the 48-hr stage. No significant reduction of hatchability of the bobwhite eggs by high temperatures was evident.

It seems probable that vulnerability of pheasant embryos to air temperature during the laying period has an important influence in limiting the southern distribution of pheasants. Pheasants reported breeding locally in the southern Pacific Coast and Rocky Mountain regions may be predominantly of southern Asiatic origin, and possibly thus more tolerant of higher temperatures.

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Distribution of Absorbed Energy around a Point Source of β Radiation[1]

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The radiation dose delivered to tissue by sources of β radiation distributed through the tissue is easily computed in the interior of a uniform distribution in homogeneous tissue (*1*). The energy delivered to the tissue per second is just the energy emitted by the β radiation per second. Moreover, on the edge of such a homogeneous distribution, at a surface facing tissue free of β emitter, the dose is just half that at the interior. These two simple statements exhaust the generally available information on the distribution of tissue dose caused by β emitters. In order to compute the absorbed energy (or observed ionization) about an arbitrary distribution, it is necessary to know the spherically symmetrical function which gives these quantities as a function of distance from a point source of β radiation in absorbing material.

The direct measurement of the radial ionization function around a point source presents a difficult experimental problem. If attempted in unit density material, the spherical isoionization surfaces will not conform to a practical ionization chamber. If attempted in air, the scattering off the source, external objects, and the ionization chamber will be sources of error, as well as absorption in the walls of the ionization chamber. By using a plane source and plane ionization chamber in unit density material, these difficulties can be avoided. The method is based on the fact that the ionization per cc (I_v) in a vanishingly small cavity in an absorbing material traversed by a flux of ionizing radiation is related to the energy absorbed per cc (E_v) by the equation

$$I_v = E_v/\rho W,$$

where ρ is the stopping power of the absorbing material relative to the gas in the cavity, and W is the average energy per ion pair formed in the gas of the cavity for the ionizing particles (*2*).

Consider now a point source of β radiation in an "infinite" (i.e., larger than the maximum β range) block of unit density absorbing material of low atomic number. Let the energy absorbed in a very thin spherical shell around the point source be

$$4\pi r^2 I(r)\,dr \text{ energy/disintegration.}$$

Then the total energy absorbed per distintegration is the average β particle energy

$$\overline{E}_\beta = 4\pi \int_0^\infty r^2 I(r)\,dr.$$

By straightforward integration of $I(r)$, and using the first equation given, it follows that the ionization that will occur in a very thin, plane air gap parallel to a very thin, plane source in a large block of material is given by

$$D(z) = \frac{2\pi\sigma}{\rho W}\int_z^\infty rI(r)\,dr \text{ ion pairs/cc},$$

where σ is the surface intensity of the source in disintegrations/cm^2, and z is the perpendicular distance from the source to the air gap. It is easy to show that

$$\sigma = 2\kappa\rho W/\overline{E}_\beta, \qquad \text{where } \kappa = \int_0^\infty D(z)\,dz.$$

It follows that the point source function can be obtained from the equation

$$I(r) = \frac{\overline{E}_\beta}{4\pi\kappa}\,\frac{1}{r}\left(-\frac{dD}{dr}\right) \text{ (energy/disintegration)/cc.}$$

Thus we have an explicit method of computing the radial energy absorption about a point source of β radiation, if measurements are made of the ionization normal to a very thin source. It is seen that $D(z)$ may be arbitrarily multiplied by any constant without affecting the value of $I(r)$. As a result, only relative ionization measurements need be made. Moreover, the numerical value of ρ and W do not enter into the calculation of $I(r)$, to the extent that they are independent of the energy of the β particles.

The experiment has been performed with radioactive phosphorus. Sources not thicker than 0.05 mg/cm^2 were prepared by spraying a solution of P^{32} onto a plane block of polystyrene with a penicillin nebulizer. The absorbing material was sprayed carbon of about 0.1 mg/cm^2, nylon of about 1 mg/cm^2, and polystyrene from 2 to 10^4 mg/cm^2. Measurements were made in a parallel-plate ionization chamber of variable air gap, using a vibrating reed electrometer.[2] The electrodes were carbon-sprayed onto

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[2] The basic design of the ionization chamber used is that of G. Failla and N. Baily, of the College of Physicians and Surgeons, New York City. The instrument was designed and constructed by the Instruments Branch, Medical Division, New York Office, AEC (H. D. LeVine, chief, and H. J. DiGiovanni, assistant chief).

polystyrene or nylon, to a thickness of not greater than 0.1 mg/cm². The collecting diameter was defined by a circle scribed in the carbon and was surrounded by a guard ring. The air gap was determined by a capacity measurement for each measurement of ionization current. The ionization per unit volume was determined for several different air gaps, and extrapolated to zero air gap, for each absorber thickness. The measuring volume was at all times surrounded by an "infinite" thickness of polystyrene.

