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A Brief History And Critique Of The Low Dose Effects Paradigm

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"Man has such a predilection for systems and abstract deductions that he is ready to distort the truth intentionally, he is ready to deny the evidence of his senses in order to justify his logic."[1]

"Risk assessment data can be like the tortured spy. If you torture it long enough, it will tell you anything you want to know."[2]

"Knowledge is like a ship because once it is in the bottle of truth it looks as though it always has been there and it looks as though it could never get out again."[3]

Many members of the public are frightened of even trivial exposures to environmental chemicals and radioactivity and are therefore willing to support the expenditures of large sums of money to reduce those exposures. While some scientists decry this exaggerated fear, the public is justified in their fears, not because the fears are based on demonstrated risks, but because many of those same scientists have themselves promulgated theories upon which those fears are based. The theory which I have in mind is that if harm is demonstrated at very high doses, then even very small exposures are treated as though they are harmful, i.e., the no threshold model.

Those public fears of small environmental exposures have created a paralysis of environmental policy. For example, no waste repository for the medical uses of radioactivity can be sited, threatening to shut down the use of medical radioisotopes. The Department of Energy has embarked on a program of radiation cleanup at DOE facilities which is anticipated to cost as much as 200 billion dollars. Yet, studies show that radiation exposures to the public will be reduced only by trivial amounts and human health will benefit not at all. Our chickens have come home to roost.

Another example: tens of billions of dollars have been spent in the "clean-up" of chemical waste sites without any persuasive evidence that human health has benefited.

How did this no-threshold model develop? It originated from the difficulty or impossibility of detecting the very small effects whether harmful, beneficial or null, which may result from low levels of exposure. Out of the need to regulate, and out of a sense of what at the time appeared to be prudence, the assumption was made that very low exposures are harmful at any level, no matter how small. This model, or paradigm, became widely adopted in the 1970's by regulators, but also came to be accepted as established truth by the public and by scientists themselves.

How is it that scientists would buy into a model for which there was little evidence? The popular view of scientists is that they are cold, aloof, dispassionate and free of social or political values. Similarly, the popular view of scientific knowledge is that it is also objective and value free. The thesis asserted here is that, particularly when there is great scientific uncertainty, as is true of risks from low environmental exposures, that social and political ideology will influence the interpretation of science.

ACCEPTED MODELS, OR "PARADIGMS"

In his book, On Scientific Revolutions, Thomas Kuhn alleged that most scientific thinking is dominated by certain sets of assumptions or models, developed as explanations of observed phenomena.[4] He called these "paradigms," and observed that scientists working in the field adopt the paradigm unthinkingly, never challenging the underlying assumptions, and are in fact more likely to attack challengers than to question the paradigm itself, i.e., scientists are essentially a conservative lot.

Scientific models are constructs devised by scientists to explain observable phenomena. They are to be distinguished from facts, in that facts are observable, and under specified conditions can easily be replicated, something like a cooking recipe can be, by other interested scientists. Many of the assumptions built into models, however, cannot be replicated; they may be reasonable guesses about how things work, but they cannot be observed; they are not "facts." For example, it was assumed by scientists on the basis of their observations that the Earth is flat and that the Earth rotates around the sun. That was a reasonable model for many hundreds of years. It fit the available facts. Ultimately, that model was abandoned when facts became available which were inconsistent with the model. Another model was adopted, one in which the Earth was round and rotated around the sun. Now, the interesting thing about all of this is that scientists themselves frequently ignore the difference between the facts and the assumptions built into a model or paradigm the model which was developed as a useful tool becomes a universal truth.

Kuhn also alleged that information inconsistent with the accepted model is ignored and censored as heretical until contrary evidence becomes so strong that a "paradigm shift," or new model is adopted. New models emerge, not through gradual evolution, but through revolutionary change driven from outside of the "establishment," not from within; members of the establishment have too much invested, intellectually and economically, in the traditional model. Think of how the Church resisted the new model of the Earth rotating around the sun, and how Galileo was nearly excommunicated.

