mates of Internal Dose. Oak Ridge, TN: Oak Ridge National Laboratory, report ORNL/NUREG/TM-367.

3. Nagarajan, P. S., Wittman, A., and Burger, G., 1981. Fast neutron organ dose calculations using a MIRD phantom. In *Proc. Fourth Symp. on Neutron Dosimetry,* Vol. I Radiation Protection Aspects, G. Burger and H. G. Ebert, Eds., pp. 49-61. Luxembourg: EURATOM, report EUR 7448.
4. Kerr, G. D., 1982. *Photon and Neutron Fluence-to-Kerma Conversion Factors for ICRP-1975 Reference Man Using Improved Elemental Compositions for Bone and Marrow of the Skeleton.* Oak Ridge, TN: Oak Ridge National Laboratory, report ORNL/NUREG/TM-367.
5. Snyder, W. S., Ford, M. R., Warner, G. G., and Watson, S. B., 1974. *A Tabulation of Dose Equivalent per Microcurie-day for Source and Target Organs of an Adult for Various Radionuclides: Part 1.* Oak Ridge, TN: Oak Ridge National Laboratory, report ORNL-5000.
6. Ryman, J. C., Warner, G. G., and Eckerman, K. F., 1985. *ALGAMO - A Monte Carlo Radiation Transport Code for Calculating Specific Absorbed Fractions of Energy from Internal or External Photon Sources.* Oak Ridge, TN: Oak Ridge National Laboratory, report ORNL/TM-8377 (in preparation).
7. Fraley, S. K., 1976. *User's Guide to MORSE-SGC.* Oak Ridge , TN: Oak Ridge National Laboratory, report ORNL/CSD-7.
8. International Commission on Radiation Protection, 1975. *Report of the Task Group on Reference Man.* Oxford: Pergamon.
9. Kramer, R. and Drexler, G., 1981. Representative breast size of reference female. Health Physics 40:913-914.
10. Kramer, R., Williams, G., and Drexler, G., 1982. Reply to M. Cristy. Health Physics 43:932-935.
11. Cristy, M., 1982. Representative breast size of reference female. Health Physics 43:930-932.
12. Katch, V. L., Campaigne, B., Freedson, P., Sady, S., Katch, F. I., and Behnke, A. R., 1980. Contribution of breast volume and weight to body fat distribution in females. Am. J. Phys. Anthropol. 53:93-100.
13. Cristy, M., 1984. Calculation of annual limits of intake of radionuclides by workers: significance of breast as an explicityly represented tissue. Health Physics 46:283-291.

Chapter 8 Appendix 1a

SUMMARY OF ORGAN MASSES IN THE JAPANESE ADULT PHANTOM

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As mentioned in the text, the densities of skeletal and soft tissues used in the current ORNL phantoms and in the Japanese adult phantom (this report) were changed slightly from those used in earlier ORNL phantoms. It should be appreciated that the assumed density

