organ is not known, it can be approximated by means of equations similar to Spencer's Eq. 3. It is not necessary to compute percent injected dose per gram as an intermediate step, although it is often convenient to do so.

As pointed out by Spencer, the expressions RC and RR do not show the fraction of an administered quantity of radionuclide in a whole organ directly and are not intended to do so. They do show the relation of the concentration of radionuclide actually present in an organ (as distinguished from the amount) and the concentration that would be present if the administered quantity were uniformly distributed or retained throughout the whole body. This permits quantitative comparison of metabolic patterns and kinetics and of radiation dose in different organs of the same body independently of the size of that particular body. It also permits cross-species and intraspecies comparisons provided there are no major differences in body proportions.

Spencer makes the important point that body proportions may vary considerably between species and to some extent with age and size within a species. Additional examples not discussed by him are the relatively greater weight of the human brain and the relatively greater skeletal weight in large animals. Usually the radionuclide is distributed in different concentrations in numerous tissues all of which contribute to the total-body retention. While correction for the varying proportions of these tissues between species could be made, the variations between individuals of the same species, as shown by Stahl (*1*), are so large that little would be gained. Correction may be necessary, however, in cases in which the fraction of an administered dose retained in a single organ approaches 100%. An example is the ^{18}F retained in the skeleton after the initial rapid renal clearance from the rest of the body. In such a system the skeletal RR will be smaller in a large-boned animal than in a small-boned one, because the retained fraction of the administered dose is distributed in a larger fraction of the total-body mass. Investigators should keep this possibility in mind when interpreting observed differences in RC or RR between species.

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Coincidence-Counting Assays of ^{123}I

The assay of ^{123}I using a NaI well counter was discussed recently by Hudson et al. (*1*). They pointed out some of the difficulties introduced into sample counting in a scintillation well detector, due to summing effects from the x-ray–x-ray coincidences at 61 keV and x-ray–γ-ray coincidences at 187 keV. They found that those effects can introduce as much as a 50% error in the determination of a given amount of ^{123}I activity.

We outline here an alternative more accurate method of assaying ^{123}I activity, used in our laboratory for pediatric thyroid uptake studies. This method is based on coincidence counting of the x- and γ-rays emitted during the disintegration of the ^{123}I nucleus, as reported by Herman et al. (*2*). A dual-crystal NaI probe was used to measure the counting rates N_γ, N_x, and N_c of the 159-keV γ-ray, the 28-keV x-ray, and the net γ-ray–x-ray coincidences. The absolute disintegration rate N_0 of an ^{123}I sample was then given by the equation:

$$N_0 = \frac{0.86\, N_x N_\gamma}{N_c}. \qquad (1)$$

Using a 3 × ¼-in. NaI crystal as the x-ray detector and a 3 × 1-in. NaI crystal as the γ-ray detector, and setting the x-ray and γ-ray spectrometer windows to encompass the entire photopeaks, we explored the various factors that may influence the accuracy of this assaying method. The 99.9% pure ^{123}I used in these studies was obtained from the Crocker Nuclear Laboratory Cyclotron of the University of California at Davis, where it was produced by ^{127}I (p, 5n) ^{123}Xe reaction and subsequent β^+ decay of the ^{123}Xe to ^{123}I. The shipment was assayed in a NaI well counter to an accuracy of ± 10%.

First, the dependence of indicated activity on the separation distance between the center of the source and the faces of the two crystals [namely, the source-to-crystals distance (SCD)] was investigated for three different activities. Aliquots of ^{123}I solution were diluted in a 1-ml volume of water and counted while the center of the source was at various equal distances from the NaI crystal surfaces. The results are shown in Fig. 1. Both the 1.10 ± 0.11-μCi and the 11.3 ± 1.13-μCi nominal sources (Crocker Laboratory assay) show the same dependence of indicated activity on

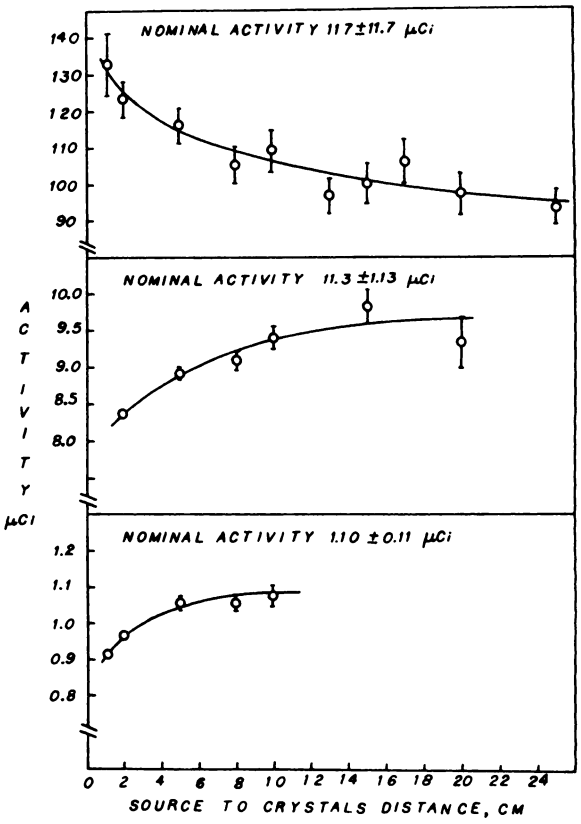

FIG. 1. Assays of three activities for various source-to-crystal distances.

