Low-Dose Radiation (LDR) is Not Harmful;
Pretending Otherwise Corrupts our Economy, our Safety and our Credibility

For more than thirty years we have had major policy studies advising us that although there is **no evidence that low-dose radiation is harmful,** prudence requires us to **regulate as if radiation were harmful down to zero dose**, with the harm or risk proportional to the dose. This idea makes radiation seem uniquely fearsome, and the price we pay for that is horrendous. The problem has spread to drinking water, granite walls, phosphate fertilizer, airport exit signs, and other "natural" radiation sources previously presumed safe. Even bananas are now listed in the dreaded hazardous zone.

The embarrassing discrepancy between science and policy in radiation protection has been openly acknowledged in many of these reviews, but there seems to be little will to resolve it. We are falsely told that there are no reliable data in the low dose range, and further, that it would take a prohibitively large irradiated population to make a good epidemiological test. So, the status quo is sustained, with many people believing the fiction that the truth of the matter is "unknowable."

During the spring of 2008, **this dilemma is being examined yet again** in extended international conferences by the US NRC's ACNW (Apr.8-10), WNA (Apr 11), the NCRP (Apr 14-15), IDRS (Apr 11), followed in Nov 27-28 by WONUC. In addition, EPRI and the DOE have extensive investigations of their own under way, from which the data are not being widely shared. So this seems to be a propitious time to tackle the problem seriously and resolve it. The fact is, that for over 100 years there has been a great deal of credible data in the radiation range of interest, including epidemiological data with excellent statistical precision. **Much of this information** has been presented to the advisory bodies, often multiple times. Yet it has been **deliberately ignored**, or accepted for consideration and then dismissed out of hand.

This situation cannot continue. We intend to ensure that this information is made available to these reviews and to the relevant policy-makers, including the U,S. Congress and the international community. Each must decide whether they wish to be seen as assisting or resisting this transition. **Advisory groups** are freed from responsibility of regulating or implementing the resulting policies; they **can speak the truth** to those who must carry them out. This is a serious obligation, and the time for action is long overdue.

The purpose of this report is to recap the enduring historical record referencing a brief selection of the significant factual scientific and historical information. This indicates that there is abundant **credible evidence that low-dose radiation is not harmful and that collective dose is biologically meaningless**.

It has been recognized, since a few months after Roentgen's discovery of x-rays in 1895, that low-dose irradiation can benefit organisms while high doses cause burns. It is also well-known that **low-dose** irradiation initiates this healing process by activating and deactivating **different groups of genes**, proteins, transcription factors and other molecular and immune system responses **than those activated by high-dose** irradiation. The discontinuity in these different high- and low-dose responses cannot be described by a single linear dose-response relationship.

All organisms on earth are bombarded by radiation and **could not survive if damage to a single cell were life-threatening.** Further, experiments to "protect" organisms from background radiation prove harmful. Background radiation is only a fraction of what it was when life began, and it varies one hundred-fold and more from one place to another. (While we regulate picocuries –billionths of a curie - of radioactivity, Mount St. Helens in 1980 dumped 40 *megacuries* – millions of curies - of radon into the biosphere.) In addition, **normal metabolism damages millions of times more cells** than even a harmful dose of radiation. Our survival depends on the effectiveness of our defense and repair mechanisms. Thus, **cell damage from irradiation of isolated tissue does not imply health effects in a living organism.** Indeed, the data indicate that low-dose radiation is likely to be essential to biological functions, i.e., to life.

The notion of "**collective dose**," adding together large numbers of trivial individual doses, is wholly artificial with no valid physical meaning. Cell damage does not build up; DNA in cells are damaged and repaired thousands of times each day. **Attributing adverse health effects** and deaths to such a source **has no scientific validity**. Low-dose radiation health effects can be neither contagious nor heritable.

These facts has been reported and confirmed in credible peer-reviewed journals, and have not been seriously challenged scientifically. Moreover, many of these facts have been stated in the various advisory and policy-setting documents issued by ICRP, NCRP, BEIR, et al. that recommend **policies based on just the opposite premise**: that no amount of radiation is small enough to be harmless.

This contradictory policy **casts a fearsome pall over many activities that involve radiation.** The nuclear community and government **policymakers have actively fostered this fear**, by creating extreme, unrealistic, scenarios of nuclear dangers, and failing to challenge outlandish warnings of potential public disasters. The deep-grained public fear of nuclear power has been characterized as **clinically phobic** by Robert L. DuPont, M.D., internationally known expert on phobia. "The phobic terror has a life of its own, like nightmares," he writes (DuPont, RL, *Nuclear Phobia: Phobic Thinking About Nuclear Power.* Washington, DC: The Media Institute,1980) "In phobic thinking, the event as it actually occurred is rarely feared. The *what ifs* are feared." And he concludes with a message to those who created the *what ifs*: "If nuclear power is to play a meaningful role in our energy future, this fear must be accepted and dealt with."

One factor in dealing with public fear is the **attitude of policy-makers**. For more than 30 years they have stated in the strongest terms that we must drastically reduce our use of fossil fuels, and then **refused even to *discuss* nuclear power** as a way to do that. This is grounded on, and reinforces, public fear that radiation from nuclear power is just too frightening to deal with. The **opposite side of the coin** is strikingly illustrated by the situation in **France**. Marcel Boiteux, Director, 1967 to 1979, of EDF, France's national public utility, describes the situation there as follows (1993):

> Our employees received death threats. Coffins were delivered to the plant sites. My apartment was bombed… At the end of July 1977, the President of the Republic, Giscard d'Estaing, courageously …announced that the nuclear policy was not an EDF [utility] policy, **it was a French policy. And that changed the climate completely**, because once the whole of the political scene had taken a positive position in relation to nuclear power, there was little protest.

The most fearsome charge one could raise is the possibility of **irreversibly degrading the human gene pool.** This charge arises from time to time, although it has been **indisputably proven baseless.** (e.g. W. Schull, et al., "Genetic Effects of the Atomic Bomb: Reappraisal*, Science,* 212, 1220-1227,1981) The nuclear community must be clear, prompt and unambiguous in refuting that charge whenever it arises.

The unexplained gap between policy and the relevant science has been maintained so blatantly and for so long that **it will take determined, sustained action by top officials** in the affected agencies to correct it. We urge the Committee to take this occasion to again recommend the clearly indicated actions needed to **bring our policies concerning radiation into line with the scientific data and simple common sense.** To do otherwise is to be complicit in a policy that is scientifically indefensible, exorbitantly expensive, and antithetical to safety and the public welfare.

References-0*: Previous Discussions with ACNW et al. on this Issue:*
March 96 Joint Subcomm transcript plus slides (Muckerheide, Pollycove, Willis),
July '96 ltr ACNW/Pomeroy to NRC Chairman/Jackson,
Chair direction to RES to require (NRC-funded) NCRP Committee-1 LNT review,
Oct 98 draft; Mar 99 ACNW meeting

Supporting the above statements is the following evidence:

1. **The Research Reports** - The biological processes that characterize the interaction of radiation with living organisms are reasonably well defined. This work repeatedly shows that the **effects of radiation are generally beneficial in low doses and harmful at higher levels**. This phenomenon, called hormesis, is exhibited by nearly all chemicals, bacteria, exercise, red wine, and sunshine, as well as ionizing radiation. As toxicologists Calabrese and Baldwin wrote: *Nature,* 421 (6924):691 (2003), "**Hormesis is not an exception to the rule; it is the rule**." Or, as Marshall Brucer, "father of nuclear medicine" put it, "In August 1985, a Conference on Radiation Hormesis…finally recognized that low-dose radiation is not only good for you, it is essential to life." (*HPS Proceedings,* published in *HPJour*, 1987)

Scores of these reports were submitted to the NCRP, ICRP BEIR and other groups preparing policy-making reports. Numerous technical sessions and special panel discussions, with many authors of these papers, were presented to American Nuclear Society technical meetings from 1994 to 2004. These were very well attended, many with standing room only. A summary of these sessions is provided by url.

***References-1*:** *Testing basic response mechanisms and some overall hormesis reports*

2. The vast body of **credible, peer-reviewed scientific data** showing that low-dose radiation is not harmful is consistently and **repeatedly excluded from policy-setting "reviews."** The means by which this is accomplished is documented below. A few examples are given to show how extensive, and how technically substantive, this omission has been. That is then exploited to **argue that, since there is no good data at low doses, it is prudent to assume the worst**. There is no valid basis for that argument.

References: 2a: *Examples of excluded data*
2b: *Exclusion situation on-the-record*

3. **Statistical challenge** - It is argued that to produce statistically valid epidemiological dose-response data in the low-dose range would require impractically large populations. This is simply not true:

First, as a matter of logic, the statement is true only if the relationship is in fact linear all the way to zero dose--the Linear No Threshold (LNT) hypothesis. This leads to the silly syllogism: We can't prove the LNT is true if the LNT is true, so we should assume that it's true. But actual data in the low dose range is statistically valid in groups of easily obtainable size.

Second, there are in fact good epidemiological data involving populations of millions: people living in naturally high-radiation backgrounds vs. low; people exposed to radiation for medical therapy; people exposed to radiation occupationally. These data consistently show that those exposed to low-dose radiation are not harmed and are usually benefited thereby.

