

APPENDIX I

SPECIFIC ABSORBED FRACTIONS OF PHOTON ENERGIES FOR REFERENCE MAN

DOSE from nonpenetrating radiation, i.e., beta-like and alpha radiation, is absorbed within relatively short distances from the source. However, for photons (that is, penetrating radiation) much of the body may be irradiated by a source in one organ. The fraction of energy absorbed in a target organ T of that emitted in a source organ S is termed the absorbed fraction and is denoted by $\varphi (T \leftarrow S)$ (ref. 1). The fraction of energy absorbed per gram of the target organ is termed the specific absorbed fraction and is denoted by $\Phi (T \leftarrow S)$ (ref. 1). It is this latter quantity that is tabulated in Table I.2 of this appendix as a dosimetric characteristic of reference man. Clearly, the dose to T from photons emitted from the source in S is given by

$$D (T \leftarrow S) = 51.1 U (S) \sum_{\gamma} f_{\gamma} E_{\gamma} \Phi_{\gamma} (T \leftarrow S) \quad (\text{rads}), \quad (1)$$

where 51.1 represents (g-rads/MeV)/ $\mu\text{Ci-day}$, $U(S)$ is the $\mu\text{Ci-days}$ of the source in S , E_{γ} is the energy of a photon of yield f_{γ} per disintegration, and $\Phi_{\gamma} (T \leftarrow S)$ is the specific absorbed fraction mentioned above.

To be exact, the value of Φ_{γ} will depend upon the distribution of the activity in S , but biological data on this distribution are so sparse that one generally makes the simplifying assumption that it is uniformly distributed. That assumption is made here, and consequently the values tabulated are all for sources uniformly distributed in a source organ. For example, the values tabulated for total body (TB) must not be used for the total $\mu\text{Ci-days}$ accumulated in the body unless they are distributed in a fairly uniform manner. In many cases, this total $\mu\text{Ci-days}$ in the body can be grouped into one portion which is fairly uniform in distribution but with a certain number of other organs in which there is an excess, or a deficiency, of $\mu\text{Ci-days/g}$. The total dose to a target organ can then be obtained as a sum or difference of the doses from the source in the total body and of the excess or deficiency in these other organs.

Most of the data are those computed by the Monte Carlo method, using the anthropomorphic phantom described in ref. 2. The source was placed in 16 different "organs" including the total body, and only results for which the coefficient of variation ($\text{CV} = 100 \sigma/m$) did not exceed 50% are given. Twelve source energies ranging from 10 keV to 4 MeV were used in all cases, and the sample size was at least 60,000 photons. Values not obtained in this way are distinguished in the tables by various insignia, and these are now discussed.

Red bone marrow has been distinguished as a target organ but has not been used as a source organ. The distribution of red marrow used is that given in Table 31 (p. 91). The four sections of the gastrointestinal tract and the bladder were considered as solid organs in ref. 2. This was done to obtain better statistics. However, when the source is in the contents of these organs, the dose varies by as much as a factor of 2 in the wall and the contents. In Table I.2, the values of Φ for these five organs were obtained on the basis of new Monte Carlo type calculations using a phantom such that the organs and their contents were separated except in the case of the small intestine. No standard configuration for the small intestine was found except for the two ends of the tube, and thus the wall and contents are considered to occupy a certain volume without specification of walls and contents. These organs, and other organs of the revised phantom as used in the above calculations, have the masses listed in Table I.1 which contains the masses of the various

TABLE I.1. MASSES OF ORGANS OF THE PHANTOMS USED IN ESTIMATING SPECIFIC ABSORBED FRACTIONS

Body organ	Phantom of MIRD 5	Revised phantom
Bladder	502 ^(a)	45.1 walls; 200 contents
Stomach	397 ^(a)	150 walls; 247 contents
Small intestine	1,670 ^(a)	1,040 walls plus contents
Upper large intestine	411 ^(a)	209 walls; 220 contents
Lower large intestine	272 ^(a)	160 walls; 137 contents
Kidneys (both)	284	284
Liver	1,810	1,810
Lungs	999	999
"Other tissue" (muscle, fat, etc.)	48,700	48,200
Ovaries (both)	8.27	8.27
Pancreas	60.3	60.3
Skeleton	10,100	10,500
Total marrow	3,820	3,000
Red bone marrow		1,500
Skin	2,560	2,830
Spleen	174	174
Testes (both)	37.1	37.1
Thymus	24.8	24.8
Thyroid	19.6	19.6
Uterus	65.4	65.4
Total body	70,200	69,900

^(a) Weight of walls plus contents.

organs as used in the earlier calculations. The bladder is assumed to consist of a wall of 45 g surrounding 200 ml of contents. This value is less than half that indicated in ref. 2 where the size was chosen to represent a rather full bladder. All estimates of Φ obtained by a Monte Carlo calculation are based on the revised phantom unless there is some other designation on the target organ. In comparing results with those published previously in MIRD Pamphlet No. 5, the results will frequently be found to differ. This difference is due to the statistical character of the estimate as well as to the fact that the estimate of ϕ varies with the mass of the target organ. That is, if M^* and M are, respectively, the newer mass and the mass used in the earlier model for the target organ, one should have

$$\varphi(T^* \leftarrow S) = (T \leftarrow S) \frac{M^*}{M}$$

and hence

$$\Phi(T^* \leftarrow S) = \Phi(T \leftarrow S).$$

The specific absorbed fraction is known to be relatively insensitive to the mass of the target organ for which it is defined provided the source is not in the organ (refs. 1; 3). The scaling procedure used would be expected to provide a reasonably accurate estimate in these cases. Since the specific absorbed fraction remains unchanged, such values may be regarded as obtained from the MIRD Pamphlet No. 5 calculation or, alternatively, as the result of scaling φ and then converting to Φ .

It has been found that the specific absorbed fraction obtained by integrating the buildup factor for an infinite homogeneous medium does not differ by more than a factor of 2 from the results obtained reliably from the Monte Carlo estimates using the phantom. Moreover, as the statistics of the Monte Carlo estimates are improved, the disagreement is reduced to 20–30% (refs. 4–6). When the coefficient of variation of the Monte Carlo estimate exceeds 50%, an estimate obtained by integrating the buildup factor formula is used instead. This formula is

$$\Phi(T \leftarrow S) = \frac{1}{|S| |T|} \int_S dx \int_T dy \frac{\mu_{ab} e^{-\mu|x-y|}}{4\pi|x-y|^2} B(\mu|x-y|), \quad (2)$$

where μ and μ_{ab} are the mass attenuation and mass absorption coefficients for water, respectively; $|S|$ and $|T|$ denote the volumes of S and T , the source and target organs, respectively; and B is the buildup factor tabulated by Berger (ref. 7). Actually, Berger supplied data to 40 mean-free paths to the authors, and his polynomial approximations to this data were used. The method is explained in refs. 4 and 5 and consisted of a Monte Carlo evaluation of eq. (2). The estimate was used only when the coefficient of variation of the estimate of eq. (2) did not exceed 20%. Values in Table I.2 obtained by this procedure are distinguished by the sign †.

Several corrections were made to these values because of the inhomogeneity of the body and its organs. It was found that when bone was a target organ, the results were low as compared with the Monte Carlo calculated values in all the cases where energy was less than 0.2 MeV. This is precisely the energy region in which bone may be expected to have a higher mass absorption coefficient, and when the estimates obtained from eq. (2) were multiplied by $\sigma_{ab}^{\text{bone}}/\sigma_{ab}^{\text{water}}$, they appeared to agree more closely with the Monte Carlo estimates. Actually, this correction was used in Table I.2 only for a few cases at photon energies below 30 keV, the Monte Carlo results being sufficiently accurate in other cases. It is clear this correction would be needed on the basis of the difference of bone and water for absorption of energy. At low energies, a factor of $1/0.3 = 3.3$ was used whenever lung was the source. Although made largely on empirical grounds, it appears that some such factor might be required at low energies, since the amount of radiation effectively escaping from the lungs would differ considerably from that escaping from an organ with specific gravity 1. However, the correction is made on an empirical basis and is only used if photon energy is less than 100 keV. Values obtained by use of either of these adjustment factors are distinguished in Table I.2 by the symbol \oplus .

