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Commentary

Physiological Parameters in Laboratory Animals and Humans

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There is a wide diversity of values in the literature for physiological parameters in the common laboratory animal species and humans. Because of the enormous variability in some values quoted in the scientific literature, it has always been difficult to decide on what would be reasonably normal ranges that would reflect the situation in the majority of a population. There are a number of very good reference works, some of which are listed below, which summarize physiological and biochemical data in a large number of different animal species. These books are conveniently designed in the form of a series of tables divided up into a number of sections. One fault of the majority of these reference works is that they do not quote just one value but list all of the values that have been determined, without any suggestion as to which may be the more accurate value for the majority of that population. Scientists have, therefore, tended to use their "favorite" values when performing physiological pharmacokinetic modeling or interspecies scaling. This document was originally started to provide the authors with an easily available summary of physiological parameters and developed over a period of time into its present form. Its design is similar to that of the large reference volumes in that it is composed of separate tables, each with its own reference source. The values quoted are for particular body weights which represent acceptable weight values for adults of the listed species. In all cases, the values in the tables represent actual published data for those body weights and have not been extrapolated from other data.

Even though there is only one reference given for each parameter, the values have been verified, where possible, by a separate reference, and in some cases the values quoted here are the means of many individual data values. For some of the data, e.g., blood flows, the authors have attempted where possible to give values determined by the same, widely acceptable methodology. In addition, these references can be consulted to review the methodology used and verify the strain and, where appropriate, the species of animal used.

There are a number of gaps in the data tables where the authors were unable to trace particular references. It may be that some of these missing values are freely available to readers of this article, and if this is so, the authors would be grateful for any communication which would help them to complete their data base or modify it in the light of new information. On occasion, differences in values may occur, such as the sum of individual flows being different from the measured total flow of a particular system. These differences do not result from oversights or failure to choose between alternatives but because values within a species may be taken from a number of references.

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Table I. Weights of Various Organs in the Mouse, Rat, Rabbit, Monkey, Dog, and Human

	Mouse (0.02 kg)[a,b]	Rat (0.25 kg)[c]	Rabbit (2.5 kg)[d,e]	Rhesus monkey (5 kg)[f]	Dog (10 kg)[c,g]	Human (70 kg)[h]
Organ weights (g)						
Brain	0.36	1.8	14	90	80	1400
Liver	1.75	10.0	77	150	320	1800
Kidneys	0.32	2.0	13	25	50	310
Heart	0.08	1.0	5	18.5	80	330
Spleen	0.1	0.75	1	8	25	180
Adrenals	0.004	0.05	0.5	1.2	1	14
Lung	0.12	1.5	18	33	100	1000

[a] In H. Foster, J. Small, and J. Fox (eds.), *The Mouse in Biomedical Research, Vol. III,* Academic Press, New York, 1983, pp. 108–109.
[b] In C. Crispens (ed.), *Handbook on the Laboratory Mouse,* Charles Thomas; Springfield, IL, 1975, pp. 82–91.
[c] In V. Fiserova-Bergerova and H. C. Hughes, *Modeling of Inhalation Exposure to Vapors,* CRC Press, Boca Raton, FL, 1983, pp. 97–106.
[d] In S. Weisbroth, R. Flatt, and A. Kraus (eds.), *The Biology of the Laboratory Rabbit,* Academic Press, New York, 1974.
[e] In E. C. Mibby and N. H. Altman (eds.), *Handbook of Laboratory Animal Science, Vol. III,* CRC Press, Boca Raton, FL, 1976, p. 429.
[f] R. P. Forsyth. *J. Appl. Physiol.* 52:736–741 (1968).
[g] M. W. Fox. *Growth* 28:135–141 (1964).
[h] In *International Commission on Radiological Protection—Report of the Task Group on Reference Man,* ICRP No. 23, Pergamon Press, London, 1975.

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Table II. Volumes of Various Body Fluids and Organs in the Mouse, Rat, Rabbit, Monkey, Dog, and Human

	Mouse (0.02 kg)[a,b]	Rat (0.25 kg)[a,c,d]	Rabbit (2.5 kg)[a,e]	Monkey (5 kg)[a,b]	Dog (10 kg)[a,f]	Human (70 kg)[d,g]
Organ volumes (mL)						
Brain	—	1.2	—	—	72	1,450
Liver	1.3	19.6	100	135	480	1,690
Kidneys	0.34	3.7	15	30	60	280
Heart	0.095	1.2	6	17	120	310
Spleen	0.1	1.3	1	—	36	192
Lungs	0.1	2.1	17	—	120	1,170
Gut	1.5	11.3	120	230	480	1,650
Muscle	10.0	245	1,350	2,500	5,530	35,000
Adipose	—	10.0	120	—	—	10,000
Skin	2.9	40.0	110	500	—	7,800
Blood	1.7	13.5[h]	165[h]	367	900[h]	5,200
Total body water (mL)[h]	14.5	167	1,790	3,465	6,036	42,000
Intracellular fluid (mL)[h]	—	92.8	1,165	2,425	3,276	23,800
Extracellular fluid (mL)[h]	—	74.2	625	1,040	2,760	18,200
Plasma volume (mL)[h]	1.0	7.8	110	224	515	3,000

