ratio of the agar layers. The plates were then inoculated with a thin streak of organisms using a small sterile brush. The plates were inverted and incubated for 18 hours. At this time the growth of the organisms could easily be seen and the point where growth was just inhibited determined. Concentrations up to 250 μg per ml were run at least in duplicate. The microorganisms were obtained from stock cultures belonging to the Department of Bacteriology, Oregon State College. The values obtained by this method compared within 15% of those found by standard dilution techniques when using phenol or penicillin G, sodium salt.

Results. In Table I is summarized the results obtained by screening the miscellaneous compounds for their abilities to inhibit growth of the five selected microorganisms. In general the ketones were inactive at a concentration of 250 μg per ml which was the highest level used. Many of the alcohols, however, were quite active in inhibiting growth, some at rather low concentrations. In addition to the organisms listed, most of the compounds prepared were screened against *Candida albicans*. In general no inhibitory effects were noted against this pathogenic yeast; however, 4, 4'-dichlorobenzhydrol completely inhibited growth at 140 micrograms per ml.

Summary. A number of miscellaneous compounds related to DDT have been screened for their abilities to inhibit the growth of 5 select bacteria and yeasts. The alcohols were much more active than the corresponding ketones.

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Received September 12, 1955. P.S.E.B.M., 1955, v90.

Failure of Y^{90} to Escape from Skeletally-Fixed Sr^{90}.* (22001)

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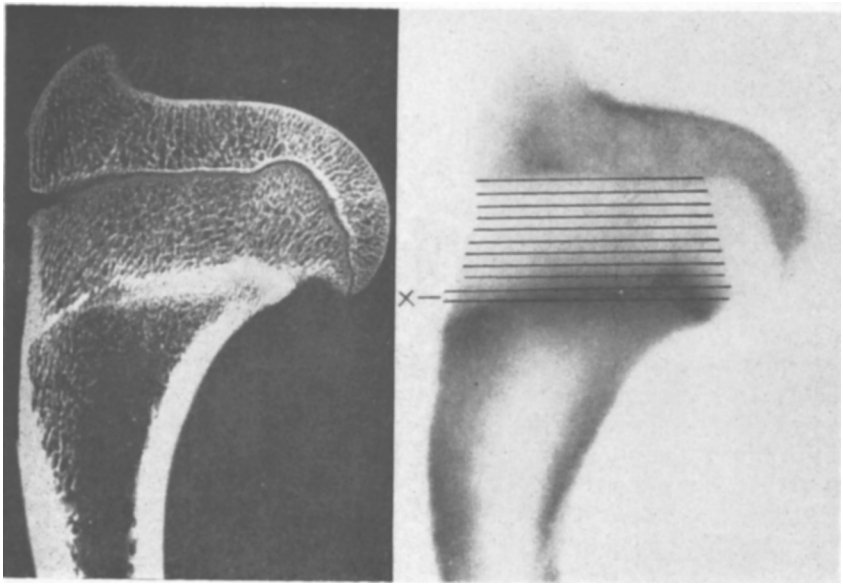
In the evaluation of the toxicity of radioactive elements deposited in living animals it is essential to know how much energy is delivered to the irradiated tissues. When the radioactive element gives rise to daughter products of different atomic species possessing physical and chemical properties different from the parent species, particular caution is necessary. This fact was recognized early in the work on radium toxicity when it was discovered that a large fraction of Rn^{222} escaped from skeletally deposited Ra^{226} and was exhaled in the breath. It has also been found recently(1) that considerable ThX (Ra^{224})

* Supported by U. S. Atomic Energy Commission.



b a

FIG. 1. a. Autoradiogram of slab of bone taken from proximal end of right humerus (magnification 1.5×). b. X-ray picture of same slab of bone at same magnification.

daughter escapes from parent RdTh (Th^{228}) deposits in bone. Sr^{90} is an important component of the radioactive fallout from atomic explosions. In considering its toxicity, particular interest is focused on the contribution to beta ray dosage which is made by the more energetic beta rays of its 2.7 day daughter, Y^{90}. A comparison of the energies of the Sr^{90} and Y^{90} beta rays shows that, under conditions of radioactive equilibrium, tissue would receive approximately four times as much energy from the more energetic beta rays of Y^{90}. Hence, we have studied the metabolic fate of the potentially more damaging Y^{90} formed from Sr^{90} deposits in the skeleton of a young beagle dog. The following are the possible metabolic pathways for the Y^{90}: (1) Excretion from the body; (2) Retention at sites of formation in the skeleton; (3) Escape from sites of formation and re-deposition in skeleton in different sites; (4) Some combination of the above.

