiologists to shift the burden of proof away from proving an adverse effect to proving that radiation is safe. The attitude assumes one is guilty until proven innocent (John Cardarelli, S.A.R.I.). The National Nuclear Security Administration (NNSA) has been formed to help prevent unnecessary radiophobia-related deaths, morbidity, and injuries associated with nuclear (radiological) emergencies by countering phobia publications that use misinformation to spread alarmist views. The news media and other media forms are most guilty of promulgating radiophobia. I submitted letters to our local newspaper in Colorado (Loveland Reporter-Herald) concerning radon and radiation hormesis. Not being politically correct with respect to the LNT, they were not published.

Political correctness prevents advancement of science.

ICRP Task Group 94, entitled *Ethics of Radiological Protection*, was empowered to present ethical foundations for radiological protection. Task Group 94 was to provide a basis for communication on radiation risk and its perceptions. Perception of radiological risk is different for the general population. The mass media does not use the language of technical experts in addressing radiological risk. The communication gap between experts and the general public presents a great challenge [126]. The ICRP was to be benevolent (do more good than harm), prudent (keep exposure As Low As Reasonably Allowable—ALARA), and just (reduce inequities among nations and peoples), to provide dignity (involve the stakeholders), and to integrate reasonableness and tolerance. ICRP Publication 60 examines the tolerability of the current risk model (i.e., the LNT assumption) with respect to differences between unacceptable, tolerable, and acceptable risks of ionizing radiation.

A recent workshop in Daejeon, South Korea, revisited the issue of tolerability of radiation risk in relation to varying types of exposure situations. The workshop claimed to follow scientific and societal evolutions, to clarify ethical and societal values underlying the system of radiological protection and promised to maintain a separate perspective from regulatory requirements. The workshop expressed attitudes toward risks and exposure situations with terms like quietude (have

confidence in the arrangements put in place and we trust the institutions and people responsible for radiation protection), vigilance (take action to try and reduce risk in order to reassure ourselves that everything has been done), and reaction (proper responses are carried out when facing an imminent danger to protect ourselves). The principles of justification, optimization of protection, and of application of dose limits were to be explained directly in terms of ethical principles (precaution, equity, fairness, or justice). Hence, communications may be more effective when referring to ethical principles rather than to actual facts of radiological protection.

The three pillars for the Korean workshop were science, values, and experience. The science overwhelmingly tells us that low-dose ionizing radiation exhibits a threshold and is good for us. The values should express how much more healthy we would be if exposed to low-dose radiation and how much less is the cost to apply the concept of radiation hormesis. The present LNT-based regulations impose excessive costs to the society, effectively leading to loss, rather than saving, of life. According to researchers from the Harvard T.H. Chan School of Public Health, spending $100,000,000 per year on controlling radiation emissions might save one life-year per year, if the LNT model were valid, while life-saving medical program median cost is $19,000 per life-year saved. Another study concluded that costs of radiation protection are about 5000 times higher than the cost of protection of workers from all other and much more probable events [127]. Finally, individual experience and experience of hundreds of researchers show that the ICRP's promotion of the LNT assumption in determining health risk is completely wrong (Table 3.4).

There have been four fatal space flights out of a total of 126 launches or 3%. That should be the main concern about any space flight. However, radiation exposure accumulated through the entire flight and the predicted resultant small cancer risk using the LNT assumption take overriding emphasis to the point of using precious cargo weight delivery to reduce the phantom risk [128]. The predicted, mission, radiation dose accumulated on the Mar's surface is estimated at 75–150 mGy, well within the hormesis zone.

