LETTERS TO THE EDITOR

TO THE EDITOR:

We believe the characteristics of Hg^{197} listed by Dr. Bruce Sodee (Letter to the Editor, J. Nuc. Med. 5:74-75, 1964) to be enough in error to require some clarification. The errors arise 1. from certain faulty information furnished to Dr. Sodee by one of us (C.C.H.), 2. mistakes in interpretation of the Hg^{197} decay scheme, and a dropped word in the letter.

We compute the average "beta energy," $\bar{E}_\beta$, per disintegration to be 77.3 kev. This is almost exactly what Dr. Sodee gets, although it is not readily apparent from his letter. It should read "144 'beta particles' with an average energy of 54.4 kev per *100* disintegrations." We get Γ, specific gamma-ray emission, to be 0.35 compared with 0.48, and arrived at a different number of photons in the 67 to 78 kev region.

Generally the decay scheme is well known, but only recently has the total photon (x-ray and gamma) yield been satisfactorily settled (1). Mercury-197 decays by electron capture, (98.3% in a 420 kev transition, and 1.7% in a 230 kev transition) but it cannot be assumed (as did Dr. Sodee) that it is all K capture. We have found no reported experimental values for the ratio of L to K captures, but theory (2) predicts that about 18% ($\frac{L}{K} = .215$) of these captures result in L- instead of K-shell vacancies. This causes our total K x-rays to be different from Dr. Sodee's.

The critical item in the analysis of the decay of Hg^{197} is the conversion ratio of the 77.3 kev gamma ray. It now appears that the value for α_L of 2.3 furnished to Dr. Sodee by us, though the best value at the time, was in error. The currently accepted value is $\alpha_L = 3.3$ (L/MN = 3.6., $\alpha = 4.2$) (1). It appears that perhaps the incorrect values occurred because of improper estimation of K_β x-rays by some investigators. The difficulty arises because the K_β x-rays (occurring when a K-shell vacancy is filled by an electron from an M shell instead of an L shell) in this situation have an energy almost identical with the 77.3 kev gamma ray. This may appear to be a trivial point but is not, because most of the internal dose is due to conversion electrons from the 77.3 kev gamma ray. Clarification of this confused situation is therefore desirable.

Information on relative abundances of K_α and K_β x-rays is not plentiful, but study of available references (3,4) and analysis of scintillation spectra provided by D. A. Ross of our group leads us to believe that the following is reasonable to assume: (relative abundances per 100 K shell vacancies)

$K_{\alpha 1}$	(K-L_{III}),	68.8 kev – 48
$K_{\alpha 2}$	(K-L_{II}),	67 kev – 24
$K_{\beta 1}$	(K-M_{III}),	78 kev – 19
$K_{\beta 3}$	(K-M_{II}),	77.7 kev. – 9

Using these figures, the corrected conversion coefficients for the gamma rays, and the L/K ratio noted, we arrived at the following schedule of photons per 100 disintegrations of Hg^{197}: (L and lower-order x-rays are ignored, to be later grouped in with "particles").

57	68 kev K_α x-rays
22	77.8 kev K_β x-rays
19	77.3 kev gamma rays
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98	Total photons, 67-78 kev region (plus 0.5 191 kev gamma rays). These are the "countable" photons for assay and those that must be considered in gamma dosimetry.

Considering the L x-rays (average binding energy for shell, 12.6 kev), M, N and lower order x-rays as particles absorbed on-site, along with Auger and conversion electrons, is quite reasonable. The major L x-rays are 9.7 and 11.4 kev. The major part of the dose comes from conversion electrons from the 77.3 gamma ray; the next largest fraction results from the 146 L

shell vacancies per 100 disintegrations. Tabulation of these "particles" yields an average "beta" energy per disintegration, $\bar{E}_\beta$, of 77.3 kev. Using our schedule of photons, we find Γ, (specific gamma-ray emission) to be 0.35. This is in agreement with the value by Mann (5). We, therefore, believe these values valid for correction of the dosimetry stated by Dr. Sodee.

It should also be pointed out that our "schedule of photons" agrees with that used by the major suppliers of Hg^{197}. This assay now seems to be standardized, eliminating the confusion of the past.

We believe this analysis to be as correct as present literature will support and apologize to Dr. Sodee for any embarrassment caused by his use of the erroneous values.

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REFERENCES

1. Nuclear Data Sheets, National Academy of Sciences–National Research Council, Issue of Sept. 1962, sheets 5-1-17, 19, 26 (A = 197, A. Artna, compiler).
2. L. Slack and K. Way, Radiations from Radioactive Atoms, USAEC, issued 1959 (Appendix E, pp 64-70).
3. A. H. Compton and S. K. Allison, *X-Rays in Theory and Experiment*, Van Van Nostrand, 1935, p 638, et seq.
4. J. W. M. DuMond in *Beta and Gamma Ray Spectroscopy* ed. by K. Siegbahn, North Holland Publishing Co., Amsterdam, 1955, p. 124.
5. NBS Handbook 80, p. 45 and p 139.

TO THE EDITOR:

In his Letter to the Editor in the January Journal of Nuclear Medicine Dr. Sodee states, "In clinical scanning Hg^{197} Neohydrin has proved to be far superior to other available radionuclides". The only data cited supporting this claim are ". . . the tissue to background ratio has been increased to a factor of 2.7 as opposed to the Hg^{203} ratio of 1.7. This can be explained by Hg^{197}'s ease of collimation, increased number of usable photons per disintegration and the increased efficiency of our sodium iodide crystals at this lower engery."

The exact meaning of Sodee's ". . . tissue to background ratio" is not clear but judging by the explanations offered it involves a higher count from Hg^{197} than from Hg^{203} under comparable conditions. This improved ratio cannot come from ". . . Hg^{197}'s ease of collimation." The popular 19 and 37 hole 3″ lead collimators are grossly overdesigned for both Hg^{197} and Hg^{203} with septa and walls essentially opaque to the .28 MeV γ rays of Hg^{203}. Sodee's other explanations are qualitatively correct but quantitatively inadequate to explain such a marked improvement. The best current estimates are that Hg^{197} provides 98 usable photons per 100 disintegrations and Hg^{203} 83 usable photons. The photopeak efficiencies of the standard 3″ × 2″ crystal, 75-80% for Hg^{203} and about 90% for Hg^{197}, also favor Hg^{197}. However, any modest increase in count rate from these sources is more than compensated by the poor tissue penetration of the weak Hg^{197} γ rays. This is especially true in brain scanning where deep-seated lesions must be visualized through overlying normal brain tissue and the calvarium.

There is an important source of increased count rate not mentioned in Sodee's letter. It is the unwanted counts originating outside of the field of view of the collimator but reaching the crystal by scatter with little or no energy loss and by x-ray exitation in the collimator walls. Harris *et. al.* (J. Nuclear Med. 4, 183 (1963)) have pointed out the degradation of scan images by the smearing effect of these unwanted photons. In our own laboratory, studies with the International Atomic Energy Agency Standard Scanning Phantom indicate poor visualiza-