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY

† Build-up factor method. ⊕ Adjustment on density or composition. * Extrapolation from higher energy. ⊗ Calculated by difference.
Source in *Bladder Contents*

Target	Energy (MeV)					
	0.010	0.015	0.020	0.030	0.050	0.100
Bladder wall	8.49E-04	1.40E-03	1.43E-03	9.83E-04	4.49E-04	2.56E-04
Stomach wall	2.83E-18*	4.25E-18†	1.20E-11†	3.28E-08†	4.53E-07	1.05E-06
Small intestine plus contents	1.52E-10*	2.28E-10†	1.76E-07	5.11E-06	1.24E-05	1.22E-05
Upper large intestine wall	1.71E-10*	2.57E-10†	1.02E-07†	3.04E-06	8.59E-06	8.31E-06
Lower large intestine wall	3.42E-07*	5.12E-07	7.80E-06	3.51E-05	4.16E-05	3.01E-05
Kidneys	1.52E-19*	2.28E-19†	3.95E-12†	2.46E-08†	4.05E-07	9.98E-07
Liver	2.61E-19*	3.91E-19†	2.37E-12†	2.05E-08	2.72E-07	5.55E-07
Lungs	4.25E-29*	6.39E-29†	5.55E-17†	7.65E-11†	1.31E-08	8.89E-08
"Other tissues" (suggested for muscle)	2.00E-07⊗	2.02E-06⊗	5.42E-06⊗	9.69E-06⊗	9.26E-06⊗	6.86E-06⊗
Ovaries	6.23E-09*	9.35E-09†	1.62E-06†	2.78E-05	3.58E-05	2.82E-05
Pancreas	3.63E-22*	5.45E-22†	2.11E-13†	6.51E-09†	2.92E-07	7.24E-07
Skeleton (suggested for total endosteal cells)	2.56E-11*	3.84E-11⊕	1.60E-08	1.16E-06	4.30E-06	4.06E-06
Red marrow	2.84E-08*	4.25E-08*	5.67E-08	3.88E-06	1.23E-05	1.00E-05
Skin	2.66E-08*	3.99E-08	3.75E-07	1.70E-06	2.26E-06	2.12E-06
Spleen	2.63E-22*	3.94E-22†	1.52E-13†	4.78E-09†	1.96E-07	3.87E-06
Testes	1.79E-09*	2.69E-09†	1.39E-06	1.54E-05	2.75E-05	1.88E-05
Thymus	5.91E-37*	8.87E-37†	1.32E-20†	2.05E-12†	2.06E-09†	2.67E-08†
Thyroid	6.20E-25*	9.31E-25*	1.24E-24†	2.86E-14†	1.55E-10†	4.05E-09†
Uterus	3.88E-06*	5.83E-06	4.28E-05	1.09E-04	1.02E-04	6.21E-05
Total body	1.43E-05	1.43E-05	1.42E-05	1.31E-05	1.00E-05	7.28E-06
Target	Energy (MeV)					
	0.200	0.500	1.000	1.500	2.000	4.000
Bladder wall	2.47E-04	2.56E-04	2.22E-04	2.07E-04	1.97E-04	1.57E-04
Stomach wall	1.02E-06	1.10E-06	1.86E-06	1.30E-06	1.83E-06	1.53E-06
Small intestine plus contents	1.03E-05	8.97E-06	8.84E-06	8.17E-06	8.42E-06	6.65E-06
Upper large intestine wall	8.37E-06	8.18E-06	6.19E-06	6.15E-06	5.80E-06	5.29E-06
Lower large intestine wall	2.51E-05	2.44E-05	2.09E-05	2.16E-05	2.02E-05	1.36E-05
Kidneys	1.00E-06	1.33E-06	1.17E-06	1.69E-06	1.26E-06	1.37E-06
Liver	7.70E-07	9.76E-07	1.02E-06	9.60E-07	1.19E-06	1.04E-06
Lungs	9.33E-08	1.65E-07	2.83E-07	3.07E-07	3.31E-07	4.61E-07
"Other tissues" (suggested for muscle)	6.28E-06⊗	6.13E-06⊗	5.71E-06⊗	5.42E-06⊗	5.11E-06⊗	4.27E-06⊗
Ovaries	2.72E-05	2.17E-05	1.35E-05	2.31E-05	1.66E-05	1.48E-05
Pancreas	1.10E-06	8.92E-07	1.00E-06	8.00E-07	1.40E-06	8.26E-07
Skeleton (suggested for total endosteal cells)	2.70E-06	2.03E-06	1.78E-06	1.72E-06	1.71E-06	1.55E-06
Red marrow	6.10E-06	4.33E-06	3.72E-06	3.47E-06	3.36E-06	3.07E-06
Skin	2.01E-06	2.24E-06	2.35E-06	2.22E-06	2.12E-06	1.89E-06
Spleen	5.29E-07	7.80E-07	8.59E-07	6.34E-07	1.12E-06	4.63E-07
Testes	1.59E-05	1.75E-05	1.57E-05	1.28E-05	1.40E-05	1.21E-05
Thymus	6.22E-08†	1.10E-07†	1.54E-07†	1.78E-07†	1.94E-07†	2.10E-07†
Thyroid	1.33E-08†	3.27E-08†	5.68E-08†	7.33E-08†	8.55E-08†	1.05E-07†
Uterus	5.51E-05	5.11E-05	4.68E-05	3.98E-05	4.04E-05	3.30E-05
Total body	6.58E-06	6.44E-06	5.98E-06	5.63E-06	5.35E-06	4.44E-06

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)
 † Build-up factor method. ⊕ Adjustment on density or composition. * Extrapolation from higher energy. ⊗ Calculated by difference.
 Source in Stomach Contents

Target	0.010	0.015	0.020	0.030	0.050	0.100
Bladder wall	1.61E-18*	2.41E-18†	8.64E-12†	2.82E-08†	5.32E-07	1.17E-06
Stomach wall	3.21E-04	7.61E-04	8.96E-04	6.87E-04	1.88E-04	1.88E-04
Small intestine plus contents	1.99E-07*	2.99E-07	1.23E-06	6.72E-06	1.22E-05	1.08E-05
Upper large intestine wall	8.09E-07*	1.21E-06	5.67E-06	1.62E-05	1.90E-05	1.40E-05
Lower large intestine wall	1.71E-09*	2.56E-09†	2.80E-07	1.83E-06	4.78E-06	4.44E-06
Kidneys	3.83E-10*	5.74E-10†	4.17E-07	8.18E-06	1.65E-05	1.36E-05
Liver	2.14E-07*	3.22E-07*	4.29E-07	3.99E-06	8.27E-06	8.06E-06
Lungs	1.76E-07*	2.64E-07	2.60E-06	7.91E-06	9.61E-06	6.92E-06
"Other tissues" (suggested for muscle)	3.98E-08⊗	1.15E-06⊗	3.92E-06⊗	7.64E-06⊗	7.31E-06⊗	5.37E-06⊗
Ovaries	1.99E-14*	2.98E-14†	1.05E-09†	2.89E-07†	2.36E-06†	2.13E-06
Pancreas	8.30E-06*	1.24E-05	6.95E-05	1.40E-04	1.12E-04	7.10E-05
Skeleton (suggested for total endosteal cells)	3.86E-08*	5.79E-08	6.31E-07	3.05E-06	5.52E-06	4.00E-06
Red marrow	4.00E-08*	6.00E-08	6.67E-07	3.65E-06	8.53E-06	7.12E-06
Skin	1.38E-08*	2.07E-08	3.62E-07	1.53E-06	1.94E-06	1.66E-06
Spleen	1.12E-07*	1.69E-07†	1.06E-05	5.19E-05	5.98E-05	3.96E-05
Testes	3.42E-26*	5.13E-26†	1.89E-15†	5.20E-10†	5.50E-08†	1.58E-07
Thymus	2.19E-18*	3.29E-18†	1.18E-11†	3.41E-08†	1.58E-06	1.07E-06
Thyroid	5.67E-26*	8.51E-26†	2.27E-15†	5.70E-10†	5.82E-08†	2.59E-07
Uterus	7.51E-16*	1.13E-15†	2.81E-10†	1.90E-07†	1.45E-06	2.90E-06
Total body	1.43E-05	1.43E-05	1.42E-05	1.31E-05	9.75E-06	6.87E-06

Target	0.200	0.500	1.000	1.500	2.000	4.000
Bladder wall	7.91E-07	1.58E-06	1.65E-06	1.48E-06	1.03E-06	1.44E-06
Stomach wall	1.78E-04	1.79E-04	1.65E-04	1.48E-04	1.41E-04	1.15E-04
Small intestine plus contents	9.27E-06	9.08E-06	8.16E-06	7.37E-06	7.66E-06	6.38E-06
Upper large intestine wall	1.26E-05	1.13E-05	9.62E-06	1.17E-05	8.40E-06	7.91E-06
Lower large intestine wall	4.65E-06	4.35E-06	4.53E-06	4.51E-06	3.98E-06	2.76E-06
Kidneys	1.26E-05	1.13E-05	1.06E-05	9.84E-06	8.97E-06	7.42E-06
Liver	7.00E-06	7.02E-06	6.34E-06	6.15E-06	6.20E-06	4.89E-06
Lungs	5.97E-06	6.40E-06	5.72E-06	5.51E-06	4.91E-06	4.28E-06
"Other tissues" (suggested for muscle)	4.96E-06⊗	4.84E-06⊗	4.60E-06⊗	4.38E-06⊗	4.10E-06⊗	3.45E-06⊗
Ovaries	1.53E-06	1.70E-06	5.09E-06	3.02E-06†	2.86E-06†	2.42E-06†
Pancreas	6.37E-05	6.02E-05	5.23E-05	5.06E-05	4.40E-05	3.39E-05
Skeleton (suggested for total endosteal cells)	2.59E-06	2.08E-06	1.89E-06	1.79E-06	1.73E-06	1.61E-06
Red marrow	4.64E-06	3.61E-06	3.18E-06	2.90E-06	2.78E-06	2.66E-06
Skin	1.67E-06	2.04E-06	2.07E-06	1.96E-06	2.09E-06	1.70E-06
Spleen	3.56E-05	3.26E-05	3.04E-05	2.80E-05	2.49E-05	1.84E-05
Testes	2.41E-07	8.06E-08	5.72E-07†	5.91E-07†	5.95E-07†	5.61E-07†
Thymus	8.91E-07	7.81E-07	2.87E-06	2.26E-06	1.65E-06	1.42E-06†
Thyroid	4.35E-07†	5.26E-07†	5.82E-07†	5.96E-07†	6.02E-07†	5.67E-07†
Uterus	2.97E-06	3.08E-06	3.22E-06	3.28E-06	2.54E-06	4.00E-06
Total body	6.21E-06	6.11E-06	5.74E-06	5.39E-06	5.07E-06	4.22E-06