Kuhn assumed that the influence and operation of paradigms was peculiar to science. Barker has more recently pointed out that all areas of human activity, certainly including the business world, are controlled by paradigms.[5] Not everyone agrees with Kuhn,[6] his ideas have stirred a lively debate about the nature of science, and the nature of scientists.

HISTORICAL DEVELOPMENT - HOW DID WE GET HERE?

The observation that exposure to high exposures of ionizing radiation could produce harmful, even lethal, effects was recognized shortly after the discovery of the existence of ionizing radiation in 1895.

It was thought, however, that radiation effects obeyed a threshold response; that is, only high exposures which exceeded a threshold would produce biological effects. Occupational exposure standards were based upon such a presumption (the "old paradigm").

Historically, the common practice in setting occupational exposure standards for chemicals was to identify the lowest dose or concentration at which observed health effects occur. For the sake of prudence, the standard was then set at some appropriately lower level [7].

Following the second world war, however, this strategy was reconsidered; a "paradigm shift" occurred. I believe that there were three reasons for this, one of which came from engineering, another from biology, and the third from social psychology.

While engineers, in designing for safety, had previously followed a strategy in which they calculated maximum loads or stresses, and then added a safety factor, similar to the practice of toxicologists in setting chemical exposure standards, nuclear engineers in calculating the risks of nuclear releases rejected the notion of a threshold and of perfect safety. Accepting that there was no absolute safety, they estimated risks of accidental releases which were always finite, never zero. They then designed backup safety systems to contain or minimize the consequences of even remotely possible accidents. The successful containment of the accident at Three Mile Island illustrates the prudence of this practice. Nevertheless, the message to the public was that accidents would occur and furthermore, that technology was inevitably associated with increased risk.

There was also biological evidence that challenged the older notion of a threshold. This was based partly on the studies of mutagenesis conducted in fruit flies by Herman Muller (1890-1960), studies in which he was unable to demonstrate a threshold. Muller's concerns regarding widespread industrial uses of ionizing radiation led him to suggest that thresholds for genetic effects might not exist - no definitive thresholds had been demonstrated, or rejected.[8] Muller never ceased to warn physicians of the genetic effects of the use of radiation. Following the war, Muller delivered a lecture on the genetic hazards of nuclear testing to the National Academy of Sciences that attracted great attention. While Muller himself supported the development of nuclear weapons, his concerns about genetic effects became a focal point in the demands for a test ban treaty.[9]

At about mid century, radiation biologists were also developing a theory of radiation effects which presumed that those effects were the result of minute "hits," or damage to cells much like the hits of a bullet in a target. Indeed, the theory was known as "target theory." These hits would occur randomly, and so even the smallest dose would have some statistical probability of hitting the target and producing harmful effects. The effects which were then of greatest concern were threats to the gene pool. This assumption was based on studies, such as those of Muller, which showed the mutagenic potential of radiation. On the basis of prudence, then, public policy authorities in the nineteen fifties adopted a policy in which it was assumed that even very low exposures of radiation might be harmful.

At about the same time (the 1950's) it was also recognized that mutagenesis was often an important step in the process of carcinogenesis. This recognition was used to support the practice of assuming that even low exposures could be carcinogenic. Subsequently, as genetic research on mammalian species demonstrated that the risk of mutagenesis found in fruit flies had probably exaggerated risks to humans, the threat of cancer became the predominant concern of the radiation protection community, particularly as cancers other than leukemia began to appear in significant numbers in the survivors of the atomic bombings.

Something else happened in the 1960's that contributed still further to the concern about contamination of the environment, and that was improvement in the lower detection limits of chemical analysis.