References-3*: Examples of good epidemiological studies of LDR health effects*

4. **The prudence argument** - is that there is no harm in presuming that all radiation effects are harmful, and that it is therefore prudent to presume that the LNT model applies. That begs the question it presumes to answer, and it results in demonstrably serious harm. Moreover, saying "LNT cannot be ruled out" is **ruled out by biological theory** as well as by the direct data. **LDR and HDR evoke different processes** that cannot be described by a single straight line.

The Prudence Argument **denies the science** and thus damages our credibility

Extreme, unnecessary requirements place exorbitant costs and uncertainties on all activities involving radiation, with no public benefit. And **important beneficial uses of radiation are constrained.**

References-4a: Examples stating the "no harm" premise
4b: Examples of significant harm caused by the premise

5. **The "collective dose" fallacy** – The most egregious and harmful aspect of using the LNT model for regulation is using the concept of collective dose to "predict" health effects and judge the quality of a radiation protection program. This has no scientific merit, and in many ways works against good safety.

References-5 *Examples of Repudiation of Collective Dose*

6. **The argument that dropping the LNT would complicate regulation** – Some regulators have argued that the LNT, being linear, is a simple basis for regulation, and that any other metric would be more complicated and confusing. Since no other hazardous material is controlled under an LNT premise, this argument is **hard to understand, let alone concur in.**

Reference-6*: R. Osborne statement of concern, and T. Rockwell response*

7. Despite conceding that there is little scientific evidence to support it, the **various policy-setting reports**, ICRP, NCRP, BEIR, NCRB, et al., **recommend** that radiation protection be regulated under the **premise that no amount of radiation is small enough to be harmless**. And they have repeatedly prepared extensive reports claiming to support this conclusion scientifically. But their data and their reasoning are flawed. Not only do they ignore the data that refutes their conclusions, but the "supporting evidence" data that they do provide is flawed. Data are manipulated and misrepresented. Analytical tools are used inappropriately. Reports are cited that have no data in the low dose range. Examples of these and other breaches of scientific integrity are given here.

References-7: *Examples of flawed arguments used to support LNT*

8. A strange and important factor in keeping this situation from resolution lies in the wording of the key **policy-setting documents**: they **all recommend using the LNT model**, but generally **state that no scientific evidence supports such a requirement.** Thus, they try to have it both ways. One can create documents from excerpts of the BEIR reports, or NCRP or ICRP reports, that are quite reasonable: they say the radiation risk is minimal or zero; current procedures are adequate, all's right with the nuclear world. But applicable policies require that designers and operators of real facilities pursue a phantom goal of decreasing radiation doses, using ever-increasing real resources, toward an unreachable zero. Thus, the framers of these reports **accept no responsibility for this unworkable situation**, while basking in the glory of favoring a radiation-free world.

References-8: *Recommending LNT while conceding that science indicates otherwise*

9. There have been a few public calls from knowledgeable persons and organizations to correct this contradictory situation. These have been answered, as so often in the past, with statements that new programs to "study low-dose radiation effects" will shed light on this problem during the next few years, so do nothing now. RSH has requested assurance that existing research, heretofore ignored in setting radiation protection policy, will this time be evaluated. No such assurance has been obtained. Regardless, we have ample evidence now to resolve this discrepancy without waiting for any further information.

References-9*: Several senior policy-makers have called for reform, but there has been no action.*

References 1 – Research Reports Contradicting LNT

In 1993, after a misleading public "debate" among LNT supporters claiming that low level radiation could cause adverse health effects, **J. Muckerheide,** the Massachusetts State Nuclear Engineer, as a member of the Mass. Governor's Advisory Council on Radiation Protection (ACRP), led the conduct of a state agency–requested ACRP review of the relevant scientific literature that was not considered by the BEIR V Committee. In 1994, to further data and literature access, he began arranging technical sessions at American Nuclear Society (ANS) national meetings. Experts were recruited from around the world. Radiation, Science, and Health, Inc. (RSH), was formed in 1996 as an international non-profit organization, to search out and distribute such data and communicate results beyond the research community. Representative data is on its website (http://www.radscihealth.org/rsh/docs). His September 1995 (http://www.radscihealth.org/rsh/docs/JM509.html) coincided with forming and chairing the ANS Low Level Radiation Health Effects Committee within the Biology and Medicine Division.

There are two seminal monographs on radiation hormesis by **Prof**. **T. D. Luckey**, chairman-emeritus, Biochemistry, University of Missouri (Columbia) School of Medicine: *Hormesis with Ionizing Radiation* (1980) and *Radiation Hormesis* (1991), both CRC Press, with more than **2000 hormesis references**.

S. Hattori, VP and Director of Research at the Central Research Institute of the Electric Power Industry in Japan, read Luckey's 1982 Health Physics Journal paper, from his 1980 book. Hattori requested that the U.S. Electric Power Research Institute evaluate Luckey's results. EPRI organized a 1985 conference on hormesis in Oakland CA. Selected papers were published in a Health Physics Journal Special Issue in May 1987. Hattori encouraged **K**. **Sakamoto, S. Kondo, T. Sugahara** and many others to document, reproduce and extend this research in Japan. He made presentations at several ANS sessions to report on continuing Japanese hormesis research work in 14 research centers. Also in the 1980s-90s, **E. Calabrese** brought the toxicologists into the issue, **R. Evans** and **R. Rowland** programs documented that workers with radium body-burdens had no adverse health effects at doses below 10 Gy; **B. Cohen** demonstrated that there are no adverse effects, and more likely health benefits, from high residential radon levels; and **G. Voeltz** followed the health of plutonium-contaminated workers. Research and analyses of the relevant radiobiological mechanisms were reported by **L. Feinendegen, M. Pollycove, Z. Jaworowski, S-Z Liu, L. Wei, H. Rossi, P. Duport, R. Mitchel, G. Walinder,** and many others.

References-1: In addition to sources mentioned above, a few key references are listed below:

Citing all the research that contradicts the LNT cannot be done in this space. Summaries of selected papers presented at the **RSH sessions during the ANS annual meetings**, 1994-2000 are available at: http://www.radscihealth.org/rsh/realism/ANSsessions1994-1999a.doc

Summary of papers at RSH Symposium on Medical Benefits of Low-Dose Radiation, Nov.15, 2000: http://www.radscihealth.org/rsh/docs/RSHSympNov00/index.htm

Abstracts of 85 research and review papers between 1995 and 1999 by Shu-Zheng Liu and coworkers at the PRC Ministry of Health, Radiobiology Research Unit, Jilin University of Medical Sciences. Changchun, China, 2000. (There are 113 additional papers from 2000 to 2007 to be included on the website.) http://www.radscihealth.org/rsh/docs/shuzheng_liu_et_al_abstracts.htm

R. Mitchel and D. Boreham, "Radiation Protection in the World of Modern Radiobiology: Time for A New Approach." IRPA-10, International Radiation Protection Association, Hiroshima, Japan, May 15-19, 2000 www.physics.ox.ac.uk/users/allison/NuclearSafety/Ron%20Mitchel%20and%20Doug%20Boreham,%20AECL,%20IRPA-10,%20May%202000.htm

W. Allison, "How Dangerous is Ionising Radiation?" Oxford Colloquium, Nov. 23, 2006 www.physics.ox.ac.uk/users/allison/NuclearSafety/colloquiumNovember2006website.pdf

A. Aurengo et al., "Dose-Effect Relationships and Estimation of the Carcinogenic Effects of Low Doses of Ionizing Radiation (Executive Summary)" Unanimous Joint Statement by French Academy of Sciences and French National Academy of Medicine, 2005 www.radscihealth.org/rsh/Papers/FrenchAcadsFinal07_04_05.pdf

C.L. Sanders, "Hormesis as a Confounding Factor in Epidemiological Studies of Radiation Carcinogenesis," *Dose-Response* 6(1): 53-79, 2008, cites 182 references.

E.J. Calabrese & L.A Baldwin, "Scientific Foundations of Hormesis" *Crit Rev Toxicol 2001:* 31: 351-624

Twenty pages of RSH comments on the EPA's use of LNT in setting drinking water standards are at: www.radscihealth.org/RSH/Docs/Correspondence/EPAcomments/index.htm

M. Pollycove & L. Feinendegen, "Biologic Responses to Low Doses of Ionizing Radiation: Part I: Detriment vs Hormesis; Part II: Dose Responses to Organisms" *J Nucl Med 2001:* 42:26N-37N http://www.radscihealth.org/rsh/docs/byAuthor/Pollycove.htm

E. Lorenz et al., ""Long-Term Effects of Acute and Chronic Radiation in Mice. Part I" *J Nat Cancer Inst* 1955: 15:1049

A. Caratero et al., "Effect of a Continuous Gamma Irradiation at a Very Low Dose on the Life Span of Mice" *Gerontology* 1998: 44:272-276

N.A. Frigerio et al., "Carcinogenic Hazard from Low Level Low Rate Radiation, Part I" Argonne National Lab, 1973: ANL/ES-26

L. Wei and T. Sugahara, "An Introductory Overview of the Epidemiological Study on the Population at the High Background Radiation Areas in Yangjiang, China" *J Radiat Res* (Tokyo) 2000: 41 Suppl: 1-7

G.L. Voelz, et al., "Fifty Years of Plutonium Exposure to the Manhattan Project Plutonium Workers: An Update" *Health Physics* 1997: 73:611-619

B.L, Cohen, "Test of the Linear No-Threshold Theory of Radiation Carcinogenesis for Inhaled Radon Decay Products" *Health Physics* 1995: 68:157-174

R.D. Evans, "Radium in Man" *Health Physics* 1974: 27:497-510

R.E. Rowland, "Bone Sarcoma in Humans Induced by Radium: A Threshold Response?" in *Radioprotection Colloques, Proceedings of the 27th Annual Meeting of the Eur Soc for Rad Biology* 1997: 32:C1/331-338

R.G. Thomas, "The U.S. Radium Luminisers: A Case for a Policy 'Below Regulatory Concern'" *J Radiat Protect* 1994: 14:141-153

K.N. Rithidech and B. R. Scott. "Evidence for Radiation Hormesis in Human Lymphocytes." Presentation at 6th International Conference on Hormesis, University of Massachusetts, Amherst, MA, May 1-2, 2007. The paper also describes significant new findings that were not reported at the Amherst conference.

