GENERAL ATOMIC
DIVISION OF GENERAL DYNAMICS CORPORATION

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June 6, 1967

Dr. Robert A. Kehoe
Kettering Laboratory
Eden and Bethesda Avenues
Cincinnati, Ohio 45210

Dear Dr. Kehoe:

I am enclosing a brief technical discussion concerning the use of radioactive Pb^{203} as a tracer for experiments with humans. As you will recall, during your visit here we suggested this technique as a means for studying the clearance of lead from the lungs.

We think it is quite feasible to make Pb^{203} using our accelerator and to label lead tetraethyl with the Pb^{203}. We estimate that the specific activity of the labeled lead tetraethyl will be sufficiently great to follow the lead using a conventional radiographic scanning technique as the lead is cleared from the lungs. We do not know exactly how to do the labelling at the moment but feel confident that we can do so after a modest amount of research on the subject. If you should be interested in using the tracer technique, we would be pleased to discuss the labelling problem in greater detail.

We have also calculated the radiation dose a person would absorb in an experiment utilizing Pb^{203}. The dose is far below the presently accepted tolerance level. Therefore, we do not feel that the use of this particular radioactive isotope should be of concern from a health point of view.

We are most anxious to continue discussions with you as to ways we can contribute to your studies. If you have questions concerning our suggestions, please feel free to call or write.

Sincerely yours,

David F. Herring

David F. Herring

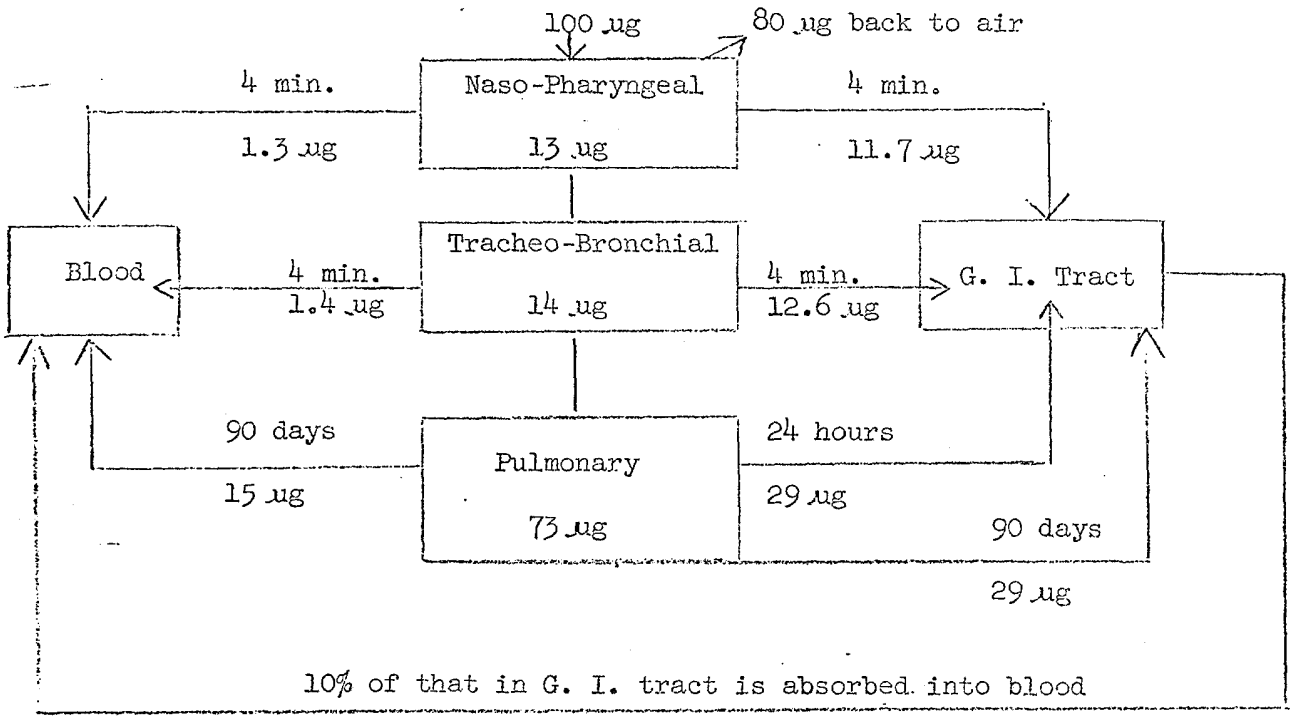
ETHYL CORPORATION

INTER-OFFICE

To	Dr. A. S. Hawkes	Address	Detroit
From	Gary Ter Haar	Address	Detroit
Subject	Lead Inhalation Studies	Date	August 23, 1967

In regard to the use of 210 Pb or 203 Pb for use in inhalation studies on humans, the following model could be considered as a working base. Assume a person breathed in 180 µg of lead, about 55% or 100 µg would be deposited in his system. Each box shows the amount of lead deposited and as a total of 100 g is present each number is the percentage of total lead deposited.