THE CULTURE OF THE 60'S - THE NEW ENVIRONMENTALISM

The 1950's and 60's were a period during which the public was becoming increasingly aware of environmental pollution with industrial chemicals. Rachel Carson's book, Silent Spring, was a milestone in arousing public concern.[10] Carson emphasized not only ecological consequences of environmental pollution but also specifically indicted environmental chemicals as important human carcinogens. She had brought to public attention observations on the effects of pesticide residues on the fertility of birds; it required only a small leap of faith to believe that environmental contaminants could also produce human health effects.

Something else was going on in the 50's and 60's that had a powerful effect on the public view of environmental radioactivity, and that was the great debate on weapons fallout. Those who were very much opposed to weapons testing emphasized the dangers of fallout to human health, even at very low levels. These estimates of disease were not based on observations of disease, but rather on extrapolations from high level exposures. Professor Ernest Sternglass of the University of Pittsburgh criss-crossed the country, reporting on his studies showing that thousands of babies were being killed by fallout. Those studies were patently flawed, obvious attempts to exploit a scientific gloss for political purposes, yet, there was precious little response from the scientific community, which seemed satisfied to sit smugly on the sidelines.

Whatever the reasons, it is remarkable to look back at the scientific literature of the 1960's and 70's and find almost no resistance to the no threshold model. The reason is that it suited everyone's purposes. The radiation protection community benefited greatly from the increased fears of low doses of radiation. Radiation researchers benefited from increased fear and the consequent increased funding of radiation research. Lawyers benefited from increased litigation resulting from the public conviction that low levels of exposure had caused cancers. Regulators certainly had their lives made easier and their budgets enhanced by the adoption of the linear no-threshold model.

But, aside from special interest groups, did society really benefit when it was led to believe that something is true that remains unknown? The economic and social costs, and the political and environmental problems we have engendered by tacit acceptance of the nothreshold paradigm have not been quantified, but are undoubtedly enormous.

ARE SCIENTISTS INFLUENCED BY VALUES?

If there is uncertainty regarding low dose effects, why did we choose the paradigm that we did? I will suggest that when science is uncertain, values take over. My assertion is that the environmental movement benefited from the convenient but unproven assumption that environmental contamination posed an important health threat, and that scientists, who shared those environmental concerns, were perfectly happy to participate by providing risk estimates at levels of exposure below those where harm could be demonstrated.

Is it really possible that our no-threshold paradigm was an invention developed to satisfy the moral demands of society? To answer that question, let me first describe what most people think of the scientific method. Scientists are seen as those who operate in a value free world, searching in a neutral way for an objective truth. They observe the world dispassionately, collecting data in a scrupulously objective fashion, which they then dutifully report in peer reviewed journals. Those reports then become the substance of an ever expanding knowledge.

In fact, scientists themselves select the cells, tissues, or animals which are most likely to produce the desired results. They are very likely to select and interpret their data in such a way as to support their theory. Papers are then subject to the judgement of an editor, who have their own judgements of what is desirable to publish.

While unconscious bias may easily enter this process at any point, conscious bias (cheating, lying) may also be introduced. As a consequence, medical and scientific history is replete with examples of scientists who either consciously or unconsciously interpreted their data to support theory, and there are an equal number of examples of theory developed to prove social and economic theory. This is not the place for an extensive exposition, but one example might do:

As elegantly illustrated by Stephen Jay Gould, Dr. George Morton finagled his data to support the theory, popular at the time, that the intelligence of blacks was inferior to that of whites, and the intelligence of Indians was intermediate.[11] The remarkable thing is that he was scrupulous in collecting his data, which he published. His unconscious bias was so strong that he did not recognize his biases in the interpretation of the data, allowing Gould to expose those biases a hundred years later.

Now I should not like to suggest that a paradigm persists only because it is suitable to current value systems; there are other reasons as well. One is that, just as the illusion of power increased the stature of the medicine man and shaman, the illusion of precise knowledge lends prestige to the scientific community. For this reason, scientists are reluctant to admit how little they know.

