the porpoises avoided the solid but invisible Plexiglas door by means of echo ranging. The selection of the open doorway took place, moreover, while the animals were passing through a net of ⅛-inch steel wire, which they also avoided. The location and discrimination of submerged objects by reflected sound signals is without doubt a necessary and a fundamental perceptual avenue for these cetaceans.

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Dosimetry of Radioisotopes

A nomogram permits the estimation of the radiation dose delivered by 30 isotopes of biological interest.

A. J. Bertinchamps and G. C. Cotzias

The statement that radioisotopes are being used with increasing frequency both in biology and in medicine need not be defended here. Indeed the entire problem of irradiation from internally received radioisotopes is assuming increasing importance. Nevertheless, observations are often reported merely in terms of counts per minute or of millicuries without cognizance of whether the isotope provides simply a weak signal or a substantial source of energy. Results so reported are of little quantitative meaning in the evaluation of the degree of change to be anticipated in a biological (or other) system.

A more definitive additional specification, such as the dose rate, is often not reported because of the discouragement caused by the necessary calculations, even when the distortion of a biological system is the primary concern. Therefore, we have developed a simple nomogram (Fig. 1) which permits direct reading of the dose rate for numerous radioisotopes of biological and medical interest (*1*). The use of this device in our center has improved the planning of two types of experiments—namely, tracer as well as radiobiological work. Its use has developed the habit of thinking directly in terms of the forces at work rather than in terms of a partial datum which happens to appear on a luminous dial.

The nomogram permits the reading of beta plus gamma dose rate or either one alone for the center of a cylindrical or of a spherical system. Conversely it aids in choosing isotopes for the delivery of desired dose rates of radiation. The classical dosimetric assumptions (*2*) were employed in constructing it: 1 microcurie is immediately and homogeneously dispersed per kilogram; the system has a density of 1 and behaves like water vis-a-vis irradiation; the entire β-particle energy is absorbed by the system, and the gamma rays have a linear absorption coefficient of 0.03 per centimeter.

The energy due to conversion electrons is included with the β energy; bremstrahlung is neglected, while x-rays due to k capture are not accounted for.

Use of the Nomogram

The formula on which the nomogram is based is the classical one

$$D_{\beta+\gamma} = 51.2\, \overline{E}_{\beta} \cdot n + I_{\gamma} \cdot G \cdot n$$

where $D_{\beta+\gamma}$ is the dose rate in millirad per day at the center of a cylinder or sphere due to β and γ emission; $\overline{E}$ is the average energy in Mev of the beta emission; I_{γ} is the dose rate in rad per microcurie per day at 1 centimeter due to the gamma emission from a point source; G is the geometry factor handling variance in size and shape of the system [its values were calculated from Marinelli, Quimby, and Hine (*3*)]; and n is the concentration of radioactivity in microcuries per kilogram at the onset of the observation.

The beta plus gamma dose rate (per hour or per day) is read as follows.

1) Draw the diagonal corresponding to your isotope on scale A.

2) Choose a cylindrical or spherical model, whichever fits your system best.

3) Draw the vertical from the weight or radius of this model to the diagonal corresponding to your isotope.

4) From the intercept draw a horizontal to scale B.

5) Connect the new intercept on scale

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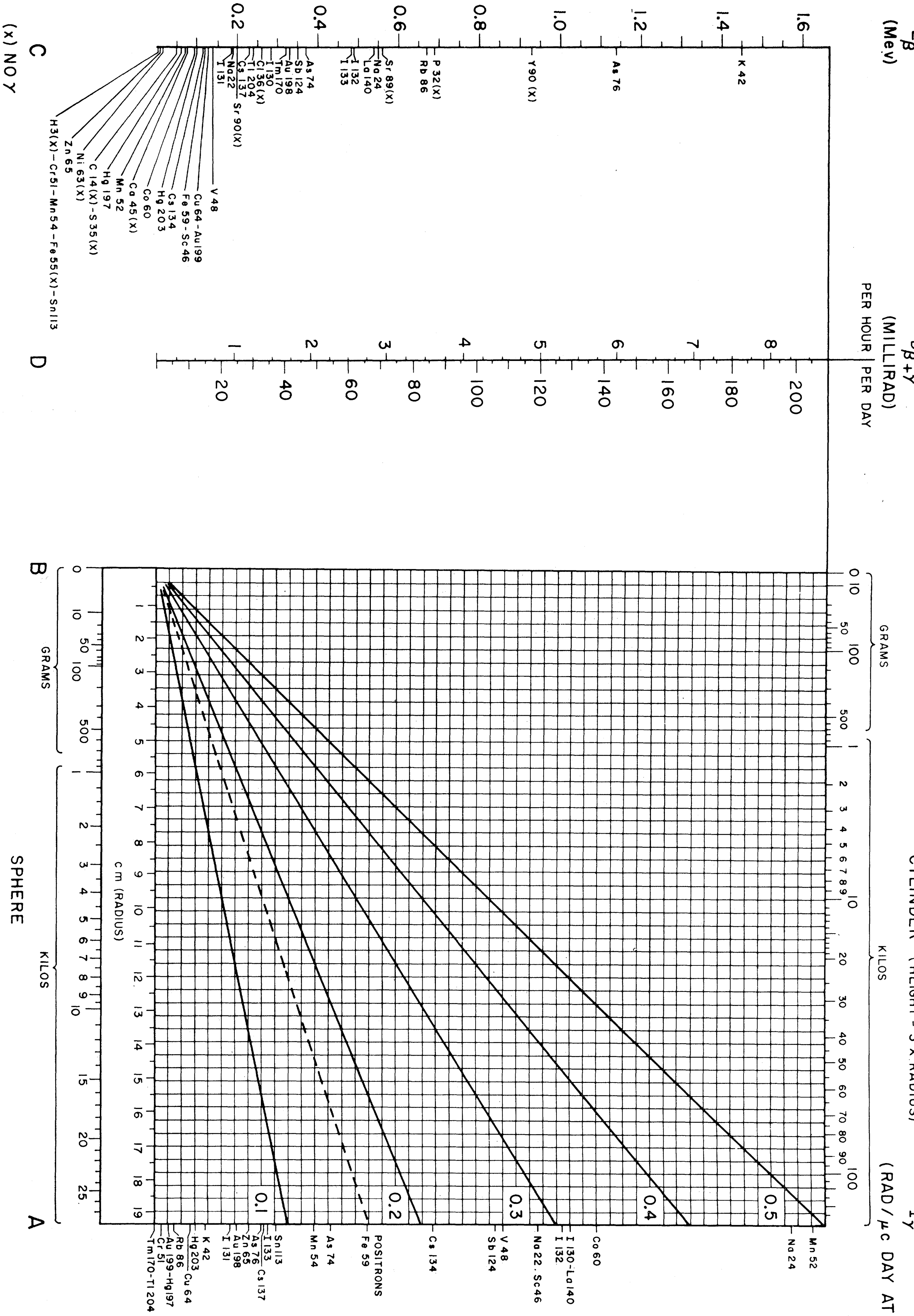