S. Kondo, "Health Effects of Low-Level Radiation," Kinki University Press, Osaka, Japan, via Medical Physics Publishing, Madison, WI 1993 (www.radscihealth.org/RSH/Docs/Kondo93/sk1_2Ti.html)

J. Muckerheide, "There has NEVER been a Time when the Beneficial Effects of Low-Dose Ionizing Radiation were NOT Known," 2002, (www.radscihealth.org/rsh/docs/byAuthor/Muckerheide.htm)

T. Rockwell, "Bad Science in Service of a Bad Hypothesis," *Health Physics News* 2006: 34:9-10

D. Higson, et al., "Effects of Low Doses of Radiation," *Dose-Response* 5, 259-262 (2007) by seven senior participants in the 15th Pacific Basin Nuclear Conference at Sydney, Australia, October 2006. Excerpts:

> "In summary, research reported at the 15PBNC showed that the popular concept of radiation being harmful at any level of dose or dose rate (no matter how small) is not supportable, *viz*:
> • The risk of cancer generation is trivial or zero up to more than a hundred times the average of natural background radiation.
> • There are adaptive responses to low levels of radiation exposure which reduce the effects of damage from all causes, including those from radiation, thus reducing risk to levels lower than those observed in the absence of the radiation exposure.
> • Because of this adaptive or hormetic effect, the dose and dose rate effectiveness factor (assumed to be 2 in the application of the LNT model for the purposes of radiological protection) becomes very large and can be assumed to be infinite at low doses and low dose rates.
>
> 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."

References-2a Credible Scientific Data Barred from Policy Reports

The Radiation, Science & Health website quotes from eight formal protests that material submitted to NCRP has been completely and repeatedly ignored.
See www.radscihealth.org/rsh/docs/Correspondence/NCRP136/index.htm

Letter**, Director, DOE Office of Science, to President, National Academy of Sciences,** July 15, 2005:

> In addition, a number of significant epidemiological studies of workers exposed occupationally to low dose/low dose-rate have been published. Although some of these various studies were discussed in the **BEIR-VII Report**, they were, in the end, **left out of the Committee's final deliberations.**

Charles Willis, NRC, CHP, HPS Fellow and Board Member, in the transcript of ACNW meeting March 23, 1996, describing 1958 experiments at Oak Ridge showing that cells fed potassium with the K-40 removed were injured thereby, noted:

> So we **couldn't publish the results**, another ill effect of the paradigm about the linear hypothesis.

Myron Pollycove, MD, then NRC Special Medical Fellow and Professor Emeritus, Clinical Laboratory Medicine and Radiology, UCSF and Chairman, RSH, in transcript of ACNW meeting, March 23, 1996:

> **There has been a good deal of low-dose data available that has high statistical power and good controls** in contrast to the epidemiologic data which was accumulated during the'60s and '70s and '80s in the United States, as was pointed out by Frigerio, as well as in Brazil, India, China, China being a very well-controlled case control study. UNSCEAR '94 felt that this was done as the National Cancer Institute recommended. And all of these studies showed decreased mortality and decreased cancer in the high background areas and as compared with the low background areas. **Nevertheless, these were discarded**

Dr. R.G. Thomas of the Argonne National Laboratory report on the radium dial painters:
Thomas, R.G. (1994). "The US radium luminisers: A case for a policy of "below regulatory concern," *J. Radiol. Prot.* 14(2):141-153
(See: http://www.radscihealth.org/rsh/dd3/2.4.1_5.3.4.1Thomas94.html)

> The Scientific Advisory Board/Radiation Advisory Committee (SAB/RAC) urged EPA to base its risk assessment for radium on human epidemiology data on radium watch dial painters, rather than on modeled estimates, and urged EPA to present its rationale for adopting the modeling approach for radium risk assessment....
> EPA Reply: **"**EPA policy, supported by recommendations of SAB/RAC, is to assess cancer risks from ionizing radiation as a linear response. Therefore, use of the dial painter data requires either deriving a linear risk coefficient from significantly non-linear exposure-response data, or abandoning EPA policy and SAB/RAC advice in this case. " (1991 Federal Register 56, (138), 33050-127)
>
> This excerpt exemplifies how the **need to satisfy certain ground rules** (the use of linear modeling with what the EPA referred to as dose-squared radium dial painter data) forces the rule-makers to **use only data that tend to give the desired result**, or to use dicta for the interpretation of scientific data. One can only marvel that such results are generally acceptable by the standard-setting community.

A Unanimous Joint Report of the French Academies of Science and the National Academy of Medicine, English text March 2005, 94 pages, 306 references by M. Tubiana and A. Aurengo, cited a number of significant relevant reports and critical technical questions that were not discussed in BEIR-VII. http://radscihealth.org/rsh/docs/Correspondence/BEIRVII/TubianaAurengo5Oct05.pdf An example is cite below:

> The BEIR V-VII report **does not discuss two important review papers**, those of Tanooka (2001) and Duport (2003) which showed the high proportion of animal data with practical threshold or hormetic effect. These two papers are not quoted in the BEIR report. **If this is because the writers of the report disagree with their conclusions, it is regrettable that they do not explain why**. The BEIR report is based entirely on a technical NRPB memorandum by A.A. Edwards (1992), which is unfortunately not available…
>
> The BEIR-VII report **overlooks the complexity of the defense mechanisms** and their high efficacy at low doses (Feinendegen and Neumann 2005)…The Joint Report does not share the skepticism of the BEIR report about the significance of these data for two reasons: i) **these phenomena are not now disputed** and mechanisms are being uncovered; ii) the **absence of a mechanistic basis has never in science justified overlooking data**…These mechanisms and their variation with dose or dose rate are **not discussed in the BEIR-VII report or the ICRP preliminary report (2004)**.

Refs 2b: Recognition that Science Repudiates LNT is on the Record

The fact that low-dose radiation is harmless and often beneficial is not a new or minority opinion. It has been given multi-page coverage in *Fortune* (Jun 03), *Discover* (Dec 02), *American Spectator* (Jul/Aug 02), *Crisis* (Jun 02), *Wall St. Journal* (Dec 19, 03), and *Boston Globe* (Dec 12, 03). The proto-scientist Paracelsus said in 1540, "Nothing is poison but the dose makes it so." Within a few months after Roentgen's discovery of x-rays, articles began appearing in scientific journals on the use of x-rays to cure infection. It was recognized even then that the radiation was not strong enough to kill the bacteria directly, and that its effectiveness must result from stimulation of the immune system. This phenomenon—toxicity at high levels and stimulation of healing at low levels—is a nearly-universal biological process call *hormesis*. Calabrese and Baldwin report (*Nature* 421, 691, 2003) "thousands of studies demonstrating hormesis…we see it across the whole plant and animal kingdom… and at essentially every endpoint…**hormesis is not an exception to the rule, it is the rule.**" Jocelyn Kaiser's four-page News Focus on hormesis (*Science* 302, 376, 2003) contained a full-page sidebar documenting the phenomenon's occurrence with ionizing radiation.

There is no lack of data on the effects of low-dose radiation. T.D. Luckey, Chairman Emeritus, Biochemistry, U. Missouri-Columbia, wrote two books, *Hormesis with Ionizing Radiation* (1980) and *Radiation Hormesis* (1991) with nearly 2000 references validating hormesis in plants, animals and humans. James Muckerheide, as Chair of the ANS B&M Division Committee on Health Effects of Low Dose Radiation, organized a series of sessions on Health Effects of Low-Dose Radiation at ANS annual meetings, 1994-2003. Since 1994, the international public interest organization, Radiation, Science, & Health, has amassed and evaluated several thousand documents on the health effects of low-dose radiation dose (www.radscihealth.org/rsh/docs). Edward Calabrese and colleagues at the Northeast Regional Environmental Public Health Center, U Mass School of Public Health, publish a newsletter, *Biological Effects of Low-Level Exposures* (1990-), and run an annual international conference on Non-Linear Dose-Response Relationships (See www.belleonline.com).