Table 3.4 Accident mortality in the workplace for 2012 from Occupational Safety and Health Administration (OSHA)

Industry	Number of fatalities
Total	4383
Trade, transportation	1152
Construction	775
Agriculture, mining	475
Manufacturing	314
Education, health services	139
Financial services	81
Radiological services	**0**
Other (mostly private industry)	1447

Data taken from the US Department of Labor, Bureau of Labor Statistics. We all die, many of us from cancer. Nobody seems to have died in 2012 who worked in the radiological services industry

There are additional aspects of human cost because of the LNT model and the associated radiophobia—an irrational fear of radiation hazards: Predictions of hypothetical cancer incidence and deaths cause some patients and parents to refuse medical imaging procedures, placing them at substantial risk by not receiving the clinical benefits of the prescribed procedures; present policy significantly dissuades the study of low-dose radiation therapies for beneficial effects in medicine, whereas animal studies have shown potential for treatment of diseases for which presently no treatments are available, such as treatment of Alzheimer's disease using low-dose radiation. Finally, the LNT assumption and its associated radiophobia motivate terrorists to use radioactive "dirty" weapons as a means of terror. Claims that the LNT model underestimates risks from low-level radiation by orders of magnitude have been vigorously expounded elsewhere and used as the basis for attacks on the nuclear industry." There is no credible, consistent evidence to support these claims" [129].

Rockwell said it concisely and with boldness when it came to the scandal of the LNT:

> It's inexcusable that with hundreds of millions of cases of chronic exposure from medical therapy, occupational exposure, high-background locations, and accidental mass exposures in Taiwan and Russia, we still look to poorly known exposures with dose rates many orders of magnitude higher, whose situation was complicated by neutrons and war conditions totally different from situations of interest … Such repeated practice in the radiation protection field raises the question of whether it is time for one or more formal charges of scientific misconduct … It is a scientific issue, tried and judged by scientists in the defendants institution. The key issues to be proved are fabrication or distortion of data and selection and omission of data for the purpose of supporting a preferred conclusion-exactly the concerns raised (but not dealt with) in radiation protection [130].

3.5 Muller's Deception and Russell's Mistake

Fraud is found in research everywhere. Bernard Kettlewell (1907–1979) claimed to show that dark-colored moths had evolved in soot-black areas of England. His published photographs of moths perching on tree trunks turned out to be dead glued ones. His case for natural selection was fiction. I learned the mantra "ontogeny recapitulates phylogeny" in my freshman biology class at the College of William and Mary (1956). This is a fancy way of saying that embryos repeat their evolutionary history by passing through to their adult forms. This idea was presented from research studies of Ernest Haeckel (1834–1919). Haeckel's peers claimed similarities in embryos were faked, and drawings and woodcuts were doctored by Haeckel. His colleagues knew he was a fraud. Yet I still had to learn it in a freshman biology class in 1956. The evolutionary deception continues today with imaginary sprouting of new stars and galaxies, retrodictions of black energy and black matter which cannot be seen or measured, "hopeful" appearance of incredibly complex life by random chance, and the total inability to find one transitional fossil, a problem that even bothered Darwin.

Science should be in the business of making observations of nature with machines and calculations, and doing experiments to test ideas and interpret the results,

hopefully without prejudice. Scientists, unfortunately, are not always as objective as one would like. Many find it difficult to completely detach themselves from the hypotheses that they espouse. They find pride in authorship and an intense personal loyalty to the ideas they have developed. As a result, there can be subjectivity, prejudice, and ignoring of opposing data. This may lead to the need to "fudge" their interpretations in favor of their preconceived hypothesis. This is *misinformation* when the scientist knows the data is correct or incorrect, yet spins the data otherwise. It is *dishonesty* when the scientist knows the data is correct yet ignores it. It is *fraud* when the scientist clearly knows the data is incorrect yet posits it to be correct.

Herman J Muller (1890–1967) was born in a working class of German-Irish home in Harlem and attended public schools in Brooklyn, NY. Muller was a socialist and eugenicist who believed in removing all class barriers and carrying out studies in human breeding to develop a "superior" class of humans. Muller attempted suicide in 1932 from an overdose of sleeping pills. Later in the 1930s, he worked in Nazi Germany at the Kaiser Wilhelm Institute and then jumped to Stalinist Russia where he attempted to convince Stalin to produce an army of supermen to conquer capitalism [131]. Eugene Fisher, anthropology professor at Kaiser Wilhelm Institute believed at that time that selected" young women should be forcibly sterilized after receiving a simple diagnostic X-ray examination. The essence of evolution is natural selection. The essence of eugenics is the replacement of "natural" selection by conscious, premeditated, or artificial selection in the hope of speeding up the evolution of "desirable" characteristics and the elimination of undesirable ones [132]. That is precisely what Nazi Germany attempted to accomplish in promoting the "superiority" of the Aryan race. Eugenicists wanted to improve the human race (gene pool) by social and political interventions and tinkering.