Fig. 1. Nomogram for the radiation dosimetry of internally administered radioisotopes.

B with your isotope on the average β energy scale C.

6) Read the dose rate on scale D.

To read β dose rate only or in the case of pure β emitters use the nomogram as follows. Connect your isotope on scale C with the origin of B (at the intercept of B with the sphere's radius scale) and read dose rate on scale D. To read only the gamma dose rate, connect the intercept on B with the origin of C and read dose rate on D.

Further calculations may be made as follows, if desired.

1) To obtain the dose rate for n microcuries per kilogram, multiply by n, which may be any number larger or smaller than unity.

2) To obtain the "infinite dose," multiply by 1.44 T eff. (effective half-life).

$$T\text{ eff.} = \frac{(\text{physical } T/2) \times (\text{biological } T/2)}{(\text{physical } T/2) + (\text{biological } T/2)}$$

3) To obtain the cumulative dose after time t, multiply the infinite dose by

$$1 - e^{-0.693\, t/T\text{ eff.}}$$

Remarks

The assumptions made in constructing this nomogram should always be kept in mind, particularly in reference to β dosimetry: a highly energetic β ray (for example, K^{42}) will not be totally absorbed in a small volume (for example, a mouse). The unit of time for the dose rate should be chosen very much shorter than the effective half-life. The latter can be estimated with the above formula if the biological decay either follows a single exponential or is negligible as compared to the physical decay. If this is done, this nomogram will not only lead to saving of time and mental wear and tear but, if properly used, it will also minimize the chance of error.

Large working copies of this nomogram, which will be revised if so warranted by new data, are available.

References and Notes

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Taxonomic Codification of Biological Entities

A system is proposed for taxonomic codification of biological entities adaptable to machine handling.

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The vast accumulation of biological data presents the ever-increasing problem of filing these data in an easily accessible manner. Since efficient methods of coding quantitative and qualitative data and the use of machine methods have proved their value in business and in the medical profession, it is time that more workers in the biological fields realized the advantages of a well-organized coded system adaptable to machine sorting.

The need for a uniform taxonomic code is becoming more evident with the increasing importance of coordinating work. Some workers are attempting to solve the problem of coding in their fields of special interest. G. Congdon Wood (*1*) compiled an unpublished list of 24 such people in the United States, Canada, England, Italy, and Africa. Of the 24 listed, there are 14 people, representing as many organizations, using a coding system for sorting data. We believe that the code proposed in this article could serve the needs of all biological fields, including our own separate fields.

One of the primary purposes of coding biological information is to facilitate the sorting of mass data by a machine system. The increasing number of subjects to be filed has overtaxed filing systems that use a cross-filing index as the only means of extracting data. The coding of all biological entities would serve as a tool for extracting data and would not affect the present taxonomic nomenclature. A uniform code would permit the rapid exchange of information between organizations, and duplicate cards could be made available to workers interested in coded information. Mass statistical data could be extracted from these coded files by machine in a minimum period of time and with a high degree of accuracy.

Since quantitative and qualitative data can be coded, the first problem is to decide what coding system would best meet the needs of biological workers. A coding system permitting almost unlimited expansion within a category should be selected.

A central clearinghouse for the coding of all biological entities should be created and supported by those interested in such an undertaking. This would necessitate the employment of a full-time staff of specialists, which would include animal and plant taxonomists and trained specialists who would operate the machine system. For uniformity of coding, the proposed clearinghouse should assign all code numbers, and these numbers should be sent to those organizations working with the animals or plants, or both, that are being coded.

Open-Ended Code

The Entomology Department of the State Plant Board of Florida and the Statistical Laboratory of the University of Florida have adopted an open-ended code for the coding of all biological entities. This code may be described best as an "open-ended group classification code." The taxonomic coding of biolog-

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