The nuclear medicine pioneer, **Rosalyn Yalow, Nobel Laureate** in Medicine, asserted:

> **No reproducible evidence exists of harmful effects** from increases in **background radiation** three to ten times the usual levels. There is no increase in leukemia or other cancers among American participants in **nuclear testing**, no increase in leukemia or thyroid cancer among **medical patients** receiving I-131 for diagnosis or treatment of hyperthyroidism, and no increase in lung cancer among non-smokers exposed to increased **radon** in the home.
>
> The association of radiation with the atomic bomb and with excessive regulatory and health physics ALARA practices [As Low As Reasonably Achievable] has **created a climate of fear** about the dangers of radiation at any level. However, there is no evidence that radiation exposures at the levels equivalent to medical usage are harmful.
>
> The **unjustified excessive concern with radiation** at any level, however, precludes beneficial uses of radiation and radioactivity in medicine, science and industry. (*Mayo Clinic Proc 69:436-440, 1994*)

Hugh F. Henry at Oak Ridge summarized the low dose data in the *Journal of the American Medical Association:*

> **A significant and growing amount of experimental information** indicates that the overall effects of chronic exposure (at low levels) are **not harmfu**l…The preponderance of data better supports the hypothesis that low chronic exposures result in an increased longevity… Increased vitality at low exposures to materials that are markedly toxic at high exposures is a **well-recognized phenomenon**. (*JAMA176, 27 May 1961)*

The "**Wingspread Conference**" August 1-3, 1997, concluded:

> In a surprise move, **leading US and international scientific experts agreed** in an historic accord that an **increase in cancer has not been observed** at radiation exposures below 10,000 millirem given to the whole body in a short time.

Prof. W.V. Mayneord, former member of UNSCEAR and ICRP, wrote:

> **I have always felt that the argument**, because at higher values of dose an observed effect is proportional to dose, at very low doses there is necessarily some effect of dose, however small, **is nonsense**. (Mayneord, *Radiation and Health,* p. 140 (1964).

References 3 – Some Good Epidemiological Studies of LDR Health Effects

1. The Nuclear Shipyard Worker Study

(R Sponsler & J Cameron, "Nuclear Shipyard Worker Study", *Int J Low Radiation,* 1, 4, 463 (2005)
www.ecolo.org/documents/documents_in_english/low-dose-NSWS-shipyard.pdf

> The NSWS compared three cohorts: a high-dose cohort of 27,872 nuclear workers, a low-dose cohort of 10,348 workers, and a control cohort of 32,510 unexposed shipyard workers. The cohorts were matched by age and job categories…(from the Abstract)
>
> The NSWS is the **world's largest and most rigorously controlled study of radiation workers**. Significantly lower total mortality was observed in both groups of nuclear workers. Significantly lower mortality from all causes was observed among the cohort of nuclear workers who were exposed…than among unexposed controls…**This significantly lower mortality contradicts the linear non-threshold (LNT) model of radiation risk**…(from the Conclusions)
>
> The key comparisons in the NSWS were between non-nuclear and nuclear workers with the same jobs and ages and among dose-ranked groups of nuclear workers. Since cohorts and controls were compared to each other, there should be little "healthy worker effect," especially of the magnitude of 24% difference in SMR…Lea et al. (2000) and Pollycove and Feinendegen (1999) noted errors in methodology and small sample sizes in smaller published studies that have been cited as evidence of harm from low-dose radiation where harm did not exist. (from the Discussion)

The hormetic effect was **dismissed by the government** as a "healthy worker effect." **That explanation doesn't hold** since the major objective of the study was to avoid that problem, as discussed above. So a new objection was raised: a few workers were discouraged from assignment to nuclear work, because of a family history of cancer. Neither of these objections had been raised during the 10 years of the study. Arthur Upton, Committee Chairman of BEIR V, which ignored this study, and NCRP-136, which claimed a healthy worker effect, also headed the NSWS Technical Advisory Panel (TAP) charged with dealing with such questions. The second author, Dr. John Cameron, was also on the TAP and "recalls no discussion of selection bias during the many meetings of the TAP" and adds: "All TAP members approved the NSWS Final Report, and evidence of selection bias could have been brought up at that time." In any event, the few workers screened from nuclear work was too small to affect the conclusions, and the practice did not last long, because the workers objected to being barred from the more lucrative nuclear jobs.

This report also discussed an **epidemiological study on British radiologists that yielded the same kind of results.** (P.G. Smith & R. Doll, "Mortality from cancer and all causes among British radiologists." 1981 *British Journal of Radiology*, **54,** 187-194)

2. Effects of High Natural Radiation Backgrounds

Fifteen reports on studies of the health effects of high natural radiation backgrounds are cited on the RSH website, at: www.radscihealth.org/RSH/Data_Docs/1-2/6/2/1262list.html . Zbigniew Jaworowski, Professor Emeritus, and Chairman-Emeritus of the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), of the Central Laboratory for Radiological Protection, discusses some of these findings: (Jaworowski Z. "Stimulating effects of ionizing radiation: new issue for regulatory policy." *Regulatory Toxicol and Pharmacol* **22**, 172-179, 1995.)

The question arises: why governments of various countries do not relocate populations living in areas where lifetime dose of natural radiation is higher than 350 mSv. For example, why are people not evacuated from Norway where all country average lifetime dose is 365 mSv (Henriksen 1988), or from high background regions in India with a lifetime dose of >2000 mSv (Sunta 1990) and in Iran with lifetime dose of >3000 mSv (Sohrabi 1990)? Perhaps in Iran, for example, the government considered not to follow the ICRP guidelines when it considered the fact that in a house in the city of Ramsar several generations were receiving average individual lifetime doses of natural radiation of 17,000 mSv (240 times more than the current ICRP limit for exposure of members of the public to natural sources of radiation). Yet these individuals show no increased incidence of any disease, and some of them lived to 110 years of age (Sohrabi 1990).

The best radio-epidemiological study at low doses to date has been carried out in China. Between 1970 and 1986, 74,000 people in Yangjiang county, which has a high level of natural background radiation (5.5 mSv per year), were compared to 77,000 people in two adjacent low-background counties (Enping and Taishan, 2.1 mSv per year). In the high-background county, the inhabitants receive a 70-year lifetime dose of 385 mSv, which is higher than the intervention level for evacuation adopted for Chernobyl, and 5.5 times higher than the dose limit proposed in the EPA. Should the Chinese government evacuate Yangjiang county? The epidemiological data show that.... in an age group of 10-79 years the general (non-leukemia) cancer mortality was 14.6% lower in the high-background county than in the low-background counties. The leukemia mortality among men was 15% lower and among women 60% lower in Yangjiang (Wei et al. 1990)."

N. Frigerio, K. Eckerman, and R. Stowe ("Carcinogenic hazard from low-level, low-rate radiation, part I" Argonne Nat. Lab.: ANL/ES-26, 1973) reported that Argonne was contracted to aid AEC for environmental statements for nuclear facilities being licensed, and that "the hypothesis has been advanced that a significant fraction of human cancer mortality may be due to the human radiation background", i.e., at 170 millirem/yr, U. S. cancer mortality excesses are about 3,000 to 100,000 per year (about 1% to 30% of current experience). Since so important an etiologic factor would be of major significance in cancer epidemiology, we examined these hypotheses from current vital statistics and known radiation background. At about 33,600 cancer deaths/yr, i.e., about 10% of experience, spread over 56 Mn types, about 54 radiogenic deaths per million population per Mn type for the 18-year period of observation is expected.

Populations at rates below 0.3 and 0.03, by sex, race, Mn type, and state of residence, were applied to bracket a rate at which the linear additive model would be easily tenable. Cancer epidemiology does not usually consider expectations <5 or so, much less as decimals, but this is the practice in radiation carcinogenesis studies. Thus, we have allowed this practice at rates of 0.3 or 0.03. At 0.003 a plus sign (+) indicates that the value is mathematically real but less than 1. With so many Mn sites "violating the requirements of the model", even as judged simply by the 't'-test, we had to admit that it was extraordinarily improbable, at least at these levels. So, we dropped our search value until, at 0.006, all of the observations went to zero except for the three stalwarts, ICD 151, 153 and 171. Since we might have something, we did our estimations on 0.003, the mid-value of the interval, rather than 0.006, its upper bound. In this range level, the normal 't'-test becomes awkward, so we resorted to the more powerful Monte Carlo method. The U.S. population was subjected to a random "rain" of radio-carcinogenic deaths at 0.003 for 100 18-year periods. Ergo, not only is the null hypothesis, at 0.003, improbable, but Monte Carlo results suggest that a level of roughly 0.003/20 would be needed to reach even a 63% confidence level. This corresponds to about 16 deaths/yr per 200,000,000 population, about 0.005% of current U. S. mortality. In any case the model certainly seemed untenable at any level much greater than $0.003/20 = 1.5 \times 10^{-4}$, at least as its authors originally presented it.

3. Epidemiological Studies of the Health Effects of Radon

3a - Dr. Bernard Cohen, Professor-Emeritus of Physics at the University of Pittsburgh has published a great deal of information on his epidemiological work on the health effects of radon, showing that in the range of interest, **radon is beneficial rather than harmful.** Because his findings were so persuasive, being based on **real people in their homes**, and **including nearly 90% of the American people**, they were attacked on the basis that such studies cannot be "informative" in determining the validity of the LNT model. So Cohen has devoted effort to responding to these generic criticisms, pointing out that they do not invalidate his findings. (www.phyast.pitt.edu/~blc/)

His basic paper, "Test of the Linear No-Threshold Theory of Radiation Carcinogenesis for Inhaled Radon Decay Products" and follow-up papers by him and others have been widely discussed but never successfully repudiated.