Table 1. Summary of Organ Masses in Japanese Adult Phantom

Organ	Mass (g) of organ	Organ	Mass (g) of organ	Organ	Mass (g) of organ
Skeletal system—active marrow	1050	Skeletal system—total	7500	Adrenals	10.5
Leg bones—upper portion[a]	48.3	Leg bones—upper portion[a]	752	Brain	1410
Leg bones—middle portion[a]	21.4	Leg bones—middle portion[a]	1120	Breasts—including skin	310
Leg bones—lower portion[a]	0	Leg bones—lower portion[a]	923	Breasts—excluding skin	272
Arm bones—upper portion[a]	33.0	Arm bones—upper portion[a]	386	Gall bladder—wall	9.27
Arm bones—middle portion[a]	7.35	Arm bones—middle portion[a]	290	Gall bladder—contents	49.0
Arm bones—lower portion[a]	0	Arm bones—lower portion[a]	347	Gastrointestinal tract & contents	
Pelvis	353	Pelvis	645	—stomach wall	118
Spine—upper portion[b]	23.6	Spine—upper portion[b]	177	—stomach contents	195
Spine—middle portion[b]	155	Spine—middle portion[b]	583	—small intestine, wall and contents	838
Spine—lower portion[b]	87.0	Spine—lower portion[b]	220	—upper large intestine wall	168
Skull—cranium	72.8	Skull—cranium	712	—upper large intestine contents	176
Skull—facial skeleton	33.5	Skull—facial skeleton	327	—lower large intestine wall	127
Ribs	171	Ribs	744	—lower large intestine contents	109
Clavicles	10.3	Clavicles	58.3	Heart—walls	241
Scapulae	34.2	Scapulae	216	Heart—contents	347
				Kidneys	248
Skeletal system—inactive marrow	1550			Liver	1410
Leg bones—upper portion[a]	59.4			Lungs	890
Leg bones—middle portion[a]	194			Ovaries	8.66
Leg bones—lower portion[a]	568			Pancreas	89.1
Arm bones—upper portion[a]	40.6			Skin (approximate)	2130
Arm bones—middle portion[a]	66.5			Spleen	123
Arm bones—lower portion[a]	144			Testes	35.1
Pelvis	206			Thymus	28.4
Spine—upper portion[b]	7.91			Thyroid	18.0
Spine—middle portion[b]	51.8			Urinary bladder wall	35.9
Spine—lower portion[b]	29.5			Urinary bladder contents	160
Skull—cranium	59.8			Uterus	79.0
Skull—facial skeleton	27.5			Whole body	55,000
Ribs	57.4				
Clavicles	9.46				
Scapulae	28.2				

[a]The upper, middle, and lower portions of the leg bones and arm bones are defined in Table 2 of Appendix 8-1.
[b]The upper, middle, and lower portions of the spine are defined in the section of Appendix 8-1 defining the spine.

values not only determine the mass of the organ from its geometric volume but also the linear attenuation coefficients for interactions in the organs.

It is also important to understand that Cristy viewed the design of the phantom series as a geometry problem where volume, not mass, values were of prime interest. Consider for example, the design of a particular organ in a phantom whose mass (M) and specific gravity or density (d) are available from ICRP Publication 23. A volume of M/d is thus associated with the organ. Note that the value of d cited in Reference 8 for the specific organ under consideration was used to derive the organ volum, a volume that Cristy refers to as the "targeted volume" in that the design was targeted to this volume.

In the Monte Carlo calculations only three tissue densities are considered. During the course of preparing the data for calculations for internal emitters, it became apparent that the density values of Snyder et al were not consistent with the design approach of Cristy. Although these differences were minor, Cristy and Eckerman felt that this inconsistency should be removed prior to undertaking the calculations for the entire series.

Cristy and Eckerman's review of the data in Reference 8 (see text) indicated that a soft tissue density of approximately 1.04 g cm^{-3} was representative of soft tissue organs and that a skeletal density of 1.4 g cm^{-3} was in good agreement with the Reference Man data. The lung density value was not changed, other than to carry fewer significant figures into the calculations. These density values result in a total body density of about 1.07 g cm^{-3}, which is in good agreement with the literature.

Too much attention to small differences between masses of organs in a phantom and in the population data is not warranted. As mentioned above, the construction of the phantoms is a volume problem; furthermore, Cristy[1] showed that if the design approach had been to obtain correct (numerical value) masses at the expense of correct (numerical) volumes, the errors in the specific absorbed fraction would have been larger than with his approach. Thus the approach taken is more accurate than the alternate method with a phantom having more accurate organ masses but poorer volume descriptions. In addition, the absolute masses of active marrow in given bones are less important than is the distribution of the marrow - comparison of the distribution (the amount of active marrow in a given bone expressed as a percentage of active marrow in the body) in Japanese adults with the Japanese adult phantom is given in Table 2, Appendix 8-1 (the distribution for the Japanese adult given in that table is the same as that in the Western 15-year-old phantom).

With these caveats, organ masses are given in Table 1.

Reference

1. Cristy, M., 1981. Development of mathematical pediatric phantoms for internal dose calculations: designs, limitations, and prospects. In *Third International Radiopharmaceutical Dosimetry Symposium*, E. E. Watson, A. T. Schlafke-Stelson, J. L. Coffey, and R. J. Cloutier, Eds., Washington: Department of Health and Human Services, publication FDA 81-8166.