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)

Target	Energy (MeV)				
	0.010	0.015	0.020	0.030	0.100
Bladder wall	4.21E - 10*	6.31E - 10†	1.74E - 07†	5.86E - 06	1.02E - 05
Stomach wall	5.69E - 07	1.80E - 06	8.17E - 06	1.42E - 05	1.45E - 05
Small intestine plus contents	7.40E - 04	6.61E - 04	5.60E - 04	3.71E - 04	1.13E - 04
Upper large intestine wall	4.50E - 04	4.48E - 04	3.95E - 04	2.74E - 04	8.66E - 05
Lower large intestine wall	2.81E - 05	5.12E - 05	8.43E - 05	6.33E - 05	2.82E - 05
Kidneys	4.94E - 09*	7.41E - 09†	8.43E - 07	6.92E - 06	1.30E - 05
Liver	7.60E - 08	3.52E - 07	1.33E - 06	4.59E - 06	7.17E - 06
Lungs	4.44E - 18*	6.67E - 18†	9.65E - 12†	6.31E - 08	7.93E - 07
"Other tissues" (suggested for muscle)	6.96E - 07⊗	2.14E - 06⊗	4.24E - 06⊗	7.31E - 06⊗	5.95E - 06⊗
Ovaries	1.38E - 05*	2.07E - 05	4.43E - 05	6.26E - 05	4.23E - 05
Pancreas	2.64E - 11*	3.96E - 11†	4.11E - 08†	2.45E - 06	8.13E - 06
Skeleton (suggested for total endosteal cells)	2.15E - 07	7.10E - 07	1.79E - 06	5.23E - 06	5.61E - 06
Red marrow	9.04E - 07	2.97E - 06	7.39E - 06	2.08E - 05	1.92E - 05
Skin	5.31E - 08*	7.96E - 08†	1.06E - 07	7.67E - 07	1.49E - 06
Spleen	2.12E - 10*	3.18E - 10†	6.00E - 08†	2.67E - 06	5.95E - 06
Testes	2.76E - 18*	4.13E - 18†	1.68E - 11†	4.80E - 08†	1.10E - 06
Thymus	1.05E - 26*	1.58E - 26†	1.07E - 15†	4.01E - 10†	2.52E - 07†
Thyroid	4.34E - 35*	6.50E - 35†	1.11E - 19†	5.17E - 12†	3.84E - 08†
Uterus	1.36E - 06*	2.05E - 06	1.97E - 05	5.49E - 05	3.83E - 05
Total body	1.43E - 05	1.43E - 05	1.43E - 05	1.37E - 05	7.82E - 06
				Energy (MeV)	
				1.500	4.000
Bladder wall	9.28E - 06	1.18E - 05	6.79E - 06	1.07E - 05	5.56E - 06
Stomach wall	1.31E - 05	1.16E - 05	1.14E - 05	1.08E - 05	7.84E - 06
Small intestine plus contents	1.07E - 04	1.07E - 04	9.57E - 05	9.07E - 05	6.68E - 05
Upper large intestine wall	8.23E - 05	7.83E - 05	7.21E - 05	6.69E - 05	4.98E - 05
Lower large intestine wall	2.52E - 05	2.32E - 05	2.19E - 05	2.03E - 05	1.63E - 05
Kidneys	1.08E - 05	1.09E - 05	1.03E - 05	8.67E - 06	6.26E - 06
Liver	6.64E - 06	6.20E - 06	6.11E - 06	5.67E - 06	4.39E - 06
Lungs	9.02E - 07	1.16E - 06	1.17E - 06	1.07E - 06	1.13E - 06
"Other tissues" (suggested for muscle)	5.51E - 06⊗	5.33E - 06⊗	5.00E - 06⊗	4.73E - 06⊗	3.77E - 06⊗
Ovaries	3.75E - 05	3.00E - 05	3.39E - 05	2.31E - 05	2.81E - 05
Pancreas	7.30E - 06	7.17E - 06	6.55E - 06	5.08E - 06	5.21E - 06
Skeleton (suggested for total endosteal cells)	3.54E - 06	2.69E - 06	2.53E - 06	2.34E - 06	1.95E - 06
Red marrow	1.16E - 05	8.57E - 06	7.78E - 06	7.07E - 06	5.52E - 06
Skin	1.63E - 06	1.83E - 06	1.93E - 06	1.97E - 06	1.54E - 06
Spleen	5.55E - 06	5.41E - 06	5.05E - 06	5.28E - 06	3.59E - 06
Testes	1.28E - 06	1.24E - 06	1.79E - 06	1.92E - 06	1.18E - 06
Thymus	3.89E - 07†	4.81E - 07†	5.38E - 07†	5.54E - 07†	5.34E - 07†
Thyroid	8.31E - 08†	1.38E - 07†	1.85E - 07†	2.10E - 07†	2.40E - 07†
Uterus	3.31E - 05	2.99E - 05	2.71E - 05	2.42E - 05	1.85E - 05
Total body	7.02E - 06	6.74E - 06	6.27E - 06	5.92E - 06	4.60E - 06

† Build-up factor method. ⊕ Adjustment on density or composition. * Extrapolation from higher energy. ⊗ Calculated by difference.

Source in *Small Intestine Plus Wall*

TABLE 1.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)
 † Build-up factor method. ‡ Adjustment on density or composition. * Extrapolation from higher energy. ⊗ Calculated by difference.
 Source in Upper Large Intestine Contents

Target	Energy (MeV)					
	0.010	0.015	0.020	0.030	0.050	0.100
Bladder wall	3.32E-10*	4.97E-10†	1.25E-07†	3.87E-06	7.40E-06	8.92E-06
Stomach wall	2.11E-06*	3.16E-06	1.14E-05	2.22E-05	2.05E-05	1.49E-05
Small intestine plus contents	5.46E-06	5.06E-05	1.19E-04	1.50E-04	1.03E-04	6.49E-05
Upper large intestine wall	3.63E-04	8.01E-04	8.62E-04	5.77E-04	2.61E-04	1.52E-04
Lower large intestine wall	2.47E-06*	3.70E-06	1.14E-05	1.81E-05	1.51E-05	1.30E-05
Kidneys	3.18E-10*	4.77E-10†	3.55E-07	5.76E-06	1.25E-05	1.14E-05
Liver	1.58E-07*	2.37E-07	1.93E-06	7.43E-06	1.18E-05	1.00E-05
Lungs	3.97E-18*	5.95E-18†	1.18E-11†	7.16E-08	6.14E-07	9.96E-07
"Other tissues" (suggested for muscle)	7.42E-08⊗	8.77E-07⊗	3.19E-06⊗	6.95E-06⊗	7.28E-06⊗	5.74E-06⊗
Ovaries	2.01E-05*	3.02E-05	5.33E-05	7.41E-05	5.59E-05	4.53E-05
Pancreas	2.25E-11*	3.38E-11†	5.01E-08†	2.71E-06	8.10E-06	9.01E-06
Skeleton (suggested for total endosteal cells)	1.64E-07*	2.47E-07	1.37E-06	4.87E-06	7.35E-06	5.08E-06
Red marrow	6.91E-07*	1.04E-06	5.73E-06	1.93E-05	2.62E-05	1.66E-05
Skin	8.49E-10*	1.34E-09†	9.59E-08	9.69E-07	1.64E-06	1.52E-06
Spleen	5.77E-11*	8.66E-11†	5.09E-08†	1.57E-06	6.08E-06	5.82E-06
Testes	1.23E-17*	1.85E-17†	2.55E-11†	4.81E-08†	5.08E-07	9.33E-07
Thymus	1.34E-26*	2.02E-26†	1.58E-15†	5.43E-10†	5.78E-08†	3.51E-07
Thyroid	5.27E-35*	7.90E-35†	1.59E-19†	6.86E-12†	4.15E-09†	4.30E-08†
Uterus	4.28E-09*	6.41E-09†	1.21E-06	1.39E-05	2.81E-05	2.27E-05
Total body	1.43E-05	1.43E-05	1.43E-05	1.35E-05	1.05E-05	7.61E-06
	0.200	0.500	1.000	1.500	2.000	4.000
Bladder wall	7.67E-06	6.53E-06	7.06E-06	4.83E-06	7.28E-06	4.26E-06
Stomach wall	1.32E-05	1.24E-05	1.16E-05	9.48E-06	1.01E-05	7.76E-06
Small intestine plus contents	5.89E-05	5.61E-05	5.05E-05	4.54E-05	4.21E-05	3.29E-05
Upper large intestine wall	1.47E-04	1.47E-04	1.39E-04	1.24E-04	1.18E-04	9.33E-05
Lower large intestine wall	1.06E-05	1.03E-05	1.08E-05	8.63E-06	8.14E-06	5.99E-06
Kidneys	9.84E-06	9.32E-06	9.40E-06	8.59E-06	7.31E-06	6.25E-06
Liver	9.31E-06	8.45E-06	8.11E-06	7.67E-06	7.24E-06	6.32E-06
Lungs	9.83E-07	1.17E-06	1.38E-06	1.43E-06	1.28E-06	1.13E-06
"Other tissues" (suggested for muscle)	5.22E-06⊗	5.10E-06⊗	4.80E-06⊗	4.55E-06⊗	4.36E-06⊗	3.60E-06⊗
Ovaries	4.10E-05	4.39E-05	2.31E-05	1.87E-05	3.33E-05	2.08E-05
Pancreas	8.74E-06	6.11E-06	6.85E-06	6.31E-06	7.00E-06	7.77E-06
Skeleton (suggested for total endosteal cells)	3.18E-06	2.49E-06	2.21E-06	2.13E-06	2.04E-06	1.75E-06
Red marrow	9.96E-06	7.45E-06	6.40E-06	6.05E-06	5.86E-06	4.85E-06
Skin	1.63E-06	1.92E-06	1.87E-06	1.86E-06	1.82E-06	1.76E-06
Spleen	5.01E-06	4.21E-06	4.55E-06	4.73E-06	3.66E-06	3.79E-06
Testes	1.15E-06	1.78E-06	1.92E-06	1.30E-06	1.74E-06†	1.51E-06†
Thymus	4.33E-07†	5.27E-07†	5.80E-07†	5.94E-07†	6.01E-07†	5.66E-07†
Thyroid	9.11E-08†	1.48E-07†	1.95E-07†	2.21E-07†	2.37E-07†	2.49E-07†
Uterus	1.68E-05	1.53E-05	1.53E-05	1.55E-05	1.44E-05	1.16E-05
Total body	6.79E-06	6.57E-06	6.17E-06	5.77E-06	5.46E-06	4.50E-06