> **Abstract**: Data on lung cancer mortality rates vs. average radon concentration in homes for 1,601 U,S. counties are used to test the linear no-threshold theory. The widely recognized problems with ecological studies, as applied to this work, are addressed extensively. With or without corrections for variations in smoking prevalence, there is a **strong tendency for cancer rates to decrease with increasing radon exposure**, in sharp contrast to the increase expected from the theory. The discrepancy in slope is about 20 standard deviations. It is shown that uncertainties in lung cancer rates, radon exposures, and smoking prevalence are not important, and that confounding by 54 socioeconomic factors…can explain only a small fraction of the discrepancy…In spite of extensive efforts, **no potential explanations for the discrepancy other than failure of the [LNT] could be found.** (*Health Physics* 68, 2 157-174, 1995)

Five years later, Cohen published a follow-up paper, "Updates and Extensions to Tests of the Linear Non-Threshold Theory" (see www.phyast.pitt.edu/~blc/Update_of_LNT.pdf) of which the Abstract read:

> Two weaknesses in a 1995 article on tests of the linear no-threshold theory of radiation carcinogenesis are pointed out. One is addressed by introducing more recent cancer mortality statistics, and the other is addressed by introducing 450 newly available potential confounding factors. The later cancer statistics give results very similar to the original ones for the nation as a whole, but do cause some significant changes for some geographic areas. **None of the new confounding variables helps to explain the large discrepancy with predictions of the linear no-threshold theory**, nor does the use of more recent cancer statistics. (*Technology,* Vol. 7 pp.657-670, 2000)

3b - A large number of reports on **beneficial health effects of radon** are cited on the RSH website at: www.radscihealth.org/RSH/Docs/Radon/RnTherapiesIndex.htm Three examples are given here:

Beneficial Effects of Radon - 100 Years of Radon Therapy [PDF, 114 KB], by Prof. Dr. Klaus Becker.
http://www.radscihealth.org/RSH/Papers/Becker04IJLR-RnTher.pdf

> **Abstract:** Supplementing a recent review on human health effects of radon as a potential test for the LNT hypothesis (Becker 2003), this compilation of biopositive radon uses, in particular for the treatment of painful degenerative joint and spine diseases, covers mainly the century of large-scale use and scientific studies on this subject since the discovery of radon. Most of those studies and experiences originated in Western Europe, in particular Germany and Austria, but also in the

former Soviet Union other countries such as Japan. They have in common that they are relatively little represented and known in the anglophonic scientific literature, where radon therapy is still frequently considered as a somewhat controversial "traditional medicine" closely related to placebo effects, which should not be compared with the use of drugs such as non-steroid anti-rheumatics.

This review summarizes, based on the substantial experiences as reflected in a selection of about hundred references, from more than one thousand which have been published on this subject, that radon therapy by inhalation or bathes is established as an effective treatment not only by empirical observations in different civilizations, but also in randomized clinical double-blind studies (Pratzel 1992). It should be further explored as an effective and inexpensive alternative to the use of pharmaca, which cause, unlike radon, serious side-effects with more than 10.000 casualties annually. It is demonstrated that the benefits in the adequate use of low-dose radiation exposures far exceed the hypothetical lung cancer risk attributed to the inhalation even of low radon concentrations, which is claimed by supporters of the LNT/collective dose assumption. Further research could provide further explanation of the mechanism of the stimulatory radon effect on the body's defense systems.

Gasteiner Heilstollen: The Radiation Effect of the Gastein Healing Gallery," Bad Gastein, Austria. http://www.radscihealth.org/RSH/Docs/Radon/RadiationEffectOfGasteinHealingGallery.mht

Dr. Peter Brandmaier, in charge of radiation protection. [Note: This page has been removed from the revised Heilstollen website - it has temporarily been replaced by the Google cache of the original page. Unfortunately, the most useful graphic is absent.]

Moderate alpha rays in the form of the inert gas Radon coming from deep cracks in the mountain massive around Bad Gastein have been made medically useful for the public coming for cures for thousands of years (Gastein Thermal Springs). The opening up of just such a system of cracks by the miners led to the founding of the Cure Enterprise Gasteiner Heilstollen (Gastein Healing Gallery) in the fifties, in which Radon concentrations of an average of 43 kBq/m³ (maximal 160 kBq/m³) in temperatures of up to 41.5°C and air for breathing that is saturated with humidity are available for therapies.

Scientific Principles of the Health Treatments in Bad Gastein and Bad Hofgastein by Peter Deetjen, Professor, Ph.D. Head of the Scientific Staff of the Research Institute Gastein - Tauernregion, and Head of the Department of Physiology and Balneology, University of Innsbruck, 1997, Sem. Reports Salzburg Austria ISSN 0256 - 4173.

The history of the Gastein region as a health resort dates back to the Middle Ages. Long before the spring water became the subject of any scientific research, practical experience had shown which diseases were most helped by the treatment. These include the more painful chronic rheumatic conditions such as deformation or degeneration of the joints and inflamation of muscles, tendons or joints. Bechterev's disease, spondylitis, spondylarthritis, osteochondrosis, neuralgia, chronic neuritis, difficulties in movement after an accident or sport injury, peripheral circulatory problems, slow healing wounds or injuries (e.g. ulcer cruris, parodontosis) and some of the problems associated with old age and degeneration have all been treated in Bad Gastein and Bad Hofgastein with some degree of success.

Finally, to this list should be added complications involving the endocrine system, preclimacteric and climacteric difficulties, and impotentia coeundi et generandi.

It may seem surprising that one treatment is prescribed for such a wide range of conditions. Indeed, many of the effects are only known from experience, and have still to be properly explained on a medical basis. However, modern scientific methods are producing more and more significant findings that lead to better understandings of the subject. Analysis have shown that the most active component of the Gastein thermal water is Radon-222.

The Gastein water meets all the official Austrian standards for "treatment water" as defined by the "Austrian Heilvorkommen-law" and "Austrian Kurort-law".

The temperature markedly exceeds the required minimum of 20 °C and the concentration of Radon-222 (20.0 nCi/l) is also higher than the minimum of 10 nCi/l. (i.e., 10,000 pCi/l)"

References 4a – "No harm in presuming radiation is never beneficial"

Although this premise ***presumes to answer*** **the very question it claims to examine**, the premise nonetheless plays a key role in many of the policy-setting reports on radiation protection. For example:

ICRP-2005 Task Group C-1 states (page 12, line 9) as "The conclusions of this report" that "there seems to be no particular reason to factor the possibility of a threshold into risk calculations for purposes of radiation protection. The LNT hypothesis…remains a prudent basis for radiation protection at low doses and low dose rates."

ICPR-2005 enshrines this notion by requiring "Dose Optimization," which it defines as simply dose reduction: "The concept of optimization…is to engender a state of thinking in everyone responsible for control of radiation exposures such that they are **continually asking themselves the question, 'Have I done all that I reasonably can to reduce these doses?**'"

Cardis et al. Cancer in Nuclear Workers

Cardis E, Gilbert, ES, Carpenter L, Howe GR, Kato I, et al. "Effects of low doses and low dose rates of external ionizing radiation: cancer mortality among nuclear industry workers in three countries." *Radiation Research* 142:117-132 (1995):

> **As there was no reason to suspect that exposure to radiation would be associated with a decrease in risk** of any specific type of cancer…one-sided tests are presented throughout…For leukemia excluding CLL, the number of deaths was less than 30…P value presented was **estimated using computer simulations based on 5000 samples**, rather than the normal approximation."

BEIR-VI Report on radon (page G-20) dismissed Cohen's extensive series of measurements and analysis as follows:

> The results of Cohen's analysis will seem biologically implausible to many investigators, although it is probably theoretically possible at the individual level….**Most of us would not be willing to discard a useful theory on the basis of such a test.** [i.e., actual measurements of radon levels and lung cancer fatalities in real people in houses.]

References 4b – But Defining Low-Dose Radiation as Hazardous *IS* Harmful

Below are some examples of what happens when a government agency takes seriously the statement that no amount of radiation is small enough to be safe and ALARA-to-zero is the order of the day. Many other potential opportunities exist that have not yet been exploited.
(T. Rockwell, "What's Wrong With Being Cautious?" *Nuclear News,* June, 1997)
www.radscihealth.org/rsh/docs/TR_6-97_FOF.html

a. Since radiation dose is often caused by discretionary time spent **inspecting and testing in radiation zones**, this quixotic quest for zero dose creates an **ill-advised incentive to reduce that time for no health benefit,** at increased risk of downgrading a situation (such as corrosion or leakage) important to real safety. This problem is aggravated by awarding financial incentives for lowering a facility's collective dose during a given time period. A facility's NRC Safety Rating is also affected by its change in collective dose. This is a real and significant negative impact on safety caused by the current practice of emphasizing radiation dose far beyond its real hazard.

b. **C.L. Sanders**, "Hormesis as a Confounding Factor in Epidemiological Studies of Radiation Carcinogenesis" with 182 references, Korea Advanced Institute of Science & Technology (2006), concludes:

> 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 the 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.