Ninety years of research with mutations in millions of irradiated fruit flies shows that all you get are odd-looking flies. None of the mutations are beneficial nor do any add new genetic information, just genetic mistakes. Herman Muller received a Nobel Prize in 1946 for showing that mutations in fruit flies increased in direct proportion to the dose of X-rays. In the process, Muller ignored and withheld data that showed he was wrong. The Rockefeller Foundation sponsored Herman Muller fly studies and, in 1956, awarded grants amounting to $991,000 for genetic studies, which included Muller.

Muller was also paranoid in believing that other scientists wanted to steal his ideas [131]. His actions were incredibly important because the world came to believe that if mutagenesis from ionizing radiation is true for fruit flies, then it is also true for cancer in humans. In his Nobel Prize speech, Muller said: that there is no escape from the conclusion that there is no threshold. This was a statement that he knew or should have known was not true.

Edward Calabrese recently exposed Hermann Muller's scientific dishonesty explaining how the NAS had misled the world on cancer risk assessment. Muller in published studies carried out during 1927 claimed to have shown a linear increase in mutations in irradiated fruit flies (*Drosophila*) with increasing dose of X-rays [133]. The mutation assay used was the sex-linked recessive lethal test in male flies. The radiation doses were high. Muller in his acceptance lecture for the Noble Prize

on December 12, 1946 made deceptive statements in an attempt to promote the acceptance of the LNT assumption for risk assessment from ionizing radiation. Muller also wanted to exaggerate the health risk from low-level radiation because he was opposed to aboveground nuclear weapon testing.

Questionable actions by his colleague, Curt Stern, a well-known geneticist of that time, influenced radiation protection policy and caused the policy members on the NAS and Biological Effects of Atomic Radiation (BEAR) Committee to adopt the LNT assumption in 1956, switching from a previous position of a threshold [134]. Findings of Caspari and Stern (1948) [135] demonstrated a doserate response in fruit flies. These findings along with results of Spencer and Stern (1948) [136] demonstrated both a threshold and dose rate effect. In his 1946 Nobel lecture, Muller said that the mutation rate was linear function of dose down to zero with no threshold; his test doses went from 1000 to 4000 R. Curt Stern (1948–1949) found doses <50 R or about 500 mGy did not increase the mutation rate when given continuously over a 21-day period; the results were dose rate dependent [135, 137]. Interestingly, Muller did not find linearity in mutation frequency following exposure to UV radiation in fruit flies [138].

> In a young adult, living in a low LET background of 0.1 cGy/y, the antimutagenic system of prevention, repair, and removal of DNA alterations reduces about one million DNA alterations/cell/d to about one mutation/cell/d. DNA alterations from background radiation produce about one additional mutation per 10 million cells/d [139].

Muller knew prior to his Noble lecture that data by Caspari and Stern [135] and by Uphoff and Stern [137] had demonstrated a threshold of about 50 R for mutations in fruit flies that strongly challenged the LNT [93]. Data from Caspari and Stern [135] and repeated in a note published in Science by Uphoff and Stern [137] shows a threshold for sex-linked fruit fly mutations following 50 R when the dose was given continuously for 21 days. For one group of flies, the dose rate was 13,000 lower than the high acute doses used by Muller and 80 times lower than the highest dose used by Muller. Yet Muller proudly proclaimed that one could no longer consider a threshold. Muller claimed linearity over a huge dose range. He also claimed that dose rate had no impact on his results. Muller had manipulated the data on fruit fly mutations to protect his prize and reputation and promote his ideological goal of linearity [140]. Muller in a 1930 article noted that background doses of radiation are not responsible for natural (spontaneous) mutation rates. He also failed to report that natural background levels ranged several hundredfold.

