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HEALTH EFFECTS OF LOW LEVEL RADIATION: WHEN WILL WE ACKNOWLEDGE THE REALITY?

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□ The 1986 April 26th Chernobyl event was the worst nuclear power accident—it killed 31 people. Its significance was exaggerated immensely because of the pervasive fear of ionizing radiation that has been indoctrinated in all of humanity. In reality, our environment includes radiation from natural sources, varying widely in intensity, to which all living things have adapted. The effect of radiation on organisms is primarily on their damage control biosystem, which prevents, repairs and removes cell damage. Low doses stimulate this system, while high doses inhibit it. So low doses decrease the incidences of cancer and congenital malformations; high doses have the opposite effect. Efforts by radiation protection organizations to lower exposures to (human-made) radiation to as low as reasonably achievable (ALARA) provide no benefit. They only create inappropriate fear—barriers to very important applications of nuclear technology in energy production and medicine.

Keywords: Chernobyl, radiation hormesis, LNT hypothesis

At the 20th anniversary of the Chernobyl disaster, the media commemorated the event with many stories designed to draw attention to its causes and consequences. The most important element was our fear of radiation. Did the media expose the fraud of the linear-no-threshold (LNT) hypothesis of radiation carcinogenesis (and congenital malformations)—the principal cause of this fear?

The fear stems from the common belief that any dose of radiation increases the likelihood of the dreaded diseases: cancer and congenital malformations. No one questions the fact that any dose (1 Gray = 1 joule of ionizing radiation energy per kilogram of tissue) damages cells, and that large doses of radiation are harmful. Cancer and congenital malformations are diseases of living organisms, so it is essential to study the biology of organisms to understand how these diseases arise and determine whether this fear is based on myth or reality. In plain language, the LNT hypothesis—the linear extrapolation of the incidences of these diseases from the high dose range to the low dose range—is contradicted by a very large amount of evidence that has been accumulated since the discovery of ionizing radiation, more than a century ago. Some of this evidence appears in the references listed in this paper, and it is very important that the reader examine the evidence. The scientific method requires that a hypothesis be rejected or modified if just one fact contradicts the hypoth-

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esis. Scientific fraud occurs when this hypothesis is retained and employed, against the advice of technical societies, to predict the number of excess cancer deaths that will occur following a population exposure to radiation in the low dose range, specifically the prediction of 4000 excess cancer fatalities following the Chernobyl accident. This fraud is not only an affront to science; it is a very serious moral issue because there is a large amount of evidence, some in the references, that low doses of radiation are stimulatory. Predictions of cancer deaths and birth defects caused unnecessary suffering to many millions because their exposures were in the dose range where beneficial health effects are expected.

Radiation biologists and medical practitioners have known, since the discovery of X-rays in 1895, that low doses of radiation stimulate *all* organisms, usually resulting in beneficial health effects (Calabrese and Baldwin 2000). They also observed that high doses are harmful and defined limits (e.g., 0.2 R/d in 1934 and 0.3 R/wk in 1951) (Clarke 2001).

By 1955, the ICRP rejected this threshold concept in favour of a concept of cancer and genetic risks kept small compared with other risks in life. It assumes that no radiation level higher than natural background can be regarded as absolutely *safe*, as it continues to seek a practical level that involves negligible risk (Clarke 2001). The basis for this assumption is epidemiological evidence of excess cancer incidence among British radiologists and the survivors of the atomic bombings at Hiroshima and Nagasaki (H-N).

There is no evidence in the H-N survivors of excess congenital malformations; there is no evidence of excess cancer deaths in the dose range (0 to 0.5 Gy) (Kondo 1993). The ICRP addresses the lack of low-dose evidence by its LNT hypothesis, which extrapolates a straight line from the H-N high-dose data through the no-evidence range to zero dose. A risk reduction factor (2 to 10) is used for chronic exposures. Physics and mathematics are used, but not biology. Applying this model to calculate excess cancer deaths in large populations exposed to low doses produces alarming results.

Evidence has been presented that cancer mortality of British radiologists decreased *below* that of other physicians after dose control measures were introduced in 1920 (Smith and Doll 1981; Berrington et al. 2001; Cameron 2002). Evidence has been presented that cancer mortality of the H-N survivors is *lower* than unexposed groups (Kondo 1993). And many thousands of scientific publications provide evidence of improved health and *reduced* risk of cancer and congenital malformations following low-dose exposures (Calabrese and Baldwin 2000; Kondo 1993; Luckey 1991; UNSCEAR 1994; Liu et al. 1987; Liu 2003; Makinodan and James 1990; Sponsler and Cameron 2005; Mitchel 2007; Feinendegen 2005). There is no evidence that an acute exposure below 0.1 Gy increases risk (HPS 2001; Jaworowski 2004; French Academy of Sciences – French

National Academy of Medicine 2005). The ICRP appears to disregard the on-going accumulation of evidence that contradicts the LNT model, as it advocates a precautionary approach to avoid exposure to any amount of radiation.