The observed ionization due to the thin sources had the functional form

$$D(z) = A - B \ln z \qquad 0 < z < 200 \text{ mg/cm}^2$$
$$D(z) = C \exp(-\mu z) \qquad 80 < z.$$

The constants A, B, and the joining point z_1 can be determined in terms of μ by using the conditions that $D(z)$, the point source function $I(r)$, and the first derivative of $I(r)$ must be continuous at the joining point. The remaining constant, C, can be fixed at any convenient value, because of the arbitrary multiplicative constant in $D(z)$. Then the ionization, in arbitrary units, normal to a thin plane source is given by

$$D(z) = 1 - \ln \mu z \qquad 0 < \mu z \leq 1$$
$$D(z) = \exp(1 - \mu z) \qquad 1 \leq \mu z,$$

where $\mu z_1 = 1$. It is found experimentally that $\mu = 9.10$ cm²/g, and hence $z_1 = 110$ mg/cm² for P^{32}. Since the last equations imply $\kappa = 3/\mu$, we get for the distribution of absorbed energy around a point source of P^{32} in polystyrene

$$I(r) = \frac{\overline{E}_\beta \mu^3}{12\pi} f(\mu r) \qquad \text{(energy/dis)/cc,}$$
$$\text{where } f(\mu r) = 1/(\mu r)^2, \qquad 0 < \mu r \leq 1$$
$$f(\mu r) = (1/\mu r)\exp(1 - \mu r), \quad 1 \leq \mu r.$$

It is implied that the point source is contained in a block of the absorbing material larger in all directions than the maximum range of the β particles. Then the dose at a distance r from a small volume dV cc containing C μc/g of β emitter is given by

$$0.0608\ \overline{E}_\beta C f(\mu r) \mu^3\, dV \quad \text{rep/hr,}$$

where now $\overline{E}_\beta$ is the average β energy per disintegration in mev and has the value 0.695 for P^{32} (*3*). The rep (roentgen equivalent physical) has been taken as 93 ergs/g of absorbed energy (*4*), so the resultant dose rate will be 12% lower than in earlier publications, which used the figure 83 ergs/g (*1*). In using this formula for computation, the products μr and $\mu^3 dV$ are dimensionless. With this result, it is a straightforward matter to compute the dose due to any known distribution of β emitter, though only the relatively simple sources such as plane slabs and spheres can be computed in analytic form.

The noteworthy features of the result are these: (1) the dose is given by simple, analytical functions; (2) only two physical parameters are involved in the calculations, $\overline{E}_\beta$ and μ, the first affecting the magnitude and the second the distribution of the dose; (3) the entire dose distribution calculation can be carried out in dimensionless equations if the unit of distance is taken as $z_1 = 1/\mu$; and (4) the initial attenuation around a point source is inverse square.

The experimental value of $D(z)$ is actually not exponential out to the end of the β range, as the equations would imply, but begins to be measurably less than the exponential values for $z \geqq 400$ mg/cm². The intensity at these distances is, however, so small that, at least for biological and medical dose calculations, the equations as stated are entirely adequate.

A few measurements are available on thick sources of other isotopes (*5*). From these it is provisionally concluded that the same type of analysis can be made for other β emitters, and that the product $\mu\overline{E}_\beta$ is approximately constant for all β emitters. Under these circumstances, a calculation of dose distribution for β sources in tissue can be made in dimensionless form, and then applied to any β-emitting isotope for which the mean β energy is known or can be computed. Measurements on other isotopes are now under way. Full details will be published elsewhere.

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Errors of Combustion of Compounds for C^{14} Analysis[1]

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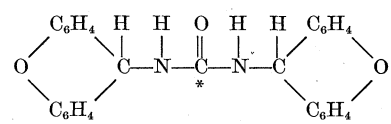
The precipitation of xanthydrol ureide affords a simple method for the isolation of urea from urine and has been used for this purpose in tracer studies with radiocarbon (*5, 13*). Xanthydrol ureide labeled with radiocarbon only in the urea residue, as indicated in the formula below by an asterisk, was prepared in a previous study (*3*) from the urine of a rat.



Large discrepancies were noted between C^{14} assay of some of the preparations of barium carbonate obtained by wet oxidation of the compound with the Van Slyke-Folch (*12*) solution, when the technique described by Lindenbaum, Schubert, and Armstrong was used (*6*). The investiga-

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