Our experiments show that most or all of the Y^{90} daughter is retained at the sites of formation in the skeleton.

Methods. Our experiments were carried out on a single beagle dog which was sacrificed 4 months following the intravenous administration of 150 μc per kg of Sr^{90} at equilibrium with its Y^{90} daughter. The injection solution consisted of Sr^{90}, Y^{90} in a citric acid, sodium citrate buffer of pH = 3.5 and 0.08 M total citrate. The dog was 5 months old at the time of injection, and therefore, its skeleton was growing during the presacrifice interval. The fate of the Y^{90} formed from Sr^{90} decay in the bone was studied in 3 ways. 1. The right humerus was cut longitudinally into slices 1-2 mm thick, embedded in Gelva resin,† and cemented on aluminum plates. After grinding the slabs flat with fine abrasive paper, contact autoradiograms were made on Kodak no-screen x-ray film. Fig. 1a is an autoradiogram (magnified 1.5x) of one of these slabs from the proximal end of the humerus; Fig. 1b is an x-ray picture taken at the same magnification. Another slab was cut along the parallel lines shown in Fig. 1a; adjacent lines are about 1 mm apart. The bone of section X was being deposited at the time of Sr^{90} injection and the bone of sections X + 1, X + 2, etc. was deposited at progressively later times. Following wet ashing, these samples, and also samples of bone from the shaft, were counted in a

† Shawinigan Products Corp., N. Y. City.

Geiger counter. Measurements were made both with and without an aluminum absorber sufficiently thick (0.7 mm) to absorb all Sr^{90}, but not all Y^{90} beta rays. A series of such counts was made from 6 hours to 7 days after sacrifice. In all samples, the Y^{90} beta ray activity was at equilibrium ($\pm$ 3%) with the parent Sr^{90} at 6 hours after sacrifice.

Results. If Y^{90} produced *in vivo* escaped from its site of formation into the general circulation, one would anticipate its concentration in the primary spongiosa beneath the epiphyseal line, in a manner similar to the deposition of parenterally administered Y^{90}(*2*). The amount of Sr^{90} in the primary spongiosa is quite low since this was a growing dog and the bone of this area was deposited at a considerable time after injection of Sr^{90}. Because of this low Sr^{90} concentration, an excess of Y^{90} could have been readily detected. The fact that no such excess of Y^{90} occurred in the primary spongiosa indicates that little, if any, of the Y^{90} produced *in vivo* escaped from its sites of formation.

Fig. 1b also clearly demonstrates that metaphyseal trabecular bone containing a high concentration of radioactivity (section X) is markedly opaque to x-rays. This opacity is due to the presence of bone of abnormally high density in this region and is evidence of radiation damage. This point will be discussed further in a future publication. A similar effect can be seen in the radius of this dog (Fig. 2).

II. The left radius was divided into 8 segments as illustrated in the x-ray picture (Fig. 2). The pieces were quickly dissolved in nitric acid and aliquots were mounted for beta ray measurement. Aliquots of the samples were measured from 8 hours to one week after sacrifice by 2 methods. The Sr^{90} and Y^{90} beta rays were measured in a 2-π proportional counter; Y^{90} only was measured using an end-window G-M tube with 0.7 mm aluminum between sample and detector. Similar measurements were made on the heads and shafts of the metacarpals. The data show no significant variation with time. The measurements of Sr^{90} and Y^{90} beta rays with time are rather insensitive, and the conclusion from these data is that the Y^{90} activity at the time of sacrifice