RISK ASSESSMENT

Given a paradigm in which it is asserted that even very low exposures of radiation are damaging, there developed the practice, known as risk assessment, in which the consequences of very low exposures could be calculated, based on observations at high exposures. Such an assumption had the marvelous benefit that it became childishly easy to estimate risks at low exposures.

It also became easy to calculate aggregate risks in exposed populations and to use these for political purposes. For example, when Willard Libby calculated that the cancer risk from weapons fallout was one in a million, Linus Pauling, arguing on the other side of the weapons test ban issue, then concluded that in the world population of 4 billion one in a million would be a total of 4,000 cases of cancer.[12] The political implications of the small risk of one in a million and the large number of cases that would result from that risk in a large population, 4,000, are obvious.

In 1951, E.B. Lewis published an article in Science in which he calculated the proportion of leukemia cases occurring in the United States which could be attributed to background ionizing radiation, assuming that no thresholds existed.[13] The article created a practice which persists to the present time and is widely viewed in the scientific community as having practical validity.

The use of this risk model is now widely applied and explicitly accepted as the truth. The model is applied with great precision. For example, the British calculated 12.7 cases of leukemia in the United Kingdom as a result of the Windscale accident in 1957. How was this number arrived at? First, by making crude estimates of the very low exposures to individuals in the population, then multiplying by the large number of persons exposed throughout England, then by making the assumption of the absence of a threshold and assuming that even at trivial doses to individuals, effects nevertheless occur. Given that these cancers would, if they did occur, be dispersed among

the hundreds of thousands that would occur normally, it is clearly impossible to ascertain whether 12.7 cases occur or not.

The same assumptions are made by EPA in estimating that 15,000 lung cancer deaths occur in the U.S. each year as a result of exposure to residential radon. Similar risk estimates are conducted for trace exposures to chemicals in the food supply or air.

As noted by Ehrenfeld, "We believe implicitly in our models. The more specific their predictions are, the more we believe in them, no matter how scientifically preposterous and absurd that specificity is."[14]

IS THE PARADIGM OBSOLETE?

On scientific grounds, we have now moved considerably beyond the simplistic model of cancer as originating from a single exposure to an environmental mutagen, and beyond the assumption that industrial chemicals or radioactivity are important sources of mutagens in the diet.

Bruce Ames, Professor of Biological Chemistry at the University of California, Berkeley, once an outspoken critic of environmental pollution, has taken a leading role in challenging the notion that industrial agents in the environment are an important source of mutagens, not because they do not exist, but because their concentrations are low compared to those which occur naturally. He notes that all plant materials contain natural pesticides, as potent mutagenically as are industrial chemicals.[15] Many seasonings and spices are also known mutagens; examples are pepper and cinnamon. Furthermore, cooking, including baking and frying add considerably to the burden of mutagens in the diet. The charring one sees on meats or toasted bread are bountiful sources of mutagens and proven carcinogens when applied in high concentrations in animal studies. So too is coffee (it's the roasting of the beans which is mostly responsible).

From these natural sources, the quantities of mutagens of natural origin in the usual diet dwarf the concentrations of mutagens represented by industrial pesticides by a factor of hundreds or thousands. Ames estimates that each day the average person consumes about 1500 milligrams of pesticides of natural origin compared with less than 0.1 milligram of synthetic pesticide. Unlike the older theories of mutagenesis which attribute ominous risks to each mutagenic event, we now know that damaging events to chromosomes occur very frequently, both because of exposure to environmental agents and because of the mutagenic effects of the body's own metabolic activities. Estimates are that each cell in the body is exposed to such possibly damaging events thousands of times per day. Fortunately, we now know, the body also has elegant mechanisms for repairing the great majority of the damage to the body's DNA. This repair mechanism declines with age, more rapidly in some than in others.