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)

† Build-up factor method. ⊕ Adjustment on density or composition. * Extrapolation from higher energy. ⊗ Calculated by difference.
 Source in Lower Large Intestine Contents

Target	Energy (MeV)					
	0.010	0.015	0.020	0.030	0.050	0.100
Bladder wall	1.38E-07*	2.08E-07†	6.01E-06	2.70E-05	3.34E-05	2.80E-05
Stomach wall	1.25E-08*	1.88E-08†	8.62E-07	5.03E-06	7.97E-06	6.96E-06
Small intestine plus contents	2.42E-06	2.78E-05	6.14E-05	7.81E-05	5.42E-05	3.65E-05
Upper large intestine wall	1.03E-05	2.22E-05	3.16E-05	3.07E-05	2.21E-05	1.61E-05
Lower large intestine wall	5.53E-04	1.13E-03	1.16E-03	7.02E-04	2.97E-04	1.76E-04
Kidneys	4.24E-12*	6.36E-12†	1.31E-08†	8.91E-07	2.59E-06	3.12E-06
Liver	2.92E-17*	4.38E-17†	2.34E-11†	3.25E-08	4.60E-07	8.95E-07
Lungs	2.61E-17*	3.92E-20†	4.15E-13†	2.91E-09†	1.15E-07	2.87E-07
"Other tissues" (suggested for muscle)	6.79E-08⊗	1.35E-06⊗	4.12E-06⊗	7.92E-06⊗	8.26E-06⊗	6.51E-06⊗
Ovaries	4.10E-05*	6.16E-05	1.62E-04	1.77E-04	1.06E-04	6.25E-05
Pancreas	1.71E-14*	2.57E-14†	1.18E-09†	5.69E-07	1.69E-06	3.05E-06
Skeleton (suggested for total endosteal cells)	4.30E-08	1.36E-06	5.69E-06	1.31E-05	1.30E-05	7.25E-06
Red marrow	1.81E-07	5.70E-06	2.37E-05	5.24E-05	4.68E-05	2.28E-05
Skin	8.10E-08	2.36E-07	4.75E-07	1.14E-06	1.88E-06	1.79E-06
Spleen	1.52E-12*	2.29E-12†	7.72E-09†	7.72E-07	3.20E-06	3.22E-06
Testes	4.67E-10*	7.01E-10†	2.21E-07†	4.41E-06	8.59E-06	6.27E-06
Thymus	1.02E-29*	1.53E-29†	2.27E-17†	4.46E-11†	1.03E-08†	7.60E-08†
Thyroid	1.05E-37*	1.58E-37†	3.76E-21†	7.26E-13†	8.56E-10†	1.26E-08†
Uterus	5.13E-09*	7.69E-09†	2.33E-06	2.25E-05	3.65E-05	2.79E-05
Total body	1.43E-05	1.43E-05	1.43E-05	1.37E-05	1.08E-05	7.62E-06

Target	Energy (MeV)					
	0.200	0.500	1.000	1.500	2.000	4.000
Bladder wall	2.34E-05	1.94E-05	1.62E-05	2.02E-05	1.67E-05	1.04E-05
Stomach wall	6.34E-06	6.23E-06	4.98E-06	4.73E-06	5.49E-06	4.92E-06
Small intestine plus contents	3.32E-05	3.07E-05	2.84E-05	2.64E-05	2.51E-05	1.99E-05
Upper large intestine wall	1.50E-05	1.45E-05	1.25E-05	1.35E-05	1.08E-05	9.87E-06
Lower large intestine wall	1.74E-04	1.77E-04	1.62E-04	1.52E-04	1.39E-04	1.08E-04
Kidneys	3.47E-06	2.84E-06	3.08E-06	2.98E-06	3.54E-06	2.50E-06
Liver	1.02E-06	1.19E-06	1.29E-06	1.50E-06	1.24E-06	1.18E-06
Lungs	3.14E-07	3.49E-07	5.49E-07	5.49E-07	7.81E-07	5.78E-07
"Other tissues" (suggested for muscle)	6.01E-06⊗	5.84E-06⊗	5.48E-06⊗	5.18E-06⊗	4.89E-06⊗	4.09E-06⊗
Ovaries	7.13E-05	5.42E-05	5.50E-05	5.02E-05	4.63E-05	3.51E-05
Pancreas	2.49E-06	2.58E-06	2.43E-06	2.00E-06	2.48E-06	1.45E-06
Skeleton (suggested for total endosteal cells)	4.49E-06	3.59E-06	3.25E-06	3.02E-06	2.97E-06	2.43E-06
Red marrow	1.36E-05	1.07E-05	9.65E-06	8.77E-06	8.46E-06	6.82E-06
Skin	1.89E-06	2.03E-06	2.05E-06	2.23E-06	2.03E-06	1.85E-06
Spleen	2.76E-06	3.24E-06	3.56E-06	3.05E-06	3.20E-06	2.22E-06
Testes	7.25E-06	7.14E-06	4.86E-06	4.82E-06	6.10E-06	3.92E-06
Thymus	1.39E-07†	2.01E-07†	2.51E-07†	2.74E-07†	2.89E-07†	2.93E-07†
Thyroid	3.19E-08†	6.26E-08†	9.34E-08†	1.13E-07†	1.27E-07†	1.45E-07†
Uterus	2.53E-05	1.91E-05	1.79E-05	1.78E-05	1.52E-05	1.29E-05
Total body	6.77E-06	6.53E-06	6.10E-06	5.76E-06	5.44E-06	4.48E-06

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)

† Build-up factor method. ⊕ Adjustment on density or composition. * Extrapolation from higher energy. ⊗ Calculated by difference.
Source in Kidneys