It is still the case that Muller and Stern published data that disproved their LNT contention with regard to dose rate. That's just too simple, clean, and one-sided an explanation for Muller's role, but when it rises to the level of manipulation of panels of scientists and direct payment for advocacy, paradigm becomes less contributory and deliberate lying becomes more so—even to the point of eclipsing the former almost entirely (Bill Sacks, S.A.R.I.).

More recent studies have shown that there was no effect on lifespan or on permanent gene expression in fruit flies at doses less than 10,000 r [141]. Irradiation of fruit fly spermatozoa with only 200 mGy significantly reduced mutation frequency below that observed in sham-exposed control flies [142]. Ogura later showed that the mutation frequency for sex-linked recessive lethal mutations in fruit flies was significantly reduced by a dose of only 500 μGy [143]. The threshold for fruit fly mutations was found to be 80 mGy by Shiomi [144], 800 mGy by Koana, [142] and >1000 mGy by Ogura [143]. Muller had argued that background radiation had a negligible impact on spontaneous mutations. Calabrese believed that the deliberations of the Genetics Panel of the NAS should be charged with scientific misconduct and deliberate misrepresentation of the scientific record in order to promote their ideological agenda [37]. This has led to consistently incorrect conclusions [145] (Fig. 3.7).

Numerous studies on irradiated populations of insects in the 1920s had shown beneficial effects. Flour beetles, mosquitos, crickets, codling moth, tsetse fly, housefly, and fruit flies all experienced enhanced lifespans of from 20 to 60% following radiation exposures of 1–40 kR. Exposure at egg and larval stages increased

Fig. 3.7 Hermann Muller (1890–1967)

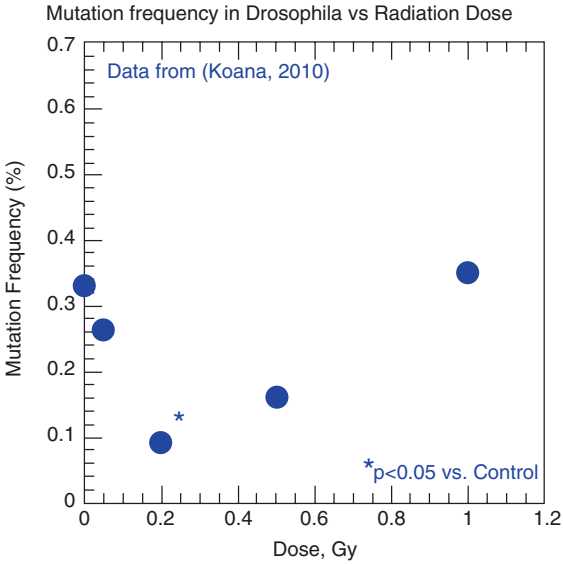

Fig. 3.8 Evidence for radiation hormesis in X-irradiated fruit flies (With kind permission of Mohan Doss) [142]

longevity in insects at much lower doses, typically from 10 to 100 R. More recent studies in fruit flies have shown that X- and γ-ray doses as low as 200 mGy to eggs significantly increased adult fly longevity, whether given as an acute or chronic dose (Fig. 3.8).

In 1996, the Department of Energy investigated allegations about the now-accepted fact that the Oak Ridge National Laboratory (ORNL) mega-mouse studies presented false data on genetic effects, starting in 1951. These mouse studies, along with Muller's fruit fly studies, were emphasized as proof of genetic effects in mammals when I was a PhD student at the University of Rochester from 1963 to 1966. ORNL underreported the number of mutations in the control animals. WL Russell was a member of the 1972 NAS, Biological Effects of Ionizing Radiation (BEIR I) Committee, and Genetics Panel which used his mega-mouse dose rate data to support the adoption of the LNT for genetic and cancer risk assessment [146].