c. The problem extends beyond nuclear power. **EPA's latest limits on radium, uranium and other radioactive elements in potential drinking water sources makes illegal many large and small water treatment facilities.** In hearings, EPA argued that the cost of the chemicals necessary to reduce radioactivity to meet the new limits was only a few hundred dollars a month for a typical facility. But the reality is that the rules **change many small treatment plants from locally controlled operations run by minimally trained personnel to federally licensed nuclear facilities.** The sludge they used to sell locally for **fertilizer is now defined as a hazardous radwaste**, requiring specially controlled transportation, handling, storage and ultimate disposal. Considerable documentation exists on this matter, since RSH and others unsuccessfully sued EPA over this regulatory ruling.
www.radscihealth.org/rsh/docs/Correspondence/EPAcomments/index.htm

d. **Radium-dialed aircraft instruments** have been manufactured for decades under US government specifications. When the military accrued far more instruments than it needed, it auctioned them off for civilian aircraft. Lawsuits that these instruments caused cancer were successfully defended by the government on the basis that the radiation from the instruments was not sufficient to cause cancer. Preservation Aircraft, Inc. was one of the "buyers in good faith" that bought these instruments for use in its historic aircraft museum. Despite the legal finding that the instruments were not hazardous, the California Department of Health Services destroyed over one million irreplaceable historic aircraft instruments and associated equipment at a cost of $7M. The EPA then declared the entire museum building "contaminated" and razed it to bare ground, although extensive testing by two independent contractors found no contamination hazard. Although less than 2% of the equipment had radium instruments, none of which had measurable contamination, the company was unable to reclaim any of their inventory. Not only was the company not compensated for this loss, but the owner was billed as an individual for the demolition, and his house and personal belongings were inventoried by the government for seizure.
www.the-boondocks.org/forum/index.php?t=msg&goto=13680&

e. Exxon was sued for over a billion dollars because its **naturally-radioactive drilling mud** exposed eleven drill operators to radiation without their informed consent. Legal defense was made difficult by the claim that, under the law, "no amount of radiation is considered small enough to be safe." The original award was reduced to $112 million.

http://smithstag.com/Articles/BLOOMBERG.COM%2004012005%20Exxon%20Wins%20$888%20Mln%20Verdict%20Reduction,%20Loses%20Appeal%20%20Update3.pdf

f. Many years ago, a potentially **large bed of uranium ore** was discovered in Virginia. If this much energy had been in the form of oil, we would be prepared to sacrifice a generation of soldiers to secure it. But instead of rejoicing at this unexpected bounty, the state promptly passed a **law forbidding any mining of it**. (See: www.washingtonpost.com/wp-dyn/content/article/2008/01/01/AR2008010101811.html)

g. Most of the **fears people have regarding the safety of nuclear energy and other beneficial uses of radiation** are based on the false concept, repeatedly proclaimed and not denied, that radiation poses a mysterious and unprecedented hazard. The idea of **"no safe dose" is at the root of that fear.** It applies to no other hazard and there is no basis for applying it to radiation.

References 5 - The Harmful Fallacy of Collective Dose

Use of Cumulative Radiation Dose as a Measure of Good Practice or of Casualty Magnitude

Radiation protection policy uses as a prime measure of the severity of a casualty, or the efficacy of "good plant operation," the total collective radiation dose in person-rem, multiplying trivial individual radiation doses by large numbers of people to "predict" many induced cancer deaths. **That process has been repeatedly condemned as scientifically indefensible**. Yet current policy presumes that, in the absence of more data, this is the prudent course. That contention is wrong on both counts: there is no lack of applicable credible data and the data show persuasively that low-dose radiation is not harmful. And use of this unwarranted practice continues to have serious detrimental effects.

NCRP-121 specifically warns that collective dose should not be used to predict death or injury from low-dose radiation:

> "The summation of trivial average risks over very large populations or time periods…has **produced a distorted image of risk**, completely out of perspective with risks accepted every day, both voluntarily and involuntarily." (p.58)

And again:

> "…it is **recommended that regulatory limits not be set in terms of collective dose**…When the uncertainty in the number of individuals …is large… collective dose should not be used as a surrogate for risk, even at relatively high levels of individual radiation dose." (p. 62)

*Roger Clarke, Chairman of the **International Commission on Radiological Protection** wrote (1 Oct 98 at* http://hps.org/documents/controllable.pdf*) :*

> "If the risk of harm to the health of the **most exposed individual is trivial, then the total risk is trivia**l—irrespective of how many people are exposed".

And the **Health Physics Society**, in its March 1993 Position Statement, emphasized in bold-faced type:

> *"We strongly recommend that dose limits be applied only to individual members of the public, not to the collective dose to population groups."*

The French Academy of Medicine **quoted and concurred with the above statement from NCRP-136, and stated in a press release 4 Dec 01**:

> [the Academy] associates with many international institutions to denounce improper utilization of the concept of the collective dose to this end. These procedures are **without any scientific validity**, even if they appear be convenient to administrative ends.

A Unanimous Joint Report of the French Academies of Science and the National Academy of Medicine, English text March 2005, 94 pages, 306 references, by M. Tubiana and A.Aurengo, objected to endorsing the LNT and made the following simple statement about collective dose:

> The concept of **collective dose cannot be used for evaluating the cancer risk** in a population

Zbigniew Jaworowski, MD, PhD, the noted member and former chair of UNSCEAR, wrote in "Radiation Risk and Ethics" (Physics Today, Sept 1999, 24-29) that use of collective dose:

was introduced in the early 1960s…the concept is still widely used, although **both the concept and the concern [about harmful hereditary effects] ought to have faded into oblivion** by now…Individual doses cannot be additive over generations, simply because humans are mortal and the dose dies when an individual does. Similarly, individual doses cannot be added for individuals of the same generation because we do not contaminate one another with a dose that we have absorbed…

If harm to the individual is trivial, then the total harm to members of his or her society over all past or future time **must also be trivial**—regardless of how many people are or will have been exposed.

References 6 – "Dropping LNT Would Complicate Regulation"

Some regulators have **argued that the LNT, being linear, simplifies regulation**, and that any other metric would be more complicated and confusing. For example, Richard Osborne writes in the *Canadian Nuclear Society Bulletin:*

> [R]adiation measurements, dosimetry, and environmental modeling would become much more complicated with a departure from an assumption of linearity of dose and response for protection purposes. The instruments and models would need to be much more clever than the ones with which I have been involved in my near four decades. Operational protection, too, would be much more complicated. (*CNS Bull.* Vol 19 No 4, Oct-Dec 98)

This problem arises only if one assumes that cells damaged by radiation are somehow different from those damaged by normal metabolism, and thereby resist the repair process continually going on for all other damaged cells. It is true that radiation inflicts more double breaks than the oxidation damage caused by metabolism. But, because of the much greater number of cells damaged by metabolism, there are still **more than 1000 times as many double breaks from metabolism than from low-dose radiation**, and measurements of the **number of mutant cells remaining after repair confirm this fact**. The radiation-damaged cells do not add to the remaining mutants; in fact, by stimulating the defense mechanisms, the **number of mutant cells is significantly reduced**. (M. Pollycove & L. Feinendegen, "Biologic Responses to Low Doses of Ionizing Radiation: Part I: Detriment vs. Hormesis; Part II: Dose Responses to Organisms" *J Nucl Med 2001:* 42:26N-37N http://www.radscihealth.org/rsh/docs/byAuthor/Pollycove.htm

Since **few, if any, other hazardous materials are controlled under an LNT premise**, this argument is hard to understand, let alone concur in. With LNT, unlike a typical permissible concentration regulation, no amount of dilution in time or space can diminish the defined hazard. This creates problems and uncertainties never encountered in other types of hazard control. **The unreachable zero becomes the implied requirement for radiation and radioactivity, in a natural background whose magnitude and variation create a hundred-fold noise-to-signal ratio.** (See response by T. Rockwell in *CNS Bull*, 20, 1, Jan-Mar 99)

Refs 7: Bad Science & Flawed Arguments Used to Defend LNT

Sir Francis Bacon described scientific research as putting nature on the rack and torturing her to reveal her secrets. In this context, it has been said that scientific data are like captured spies: if you torture them long enough, they'll tell you whatever you want to hear. **The raw data on the effects of low-dose radiation**—on A-bomb victims, people living in high natural radiation areas, patients irradiated therapeutically, workers irradiated occupationally, and well as on lower organisms—the **results are the same: High doses are deleterious, low doses are harmless or beneficial.** It takes a lot of manipulation to make the data say the opposite. Here are some examples as to how this has been done.

a. Biased selection of data, e.g. rejecting unwanted data is a prime anathema in science. As noted above (Refs-2) , this is a repeated offense in reports advocating use of LNT.

b. Calculating cancers and deaths from "collective dose" has also been repeatedly discredited as being scientifically invalid (Refs-5), yet is also a common offense in these reports (Refs 4a).

c. Discovery of "Cancer Clusters." This practice, common among anti-nuclear activists such as Steven Wing, Ernest Sternglass et al., is tolerated too often by the nuclear community. It involves collecting (say) cancer rates in counties around a nuclear facility. The raw data nearly always shows no increased cancer. But a **diligent parsing of the data will show that in some counties, some types of cancers, for some age groups of "victims," are above average, and some are below**. Ignoring those below average, the researcher announces with alarm that there are "cancer clusters" downwind of the facility. It is important to note that **the age groups and the cancer types showing high values** in one location are **not generally the same for another location**. (And it often turns out that **some of the counties with high cancers are not downwind**, and some downwind counties are not high cancer. When Sternglass was asked publicly how he selected the counties, he replied that **he took those with high cancer rates**.) There have been a few such reports for which an increase was valid, but this was shown to be unrelated to radiation and associated with such factors as groups of recent immigrant workers for whom the normal cancer base differed from the rest of the local population. In this connection, it is interesting to note that, whereas nuclear plants do not generally release significant amounts of radiation, coal-burning plants do.

d. Inappropriate manipulation of data can take many forms. A common one is to **lump all low-dose data into one dose-range bin** (e.g. 0 to 50 rad), even though that may be up to 80% of the data points into one of six or more bins. Thus, the higher values in this bin will offset the hormetic effect of the lower values. This is done with the A-bomb data and some other examples below. Another type of inappropriate manipulation occurs when the numbers of cases is too small for good statistics, so a **computer-synthesized larger population is used** for calculating uncertainties. Some examples follow:

Cardis et al. Cancer in Nuclear Workers

Cardis E, Gilbert, ES, Carpenter L, Howe GR, Kato I, et al. "Effects of low doses and low dose rates of external ionizing radiation: cancer mortality among nuclear industry workers in three countries." *Radiation Research* 142:117-132 (1995).