Target	Energy (MeV)				
	0.010	0.015	0.020	0.030	0.100
Bladder wall	4.59E-19*	6.88E-19†	5.48E-12†	2.72E-08†	1.04E-06
Stomach wall	1.35E-09*	2.03E-09†	5.45E-07	7.99E-06	1.47E-05
Small intestine plus contents	6.51E-09*	9.77E-09†	9.63E-07	6.48E-06	1.14E-05
Upper large intestine wall	7.46E-10*	1.12E-09†	3.70E-07	6.25E-06	1.13E-05
Lower large intestine wall	8.29E-12*	1.24E-11†	1.16E-08†	6.63E-07	2.49E-06
Kidneys	3.28E-03	2.74E-03	2.04E-03	1.03E-03	2.35E-04
Liver	4.43E-07*	6.65E-07	4.68E-06	1.54E-05	1.53E-05
Lungs	3.57E-08*	5.36E-08*	7.15E-08	1.18E-06	3.37E-06
"Other tissues" (suggested for muscle)	1.42E-06⊗	4.42E-06⊗	7.39E-06⊗	8.82E-06⊗	5.12E-06⊗
Ovaries	3.68E-14*	5.53E-14†	1.76E-09†	4.81E-07†	4.13E-06
Pancreas	2.34E-08*	3.51E-08†	4.45E-06	2.44E-05	2.63E-05
Skeleton (suggested for: total endosteal cells)	2.24E-07*	3.36E-07	2.18E-06	7.54E-06	6.40E-06
Red marrow	5.99E-07*	8.99E-07	5.72E-06	2.01E-05	1.69E-05
Skin	1.66E-07*	2.49E-07	1.16E-06	2.50E-06	1.93E-06
Spleen	6.19E-06*	9.28E-06	3.63E-05	6.69E-05	3.30E-05
Testes	4.39E-27*	6.58E-27†	8.52E-16†	4.33E-10†	2.76E-07†
Thymus	7.07E-22*	1.06E-21†	2.52E-13†	6.17E-09†	8.06E-07
Thyroid	8.15E-30*	1.22E-29†	3.87E-17†	9.30E-11†	1.40E-07†
Uterus	1.46E-15*	2.19E-15†	4.32E-10†	3.26E-07	3.31E-06
Total body	1.43E-05	1.43E-05	1.40E-05	1.23E-05	6.45E-06
Bladder wall	1.12E-06	1.32E-06	1.59E-06	1.47E-06	1.92E-06
Stomach wall	1.20E-05	1.16E-05	1.07E-05	8.44E-06	8.14E-06
Small intestine plus contents	1.02E-05	9.42E-06	9.02E-06	8.91E-06	6.66E-06
Upper large intestine wall	1.03E-05	9.90E-06	9.20E-06	9.23E-06	6.25E-06
Lower large intestine wall	3.05E-06	3.03E-06	2.84E-06	3.39E-06	2.52E-06
Kidneys	2.39E-04	2.52E-04	2.26E-04	2.14E-04	1.63E-04
Liver	1.36E-05	1.38E-05	1.22E-05	1.15E-05	8.79E-06
Lungs	2.99E-06	3.28E-06	3.30E-06	2.96E-06	2.72E-06
"Other tissues" (suggested for muscle)	4.95E-06⊗	4.93E-06⊗	4.71E-06⊗	4.47E-06⊗	3.55E-06⊗
Ovaries	4.44E-06	3.96E-06	5.43E-06	3.83E-06†	1.77E-08
Pancreas	2.28E-05	2.25E-05	2.24E-05	1.96E-05	1.47E-05
Skeleton (suggested for: total endosteal cells)	4.06E-06	3.39E-06	3.10E-06	2.99E-06	2.46E-06
Red marrow	1.05E-05	8.59E-06	7.77E-06	7.43E-06	5.85E-06
Skin	2.06E-06	2.29E-06	2.24E-06	2.13E-06	1.89E-06
Spleen	3.11E-05	2.85E-05	2.70E-05	2.41E-05	1.73E-05
Testes	4.23E-07†	5.18E-07†	5.77E-07†	5.93E-07†	5.65E-07†
Thymus	6.92E-07	1.41E-06	2.72E-07	1.13E-06†	9.90E-07†
Thyroid	2.42E-07†	3.27E-07†	3.86E-07†	4.11E-07†	4.15E-07†
Uterus	3.91E-06	2.87E-06	2.77E-06	3.66E-06	3.98E-06
Total body	5.90E-06	5.84E-06	5.48E-06	5.21E-06	4.12E-06

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)

† Build-up factor method. ⊕ Adjustment on density or composition. * Extrapolation from higher energy. ⊗ Calculated by difference. Source in Lungs

Target	Energy (MeV)				
	0.010	0.015	0.020	0.030	0.100
Bladder wall	3.53E-28*	5.30E-28⊕	2.65E-16⊕	2.75E-10⊕	5.21E-08⊕
Stomach wall	5.37E-07*	8.05E-07	3.45E-06	8.04E-06	9.44E-06
Small intestine plus contents	1.65E-17*	2.47E-17⊕	2.92E-11⊕	4.67E-08	3.60E-07
Upper large intestine wall	2.53E-17*	3.80E-17⊕	4.52E-11⊕	7.70E-08	5.12E-07
Lower large intestine wall	6.26E-20*	9.39E-20⊕	1.13E-12⊕	7.29E-09⊕	8.32E-08
Kidneys	6.42E-11*	9.64E-11⊕	5.81E-08⊕	1.24E-06	3.25E-06
Liver	7.16E-08	2.28E-06	7.25E-06	1.40E-05	1.29E-05
Lungs	8.17E-04	6.58E-04	4.71E-04	2.30E-04	8.99E-05
"Other tissues" (suggested for muscle)	3.89E-06⊗	6.82E-06⊗	9.44E-06⊗	1.00E-05⊗	7.05E-06⊗
Ovaries	5.25E-24*	7.88E-24⊕	3.48E-14⊕	3.13E-09⊕	2.30E-07⊕
Pancreas	8.53E-09*	1.28E-08⊕	6.38E-07	9.00E-06	1.27E-05
Skeleton (suggested for total endosteal cells)	2.71E-08	7.11E-07	3.56E-06	1.04E-05	1.20E-05
Red marrow	2.81E-08	7.53E-07	3.97E-06	1.20E-05	1.46E-05
Skin	4.70E-08*	7.05E-08	6.44E-07	1.94E-06	2.19E-06
Spleen	6.63E-07*	9.95E-07	4.70E-06	1.27E-05	1.10E-05
Testes	8.51E-36*	1.28E-35⊕	5.76E-20⊕	5.56E-12⊕	5.03E-09⊕
Thymus	2.22E-07*	3.33E-07⊕	3.35E-06	1.78E-05	2.09E-05
Thyroid	4.05E-12*	6.07E-12⊕	2.29E-08⊕	8.09E-07	2.30E-06
Uterus	3.81E-25*	5.72E-25⊕	1.11E-14⊕	2.07E-09⊕	1.86E-07
Total body	1.43E-05	1.43E-05	1.41E-05	1.26E-05	8.78E-06
Bladder wall	1.83E-07†	2.55E-07†	3.09E-07†	3.32E-07†	3.43E-07†
Stomach wall	6.61E-06	6.32E-06	6.34E-06	6.14E-06	6.45E-06
Small intestine plus contents	7.14E-07	9.57E-07	1.08E-06	1.04E-06	1.16E-06
Upper large intestine wall	8.57E-07	1.32E-06	1.38E-06	1.45E-06	1.37E-06
Lower large intestine wall	4.05E-07	2.69E-07	3.21E-07	2.13E-07	2.34E-07
Kidneys	3.14E-06	3.61E-06	3.22E-06	3.61E-06	2.31E-06
Liver	8.81E-06	8.18E-06	7.72E-06	7.20E-06	6.52E-06
Lungs	5.00E-05	5.01E-05	4.55E-05	4.32E-05	3.92E-05
"Other tissues" (suggested for muscle)	4.61E-06⊗	4.62E-06⊗	4.31E-06⊗	4.04E-06⊗	3.81E-06⊗
Ovaries	4.41E-07†	5.28E-07†	5.74E-07†	5.87E-07†	5.94E-07†
Pancreas	8.94E-06	9.63E-06	7.11E-06	7.54E-06	5.86E-06
Skeleton (suggested for total endosteal cells)	4.08E-06	3.45E-06	3.17E-06	2.87E-06	2.93E-06
Red marrow	5.21E-06	4.35E-06	4.02E-06	3.69E-06	3.70E-06
Skin	2.10E-06	2.34E-06	2.30E-06	2.25E-06	2.16E-06
Spleen	8.18E-06	7.31E-06	7.18E-06	5.31E-06	6.23E-06
Testes	4.62E-08†	8.43E-08†	1.22E-07†	1.43E-07†	1.58E-07†
Thymus	1.42E-05	1.26E-05	1.37E-05	1.35E-05	1.17E-05
Thyroid	2.97E-06	4.15E-06	4.66E-06	2.75E-06	3.00E-06
Uterus	3.53E-07	3.29E-07	4.05E-07	9.28E-07	5.55E-07
Total body	5.11E-06	4.99E-06	4.66E-06	4.36E-06	4.12E-06

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)

