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Comment on NCRP Report No. 104, "The Relative Biological Effectiveness of Radiations of Different Quality"

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Dear Editors:

THE VALIDITY of a linear extrapolation to lowest fluences of charged particles demands that the transit of a single charged particle through the target volume is capable of inducing the chain of events leading to an observable end-point. This is always the case for one-hit detectors. It is not always the case for biological cells and tissues (Katz and Hofmann 1982).

By way of example, Cole et al. (1980) found that, on average, some 500 electrons pass into the nucleus of a CHO cell for inactivation. Similarly, Warters et al. (1977) found that some 500 tritium β decays in the nucleus of a CHO cell are required for observable killing.

Data from Raju et al. (1987) on ultrasoft x-rays offer yet another problem. We estimate from their data that a dose of about one gray of carbon K x-rays yields about 75% survival of cultured V-79 hamster cells. These photons have energy 0.28 keV and produce photoelectrons of range 7 nm with an average energy loss crudely estimated to be about 40 keV/μm. We find that the average number of photons absorbed in a cell nucleus (of estimated volume 200 μm^3) for 25% killing to be 4500. The extrapolation from the experimental dose of one gray to that of a single such photon absorbed in the cell nucleus is four orders of magnitude.

Single electrons through cells are even more unlikely to cause cancers. Electron-induced carcinogenesis in rat skin, by Burns and Albert (1986), displays nearly quadratic response with dose with tumors/rat at 99 weeks as end point. The lowest dose point is at about 0.7 gray with a yield of 0.01 tumors/rat. For electrons of LET 0.34 keV/μm, we find the fluence to be about 1280 electrons/μm^2. Taking the cell area to be about 100 μm^2 we have about 12,800,000 electrons passing through a cell to induce a cancer in rat skin at this dose level.

One cannot ignore these results. One must question the extrapolation of the "linear quadratic model" (fitted to data at doses typically exceeding one gray and extrapolated linearly through several orders of magnitude to doses below one milligray) that forms the basis of the evaluation of low dose RBE in NCRP report No. 104 (6).

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Reply to Drs. Katz and Waligorski

Dear Editors:

IN FULFILLING its responsibilities to develop numerical values for RBE for a variety of biological systems, the committee that drafted NCRP Report No. 104 elected to use the ratio of alpha terms of a "linear quadratic" fit to the actual data used to develop dose-response curves. Justification for this procedure was found in that, for some single cell systems, data points on apparently linear curves extended into the 0.005 Gy range for x-rays, lower for higher LET radiations.

Because the Committee focused on ratios, there was no requirement to address the question in depth as to what may happen with any one apparently-linear curve at still lower doses. Furthermore, observations such as those put forth by Drs. Katz and Waligorski do not permit the derivation of RBE ratios for biological systems. Accordingly, information of this kind was not included in the Committee's report.

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