Figure I



Using the model one can calculate the number of counts to be found in a given sample if a known dose of radioactive lead were administered. The I.C.R.P. report in Health Physics, Volume 3, 1960, page 75, shows that 90 microcuries of 203 Pb and 4 microcuries of 210 Pb is the maximum permissible dose to the whole body. If we administered 1/100 of the permissible dose and assumed 50% counting efficiency for 210 Pb (α) and 10% for 203 Pb (γ) the samples deposited would have a total count of about 5×10^4 C/min for the 210 Pb and 2×10^5 C/min for 203 PB.

What counts should be expected from samples of blood urine and feces.

I. Blood

A. One hour
In the first hour 2.7% should reach the blood. If a 10 ml sample of blood were taken and a man has about 8000 ml of blood the following is true:

1. $210\ Pb - 5 \times 10^4 \times 0.027 \times \frac{10}{8000} = 1.7\ C/min$

2. $203\ Pb - 2 \times 10^5 \times 0.027 \times \frac{10}{8000} = 7\ C/min$

B. Twenty four hours
At the end of 24 hours an additional amount will enter the blood stream from the gut. If 10% is absorbed from the gut

$$[29 + 12.6 + 11.7]\ (0.1) = 5.3\%$$

1. $210\ Pb - 5 \times 10^4 \times 0.053 \times \frac{10}{8000} = 3.3\ C/min$

2. $203\ Pb - 2 \times 10^5 \times 0.053 \times \frac{10}{8000} = 13.2\ C/min$

C. Seven days
The situation in the blood at the end of the first week would be one in which nearly all of the activity is coming from absorption from the gut and the lungs. As about 90 days are needed to clear the dose from the lungs to the blood (15 ug in the model), about 1% of this 15% or 0.15% will be cleared per day. As 29% is cleared to the G. I. tract from the lungs in 90 days of which 10% is absorbed to the blood, an additional 0.029% will come from this source.

$$29\% \times 1\% \times 10\% = 0.029\%$$

$$\text{Total } 0.15\% + 0.03\% = 0.18\%$$

The half life of 203 Pb (52 hours) of course reduces its activity by about a factor of 8. 210 Pb with a half life of 22 years is not affected.

1. $210\ Pb - 5 \times 10^4 \times 0.0018 \times \frac{10}{8000} = 0.1\ C/min$

2. $203\ Pb - 2 \times 10^5 \times 1/8 \times 0.018 \times \frac{10}{8000} = 0.1\ C/min$

Examination of blood is of no use for 203 Pb at the end of a week; however, 210 Pb could readily be continued for the first month.

II. Urine

A. One-two hours
About 90% of the lead in the blood is very rapidly passed to the urine. Therefore, collecting the total sample after about 1-2 hours should show the 2.7% that had passed to the blood. Thus for 210 Pb

1. 210 Pb - $0.9 \times 5 \times 10^4 \times 0.027 = 1.2 \times 10^3$ C/min

for

2. 203 Pb - $0.9 \times 2 \times 10^5 \times 0.027 = 4.9 \times 10^3$ C/min

B. Twenty-four hours
At the end of 24 hours an additional 5.3% will be found in the urine or about twice the above counts

C. One week
At the end of a week the blood will be near equilibrium with the urine and about 0.18% should be found in one daily sample

1. 210 Pb - $0.0017 \times 5 \times 10^4 = 91$ C/min

2. 203 Pb - $0.0018 \times 2 \times 10^5 \times 1/8 = 45$ C/min

Lead-210 in the urine could be run for at least the 90-day period and lead-203 through the first 8 days

III. Feces

A. Twenty-Four Hours

During the first 24 hours about

11.7% + 12.6% + 29% or about 50% should be found in the feces

1. 210 Pb - $5 \times 10^4 \times 0.5 = 2.5 \times 10^4$ C/min

2. 203 Pb - $2 \times 10^5 \times 0.5 = 10^5$ C/min

B. Seven Days

After a week, about 1% of the 29% remaining in the lungs should pass through the G. I. tract and into the feces

1. 210 Pb - $0.29 \times 0.01 \times {}_5 \times 10^4 = 1.5 \times 10^2$ C/min

2. 203 Pb - $0.29 \times 0.01 \times 2 \times 10^5 \times 1/8 = 100$ C/min

Lead-210 could be measured in the feces for many more days while lead-203 could be measured to about 12 days. Lead-210 would best be measured by isolating it in Po-210 daughter which would require two separations of Po-210. The lead-203, being a gamma emitter could be measured simply by placing the unprocessed sample in a counter. In addition an estimate could be made of the concentration of lead-203 in the lungs, liver and spleen by using external body counters.

The advantage of Pb 203 is the ease of counting. The disadvantages are its short half life, making rapid manipulation necessary and preventing a complete long-term metabolic balance, and its preparation which involves use of a cyclatron and separation of a very hot sample from a lot of other undesirable isotopes. The advantages of lead-210 are ready availability, long half life, permitting complete study, and alpha disintegration which permits use of very low background counters. (0.02 C/min). Lead-210 has the added advantage that the early counts in the blood are sufficiently above background to determine very accurately the percent in the blood. One important disadvantage is that at least three months are needed to allow the 210 Po to grow in order to analyze the samples. According to the I.C.R.P report one hundredth of the maximum dose of either isotope should be equally safe.

G Ter Haar

Gary Ter Haar

GTH:dle

cc: D. E. Cooper
J. E. Faggan
M. E. Gluckstein
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