Target	Energy (MeV)				
	0.010	0.015	0.020	0.030	0.050
Bladder wall	1.79E-08*	2.69E-08†	3.42E-06	2.65E-05	3.99E-05
Stomach wall	8.09E-14*	1.21E-13†	2.07E-09†	5.22E-07	2.40E-06
Small intestine plus contents	2.87E-06	2.23E-05	5.91E-05	9.45E-05	7.22E-05
Upper large intestine wall	8.94E-06	6.76E-05	1.08E-04	1.03E-04	6.38E-05
Lower large intestine wall	9.94E-06	8.15E-05	1.46E-04	1.45E-04	8.86E-05
Kidneys	3.71E-14*	5.56E-14†	1.90E-09†	5.45E-07	2.64E-06
Liver	1.05E-14*	1.58E-14†	5.74E-10†	2.42E-07	1.34E-06
Lungs	5.12E-26*	7.68E-26†	1.02E-14†	9.26E-10†	8.58E-08
"Other tissues" (suggested for muscle)	4.11E-06⊗	9.31E-06⊗	1.19E-05⊗	1.23E-05⊗	1.00E-05⊗
Ovaries	9.68E-02	5.91E-02	3.26E-02	1.15E-02	3.58E-03
Pancreas	4.74E-18*	7.10E-18†	3.03E-11†	7.93E-08†	8.55E-07
Skeleton (suggested for total endosteal cells)	2.70E-08*	4.06E-08	1.39E-06	7.90E-06	1.14E-05
Red marrow	1.14E-07*	1.71E-07	5.85E-06	3.28E-05	4.51E-05
Skin	8.61E-12*	1.29E-11†	1.85E-08	5.06E-07	1.35E-06
Spleen	1.02E-16*	1.53E-16†	7.80E-11†	9.57E-08	1.03E-06
Thymus	3.01E-33*	4.51E-33†	1.05E-18†	1.83E-11†	8.00E-09†
Thyroid	2.30E-23*	3.45E-23*	4.61E-23†	2.50E-13†	5.98E-10†
Uterus	1.82E-06*	2.74E-06	5.12E-05	1.44E-04	1.26E-04
Total body	1.43E-05	1.43E-05	1.43E-05	1.39E-05	1.13E-05
					2.50E-05
					1.51E-06
					1.77E-06
					7.15E-08†
					1.09E-08†
					8.03E-05
					8.10E-06
					4.75E-06⊗
					1.72E-03
					2.66E-06
					2.16E-06
					6.32E-06
					1.52E-06
					1.98E-06
					3.13E-07†
					1.51E-07†
					3.91E-05
					4.70E-06
					5.65E-06
					8.06E-06
					1.56E-06
					2.52E-06
					3.08E-07†
					1.31E-07†
					4.77E-05
					5.65E-06
					8.06E-06
					1.52E-06
					1.98E-06
					3.13E-07†
					1.51E-07†
					3.91E-05
					4.70E-06
					5.65E-06
					8.06E-06
					1.56E-06
					2.52E-06
					3.08E-07†
					1.31E-07†
					4.77E-05
					5.65E-06
					8.06E-06
					1.52E-06
					1.98E-06
					3.13E-07†
					1.51E-07†
					3.91E-05
					4.70E-06
					5.65E-06
					8.06E-06
					1.56E-06
					2.52E-06
					3.08E-07†
					1.31E-07†
					4.77E-05
					5.65E-06
					8.06E-06
					1.52E-06
					1.98E-06
					3.13E-07†
					1.51E-07†
					3.91E-05
					4.70E-06
					5.65E-06
					8.06E-06
					1.52E-06
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					3.13E-07†
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					3.91E-05
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					1.31E-07†
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					1.51E-07†
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					3.08E-07†
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					3.13E-07†
					1.51E-07†
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					1.56E-06
					2.52E-06
					3.08E-07†
					1.31E-07†
					4.77E-05
					5.65E-06
					8.06E-06
					1.52E-06
					1.98E-06
					3.13E-07†
					1.51E-07†
					3.91E-05
					4.70E-06
					5.65E-06
					8.06E-06
					1.56E-06
					2.52E-06
					3.08E-07†
					1.31E-07†
					4.77E-05
					5.65E-06
					8.06E-06
					1.52E-06
					1.98E-06
					3.13E-07†
					1.51E-07†
					3.91E-05
					4.70E-06
					5.65E-06
					8.06E-06
					1.56E-06
					2.52E-06
					3.08E-07†
					1.31E-07†
					4.77E-05
					5.65E-06
					8.06E-06
					1.52E-06
					1.98E-06
					3.13E-07†
					1.51E-07†
					3.91E-05
					4.70E-06
					5.65E-06
					8.06E-06
					1.56E-06
					2.52E-06
					3.08E-

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)

† Build-up factor method. ⊕ Adjustment on density or composition. * Extrapolation from higher energy. ⊗ Calculated by difference.
 Source in Skeleton (suggested for Cancellous Bone, Cortical Bone, Red Marrow, and Yellow Marrow)

Target	Energy (MeV)						
	0.010	0.015	0.020	0.030	0.050	0.100	
Bladder wall	2.27E-11*	3.40E-11†	2.00E-08†	2.96E-07	1.51E-06	2.12E-06	
Stomach wall	1.45E-07*	2.18E-07*	2.90E-07	1.06E-06	1.73E-06	2.11E-06	
Small intestine plus contents	1.52E-07*	2.28E-07	5.01E-07	1.69E-06	3.09E-06	2.81E-06	
Upper large intestine wall	2.12E-07*	3.17E-07	6.44E-07	1.38E-06	2.57E-06	2.56E-06	
Lower large intestine wall	6.48E-07*	9.71E-07	1.84E-06	3.46E-06	4.10E-06	3.97E-06	
Kidneys	3.02E-07*	4.54E-07*	6.05E-07	1.81E-06	3.26E-06	3.01E-06	
Liver	1.24E-07*	1.87E-07	4.79E-07	1.67E-06	2.37E-06	2.55E-06	
Lungs	1.69E-07*	2.54E-07	1.04E-06	3.20E-06	4.42E-06	3.63E-06	
"Other tissues" (suggested for muscle)	3.85E-07*⊗	9.43E-07⊗	1.63E-06⊗	3.06E-06⊗	3.82E-06⊗	3.66E-06⊗	
Ovaries	2.12E-08*	3.18E-08†	9.03E-07†	3.85E-06†	3.20E-06	2.81E-06	
Pancreas	3.91E-07*	5.87E-07*	7.83E-07†	1.39E-06	3.22E-06	2.78E-06	
Skeleton (suggested for total endosteal cells)	9.34E-05	8.97E-05	8.42E-05	6.84E-05	4.10E-05	1.81E-05	
Red marrow	9.42E-05	8.85E-05	8.31E-05	6.45E-05	3.77E-05	1.65E-05	
Skin	4.95E-07	1.18E-06	1.85E-06	2.27E-06	2.40E-06	2.35E-06	
Spleen	6.52E-07*	9.78E-07*	1.30E-06*	1.96E-06	2.76E-06	2.09E-06	
Testes	1.81E-11*	2.71E-11†	2.22E-08†	8.29E-07†	1.73E-06	2.59E-06	
Thymus	2.85E-07*	4.27E-07*	5.69E-07†	7.64E-07	1.87E-06	2.19E-06	
Thyroid	1.32E-07*	1.98E-07*	2.64E-07†	1.94E-06†	2.91E-06	2.76E-06	
Uterus	9.28E-11*	1.39E-10†	4.96E-08†	1.23E-06	1.63E-06	2.11E-06	
Total body	1.43E-05	1.42E-05	1.40E-05	1.28E-05	9.31E-06	5.73E-06	
							4.000
							2.000
							1.500
							1.000
							0.500
							0.200
Bladder wall	1.68E-06	2.28E-06	1.37E-06	2.56E-06	1.87E-06	1.94E-06	
Stomach wall	2.07E-06	2.02E-06	1.76E-06	1.90E-06	1.72E-06	1.48E-06	
Small intestine plus contents	2.73E-06	2.77E-06	2.79E-06	2.36E-06	2.35E-06	1.98E-06	
Upper large intestine wall	2.67E-06	2.40E-06	2.61E-06	2.33E-06	2.32E-06	1.77E-06	
Lower large intestine wall	3.82E-06	3.24E-06	3.58E-06	3.03E-06	2.72E-06	2.54E-06	
Kidneys	3.29E-06	3.12E-06	4.02E-06	3.16E-06	2.43E-06	2.32E-06	
Liver	2.39E-06	2.44E-06	2.41E-06	2.30E-06	2.50E-06	2.05E-06	
Lungs	3.50E-06	3.38E-06	3.29E-06	3.03E-06	3.09E-06	2.30E-06	
"Other tissues" (suggested for muscle)	3.74E-06⊗	3.82E-06⊗	3.67E-06⊗	3.54E-06⊗	3.33E-06⊗	2.83E-06⊗	
Ovaries	2.46E-06	3.75E-06	3.16E-06†	2.79E-06†	2.75E-06†	2.22E-06†	
Pancreas	3.90E-06	3.11E-06	3.29E-06	3.71E-06	3.50E-06	1.59E-06	
Skeleton (suggested for total endosteal cells)	1.29E-05	1.19E-05	1.11E-05	1.01E-05	9.39E-06	7.79E-06	
Red marrow	1.15E-05	1.06E-05	1.01E-05	9.19E-06	8.37E-06	7.06E-06	
Skin	2.63E-06	3.00E-06	2.87E-06	2.85E-06	2.62E-06	2.46E-06	
Spleen	2.32E-06	2.90E-06	2.96E-06	2.02E-06	2.17E-06	1.23E-06	
Testes	2.23E-06	1.98E-06	2.24E-06	2.37E-06	3.88E-06	2.13E-06	
Thymus	1.65E-06	2.64E-06	2.84E-06	1.41E-06	2.17E-06†	2.78E-06	
Thyroid	3.31E-06	3.86E-06	1.60E-06	3.82E-06	1.82E-07	1.91E-06†	
Uterus	2.24E-06	1.97E-06	3.15E-06	1.98E-06	1.57E-06	1.65E-06	
Total body	5.01E-06	4.93E-06	4.70E-06	4.43E-06	4.16E-06	3.50E-06	

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)