Many scientists support this attitude. Physicians are taught the LNT ideology, and they advise their patients accordingly. High doses of radiation to destroy tumor cells are acceptable, however low doses to prevent, detect or cure serious diseases (Pollycove 2007) are shunned because of fear of the hypothetical risks. Government authorities follow "international standards", that is, the ICRP recommendations of ever-tightening dose constraints. Extreme preparedness measures increase public fears of radiation, relative to other commonplace hazards that are more dangerous. This fuels the radiation scare and makes society more vulnerable to the threat of terrorist "dirty bombs". It has become very difficult to change perceptions about radiation.

What is the basis for this unscientific behaviour? The phenomenon of low dose stimulation and high dose inhibition (hormesis) has been known from the late 1800s; however it fell into disrepute because of its early and close association with the controversial medical practice of homeopathy (Calabrese 2005). The LNT hypothesis appeared soon after the H-N bombing, at a time when many scientists were agonizing over their roles in developing the A-bomb. There was intense political activity

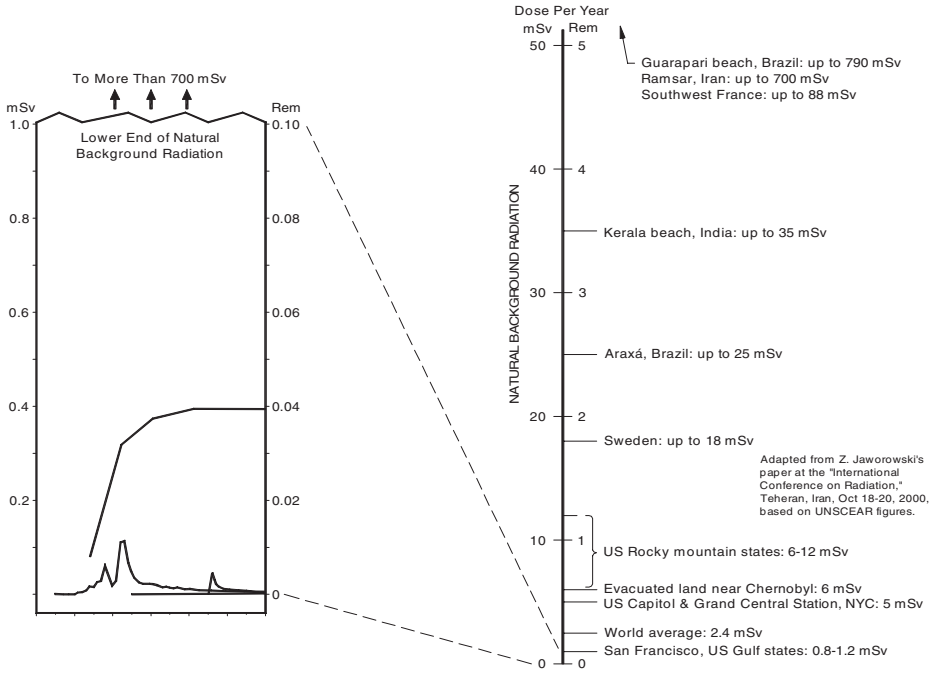

FIGURE 1. Comparing average annual dose: natural versus human-made radiation (Rockwell 2003)

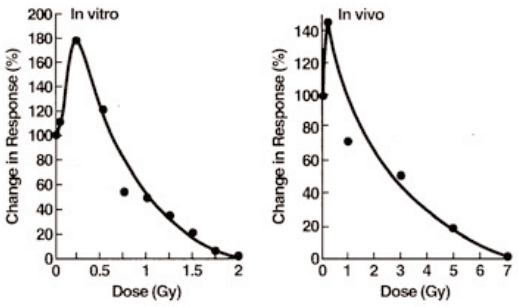

FIGURE 2. Immune system response to radiation. Mouse splenic cells primed with antigenic sheep red blood cells (Mackinodan and James 1990)

to stop bomb development, testing and production. Greatly exaggerating the consequences of exposure to low doses of (human-made) radiation "fallout" (Figure 1) was understandable and did produce the desired results (Jaffe 2003). International agreements and controls were established, which resulted in major reductions of stockpiles and risks of nuclear weapons proliferation. Having achieved this very important political objective in the 1960s, one might have expected the reality of the biology to eventually become public knowledge. However, the deception continued for the rest of the 20th century, and it continues into the 21st century in spite of the mounting evidence and the improved understanding of radiation biology (Figures 2 and 3).