[a] In P. Welling and F. Tse (eds.), *Pharmacokinetics: Regulatory, Industrial, Academic Perspectives*, Marcel Dekker, New York, 1988.
[b] F. G. King. *Toxicol. Appl. Pharmacol.* 67:390–400 (1983).
[c] H. Harashima. *J. Pharmacokin. Biopharm.* 13:425–440 (1985).
[d] A. Bernareggi and M. Rowland. *J. Pharmacokin. Biopharm.* 19:21–50 (1991).
[e] P. A. Harris and J. F. Gross. *Cancer Chemother. Rep.* 59:819–825 (1975).
[f] In A. Andersen (ed.), *The Beagle as an Experimental Dog*. Iowa State University Press, Ames, 1970.
[g] In *International Commission on Radiological Protection—Report of the Task Group on Reference Man*, ICRP No. 23, Pergamon Press, London, 1975.
[h] In D. Dittmer (ed.), *Blood and Other Body Fluids*, Federation of American Societies for Experimental Biology, Washington, DC, 1961.

Table III. Flow of Blood, Through the Major Organs, and Other Fluids in the Mouse, Rat, Rabbit, Monkey, Dog, and Human

	Mouse (0.02 kg)[a,b]	Rat (0.25 kg)[c,d]	Rabbit (2.5 kg)[e,f]	Monkey (5 kg)[d,g]	Dog (10 kg)[d,h,i]	Human (70 kg)[a,j]
Blood flows (mL/min)						
Brain	—	1.3	—	72	45	700
Liver	1.8	13.8[k]	177	218	309	1450
Kidneys	1.3	9.2	80	138	216	1240
Heart	0.28	3.9	16	60	54	240
Spleen	0.09	0.63	9	21	25	77
Gut	1.5	7.5	111	125	216	1100
Muscle	0.91	7.5	155	90	250	750
Adipose	—	0.4	32	20	35	260
Skin	0.41	5.8	—	54	100	300
Hepatic artery	0.35	2.0	37	51	79	300
Portal vein	1.45	9.8	140	167	230	1150
Cardiac output	8.0	74.0	530	1086	1200	5600
Urine flow (mL/day)[l]	1.0	50.0	150	375	300	1400
Bile flow (mL/day)[l]	2.0	22.5	300	125	120	350
GFR (mL/min)	0.28[m]	1.31[n]	7.8[o]	10.4[p]	61.3[q]	125[n]

[a] R. L. Dedrick. *Biochem. Pharmacol.* 22:2405–2417 (1973).
[b] In E. Green (ed.), *The Biology of the Laboratory Mouse*, McGraw–Hill, New York, 1966.
[c] J. Idvall. *Acta Anaesth. Scand.* 24:257–263 (1980).
[d] In V. Fiserova-Bergerova and H. C. Hughes (eds.), *Modeling of Inhalation Exposure to Vapors*, CRC Press, Boca Raton, FL, 1983, pp. 97–106.
[e] In W. Spector (ed.), *Handbook of Biological Data*, W. B. Saunders, Philadelphia, 1956.
[f] J. M. Neutze. *Am. J. Physiol.* 215:486–495 (1968).
[g] R. P. Forsyth. *J. Appl. Physiol.* 52:736–741 (1968).
[h] In A. Andersen (ed.), *The Beagle as an Experimental Dog*, Iowa State University Press, Ames, 1970.
[i] J. L. Nxumalo. *Ann. Surg.* 187:299–302 (1978).
[j] In A. C. Guyton (ed.), *Textbook of Medical Physiology*, W. B. Saunders, Philadelphia, 1976.
[k] P. D. Richardson and P. G. Withrington. *Gastroenterology*, 81:159–173 (1981).
[l] B. Clark and D. A. Smith. *Crit. Rev. Toxicol.* 12:343–385 (1984).
[m] F. G. King and R. L. Dedrick. *Cancer Treat. Rep.* 63:1939–1947 (1979).
[n] In D. Dittmer (ed.), *Blood and Other Body Fluids*, Federation of American Societies for Experimental Biology, Washington, DC, 1961.
[o] In S. Weisbroth, R. Flatt, and A. Kraus (eds.), *The Biology of the Laboratory Rabbit*, Academic Press, New York, 1974.
[p] W. R. Stahl and M. R. Malinow. *Folia Primatol.* 7:12 (1967).
[q] In P. Altman and D. Dittmer (eds.), *Biology Data Book, Vol. III*, Federation of American Societies for Experimental Biology, Washington, DC, 1972, pp. 2000–2001.