The assumption that all mutational damage is cumulative and irreversible and that dose rate is linear at low doses was promoted by Muller. Muller provided incorrect information to ICRP (1964) in an attempt to prevent the dose rate concept offered by Russell from being adopted into risk assessment [134, 147]. Russell admitted making an error in counting the control mutation rate when he was in his 80s [148]. There was no admission of fraud, but Russell did participate in a paper that quietly revealed the error (Rod Adams, S.A.R.I.). Dr. Paul Selby was Russell's only PhD student who later became a geneticist at ORNL. Selby discovered that lower-dose rates reduced mutation rates by factors of 3 and 20 in germ cells of male and female mice, respectively. This made genetic damage highly dependent upon dose rate, while earlier results assumed that it was dependent only upon total dose. A J-curve-hormesis model would have been a better fit for Russell's data based on

Selby's findings [149, 150]. The overall weight of scientific evidence supported Selby's correction factor for underreporting of mutations in Russell's control mice. Selby alleged that the misrepresentations of the data seemed to have been intentional [84]. Mice given γ-rays for 90 days (0.0014 Gy/h) did not show an increase in mutation frequency [151]. Doug Boreham also carried out a mutation study in mice given a cumulative 12 cGy in 75 weeks and failed to find an increase in mutations [152]. International programs have now abandoned the fruit fly and mouse data and are assessing the potential effects of radiation for genetic diseases using only human data (Fig. 3.9).

Four decades of genetic research on Japanese A-bomb survivors have failed to show any heritable effect in offspring [153]. Cancer risk was reduced by 27–39%

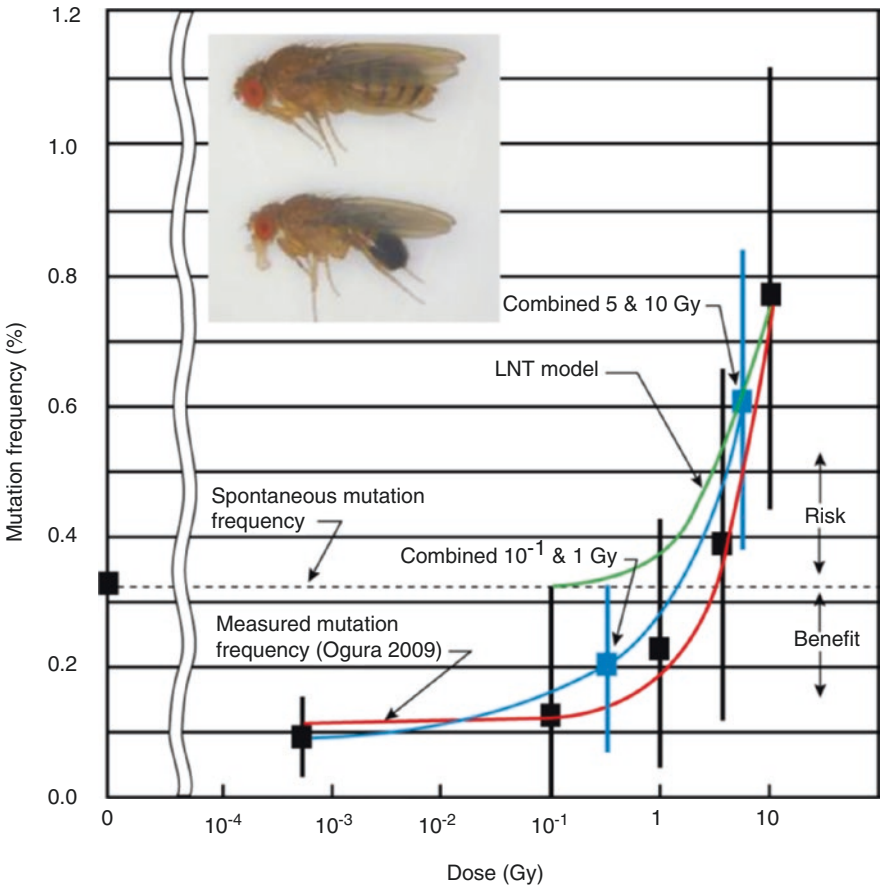

Fig. 3.9 Mutation frequency as a function of radiation dose. Error bars are two standard deviations around the mean mutation frequency. The data points at 0.3 Gy and at 7 Gy were obtained by combining data from Ogura [143] at 10 and 1 Gy and at 5 and 10 Gy, respectively. Note that mean mutation frequencies are below the spontaneous (background) level (0.32%) where the radiation dose is below 1 Gy (With kind permission of Jerry Cuttler) [125]