Target	Source in Skin				
	0.010	0.015	0.020	0.030	0.100
Bladder wall	2.14E-07*	3.20E-07*	4.27E-07	1.91E-06	1.94E-06
Stomach wall	2.74E-07*	4.11E-07*	5.48E-07	2.02E-06	2.58E-06
Small intestine plus contents	6.45E-08*	9.68E-08*	1.29E-07	8.64E-07	1.72E-06
Upper large intestine wall	1.26E-07*	1.89E-07*	2.52E-07	1.19E-06	1.95E-06
Lower large intestine wall	5.72E-08*	8.59E-08*	1.14E-07	9.04E-07	1.65E-06
Kidneys	1.82E-07*	2.72E-07	1.18E-06	2.81E-06	2.08E-06
Liver	4.77E-08*	7.15E-08	4.86E-07	1.78E-06	2.01E-06
Lungs	8.04E-08*	1.21E-07	7.45E-07	2.54E-06	2.17E-06
"Other tissues" (suggested for muscle)	4.00E-06⊗	6.06E-06⊗	6.46E-06⊗	5.41E-06⊗	3.48E-06⊗
Ovaries	8.61E-12*	1.29E-11†	1.93E-08†	7.68E-07†	1.86E-06
Pancreas	1.41E-08*	2.12E-08*	2.83E-08†	9.03E-07	1.45E-06
Skeleton (suggested for total endosteal cells)	1.85E-06	4.30E-06	6.58E-06	8.80E-06	8.06E-06
Red marrow	1.61E-06	3.90E-06	5.97E-06	7.98E-06	4.02E-06
Skin	2.05E-04	1.03E-04	5.57E-05	2.24E-05	5.33E-06
Spleen	1.67E-07*	2.50E-07*	3.34E-07	1.57E-06	2.03E-06
Testes	8.27E-07	5.82E-06	8.59E-06	9.45E-06	4.85E-06
Thymus	1.88E-08*	2.82E-08†	5.47E-07	1.56E-06	2.27E-06
Thyroid	1.25E-06*	1.88E-06*	2.50E-06	5.24E-06	2.22E-06
Uterus	5.17E-08*	7.75E-08*	1.03E-07	6.49E-07	2.50E-06
Total body	1.13E-05	9.06E-06	7.77E-06	6.17E-06	1.61E-06
					2.87E-06
					4.21E-06
					7.39E-06
					8.07E-06
					2.49E-06
					4.85E-06
					3.04E-06
					2.27E-06
					1.84E-06
					1.61E-06
					2.87E-06
					4.02E-06
					5.33E-06
					2.03E-06
					3.04E-06
					2.22E-06
					2.50E-06
					1.61E-06
					2.87E-06
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					1.61E-06
					2.87E-06
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					1.61E-06
					2.87E-06
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					7.39E-06
					8.07E-06
					2.49E-06
					4.85E-06
					3.04E-06
					2.27E-06
					1.84E-06
					1.61E-06
					2.87E-06
					4.02E-06
					5.33E-06
					2.03E-06
					3.04E-06
					2.22E-06
					2.50E-06
					1.61E-06
					2.87E-06
					4.21E-06
					7.39E-06
					8.07E-06
					2.49E-06
					4.85E-06
					3.04E-06
					2.27E-06
					1.84E-06
					1.61E-06
					2.87E-06
					4.02E-06
					5.33E-06
					2.03E-06
					3.04E-06
					2.22E-06
					2.50E-06
					1.61E-06
					2.87E-06
					4.21E-06
					7.39E-06
					8.07E-06
					2.49E-06
					4.85E-06
					3.04E-06
					2.27E-06
					1.84E-06

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)

† Build-up factor method. ⊕ Adjustment on density or composition. * Extrapolation from higher energy. ⊗ Calculated by difference.
Source in Testes

Target	Energy (MeV)					
	0.010	0.015	0.020	0.030	0.050	0.100
Bladder wall	5.00E-09*	7.50E-09†	2.26E-06	1.74E-05	2.51E-05	1.89E-05
Stomach wall	1.39E-25*	2.08E-25†	3.73E-15†	6.66E-10†	6.18E-08	8.57E-08
Small intestine plus contents	2.67E-18*	4.01E-18†	1.62E-11†	4.66E-08	8.04E-07	1.25E-06
Upper large intestine wall	1.35E-17*	2.03E-17†	2.75E-11†	4.78E-08†	6.70E-07	1.06E-06
Lower large intestine wall	1.30E-09*	1.95E-09†	7.90E-07	6.85E-06	1.31E-05	1.06E-05
Kidneys	4.67E-27*	7.01E-27†	9.01E-16†	4.33E-10†	3.81E-08	1.16E-07
Liver	2.58E-26*	3.87E-26†	9.61E-16†	2.74E-10†	2.73E-08	9.67E-08
Lungs	2.24E-36*	3.36E-36†	1.83E-20†	1.65E-12†	1.49E-09†	1.23E-08
"Other tissues" (suggested for muscle)	4.99E-08*	7.21E-07*	2.66E-06*	5.71E-06*	5.52E-06*	4.28E-06*
Pancreas	9.64E-30*	1.45E-29†	4.97E-17†	1.17E-10†	2.49E-08†	1.63E-07†
Skeleton (suggested for total endosteal cells)	7.33E-11*	1.10E-10*	2.40E-08	1.15E-06	4.36E-06	4.01E-06
Red marrow	3.24E-09*	4.86E-09*	6.49E-09	6.46E-07	3.22E-06	3.12E-06
Skin	1.47E-06	9.12E-06	1.53E-05	1.39E-05	7.51E-06	4.93E-06
Spleen	1.31E-29*	1.97E-29†	4.57E-17†	9.84E-11†	2.10E-08†	6.08E-08
Testes	2.43E-02	1.86E-02	1.23E-02	5.34E-03	1.77E-03	1.07E-03
Thymus	2.20E-24*	3.30E-24*	4.40E-24†	5.01E-14†	2.17E-10†	5.16E-09†
Thyroid	2.50E-28*	3.75E-28*	5.00E-28†	7.32E-16†	1.68E-11†	7.89E-10†
Total body	1.43E-05	1.38E-05	1.26E-05	1.00E-05	6.84E-06	5.03E-06
Bladder wall	1.70E-05	1.75E-05	1.74E-05	1.38E-05	1.35E-05	9.58E-06
Stomach wall	1.71E-07	4.07E-07	2.71E-07	4.06E-07	4.80E-07	4.52E-07
Small intestine plus contents	1.50E-06	1.85E-06	1.78E-06	1.78E-06	1.86E-06	1.58E-06
Upper large intestine wall	1.33E-06	1.10E-06	1.40E-06	1.16E-06	2.30E-06	1.42E-06
Lower large intestine wall	9.91E-06	9.83E-06	7.24E-06	7.98E-06	7.32E-06	7.40E-06
Kidneys	2.04E-07	3.51E-07	5.07E-07	5.63E-07	4.05E-07	7.27E-07
Liver	1.48E-07	1.77E-07	3.61E-07	4.16E-07	4.07E-07	3.97E-07
Lungs	4.38E-08	4.94E-08	1.01E-07	1.60E-07	1.20E-07	1.68E-07
"Other tissues" (suggested for muscle)	4.14E-06*	4.27E-06*	4.08E-06*	3.97E-06*	4.59E-06*	3.20E-06*
Pancreas	2.76E-07†	1.28E-07	3.61E-07	4.50E-07†	6.34E-07	4.48E-07†
Skeleton (suggested for total endosteal cells)	2.73E-06	2.28E-06	2.15E-06	2.00E-06	1.95E-06	1.71E-06
Red marrow	2.25E-06	1.81E-06	1.69E-06	1.51E-06	1.61E-06	1.41E-06
Skin	5.13E-06	5.48E-06	5.15E-06	5.11E-06	4.59E-06	3.93E-06
Spleen	7.38E-08	4.55E-07	2.12E-07	2.38E-07	5.73E-07	2.33E-07
Testes	1.17E-03	1.23E-03	1.16E-03	1.04E-03	9.82E-04	7.66E-04
Thymus	1.62E-08†	3.82E-08†	6.43E-08†	8.18E-08†	9.46E-08†	1.14E-07†
Thyroid	3.53E-09†	1.17E-08†	2.46E-08†	3.51E-08†	4.35E-08†	6.00E-08†
Total body	4.82E-06	4.91E-06	4.69E-06	4.47E-06	4.23E-06	3.54E-06

TABLE I.2. SPECIFIC ABSORBED FRACTION OF PHOTON ENERGY (cont.)
 † Build-up factor method. † Adjustment on density or composition. * Extrapolation from higher energy. ⊗ Calculated by difference.
 Source in Thyroid

Target	Energy (MeV)					
	0.010	0.015	0.020	0.030	0.050	0.100
Bladder wall	8.78E-25*	1.32E-24*	1.76E-24†	3.15E-14†	1.61E-10†	4.12E-09†
Stomach wall	2.07E-25*	3.11E-25†	4.50E-15†	7.26E-10†	2.01E-07	1.90E-07
Small intestine plus contents	4.58E-35*	6.87E-35†	1.08E-19†	5.26E-12†	3.49E-09†	1.97E-08
Upper large intestine wall	9.33E-35*	1.40E-34†	1.88E-19†	7.08E-12†	4.20E-09†	4.35E-08†
Lower large intestine wall	8.33E-38*	1.25E-37†	2.75E-21†	5.66E-13†	6.64E-10†	1.00E-08†
Kidneys	8.87E-30*	1.33E-29†	3.98E-17†	9.31E-11†	2.06E-08†	1.20E-07
Liver	1.26E-24*	1.90E-24†	1.16E-14†	1.19E-09†	1.93E-07	3.05E-07
Lungs	1.52E-13*	2.28E-12†	3.30E-08	1.23E-06	3.89E-06	3.67E-06
"Other tissues" (suggested for muscle)	3.35E-06⊗	8.66E-06⊗	1.19E-05⊗	1.16E-05⊗	7.22E-06⊗	4.81E-06⊗
Ovaries	2.33E-23*	3.50E-23*	4.66E-23†	2.50E-13†	5.97E-10†	1.09E-08†
Pancreas	1.24E-26*	1.86E-26†	2.08E-15†	7.80E-10†	7.98E-08†	1.91E-07
Skeleton (suggested for total endosteal cells)	1.79E-09*	2.69E-09	2.84E-07	2.99E-06	6.35E-06	4.45E-06
Red marrow	2.68E-09*	4.02E-09	3.14E-07	2.74E-06	6.46E-06	4.87E-06
Skin	5.06E-07*	7.59E-07	3.26E-06	5.35E-06	3.66E-06	2.64E-06
Spleen	6.81E-27*	1.02E-26†	9.64E-16†	4.29E-10†	1.16E-07	3.75E-07
Testes	2.48E-28*	3.72E-28*	4.96E-28†	7.32E-16†	1.67E-11†	7.87E-10†
Thymus	1.23E-09*	1.84E-09†	2.53E-07	1.13E-05	2.28E-05	1.65E-05
Thyroid	4.29E-02	2.93E-02	1.81E-02	7.41E-03	2.42E-03	1.44E-03
Uterus	5.98E-24*	8.97E-24*	1.20E-23†	2.03E-13†	5.28E-10†	9.99E-09†
Total body	1.43E-05	1.42E-05	1.35E-05	1.08E-05	6.95E-06	4.71E-06

