ALBRITTON

STANDARD VALUES *in* BLOOD

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Being the first fascicle of a Handbook of Biological Data

EDITED BY

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Foreword

On January 31, 1949, the National Academy of Sciences - National Research Council contracted with the Wright Air Development Center, United States Air Force, to gather and compile for publication the more basic established data on the composition and reactions of blood. A compact volume was desired that would contain authoritative tabular data of most pressing need to scientists working in the various fields of biology, including the medical sciences. The present work, first issued as Air Force Technical Report No. 6039, is the result.

The direction of the work was entrusted to the Committee on the Handbook of Biological Data, an organ of the American Institute of Biological Sciences. The Institute is affiliated with the National Research Council as a unit in the Council's Division of Biology and Agriculture. The membership of the Committee is representative of the major fields in plant and animal biology.

Seeking the highest degree of authoritativeness for the work, the Committee recognized that the specialist in a field from which a table is drawn can best exercise the critical judgment necessary to evaluate and select data for an authoritative table. The specialist can best identify those data born of the most acceptable methods of measurement and those having the greatest likelihood, or actual history, of reproducibility in competent hands. The Committee accordingly prescribed that in the selection and review of data the broadest collaboration be sought among investigators in hematology and related fields.

To the Editor has fallen the responsibility of determining the table of contents and the format and composition of each table as it appears on the page, and of enlisting the aid of contributors to supply the necessary data and of reviewers to give the data independent evaluation. The editorial office has also been the focus of advice and counsel sought and received in generous measure from all fields of biology. *

Acknowledgment is made, on behalf of the Committee, to the Wright Air Development Center, United States Air Force, for the foresight and scientific judgment inherent in the commission to prepare this tabular monograph on blood; to the biologists of this and other countries whose generous devotion of time as contributors and reviewers has made possible the completion of the work as it stands, and to the many others, unlisted, who have given the Committee solicited advice.

Acknowledgment is made to Dr. Cloyd Heck Marvin, President of The George Washington University, for generously making it possible for a member of his faculty to assume the editorship; to Dr. J. W. Heim, member of the Committee and project director for the Wright Air Development Center, for his unflagging effort toward bringing to realization the idea of a handbook of tabular biological data, and to Dr. Ulrich K. Henschke for giving the manuscript meticulous and critical study.

Finally the Editor acknowledges with gratitude the loyalty and labors of his administrative assistant, Mrs. Dorothy C. Stafford, and of his staff of research analysts, Dr. Habeeb Bacchus, Mr. Harold J. Berman, Mr. Albert Einheber, Mr. Howard L. Gordon, Mr. Louis P. Munan, Mr. William S. Spector and Dr. Wasley D. Yushok.

ERRETT C. ALBRITTON

*Two other comparable collections of tabular data are nearing completion as the present work goes to press, one drawn from the field of nutrition and metabolism and the other from that of growth, reproduction and life history. Both plant and animal forms are included. Other collections are planned.

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Contents

Introduction

The tables in this unusually complete collection of data on blood are unique in the high degree of reliability sought for the data. Data have been supplied and authenticated by over six hundred leading investigators in biology and clinical medicine. The tables have been exhaustively reviewed, some by as many as twenty experts in the field.

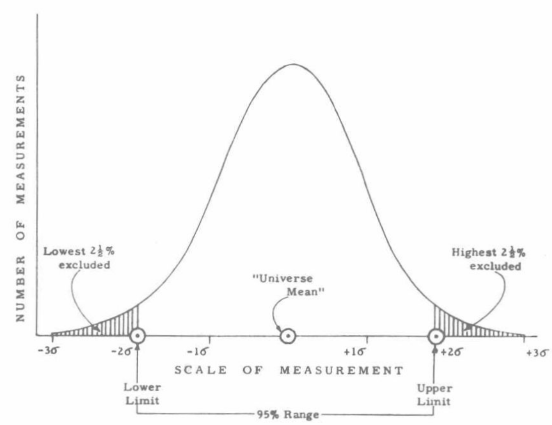
The tables are also unique in their treatment of the well known phenomenon of biological variability. In addition to giving a single representative value for each item covered in a table (the value is known in statistical terms as the estimated "universe mean") the tables present information on variability in a most easily comprehensible and directly usable form. The reader who seeks to know the range of variation of a quantity does not need to perform a calculation, as he must do when only the "standard deviation" is reported, but may read directly from the table the estimated upper and lower limits of the "95% range." The method of estimate, in each case, is identified by a simple code letter, which at the same time rates the individual range as to its trustworthiness. Range data as commonly encountered represent a mixture of variability as it exists between individuals and variability as it exists within individuals.

The significance of the code letters, used as superscripts attached to the ranges in the tables, follows:

(a) By the method of greatest accuracy, the 95% range is obtained by fitting a recognized type of frequency curve to a group of measured values and excluding the extreme 2.5% of area under the curve at each end. (See sketch to the right.)