in downwind inhabitants of a 1957 Mayak nuclear waste tank and was not increased among Techa River residents living nearby a highly contaminated river [6, 154]. Genetic effects have not been observed in residents near the Techa River, downwind from the waste tank explosion at Kyshtym or in offspring of nuclear workers at Mayak. There have been no reports of increased mutations or birth defects in the millions of people living in Ukraine or Belarus that were exposed to fallout from Chernobyl [6]. In spite of the lack of any human data, UNSCEAR in 2001 gave a doubling dose for genetic effects in humans of 3.4–4.5 Gy. BEIR VII even lowered the doubling dose to 1.0 Gy in spite of a lack of any human confirmation data. The early epidemiological studies of populations associated with Chernobyl fallout, cleanup workers, Mayak nuclear workers, downwinders from the USSR nuclear tank explosion in 1957, and Techa River inhabitants showed abundant evidence of thresholds and radiation hormesis [6]. Subsequent later studies used ERR methodology that force fitted implementation of the LNT and typically failed to provide cancer risk estimates for each radiation dose category in the publications. Follow the money! Continued research grants were given only for those who could show increased risk and not for those who showed a threshold or hormesis.

3.6 S.A.R.I.

S.A.R.I. (Scientists for Accurate Radiation Information) and other organizations monitor for misinformation and communicate correct responses. Moral-ethical issues of the LNT and ALARA have been previously addressed by Taylor [155], Jaworowski [17], Calabrese [82], Socol, [156] and Cuttler [32]. The Society for Radiation Information (SRI) was recently founded in Japan along the lines of S.A.R.I. A large workforce and bureaucracy are needed to maintain ALARA. ALARA is like a cancer grabbing resources and manpower in an economy short of jobs (Wade Allison, S.A.R.I.). There has been a several decade of long struggle to get the nuclear power industry and the radiation health physics profession to fight against the LNT and its progeny, ALARA, which are huge job generators and money makers for companies in “cost-plus” enterprises like construction, component manufacturing, and services for government or regulated monopoly customers. They know that our assertions of cost reductions by recognizing a threshold dose model would come at their expense. One man’s cost is another man’s revenue (Rod Adams, S.A.R.I.). In other words, some don’t want to kill the goose that lays the golden eggs—even if killing the goose is the right thing to do. This whole issue is “rigged” by the industries that support much of the nuclear front-end, plant, and back-end operations and just try to get committed support of these industries for killing the LNT. Yes, lip service can be gained easily, but talk is cheap and ALARA-related systems and services are not (Charles Pennington, S.A.R.I.). Last time that there was a problem like this, it was how to stop the arms race. How was that achieved? By making everybody frightened by grossly exaggerating the dangers of radiation—and it worked. Then we were left

with a reducing weapon stockpile and now have ALARA/LNT instead today (Wade Allison, S.A.R.I.).

> More scientists involved with radiation protection today claim agnosticism about the LNT. They say that we just do not know if the LNT is true or not, but, to be safe, we must use the LNT.

In the absence of the LNT model, practice of radiation safety would be trivial: Avoid high radiation doses. There would be no need for most of the work presently done by health physicists or medical physicists relating to low radiation doses. Such work would only be needed when dealing with potentially high doses. Since excellence in the practice of radiation safety would be accomplished easily and trivially, HPS would have very little to do. If HPS wants to exist in the post-LNT era, it has to change its mission. Since the LNT model is not valid (and this was known a long time ago), work done based on the LNT model did not result in "excellence in the science and practice of radiation safety" but quite the contrary (Mohan Doss, S.A.R.I.).

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