Target	Energy (MeV)					
	0.200	0.500	1.000	1.500	2.000	4.000
Bladder wall	1.35E-08†	3.30E-08†	5.71E-08†	7.36E-08†	8.56E-08†	1.05E-07†
Stomach wall	1.45E-07	4.44E-07	4.62E-07	6.42E-07	3.70E-07	5.20E-07
Small intestine plus contents	5.80E-08	2.47E-08	1.38E-07	1.91E-07	1.92E-07	2.04E-07
Upper large intestine wall	4.03E-08	3.63E-08	1.51E-07	2.29E-07	1.85E-07	3.92E-07
Lower large intestine wall	2.59E-08†	5.22E-08†	8.09E-08†	9.91E-08†	1.11E-07†	1.30E-07†
Kidneys	1.40E-07	1.69E-07	4.12E-07	5.96E-07	4.35E-07	3.09E-07
Liver	4.28E-07	5.49E-07	6.54E-07	7.28E-07	8.78E-07	7.72E-07
Lungs	3.38E-06	3.67E-06	3.83E-06	3.35E-06	3.17E-06	3.22E-06
"Other tissues" (suggested for muscle)	4.63E-06⊗	4.76E-06⊗	4.45E-06⊗	4.19E-06⊗	3.94E-06⊗	3.27E-06⊗
Ovaries	3.00E-08†	6.21E-08†	9.62E-08†	1.17E-07†	1.31E-07†	1.51E-07†
Pancreas	3.98E-07	2.34E-07	1.88E-07	1.49E-06	7.11E-07	6.61E-07
Skeleton (suggested for total endosteal cells)	2.98E-06	2.61E-06	2.39E-06	2.33E-06	2.23E-06	1.97E-06
Red marrow	3.27E-06	2.89E-06	2.57E-06	2.56E-06	2.47E-06	2.11E-06
Skin	2.87E-06	2.97E-06	3.07E-06	2.96E-06	2.76E-06	2.41E-06
Spleen	4.36E-07	4.40E-07	7.21E-07	6.30E-07	4.40E-07	6.85E-07
Testes	3.52E-09†	1.17E-08†	2.46E-08†	3.51E-08†	4.36E-08†	6.00E-08†
Thymus	1.52E-05	1.52E-05	1.23E-05	1.32E-05	1.46E-05	9.37E-06
Thyroid	1.55E-03	1.66E-03	1.54E-03	1.45E-03	1.31E-03	1.05E-03
Uterus	2.80E-08†	5.89E-08†	9.19E-08†	1.12E-07†	1.27E-07†	1.46E-07†
Total body	4.42E-06	4.50E-06	4.26E-06	4.03E-06	3.78E-06	3.18E-06

Unfortunately, Berger did not publish values of the buildup factor for 10 keV. Thus certain cases remain to be considered, namely, those for which the coefficient of variation of the Monte Carlo result exceeded 50% and where the estimate of eq. (2) had a coefficient of variation greater than 20%. These were obtained by extrapolation from the value obtained at the next highest energy in Table I.2. It was assumed that the value would be proportional to energy (linear extrapolation to zero) if the source was outside the organ. This is equivalent to defining the extrapolated value by

$$\Phi_{\text{ext}}(T \leftarrow S) = \frac{E}{E_0} \Phi_0(T \leftarrow S), \quad (3)$$

where $\Phi_0(T \leftarrow S)$ denotes the specific absorbed fraction at the energy E_0 next greater than E where a value is given. Values obtained in this way are distinguished by the symbol ‡ in Table I.2. This extrapolation was not needed when source and target organs were the same, as the coefficient of variation was always less than 50%.

There are a number of target and source organs indicated in Table I.2 in parentheses for which no precise representation in the older phantom is given. In some cases the listed value was computed for the organ indicated outside the parentheses, but it is suggested that the value may be regarded as a rough approximation to the value for the organs indicated in parentheses. Thus skeleton is suggested as the organ to be used if cortical or cancellous bone or red or yellow marrow are sources or as target organ if dose to total endosteal cells is required. Strictly, these approximations would not be valid for localized sources or for other forms of radiation (alphas, beta-like radiation, etc.). However, practical cases suggest that a nuclide depositing naturally in bone or in marrow will produce a dose commitment, averaged over these tissues, which is to a first approximation equal to these averages in the total marrow or in the skeleton. For such uses, this approximation may be useful.

Muscle requires special comment since there is no region of the phantom which is so designated. Whenever muscle is a target organ, it is considered as having the same specific absorbed fraction as the total body minus all the designated target organs. This compartment, termed "other tissues," totals some 48 kg, and thus includes much other tissue in addition to muscle. For example, about 12 kg of adipose tissue are included as well as some connective tissue and body fluids. However, muscle is rather well distributed throughout this mass, and hence the absorption per gram might be expected to be rather similar. Thus the indicated value of the specific absorbed fraction for "other tissues" is given as an approximate value for muscle. Similarly, when muscle is indicated as a source organ, the reciprocity theorem may be used if the statistics on the "other tissues" compartment are sufficiently accurate; that is,

$$\varphi(\text{muscle} \leftarrow X) = \varphi(\text{other tissues} \leftarrow X) \times \frac{M_{\text{muscle}}}{M_{\text{other tissues}}}, \quad (4)$$

$$\Phi_{(X \leftarrow \text{muscle})} = \Phi(\text{muscle} \leftarrow X) = \Phi(\text{other tissues} \leftarrow X), \quad (5)$$

may be used if the coefficient of variation of the compartment "other tissues" did not exceed 50%. If X in eqs. (4) and (5) denoted an organ with walls, the estimate was taken from the results of the calculation using the revised phantom. There remain a few cases where muscle is given as a source organ, but the target organ was never used as a source organ (marrow, muscle, thymus, uterus). In these cases, a specific absorbed fraction was

arrived at by use of the formula

$$\varphi (X \leftarrow \text{muscle}) = \varphi (X \leftarrow \text{other tissues}) = \frac{\left[\varphi (X \leftarrow TB) M_{TB} - \sum_Y \varphi (X \leftarrow Y) M_Y \right]}{[M_{TB} - \sum_Y M_Y]} \quad (6)$$

and hence

$$\Phi (X \leftarrow \text{muscle}) = \Phi (X \leftarrow \text{other tissues}) = \frac{\left[\Phi (X \leftarrow TB) M_{TB} - \sum_Y \Phi (X \leftarrow Y) M_Y \right]}{[M_{TB} - \sum_Y M_Y]} \quad (7)$$

indicates the fraction of energy absorbed per gram of a target organ X from the compartment "other tissues," and it is assumed this holds approximately for the muscle. In eqs. (6) and (7), Y ranges over all the source organs, and thus the bracketed terms in the numerator represent approximately a source in the "other tissues" category. In deriving eq. (6), a concentration of 1 photon/g is assumed so that the energy produced in each region equals the mass associated with the region. The values in Table I.2 obtained by any of these procedures is indicated by the symbol \otimes placed only on the source organ when muscle is the source but placed on each entry when muscle is the target organ.

REFERENCES

1. LOEVINGER, R., and M. BERMAN, A schema for absorbed-dose calculations for biologically distributed radionuclides, MIRD Pamphlet No. 1, *J. Nuclear Med. Suppl. No. 1*, 7 (Feb. 1968).
2. SNYDER, W. S. *et al.*, Estimates of absorbed fractions for monoenergetic photon sources uniformly distributed in various organs of a heterogeneous phantom, MIRD Pamphlet No. 5, *J. Nuclear Med.* **10**, 5 (1969), Suppl. No. 3.
3. SNYDER, W. S., Estimation of absorbed fraction of energy from photon sources in body organs, *Radiation Dosimetry*, Vol. 1, p. 108, Boris Kidrič Institute of Nuclear Sciences, Beograd, 1971.
4. SNYDER, W. S., M. R. FORD, and G. G. WARNER, Estimates of absorbed fractions for photon emitters within the body, *Second European Congress on Radiation Protection, Budapest, Hungary, May 3-5, 1972*.
5. SNYDER, W. S. *et al.*, Absorbed fractions for internal emitters, *Health Physics Division Annual Progress Report for Period Ending July 31, 1971*, ORNL-4720, p. 121.
6. SNYDER, W. S., M. R. FORD, and G. G. WARNER, Estimates of absorbed fractions for photon emitters within the body, *Health Physics Division Annual Progress Report for Period Ending July 31, 1972*, ORNL-4811, p. 86.
7. BERGER, M. J., Energy deposition in water by photons from point isotropic sources, MIRD Pamphlet No. 2, *J. Nuclear Med. Suppl. No. 1*, 15 (Feb. 1968).