The report covered 7 facilities with 95,673 workers, but omitted the 10-year multimillion-dollar study of US nuclear shipyard workers with 700,000 workers—a study that showed statistically significant decrease in "all malignant neoplasms" and in "deaths from all causes." The report states:

> "As there was no reason to suspect that exposure to radiation would be associated with a decrease in risk of any specific type of cancer…**one-sided tests are presented throughout**…For leukemia excluding CLL, the number of deaths was less than 30…P value presented was estimated using **computer simulations based on 5000 samples, rather than the normal approximation**."

There were **seven groups of data reported. Four** show 86 observed deaths below the LNT. These deaths (**72% of the total**) **were excluded from the analyses and conclusions.** The remaining 33 deaths were then increased by computer modeling to 5000, so as to construct a P value of 0.048, just under the 0.05 level considered significant.

Miller et al. Canadian Fluoroscopy Study

Miller AB, Howe GR, Sherman GJ, Lindsay JP, Yaffe MJ, Dinner PJ, Risch HA, Preston DL. "Mortality from breast cancer after irradiation during fluoroscopic examination in patients being treated for tuberculosis." *N Engl J Med* 321: 1285-1289 (1989).

32,710 women in a tuberculosis sanitarium were examined periodically by fluoroscope to monitor lung-collapse therapy. This report finds a linear increase of breast cancer mortality with radiation dose, an increase of 60 cancers in one million 30-year-old women. **The data were not plotted**, and the **hormetic (beneficial) effect was not reported**. However, the data in the report show a strong hormetic effect: breast cancer relative risk was reduced to 0.66 ($P<0.05$) at 150 mGy and 0.85 at 250 mGy. At 150 mGy, the LNT "predicts" 900 excess cancers, while the data at 150mGy show a reduction of 10,000 cancers in one million 30-year-old women. During a meeting of the BEIR-VII committee, this discrepancy was discussed. One of the authors of this study responded, "They like straight lines."

Radon in homes

Samet JM, et al. "BEIR-VI: Health effects of exposure to radon." National Research Council, Washington, DC, National Academy Press (1998).

Cohen BL, "Test of the linear no-threshold theory of radiation carcinogenesis in the low dose, low dose rate region" *Health Physics* 68:157-174 (1995) and several follow-up papers, responding to comments.

The Cohen papers reported actual average lung cancer deaths in counties containing nearly 90% of the U.S. population, and compared it with average residential radon exposure in those counties. His data **showed continuous *decrease* of lung cancer** with increased radon dose. Because of the huge population iinvolved (over 200 million), his **statistical precision was very high**. The high population number also enabled him to correct for smoking, urban vs, rural, age, gender and many other variables, none of which significantly changed the results.

Because his evidence differs from the LNT by 20 standard deviations, the policy-makers have tried to ignore, obfuscate and disparage it. But their **criticisms take the form of generic objections, which do not in fact apply to the actual case.** For example, the BEIR-VI report on radon, on which the EPA regulations are based, relegates this evidence to its Appendix G and doesn't even mention the many other studies that reach the same conclusion. Appendix G states:

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

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

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

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

Cohen's work has been replicated by others. For example, Dr. Gary Sandquist and others (1997) took EPA's radon data and cancer data from the American Cancer Society and showed the same relationship that Cohen's work shows. They found that average radon doses vary from state to state by an order of magnitude, and that the **cancer rate in the lowest radon states was nearly four times that "predicted" by the LNT model, whereas the cancer rate in the high-radon states was only one-seventh of the LNT prediction.**

So what does the BEIR committee base its conclusion on, that 15,400 to 21,800 *(3 significant figures?)* Americans die each year from radon? Even after ignoring scientific evidence it dislikes, the **huge error bars** in its own supporting documentation **make any correlation** between lung cancer and radon levels found in homes **unpersuasive.**

e. Misrepresentation of results

Having committed serious breaches of scientific protocol in its canonical literature, the radiation protection community then misrepresents the scientific knowledge base of low-dose radiation health effects by actions such as the following:

It **mandates the A-bomb victim data as the "Gold Standard"** for calculating radiation health effects, despite the enormous differences between that situation and the homes and work-places where the resulting regulations apply. **It rules out the extensive study of workers** at nuclear shipyards as "healthy worker effect," though it was designed specifically to avoid that problem; and data from **high natural background** locations for unstated reasons; and epidemiological studies of **radon in homes**, because it has been criticized (though none of the criticisms invalidated the conclusions); and studies of **medically-irradiated patients**, because their sickness makes them atypical.

It **treats natural radiation different from man-made**, except that it sometimes burdens uranium, radium, and radon with a full panoply of radiation regulations. And sometimes not. Over 60,000 websites discuss this topic, e.g.: www.arpansa.gov.au/aboutus/committees/norm.cfm#genericContent This becomes an issue only if radiation levels below natural backgrounds are defined as hazardous.

Bobby Scott, et al. (B. Scott, C. Sanders, R. Mitchel, D. Boreham, "CT Scans May Reduce Rather than Increase Risk of Cancer," *J Amer Physicians & Surgeons* 13, 1, 8-11, Spring 2008) discuss **flaws** in many papers that **disguise the presence of what they call "radiation activated natural protection"** (radiation ANP), a term they use in deference to those offended by the word ***hormesis****:*

> **Failure to Report Radiation-ANP-related Suppression of Cancer**
> Most epidemiological studies of radiation-induced cancer do not report radiation-related ANP. The designs of epidemiological studies of radiation-induced cancer are largely influenced by the presumption that the LNT model is valid. Some approaches used in such epidemiological studies that make it difficult to demonstrate or recognize adaptive response and thresholds for excess cancers are as follows:
>
> 1. Dose lagging (ignoring some of the radiation dose), which shifts the dose-response curve to the left, as was done in the analyses of Cardis discussed by Brenner and Hall as supporting evidence for increased cancer risk at low doses;
>
> 2. Averaging risk over wide dose intervals in cohort studies, as was done for A-bomb survivor cancer data cited by Brenner and Hall to infer increased risk for the entire weighted dose interval 10-150mSv;
>
> 3. Averaging odds of cancer over very wide dose intervals before calculating the odds ratio in case-control studies;
>
> 4. Including individuals who received low-dose radiation in the unexposed group in cohort and case-control studies;
>
> 5. Employing linear extrapolation from high to low doses after dose-lagging or odds-averaging over wide dose intervals;
>
> 6. Not adjusting for the impact of combined injuries and differences in genetic susceptibilities when using A-bomb survivor data to assess cancer risk for another population; and
>
> 7. Ignoring radiation ANP (which is supported by low-dose data) for no apparent reason other than it does not fit the LNT model.

Refs 8: Recommending LNT while Conceding that Science Indicates Otherwise

No credible scientific case has ever been made for the belief that low-dose radiation is harmful. Long, formal reports by the National Council on Radiation Protection and Measurements (NCRP) discuss effects from high-level radiation and in cells in culture (with no functioning immune systems), and other peripheral subjects, but they concede that science does not support the idea of deleterious health effects from low-dose irradiation. After claiming no valid LDR data exist, they argue that LNT "cannot be excluded." But **biological theory**—knowledge that LDR and HDR invoke different processes—is **enough to exclude LNT**, even if direct experimental measurement had not already done so.

For example, the report NCRP-121, states:

> Few experimental studies, and essentially **no human data, can be said to prove, or even provide direct support for the concept**…It is *conceptually possible, but with a vanishingly small probability,* that any of these effects *could* result from the passage of a single charged particle…It is a result of this type of reasoning that a linear non-threshold dose response relationship *cannot be excluded.* (p. 45, emphasis added)

And NCRP-136 goes further, to concede:

> It is important to note that the **rates of cancer** in most populations exposed to low-level radiation **have not been found to be detectably increased**, and that **in most cases the rates have appeared to be decreased**. (p. 6)

The French Academy of Medicine quotes and concurs with the above statement from NCRP-136, and states:

> The hypothesis of the risks of cancer induced by low doses and dose-rates is founded on the extrapolation of data of highly-exposed human groups, applying the risk as being constantly proportional to the received dose without being limited by a threshold, the linear no-threshold (LNT) assumption. **This hypothesis conflicts with itself and has many scientific objections** (10); it is **contradicted by experimental data** (11) **and epidemiology**. ..[the Academy] **denounces utilization of the linear no-threshold (LNT)** relation to estimate the effect of low doses… (Dec 2001)

A Unanimous Joint Report of the French Academies of Science and the National Academy of Medicine, English text March 2005, 94 pages, 306 references, by M. Tubiana and A. Aurengo, objected to endorsing the LNT and demonstrated that extensive scientific evidence backs this conclusion: http://radscihealth.org/rsh/docs/Correspondence/BEIRVII/TubianaAurengo5Oct05.pdf