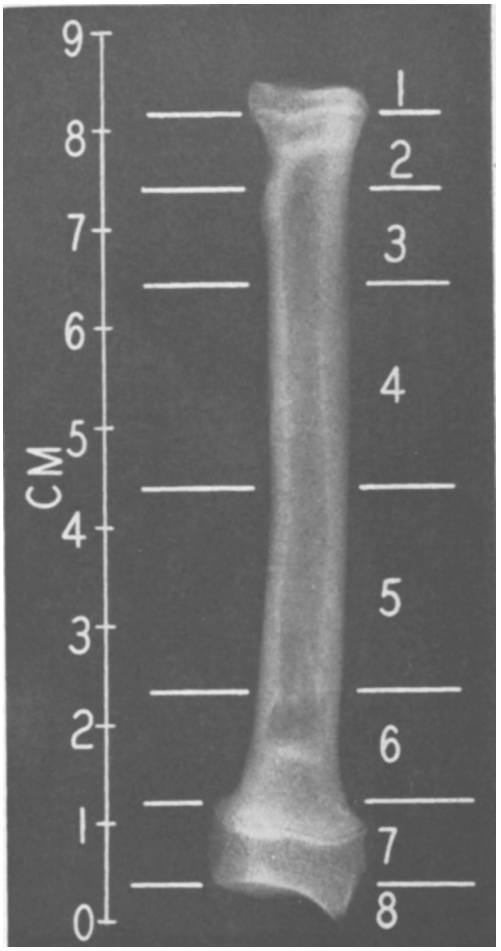


FIG. 2. X-ray picture of left radius.

equals the Sr^{90} activity ($\pm$ 20%). The Y^{90} beta ray measurements are more sensitive, and show that the Y^{90} activity at the time of sacrifice equals the Sr^{90} activity ($\pm$ 10%). Hence, Y^{90} is close to equilibrium in these bone samples which differ both in Sr^{90} concentration and morphologic composition.

Measurements were also made on the liver and plasma of this dog. The liver was homogenized, and an aliquot of the homogenate was wet ashed, as was a plasma sample. Aliquots of these samples were plated, and total beta ray activity was measured as described above.

In the plasma, Y^{90} was not in equilibrium with its parent; the Y^{90} activity was approximately half the Sr^{90} activity. In the liver, Y^{90} was in equilibrium, and the liver concentration

of Sr^{90} was about equal to the plasma Sr^{90} concentration. Since the skeleton contains approximately 5000 times as much Sr^{90} as the liver, measurement of the liver for excess Y^{90} is sufficiently sensitive to detect the escape of a small fraction of the Y^{90} formed in the skeleton, even though the deposition in the liver of parenterally administered yttrium is low. If it is assumed that any Y^{90} which leaves its site of formation in the skeleton behaves as parenterally administered tracer yttrium(3), then the lack of excess Y^{90} in the liver shows that there is no appreciable escape from the skeleton of *in vivo* formed Y^{90}.

III. The x-rays produced by the Y^{90} beta rays traversing the bony tissue of the right radius were measured as a function of time after sacrifice and of position along the axis of the bone. X-ray production by a continuous spectrum of beta rays of maximum energy E_{max} striking a thick target is approximately proportional to E^2_{max}(4). Hence the yttrium x-ray production is approximately $(2.24/0.54)^2 = 17$ times as intense as the strontium x-ray production and is responsible for most of the counter response.

A ¼ inch separation between lead bricks was used to collimate the x-rays; the detector was a NaI(Tl) scintillation counter. Sufficient thickness of lucite was used to absorb all beta rays. A series of measurements at ¼ inch intervals along the length of the right radius was made. These measurements showed no growth or decay of x-ray production (to $\pm$ 5%) along the length of the bone. Since the x-rays detected were almost entirely generated by Y^{90} beta rays, these measurements show the presence of Y^{90} rather than Sr^{90}. Hence, the Sr^{90} in all segments of the right radius was close to equilibrium with the *in vivo* formed Y^{90}.

Summary. The data presented demonstrate that Y^{90} produced *in vivo* from long term skeletal deposits of Sr^{90} in young dogs does not escape from the local areas of bone in which it is produced. This is in agreement with previous experimental evidence(5). The implications of this finding are as follows: First, the combined energy of the Sr^{90} and Y^{90} beta rays irradiates the skeleton. Hence, dosimetric data determined *in vitro* can be directly applied to *in vivo* conditions. Second, the Sr^{90} deposited in the growing skeleton is probably intracrystalline. This is in agreement with the x-ray diffraction findings of McDonald(6). Work is in progress to see whether this effect occurs in older dogs where there is less bone growth and less crystal formation.

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