The efficacy of these repair mechanisms may be more important than exposure to mutagens in determining the growth of cancers. For example, a study conducted by Dr. Lawrence Grossman of the Johns Hopkins University shows that in a study of patients with basal cell cancer, a common variety of skin cancer, the ability of the repair mechanism to repair genetic damage is inversely correlated with the appearance of these cancers, i.e., decreased repair is associated with a higher risk of skin cancer.[16]

HORMESIS

Kuhn not only claimed that scientific thinking is dominated by paradigms; he also claimed that scientists are highly resistant to challenges to the transmitted paradigm, and vigorously resist challenges to the conventional wisdom. Information which is inconsistent with the paradigm, he said, is censored, not in the sense of an official or explicit censor, but in the sense that authorities such as journal Editors and research sponsoring agencies do not accept such research as legitimate.

In contrast to the no-threshold theory, considerable evidence exists of beneficial or stimulatory effects at low exposure levels.

Qualitatively different effects at different exposure levels should not cause any eyebrows to rise. After all, our common experience is replete with such examples. While a bottle of gin taken at one time may be lethal, a martini each evening actually appears to lengthen life. Many of the common vitamins, necessary to the diet, are harmful at high exposures. Sunshine in small exposures prevents rickets, at high exposures is carcinogenic. One could extend this list endlessly. It is possible that radiation is different from martinis and chemical exposures, but common sense would suggest that they are similar rather than different.

I frequently see in epidemiological or animal studies evidence of a protective effect at low exposures. These are always ignored by the authors who appear blind to these observations. For just one example, in a study of breast cancer among women who during the course of treatment for tuberculosis were regularly fluoroscoped there is a distinct decrease in risk among those in a low dose category.[17] The author does not discuss it.

In 1979, Dr. T. Don Luckey published a book called Radiation Hormesis in which he gathered together the literature demonstrating exceptions to the general thesis that radiation is harmful at low exposures.[18] Indeed, the literature is full of reports suggesting that animals exposed to low exposures of radiation benefit from those exposures. Such benefits include enhancement of the immune system, increased resistance to infection, and increased longevity. Sagan has suggested several mechanisms which might explain how such effects could occur.[19]

There is also evidence that the original Mullerian theory of a decrease in fitness as a result of low dose radiation may be in error. John Gillespie, in reviewing the work of the geneticist, Bruce Wallace, describes how surprised Wallace was when he found that low dose radiation actually increased fitness. The experiment has now been replicated by others. Interestingly, even Wallace himself was unwilling to accept his own findings, and spent decades trying to reconcile his own work with the accepted paradigm.[20]

I am not arguing here that there is strong evidence that "a little radiation is good for you." Nor am I prepared to offer a new paradigm to replace the old. I am arguing that the evidence regarding the risks of low exposures is quite uncertain and that scientists and funding agencies should undertake the research necessary to produce the new paradigm.

I do not exclude the possibility that a little radiation may be both "good" and "bad," for different people, or even for the same person. I am also arguing that we act as though we know the answer to these questions, when in fact there is great uncertainty about this, and we are not doing the research necessary to resolve the matter because we are paralyzed by our subservience to the paradigm.

Just as with radiation, there are numerous reports in the literature which suggest that very small exposures of chemicals, generally thought of as harmful, have a stimulatory effect at low exposures. This literature has been reviewed by Edward Calabrese, a toxicologist at the University of Massachusetts.[21]

As predicted by Thomas Kuhn, suggestions that the paradigm might be in error have been censored. Not only is there little scientific interest in pursuing hormesis, there would undoubtedly be little interest among funding agencies which are themselves captives of the paradigm.

HOW EASY WILL IT BE TO SHIFT THE RADIATION PARADIGM?

Not easy at all. In addition to the intellectual commitment to the paradigm that most of us share, there are now many constituencies which thrive on that paradigm. There is the environmental community, the medical community, the regulatory community, and the legal community, to name just a few. Each of these derives enormous benefits from continued dominance of the paradigm and would lose to the same extent from a paradigm shift.

As Alan Barker points out, "New paradigms put everyone practicing the old paradigm at great risk. And, the higher one's position, the greater the risk. The better you are at your paradigm, the more you have invested in it. To change your mind is to lose that investment."[22]

SUMMING UP - WHAT IS WRONG WITH THE PARADIGM?

