# DO LOW-LEVEL RADIATION HEALTH DATA JUSTIFY FEAR OR CONTRIBUTE TO PHOBIA?

John R. Cameron's letter (March, page 13) states that Arthur C. Upton's article (August 1991, page 34) "contributes to the radiation phobia so prevalent in the United States by giving an unduly pessimistic view of radiation risks at low levels of ionizing radiation exposure." I do not agree with Cameron. In fact, I must call Cameron's letter a lot of hopeful and dangerous thinking. Although Cameron does not state that he is in accord with the radiation hormesis thesis, his letter tends to persuade one that a little exposure to ionizing radiation is beneficial.

Upton's article, which indicates a 3% increase in cancer deaths for a continuous lifetime exposure to 1 millisievert per year (that is, a cancer coefficient of about $8.5\times10^{-4}$ cancer deaths per person-rem), is not "unduly pessimistic." Cameron states, "There are no definitive data to indicate a risk to humans at doses below about 0.25 Sv (25 rem)." I agree that the data on cancer coefficients are not as definitive nor do they provide as exhaustive a proof as Kepler's laws, but for me they are extremely convincing. I will mention only six of the convincing human epidemiological studies that show a statistically significant increase in cancer risk below 0.10 Sv (10 rem).

The Hanford study of Thomas F. Mancuso, Alice Stewart and George Kneale[1] showed a statistically significant increase in cancer of the pancreas and multiple myeloma among Hanford radiation workers at an average dose of about 0.03 Sv (3 rem). The study of Baruch Modan and colleagues[2] showed a statistically significant increase in head and neck tumors among immigrants into Israel who were treated with an average dose of 0.09 Sv (9 rem) of x rays to stem an epidemic of ringworm. A follow-up study by Modan and colleagues[3] showed a statistically significant increase in breast cancer at an average dose of 0.016 Sv (1.6 rem). Studies by John W. Gofman[4] and Rudi H. Nussbaum[5] showed a 20% excess cancer death rate among the lowest-exposure categories of survivors of the Hiroshima and Nagasaki atom bombings. An evaluation by Steve Wing and colleagues[6] of film badge data and mortality records of personnel employed at Oak Ridge National Laboratory when I was director of the health physics division there showed statistically significant dose–response effects for mortality from all causes and for cancer in 8318 radiation workers whose median dose was only 1.4 mSv (140 mrem).

I applaud the recent decisions of the International Commission on Radiological Protection[7] lowering the allowable occupational level of exposure to ionizing radiation from 50 mSv/year (5 rem/year) to 20 mSv/year (2 rem/year) averaged over defined periods of five years and lowering the dose limit for the general public from 5 mSv/year (500 mrem/year) to 1mSv/year (100 mrem/year). I hope Cameron does not consider this to be uncalled-for phobia on the part of the ICRP. I appreciate the need to avoid yelling "Wolf!" at the slightest provocation, but when the wolf sneaks up with bared teeth and begins to growl, it is not time to pause and worry about frightening the public.

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CAMERON REPLIES: Karl Z. Morgan's references do not prove that low levels of radiation are hazardous to humans, nor do my references prove that low levels of radiation are harmless. The reader will have to decide which articles are more likely to represent the truth. Cancer is believed to be caused by a complex, multistep process.[1] A single radiation event might provide one or more of the steps; radiation is unlikely to provide all the steps. Radiation is a very inefficient way to produce cancer. As of 1982 the 100 000 atomic bomb survivors had about 350 excess cancer deaths caused by radiation—only about 5% more than would be expected from "natural" causes. Cancer death rates in the United States often vary by 20% from one state to another.

Victor P. Bond and colleagues suggest a new way to look at this inefficient process.[2] They calculated the collective radiation energy delivered to various dose groups of atomic bomb survivors. For each group they calculated the collective energy $\epsilon_0$ needed to produce one excess solid cancer. They determined that $\epsilon_0$ is about 3 kilojoules, independent of the average dose for the group. This amount of radiation energy is about an order of magnitude greater than the short-term lethal dose to one individual. Radiation biologists generally believe that low-dose-rate radiation is much less effective in producing cancer; therefore a more realistic $\epsilon_0$ for radiation workers might be 7 kJ. At a typical background dose rate of 1 milligray per year (excluding the dose from radon daughter products), it would take over 100 000 years for an adult to accumulate an imparted energy of 7 kJ!

About 15 million nuclear disintegrations irradiate the billions of cells of a typical human body each hour. Yet there is no evidence that background radiation causes cancer.[3] I believe that the new upper limit for radiation workers of 20 millisieverts per year proposed by the International Commission on Radiological Protection is scientifically unjustified. To me, this new limit suggests that the ICRP is suffering from radiation phobia.

