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September 19, 1963

Dr. C. L. Dunham, Director
Division of Biology and Medicine
U. S. Atomic Energy Commission
Washington 25, D. C.

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Dear Dr. Dunham:

On July 10 I attended a meeting, sponsored, I believe, by DEM, at The Lovelace Foundation, Albuquerque, New Mexico. The question posed at this meeting was, in essence, to assess the biological hazard associated with a single particle (say, 1-3 μ diameter) of Pu²³⁸ once the particle is deposited in the human lung and, in particular, to compare this hazard with that resulting from the same microcurie activity of an alpha-emitter distributed diffusely in lung. I assume you are aware of the particular application that occasioned the need for this assessment at this time.

Those present at the meeting, which was chaired by Dr. Shields Warren, agreed quickly that there was no existing body of experimental data on which a firm assessment, or even a comparison with the diffuse lung burden, could be based. Although small and intense beta-emitting sources have been implanted in the lungs of experimental animals, those present did not know of similar studies involving an alpha-emitter, nor have I found such studies reported in the literature since that meeting.

Lacking experimental data, those present at the meeting felt that, to meet the immediate need, they should not give a merely negative answer but should draw on what general principles governing effectiveness of radiation dose are known or considered plausible. On this basis a consensus was reached that was summarized by Dr. Lotz and others and endorsed by those present. I assume Dr. Lotz will be able to supply you with the exact wording of the final form of this statement, so I shall not give here the preliminary wording which is all I have in my notes.

The statement formulates the position that the biological hazard associated with a particle which is an intense source of alpha radiation is not expected to be more than the hazard associated

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with the same amount of activity distributed diffusely in lung, say, in the manner achieved in the usual inhalation experiments. The statement emphasizes that this assessment is speculative, not based on direct experimental evidence or on an established theory of radiation damage, and that direct confirmation would be desirable.

The purpose of this letter is to call to your attention directly what I consider to be a gap in our knowledge of the hazard associated with practical exposure situations. I do this because I am confident that the particular application that occasioned the meeting at Albuquerque will not be unique. In fact, there are seven other transuranic elements which pose somewhat the same problem, some of which are scheduled for extensive production at ORNL. I have little doubt that there will be other applications of Pu^{238} and similar materials apart from the program at ORNL.

Let me state the problem in semiquantitative terms. A sphere of diameter $2r \mu$ and density ρ contains $4/3 \pi r^3 \times (c/g) \times 10^{-6} \mu c$ of activity (r is taken in microns). Assuming alpha energy ϵ Mev is released per disintegration and that the range of the alpha particle is $R \mu$, the dose rate in a sphere centered at the particle with radius $R \mu$ is $2.1 \times 10^6 \rho (r/R)^3 \times (c/g) \times \epsilon$ rads/hr. Taking $r = 1 \mu$ the table below gives, for some radionuclides, the average dose in a sphere of radius equal to the range of the alpha particle and centered at the particle. Particles will not be spheres, of course, and there will be some self-absorption of energy by the

Radionuclide	T_r (days)	Energy of the α	Dose Rate in Tissue Sphere (rads/hr)
^{238}Pu	3.3×10^4	5.48	2.3×10^4
^{242}Cm	162.5	6.10	5.1×10^6
^{243}Cm	1.3×10^4	5.78	6.0×10^4
^{244}Cm	6.7×10^3	5.79	1.2×10^5
^{250}Cf	3.7×10^3	6.01	2.1×10^5
^{252}Cf	804	5.74	9.3×10^5
^{253}Es	20.03	6.63	4.3×10^7
^{254}Es	480	6.43	1.7×10^6

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particle, but it is clear that the dose rate to a small cluster of cells--perhaps two cell layers in thickness about the particle--will be very large. Other cells, if situated beyond the range, are not directly hit, although they might be affected by chemical action of radicals produced by this intense, microscopic source.

The data available from experimental implantation of small beta sources do not directly answer the question of hazard. The beta sources generally have indicated a high degree of hazard, i.e., a high rate of production of malignancies. One may conjecture that the much fewer number of cells involved by an alpha-emitter may make for a lesser hazard. However, one should not have to speculate on this point. I believe an experimental study to determine the degree of hazard of an intense, local source of alpha particles in the lung is urgently needed.

It is not my purpose to propose any specific experiment in this letter. I have thought about it some and believe it is feasible, though probably difficult, to attempt the implantation of relatively few particles of high activity in the lung and to study the effects of such exposure, at least in its gross manifestations and perhaps also at the cellular level. I would be pleased to discuss the problem with you or others, and I would be glad to cooperate with any group in planning such an experiment or to assist in the dosimetric studies or interpretation of the data that might be obtained.

In the past you have invited me to call to your attention problem areas where information is needed for proper assessment of internal dose, and I take this means of mentioning this problem to you as one which, in my opinion, is important and one where data are sorely needed.

Very sincerely yours,

Original Signed By

Walter S. Snyder, Assistant Director
Health Physics Division

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