There are several serious problems with the use of the existing radiation paradigm. One is the absence of supporting scientific knowledge of the existence of risks in whole animals or humans at low exposures.

A second is the existence of contrary information suggesting that low exposures of radiation may be associated with health benefits, not risks ("hormesis").

The third problem is that risk estimates at low exposures are accepted by the media and the public as scientifically valid, and project the view that "even the lowest dose is harmful" whereas in fact, we do not have evidence as to whether such exposures are harmful, harmless, beneficial, or all of these.

As a consequence, the costs of maintaining the paradigm are becoming enormous.

Still another problem is that the conventional paradigm no longer helps us solve problems. We have continually conducted larger and larger studies, in both animals and humans, without shedding any new light on the nature of risks from low level radiation exposure.

While radiation epidemiologists have been unable to detect harm or benefit from low level exposures, statisticians and epidemiologists have their own biases (often limited to searching for excesses of cancer), and my intuition is that those biases preclude the demonstration of a hormetic effect, if it exists.

Also, the evidence from animal studies suggests an increase in longevity, rather than a protective effect against cancer. A careful review of longevity among low dose exposed populations has not been carried out.

A strategy more likely to be useful in shifting the paradigm is likely to arise from knowledge of mechanisms operating at low exposures. Knowledge of these mechanisms could then permit more focused epidemiological studies. The rapid rise of interest in understanding mechanisms of toxicity at the molecular level, rather than continued dependency on studies of animals exposed at high levels is a promising start in that direction.[23]

WHAT CAN SCIENTISTS DO?

The difficulty in separating facts and values guarantees that scientist's values will continue to affect public policy. How can this role be reconciled with traditional democratic ideals? Lowrance has suggested the following guidelines for scientists:

"Recognizing that they are making value judgements for the public, scientists can take several measures toward converting an "arrogation of wisdom" into a "stewardship of wisdom."

"First, they can leaven their discussions by including critical, articulate laymen in their group.

Second, they can place on record their sources of bias and potential conflicts of interest, perhaps even stating their previous public positions on the issue.

Third, they can identify the components of their decisions being either scientific facts or matters of value judgement.

Fourth, they can disclose in detail the specific basis on which their assessments and appraisals are made.

Fifth, they can reveal the degree of certainty with which the various parts of the decision are known.

Sixth, they can express their findings in clear jargon free terms, in supplementary non technical presentations if not in the main report itself".[24]

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TWO THESES IN RADIOBIOLOGY

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We are confronted with two opposing theses for chronic, whole-body exposure to ionizing radiation: the "zero" thesis argues that "all radiation is harmful; the "hormesis" thesis argues that "small and large doses produce opposite effects." Although both agree that large doses are harmful, their positions on small doses are quite contradictory. Where the zero thesis predicts real harm (e.g., mutations and cancer), the hormesis thesis predicts benefit from small doses.

The zero thesis spawned several linear models that interpolate between data points from populations exposed to large doses of ionizing radiation and controls receiving about 2 mGy y-1 of whole-body radiation. Given the abundant data from exposures to low doses of ionizing radiation, it is inexcusable to make linear interpolation from results with large doses to controls. The results from large doses of ionizing radiation are applicable to those exposed to medical treatment, radiochemical accidents, or nuclear explosions. These traumatic occasions are not, however, pertinent to everyday life. Such results are of value only for subjects having no specialized cells, no hormones, no neurologic system, no immune cells, and almost no communication between differentiated cells. The zero thesis lacks evidence from whole-body exposure to low doses of ionizing radiation in vertebrates. Critical review of the vertebrate literature provides no substantial support for the zero thesis or any linear model (Radiation Hormesis, T.D. Luckey, CRC Press, Inc., 1991).