Radiation phobia does kill humans. Italy had an increase[4] of about 4000 legal abortions in the five months following the Chernobyl accident in April 1986. We can assume that this increase was due to unfounded fears of giving birth to a deformed infant. The increase in effective dose equivalent in Italy for the first year after the accident was about equal to a month or two of additional background radiation. There was no evidence of an increase in deformity among the infants born to the atomic bomb survivors.

## References

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## Teller, Wood: Silent on Goldin to Quayle

The very interesting Washington Reports story in your April issue (page 77) conveyed a number of serious misunderstandings. Since there is great interest, both scientific and human, in the NASA program, we feel that errors not already evident from the publicly accessible record must be corrected as far as our special knowledge permits us to do so:

▷ Contrary to the unnamed sources at NASA and the White House quoted in the news story, neither of us has ever spoken (or otherwise communicated) with Vice President Dan Quayle about replacing former NASA Administrator Admiral Richard Truly.

▷ Neither of us proposed NASA's present administrator, Dan Goldin, to the Vice President as Admiral Truly's replacement, though both of us did support Goldin's candidacy. The story's representation that we believe that Goldin is eminently well qualified for the post is a correct one.

We were both pleased with Admiral Truly's success in reactivating the space shuttle program. We, along with many of your readers, are most keenly interested in the continuing efforts of NASA to gather information about Earth and to extend the scope of the space program to include a permanent lunar settlement and manned exploration of Mars.

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## 'Brilliant Eyes' Not Part of NASA Asteroid Work

Your news story on NASA's "moment of truth" (April, page 77) misrepresents both concern about the hazard of asteroid impacts and the NASA response to that concern. In recognition of the impact hazard, the US House of Representatives in 1990 asked NASA to conduct two studies, one on detection of Earth-approaching asteroids and one on technologies for dealing with the threat if an object were found on an impact trajectory. The news story characterizes these studies as "two workshops on Brilliant Eyes," but Brilliant Eyes is not conceived as an asteroid survey tool, and the initiative for these studies did not come from the proponents of Brilliant Eyes or any other part of the Strategic Defense Initiative Organization. As the chair of the NASA study on asteroid detection, I assure you that the term Brilliant Eyes was never mentioned within our international team of 24 scientists, most of us astronomers with a lifelong interest in comets and asteroids. Our 50-page report, submitted to Congress early in April, proposes a survey, based on automated ground-based telescopes, that could increase by two orders of magnitude the discovery rate of asteroids whose orbits come close to Earth. Brilliant Eyes did not feature in the study of asteroid interception either, which was concerned primarily with the deflection, not the detection, of threatening objects.

The question of cosmic impacts is a serious one that stimulates widespread interest among the public as well as scientists. Cosmic impacts represent a dramatic example of an extremely rare but potentially global catastrophe, raising in extreme form some of the public policy concerns long faced within the nuclear power industry. The issue deserves better of PHYSICS TODAY than to be confused with Brilliant Eyes or any other particular SDIO proposal.

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## Superdeformed Nuclei's Nativity

Daniel Kleppner, in his Reference Frame column in the December 1991 issue (page 9), makes the point that nature is rich enough that we are often unable to predict what kinds of phenomena are going to provide the largest surprises in future decades. I agree with his basic point and only want to remind your readers about the history of one new phenomenon, nuclear superdeformation. There has been a resurgence of interest in these unusual nuclei, characterized by roughly a 2:1 major-to-minor-axis ratio, with the discovery in the last decade (mentioned by Kleppner) that nuclei such as dysprosium-152 produced with high spin can become superdeformed.

Superdeformation was actually discovered two decades earlier in the form of spontaneously fissioning isomers (americium-242 was the first such isomer identified).[1] The interpretation of this phenomenon in terms of single-particle (shell structure) corrections to the macroscopic potential energy surface was put forth soon thereafter,[2] and that theory has been successfully used to explain and predict new regions of superdeformation of current interest, such as that mentioned by Kleppner. The superdeformation of one of these spontaneously fissioning isomers was confirmed by observation of its near-perfect rotational band with a large moment of inertia,[3] and the energy difference between the superdeformed state and the normally deformed state was determined by identification of gamma decay through the barrier separating the two states.[4] The only difference between superdeformed nuclei in the two regions is that in the heavier elements the Coulomb force plays a dominant role, while an additional centrifugal force is required to stabilize deformation for the lighter elements ($A \sim 150$).

This example still illustrates Kleppner's basic point—an interesting phenomenon was unanticipated at the time of its discovery.

## References

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