Table IV. Transit Time, pH, and Enzyme Activity of the Gastrointestinal Tract of the Mouse, Rat, Rabbit, Monkey, Dog, and Human

	Mouse (0.02 kg)	Rat (0.25 kg)	Rabbit (2.5 kg)	Monkey (5 kg)	Dog (10 kg)	Human (70 kg)
Transit time (min)						
Stomach	—	—	—	—	96[a]	78[a]
Small intestine	—	88[b]	—	—	110[c]	238[c]
Whole gut	—	—	—	—	770	2350[d]
pH (fed)[e]						
Stomach						
Anterior	4.5	5.0	1.9	4.8	5.5	—
Posterior	3.1	3.8	1.9	2.8	3.4	5.0[f]
Small intestine						
Beginning	—	6.5	6.0	5.6	6.2	5.4[f]
End	—	7.1	8.0	6.0	7.5	7.5[g]
Cecum	—	6.8	6.6	5.0	6.4	6.0[h]
Colon	—	6.6	7.2	5.1	6.5	7.5[h]
Feces	—	6.9	7.2	5.5	6.2	—
β-Glucuronidase activity (nmol substrate/ hr/g contents)[i]						
Proximal small intestine	1200	304	2.4	—	—	0.02
Distal small intestine	5015	1341	45.4	—	—	0.9

[a] Y. Ueda. *Proc. 2nd Symp. Clin. Pharm.*, Tokyo, 1988, pp. 12–21.
[b] N. J. Brown. *Gut* 28:849–854 (1987).
[c] J. B. Dressman. *Pharm. Res.* 3:123–131 (1986).
[d] J. C. Mathers and J. S. Blake. *Proc. Nutr. Soc.* 42:111A (1983).
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[f] J. B. Dressman. *Pharm. Res.* 7:756–761 (1990).
[g] D. F. Evans. *Gut* 29:1035–1041 (1988).
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[i] G. M. Hawksworth, B. S. Draser, and M. J. Hill. *J. Med. Microbiol.* 4:451 (1971).

Table V. Miscellaneous Physiological Parameters of the Mouse, Rat, Rabbit, Monkey, Dog, and Human

	Mouse (0.02 kg)	Rat (0.25 kg)	Rabbit (2.5 kg)	Monkey (5 kg)	Dog (10 kg)	Human (70 kg)
Surface area (m^2)[a]	0.008	0.023	0.17	0.32	0.51	1.85
Mean life-span potential (yr)[b]	2.7	4.7	8.0	22	20	93
Total plasma protein (g/100 mL)[c]	6.2	6.7	5.7	8.8	9.0	7.4
Plasma albumin (g/100 mL)[c]	3.27	3.16	3.87	4.93	2.63	4.18
Plasma α-1-AGP (g/100 mL)[c]	1.25	1.81	0.13	0.24	0.37	0.18
Hematocrit (%)	45[d]	46[e]	36[f]	41[g]	42[h]	44[e]
Total ventilation (L/min)	0.025[i]	0.12[j]	0.80[i]	1.67[j]	1.50[j]	7.98[j]
Respiratory rate (min^{-1})	163[i]	85[j]	51[i]	38[j]	23[j]	12[j]
Heart rate (beats/min)[k]	624	362	213	192	96	65
Oxygen consumption (mL/hr/g body wt)[k]	1.59	0.84	0.48	0.43	0.34	0.20

[a] W. R. Chappell. In D. D. Hemphill (ed.), *Trace Substances in Environmental Health, Vol. XIX*, University of Missouri, Columbia, 1985, pp. 326–337.
[b] H. Boxenbaum. *J. Pharmacokin. Biopharm.* 10:201–227 (1982).
[c] A. M. Guarino. *Cancer Chemother. Rep. Part 1* 57:125–140 (1973).
[d] In E. C. Mibby and N. H. Altman (eds.), *Handbook of Laboratory Animal Science, Vol. III*, CRC Press, Boca Raton, FL, 1976, p. 429.
[e] In D. Dittmer (ed.), *Blood and Other Body Fluids*, Federation of American Societies for Experimental Biology, Washington, DC, 1961.
[f] In S. Weisbroth, R. Flatt, and A. Kraus (eds.), *The Biology of the Laboratory Rabbit*, Academic Press, New York, 1974, p. 68.
[g] In G. Bourne (ed.), *The Rhesus Monkey*, Academic Press, New York, 1975, pp. 412–414.
[h] G. W. Anderson. *Vet. Med.* 53:135 (1958).
[i] A. C. Guyton. *Am. J. Physiol.* 150:70–77 (1947).
[j] In V. Fiserova-Bergerova and H. C. Hughes, *Modeling of Inhalation Exposure to Vapors*, CRC Press, Boca Raton, FL, 1983, pp. 97–106.
[k] In P. Altman and D. Dittmer (eds.), *Biology Data Book, Vol. III*, Federation of American Societies for Experimental Biology, Washington, DC, 1972.