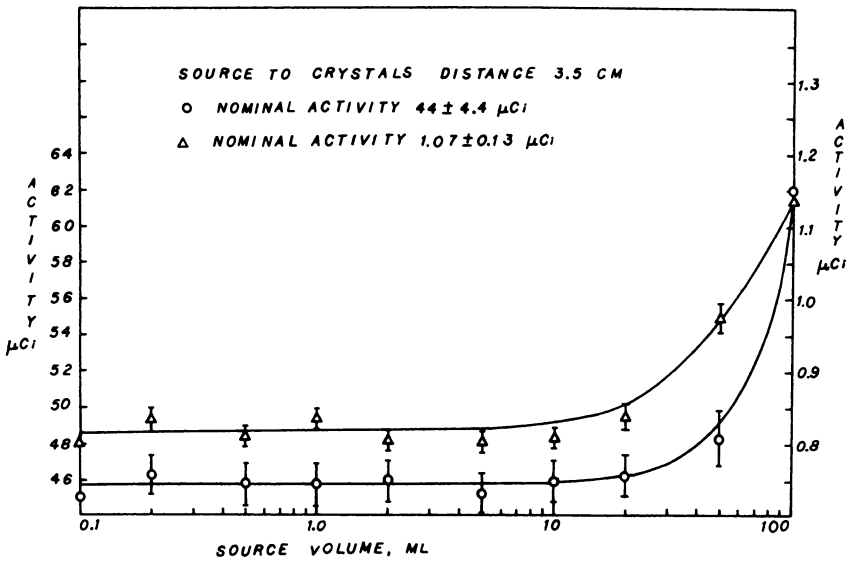

FIG. 2. Assays of two activities for various source volumes.

SCD. The 1.10-μCi line plateaus at about 6 cm and the 11.3-μCi graph plateaus at nearly 12 cm SCD. The 10% increase in the assayed activity, when the SCD is increased from 2 to 6 cm for the 1.10-μCi source and from 2 to 12 cm for the 11.3-μCi source is due entirely to the effect of the iodine x-ray escape, produced by the γ-ray photons' impinging on the crystal surface at closer and closer to 90° as the SCD is increased. The larger SCDs reduce the probability of the iodine x-ray escape through the edges of the crystal, and N_γ in the numerator of Eq. 1 becomes progressively larger than it would have been if the escape probability were constant. This effect is well understood and is discussed in detail by various authors (*3,4*). The 117-μCi source graph in Fig. 1 exhibits a shape that does not agree with the trend set by the two weaker sources. The counting rates produced by the strong source exceed the capability of the electronic circuits to handle them without significant losses. At excessive count rates, the deadtime will decrease the coincidence rate N_c faster than the corresponding decrease in N_x or N_γ of Eq. 1 and thus higher values for activity will be indicated. When the SCD is sufficiently large, this graph also levels out well within the nominal value of 117 ± 11.7 μCi. The conclusion drawn from Fig. 1 is that one must choose: (A) a geometry such that the probability of iodine x-ray escape is minimized (γ-ray crystal); and (B) distances such that the resulting counting rates can be handled adequately by the circuits used.

We next explored the effect of the source volume on the measured activity. Figure 2 shows that the assay is independent of the source volume from 0.1 to about 20 ml, when the SCD is 3.5 cm. Both sources examined show a marked rapid increase in the calculated value for the activity as the volume is increased beyond 20 ml. This effect is more pronounced for the low-activity source. This trend is also well understood and arises because any γ-ray that normally would not interact with either crystal can be Compton-scattered into the x-ray crystal by the large water volume at the extended source. If its energy falls within the x-ray spectrometer window, it will be counted as an x-ray. This increases N_x in Eq. 1 and results in a higher calculated activity. Thus, Fig. 2 shows that for an accurate assay one must use a source volume that minimizes this effect.

The overall percent error in this assaying procedure, when the SCD, the volume, and strength of the source are judiciously chosen, will depend only on the counting statistics and the dilution method, if any. In the data presented in Figs. 1 and 2 the percent error varies between 2 and 7%.

In conclusion, it can be stated that an accurate reliable method for ^{123}I assays is available through the coincidence-counting technique. The only drawback of this method is that it requires additional electronic hardware beyond that required by the single-crystal NaI counter.

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Reply

It has been encouraging to find considerable interest shown in our original note on ^{123}I coincidence summing (*1*). An analogy may be drawn between the effects in ^{123}I and in ^{125}I, and for some years coincidence counting has been used for the accurate assay of ^{125}I (*2*). It is interesting to note how practical use is being made of coincidence summing in ^{125}I (*3*) and we wonder whether this technique may be usefully applied to other summing nuclides. It would appear, however, as Mpanias et al. point out, that the method calls for a rather more complex technique that might not be