The anti-nuclear activity has expanded to encompass opposition to nuclear energy and nuclear medicine (Cuttler 2007; Cuttler and Pollycove 2003). The economic, environmental and political dimensions of what is happening are very significant. Arising in the 1970s, environmental ideologies have become a dominant influence in society. Naïve

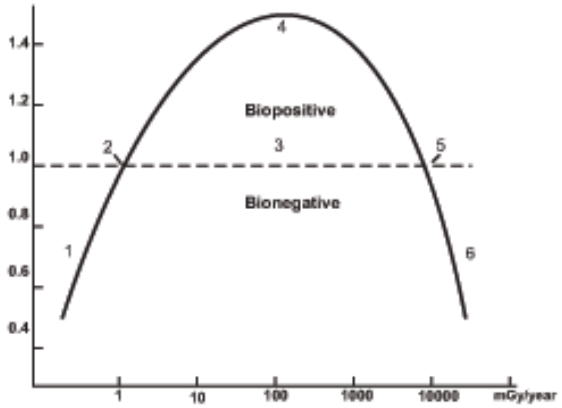

FIGURE 3. Idealized, complete dose-response curve (Luckey 1991). The ordinate indicates approximate responses compared with the controls. The abscissa suggests mammalian whole-body exposures as mGy/year. The numbered areas are: (1) deficient, (2) ambient, (3) hormetic, (4) optimum, (5) zero equivalent point, and (6) harmful.

scientists cannot fathom why environmentalists oppose nuclear energy, which produces relatively small amounts of "waste" that are well managed (and can be recycled). A prime concern is exposure risk to low level radiation, after many thousands of years.

By far the greatest exposure to low level radiation is radon gas from natural uranium in the environment. A scientific test of the LNT model, as normally used, disproved the hypothesis—cancer mortality *decreases* as radon concentration increases (Cohen 1995). Instead of discarding (or modifying) the LNT hypothesis, defenders of the hypothesis criticized the test, and the authorities continue to accept ICRP recommendations (Tubiana 2006).

Scientists are not satisfied with data; they want an explanation of the mechanism of the radiation hormesis dose-response relationship. Pollycove and Feinendegen (2003) have provided this. For more than 15 years, biologists have known that the greatest cause of cell damage (many orders of magnitude greater than any other cause) is the normal oxygen metabolism. The air we breathe damages our cells. All living organisms have a very powerful damage control biosystem that prevents, repairs and removes cell damage, or they could not exist. A low dose of radiation (0.001 to 0.3 Gy) produces a small amount of damage. This triggers increased damage control system activity, which deals not only with the trivial radiation damage, but *also* with the much larger endogenous cell damage, resulting in *less* cancer overall. Hormesis is overcompensation to a disruption in homeostasis. Conversely, a high dose of radiation decreases the activity of this biosystem (more cancer). It is the effect of the radiation on the damage control biosystem that determines the response. The cell damage caused by the radiation is not important.

The recent Chernobyl Forum (IAEA 2005) determined that:

- 31 reactor staff and emergency workers died (28 of them from high radiation within four months after the accident)
- another 19 of the 106 who recovered from high acute radiation exposure died of liver cirrhosis, emphysema, etc., during the following 18 years (conforms to *normal* mortality of ~1%/yr)
- the surrounding population and most of the cleanup workers received doses comparable to doses many people receive from background radiation
- 4000 excess cancer deaths are expected (based on the LNT model)
- no radiation-induced increase in mortality occurred
- 4000 cases of thyroid cancer were identified in the screening begun immediately after the accident; nine deaths.

Dr. Theodore Rockwell pointed out in his launch of The Realism Project (Rockwell 2004) that the nuclear community agonizes over its

inability to communicate its message to the public, but it cannot overcome a basic problem. "Our credibility is continually undermined by ostensibly authoritative statements that no amount of radiation is small enough to be harmless and that a nuclear casualty could kill as many as hundreds of thousands of people. *That* message we *have* communicated, and therefore the public and the media are not wholly to blame for the resulting public fear of radiation and all things nuclear. We cannot expect people to believe our assurances of safety so long as we acquiesce in terrifying messages to the contrary.... Although the case is persuasive that the worst realistic nuclear casualty is less harmful than that of nuclear power's serious competitors, the evidence has not yet been assembled into an overall documented statement and evaluation.... The action urgently needed now is to prepare the case, and then discuss it within our own ranks.... Until that happens, the status quo will prevail."

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