Despite the scarcity of data, linear models are promulgated on the basis that they provide a safe basis for limiting ionizing radiation to the lowest possible or reasonable dose. In spite of this unscientific support, the zero thesis and its linear models are invalid and counter-productive.

The hormesis thesis, on the other hand, is the basis for the radiation hormesis model. Stimulation by low doses of potentially harmful agents has been accepted for many centuries in toxicology and pharmacology. The inclusion of ionizing radiation broadens the base of this general thesis and, at the same time, adds validity to the radiation hormesis model. In like manner, data from vertebrates is well supported by data from invertebrates, plants, and micro-organisms (Hormesis with Ionizing Radiation, T.D. Luckey, CRC Press, Inc., 1980).

Information of everyday concern involves chronic, whole-body exposures of vertebrates to doses less than 1,000 times background radiation levels. The literature from whole-body exposures to low doses of ionizing radiation provides over-whelming support of the hormesis thesis with adequate statistically significant results to invalidate the zero thesis.

The conclusion is that we need more ionizing radiation, not less! In other words, we live in a partial deficiency of ionizing radiation. Added radiation would improve the quality of life as measured by growth, neurologic development, reproduction, immune competence, resistance to cancer, and longer average lifespan. Depriving populations of adequate amounts of this natural, beneficial agent is unreasonable. Safe supplementation of ionizing radiation to populations should be considered. We should discard the invalid linear models and accept radiation hormesis as the basis for changing current recommendations and regulations.

Future health physicists should be concerned less about probing for minimum exposures and become active in promulgating ways to provide safe supplementation, 20 to 100 mGy y-1. Except for persons with genetic inability to repair DNA, this is well below harmful effects of chronic, whole-body exposures, estimated to be over 1,000 mGy y-1 for low-LET radiation. The basic challenge is acceptance of the hormesis thesis as a practical basis for a new plateau of health.

EAST vs WEST IN RADIATION HORMESIS

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The International Conference on Low Dose Irradiation and Biologic Defense Mechanisms (ICLB, Kyoto July 12-16) revealed differences between East and West in the acceptance of radiation hormesis as the basis for future research. My two reviews present over one thousand examples suggesting radiation hormesis (Hormesis with Ionizing Radiation, 1980, and Radiation Hormesis, 1991, CRC Press, Boca Raton); about 100 with vertebrates are statistically significant. I challenge anyone to reference statistically valid data showing physiologic harm in vertebrates from whole body exposures to low dose irradiation, <20 mGy/y or <20 cGy acute.

The East accepts the statistically valid results showing that whole body exposure to large and small doses of ionizing radiation elicit opposite results. Most of the West remains committed to the zero thesis and linear models based upon interpolation from harmful doses, concepts which survive by misinterpretations of or ignoring the data.

Scientists of the East search for increased harmony of humans with nature. They ask what are the physiologic responses to near ambient levels of ionizing radiation? In China 70,000 peasants who receive high natural exposure have a lower cancer mortality rate than 70,000 controls, P 0.05. Russia has huge clinics devoted to radon therapy. In Japan many projects on radiation hormesis are in progress and some clinics use whole body exposures (0.1 Gy twice a week) for cancer therapy. Indian scientists see ionizing radiation as a benign agent of our environment.

Science advisory of the West responded to my ICLB presentation of statistically valid results showing lowered cancer mortality rates and longer average lifespans following low dose irradiation: "I don't believe in radiation hormesis." No discussion of the evidence; only "I don't believe." This is antiscience from leaders of the West!

Policies of the West emanate from decades old concepts to protect us from harmful irradiation. This "atom bomb mentality" dooms the West to increased technologic disadvantage. Our deterioration will continue as long as present restrictive regulations for radiation exposure remain and misinformed science advisors approve "irradiate and watch" experiments with our diminishing resources. Regulations and future research should be based upon scientific data, not unsubstantiated beliefs. Vital questions remain. Is ionizing radiation essential for life? The answer is tremendously important for the health of future generations and future role of health physics in our society.