

Radioactive Content and Distribution Studies

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I. General

A. Radium

Radium is an alkaline earth and its chemical properties are similar to those of calcium. Thus, the metabolism of radium is similar to that of calcium, and is affected by factors which affect calcium metabolism.

B. Plutonium and Thorium

Tetravalent plutonium and thorium have no physiological analogs and thus follow no normal metabolic pattern. In aqueous solution the high charge (+4) of plutonium and thorium is unfavorable for the existence of Pu^{+4} and Th^{+4} as such, resulting in complex ion formation, partial hydrolysis, colloid formation, or precipitation dependent upon the nature of the solution. The high pH, the presence of citrate, proteins and areas of high negative charge density of biological systems are very favorable for bonding plutonium and thorium. Both are found to deposit on the endosteum, periosteum, and trabecular surfaces of the bones, and in the liver.

II. Excretion

A. Radium

Age, an important factor in calcium metabolism, has a pronounced effect on the excretion of intravenously injected radium. A 23-day excretion study was made on a group of 3 adult beagle dogs, 5 of which were 15 months old and the other 3 were 2 1/2 to 4 years at time of injection. Even though all were skeletally mature, the older dogs excreted a significantly greater fraction of the radium.

No. Dogs	Age	% Ra Excreted in 28 days	Rate at 28 days
5	15 mos.	53	0.17%/day
3	2.5 to 4 yrs.	69	0.21%/day

The age effect is more pronounced when puppies are compared with adults.

No. Dogs	Age	% Ra Excreted in 24 hours
3	5 mos.	3.4
5	15 mos.	21
3	2.5 to 4 yrs.	26

Additional data for the older dogs are as follows:

Days after Injection	Excretion Rate
60	0.07%/day
180	0.02%/day
330	0.013%/day

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B. Plutonium and Thorium

The excretion of plutonium during the first 22 days following intravenous injection has been measured for a group of 19 adult beagle dogs ranging in age from 15 months to 4.3 years. The average excretion is 12%, and there is no measurable correlation with age.

Days after Injection	Excretion Rate
22	0.05%/day
70	0.02%/day
160	0.015%/day
225	0.013%/day
1 year	0.01%/day

III. Blood Measurements

A. Radium

During the first 24 hrs. after injection radium is removed from the blood more rapidly in puppies than in adults, indicating more rapid bone metabolism in puppies.

B. Plutonium and Thorium

Thorium is removed from the blood more slowly than radium, but eventually reaches a lower level than radium. These facts are consistent with the colloidal properties of thorium and the tenacious bonding of deposited Thorium.

IV. Distribution Measurements

A. Radium

Retained radium is found almost quantitatively in the skeleton, the tissue deposition being almost negligible after the first few days. At 24 hours after injection the skeleton of a five month old puppy contained 87% of the injected radium, while the skeleton of a 15 month old dog contained 60%.

B. Plutonium and Thorium

Retained plutonium is found almost quantitatively in the skeleton and the liver. 70% of the injected dose deposits in the skeleton and 20% in the liver. As anticipated from the low excretion rates, the gross distribution of plutonium remains approximately constant during the first year. However, zonal analysis of long bones shows that plutonium is redistributed within the skeleton. The importance of this observation is that, while the total alpha particle energy dissipated per day in the skeleton remains constant, the amount of energy which a particular part of a bone receives varies with time.