> The LNT model, used in 1956 by Russell to evaluate the radio-induced mutations in the germ cell line of the mouse…was considered a convenient pragmatic relationship but not a model based on scientific data…This procedure has become a dogma in many radioprotection circles, but the **validity of the LNT has been challenged** in the past decade for two main reasons: a) the meta-analysis of the animal data have shown the **absence of any carcinogenic effect** below 100mSv; b) scientific progress has revealed the complexity of carcinogenesis, and c) the **diversity and effectiveness of the responses of a cell to irradiation**…The lack of validity of the LNT relationship for chromosome aberrations at low doses with low LET radiation is not surprising…LNT cannot be used to predict chromosome aberrations for very low doses…These hypotheses [supporting LNT] are **not consistent with current radiobiological knowledge**…
>
> One of the main arguments of the proponents of LNT was the linear dose-effect relationship for solid tumors among the survivors of the A-bomb. In fact, the latest analysis reveals that **the** dose-

> effect relationship is not linear…**Current radiobiological data are not consistent with the implicit assumptions on which the LNT is based**…Animal experiment data suggest the existence of a threshold…These conclusions regarding differences in the efficacy of the protection system are **supported by various experimental or clinical data**, which highlight the impact of repair on the biological consequences of irradiation…Not long ago, some proponents of the LNT claimed that an analysis of the data of the A-bomb survivors (Brenner et al, 2003) showed an excess of solid tumors after low doses. However this conclusion was open to question…their conclusions for doses below 100 mSv were not convincing. The same remarks can be made regarding the data on radiation workers (Cardis 2005)…**The BEIR-VII Report is devoted to low doses (below 100 mSv) and yet over 90% of the report discusses effects resulting from much higher doses**…The basic radiobiological assumptions of the LNT are not in accordance with recent data.

The two relevant professional societies, the **American Nuclear Society** and the **Health Physics Society**, have also supported this stance in carefully considered Position Statements:

> It is the position of the American Nuclear Society that there is **insufficient scientific evidence to support the use of the Linear No Threshold** Hypothesis in the projection of the health effects of low-level radiation. (*PS-41, June 2001*)

> In accordance with the current knowledge of radiation health risks, the Health Physics Society recommends against quantitative estimation of health risks below 5 rem in one year. (*Public Statement on Radiation Risk in Perspective, Jan 1996*)

Both societies agree in these statements that:

> **Below 10 rem…risks of health effects are either too small to be observed or are non-existent.**

In addition to ignoring the most relevant evidence, **ICRP-2005, Technical Task Group C-1 Report** does not try to demonstrate that its self-restricted data pool and analyses support its conclusions. It speculates that various processes and phenomena have been "suggested" or "postulated" that "may induce" or "would enhance" various effects and "thus facilitate the accumulation of the requisite number of genetic events to produce a cancer." It then quickly adds that "most types of cancer have not been associated with specific DNA repair defects." (page 115, line 21). And in "Conclusions" (p.189, lines 16-18) it asserts:

> There is **no direct evidence**, from either epidemiological or experimental carcinogenesis studies, that radiation exposure at doses on the order of 1 mGy of less is carcinogenic, **nor would any be expected**…

Lauriston S. Taylor, charter member, ICRP; President-Emeritus, NCRP, special assistant to the President, National Academy of Sciences, wrote (*Health Physics* 1980; 32, pp 851-874):

> No one has been identifiably injured by radiation while working within the first numerical standards set first by the NCRP and then the ICRP in 1934…. [*NCRP chose 0.1 r/day on 3/17/34; ICRP chose 0.2 r/day in July 1934-- 35 times greater than the present recommendations.*] Let us stop arguing about the people who are being injured by exposures to radiation at the levels far below those where any effects can be found. The fact is, the effects are not found despite over 40 years of trying to find them. The theories about people being injured have still not led to the demonstration of injury and, if considered as facts by some, must only be looked upon as figments of the imagination.

Carl Paperiello, then NRC Director of Nuclear Material Safety & Safeguards, at that same meeting said:

> I do not believe the linear, non-threshold model, but I use it as the basis for all health effects evaluations that are my official NRC duties. I want to make something clear. **We use it in the agency. I use it. I don't as a scientist believe it.**

Gaia proponent **Prof. James Lovelock, FRS,** in his forward to Bruno Comby's *Environmentalists for Nuclear Energy:*

> Life began nearly four billions years ago under conditions of radioactivity far more intense than those that trouble the minds of certain present-day environmentalists….We need to keep in mind the thought that these fierce energies flooded the very womb of life.

References-9 Recognition that Change is Needed

US Nuclear Regulatory Commission Chairman, Dale Klein, stated in a major policy talk June 27, 2007, "A Look Ahead for NRC and the Industry":

> **The public needs to understand there is such a thing as harmless exposure—**which I think most people would grasp if you explain it in terms they can understand… like a standard banana.

Nils J. Diaz, Then-Chairman, US Nuclear Regulatory Commission, to Japanese Atomic Industrial Forum Annual Conference, April 21, 2004, Tokyo, Japan:

> I am convinced **nuclear regulation now needs to be anchored in realistic conservatism**…if we are to avoid the twin pitfalls of under-regulation and over-regulation…I use "conservatism" in the sense of preserving adequate safety margins, and I use "realistic" in the sense of being **anchored in the real world of physics, technology and experience**…When engineering margins are applied to input parameters, they can distort our understanding of what is truly important. **Safety margins are better discerned when they are applied at the decision-making stage, rather than at the analysis stage**.

Letter**, Director, DOE Office of Science, to President, National Academy of Sciences,** July 15, 2005:

> I am writing to express my **disappointment in the newly released BEIR-VII Report**, with regard to its overall conclusions and, in my view, an inadequate consideration of the significance of recent scientific advances. **Many of us in the scientific community are concerned** that the BEIR Committee chose to use only published analyses of data from the Japanese A-bomb Life-Span Study in its estimates of risks for the U.S. population, and to **reaffirm the use of the linear no-threshold (LNT)** hypothesis for extrapolation of risks to low-dose radiation.

American Nuclear Society Position Statement No. 65, "Realism in the Assessment of Nuclear Technology":

> It is customary for scientists and engineers when modeling hypothetical accident scenarios and failure mechanisms to make conservative assumptions and add safety margins. This practice, however, **should not lead to assumptions that are physically impossible or contrary to common sense**. "Worst case scenarios" should not violate the laws of nature…The absence of realism produces inaccurate results, undue alarm of the public, and, ultimately, lack of credibility…
>
> Therefore, the ANS encourages the scientific and engineering community and national leaders to apply realism to regulations, practices and public policy and information. **Scientifically unfounded or unduly exaggerated consequences are a disservice to the scientific community and the public at large**. (Approved, Board of Directors, June 17, 2004)

Philip Abelson, Editor Emeritus of *Science,* wrote:

> The current mode of **extrapolating high-dose to low-dose effects is erroneous** for both chemicals and radiation. **Safe levels of exposure exist.** The public has been needlessly frightened and deceived, and hundreds of billions of dollars wasted. **A hard-headed, rapid examination** of phenomena occurring at low exposures **should have a high priority**. (Editorial in *Science* 265, 9 Sept 1996.)

Marvin Goldman, past HPS President, wrote:

> It is time to scientifically challenge the old tenet that cancer risk is always proportional to dose, no matter how small…It is time to update our thinking and policies. (*Science 271*, Mar 1996)

Prof. Gunnar Walinder, former Chair, Swedish Radiobiology Society and UNSCEAR member, wrote in his book *Has Radiation Protection Become a Health Hazard?*:

> Not only do the current models of radiation carcinogenesis disagree with modern oncology, but most important they have contributed to a number of misconceptions about radiation risks. What concerns me most is whether the radiological doctrines have sometimes caused greater health and environmental problems that those we seek to avoid.

Walinder called this situation "the **greatest scientific scandal of the century**" and **Lauriston Taylor** called such practices "**deeply immoral uses of our scientific heritage**."

* * * * *

Some nuclear advocates say that aligning policy, practice and science in this way would not change much in the real world. They say, "Without LNT, I'd keep on doing the same thing." And with that view, they probably would. But, on at least two occasions, **leaders in the nuclear community have taken a serious look at what designing, operating, and regulating with parameters based on the applicable physics, biology and engineering could lead to.** Shortly after the TMI casualty in **1979, Chauncey Starr, Milt Levenson**, et al., published an **EPRI study on what consequences might result from a maximum realistic meltdown casualty**—no bickering about probabilities, assume the core melts. Using known properties of materials, measured rates of physical processes, and realistic estimates for radiation levels and resulting health effects, they demonstrated that **few if any deaths would be expected.** This report was well documented and widely distributed internationally, and its conclusions never effectively challenged. After 9/11, this issue was **re-examined with the latest data**, and published as a **peer-reviewed study in *Science*** by 19 members of the National Academy of Engineers. The question of low-dose health effects was again raised, and refuted with documented support. These papers suggest **how different the entire nuclear enterprise could be**, if we stopped accepting that "there is no harm" in assuming that radiation and nuclear reactors act differently than our scientific observations indicate. The *Science* report is available at: http://www.radscihealth.org/rsh/docs/Chapin20Sep02Science-PolicyForum.pdf . Comments and authors' response are at: http://www.radscihealth.org/rsh/docs/ScienceLtrs-Resp1-10-03.pdf .

The *Science* paper's many references include the 1981 EPRI report that has its own bibliography of supporting documents. How much longer will we rely on computer models that don't match reality?