(b) By a less accurate method, the 95% range is estimated by a simple statistical calculation, assuming a "normal distribution" and using the "standard deviation." This estimate is used when the group of values is too small for curve fitting, as is usually the case.

(c) A third and still less accurate procedure for estimate of the 95% range is simply to give the highest value and lowest value of the reported sample group of measurements. It underestimates the 95% range for small samples and overestimates for larger sample sizes, but may be used in preference to the preceding method when the sample shows convincing evidence that the variable is asymmetrical in distribution.



(d) The upper and lower limits of the range of variation, as commonly encountered by an investigator experienced in measuring the quantity in question, constitute still another estimate of the 95% range. The trustworthiness of limits so placed should not be underestimated.

In many instances, where information as to the manner of estimate has been lacking at the time of going to press, it has been necessary to report an estimate of the 95% range without an identifying superscript. Effort to assemble the missing information is continuing.

Although the data in each table are the best available at the time the table was prepared, it is recognized that all data are subject to revision as investigators improve techniques and make more measurements. The reader is warned against attributing significance to small differences from species to species. He is invited to submit any values or ranges that he feels should be given consideration, and is particularly invited to add to the coverage of animal forms.

TABLES

1. BLOOD SPECIFIC GRAVITY

Blood (B); RBC (C); Plasma (P)

	Animal		Value			Range	Temperature[1] (°C)	Method
	(A)		(B)			(C)	(D)	(E)
1	Man		B	♂	1.056	1.052-1.061[b]	25/4	Copper Sulfate
2			C	♂	1.093[2]	1.089-1.097[b]		
3			P	♂	1.024	1.022-1.026[b]		
4			C		1.099	1.094-1.107[c]		Gravimetric
5			P		1.028	1.026-1.031[b]		
6	Cat		B	♂	1.050	1.046-1.054[b]	T/T	Falling Drop
7			B	♀	1.051	1.045-1.057[b]		
8	Cattle	adult[3,4]	B	♀	1.052	1.046-1.058[b]	20/4	Gravimetric
9		young[3,5]	B	♀	1.053	1.046-1.061[b]		
10		adult	C	♂	1.084	1.079-1.090[b]		Gravimetric
11			P	♂	1.029	1.026-1.033[b]		
12	Dog	adult[6]	B		1.052		22-26/4	Falling Drop
13		young[7]	B		1.045			
14	Goat[8]		B	♂	1.042	1.036-1.048[b]	25/4	Copper Sulfate
15			B	♀	1.044	1.036-1.051[b]		
16			B	♂♀	1.042	1.035-1.049[b]		
17			P	♂	1.023	1.019-1.026[b]		
18			P	♀	1.021	1.018-1.024[b]		
19			P	♂♀	1.022	1.019-1.025[b]		
20	Horse		B	♂[9]♀	1.053	1.046-1.059[c]	20/4	Benzene-Chloroform
21	Mouse[10]		B		1.057	1.052-1.062[b]	25/4	Falling Drop
22	Pig, young[11]		B	♂	1.047	1.038-1.055[b]	25/4	Copper Sulfate
23			B	♀	1.043	1.035-1.052[b]		
24			B	♂♀	1.046	1.039-1.054[b]		
25			P	♂	1.022	1.021-1.025[b]		
26			P	♀	1.023	1.020-1.027[b]		
27			P	♂♀	1.022	1.019-1.025[b]		
28	Rabbit		B		1.050	1.048-1.052[b]	25/4	Falling Drop
29			C		1.098	1.093-1.104[c]		Gravimetric
30			P		1.025	1.018-1.031[b]		
31	Rat[13]		B		1.056[12]	1.054-1.058[b]	25/4	Falling Drop
32			B	♂	1.054	1.046-1.061[b]	25/4	Copper Sulfate
33			B	♀	1.054	1.046-1.061[b]		
34			P	♂	1.023	1.017-1.028[b]		
35			P	♀	1.022	1.018-1.027[b]		
36			P	♂♀	1.023	1.018-1.028[b]		
37	Sheep		B	♂[9]♀	1.051[14]	1.041-1.061[b]	20/4	Benzene-Chloroform
38			C		1.084	1.080-1.087[c]		Gravimetric
39			P		1.028	1.025-1.029[c]		

/1/ Referred to water at 4°C or to water at temperature of measurement (T). /2/ Of "packed" cells, not corrected for an estimated 7% of trapped plasma; corrected = 1.098 (1.095-1.101). /3/ Mostly Holstein-Friesian strain. /4/ 2.5-18 yrs. /5/ 18-30 months. /6/ Mongrels. /7/ 1-3 days. /8/ Angora and Toggenburg strains, 1-2 yrs. /9/ Castrated. /10/ CBA strain, 60-80 days. /11/ Duroc-Jersey, Poland-China, Chester White strains. /12/ Sprague-Dawley, 200-250g. /13/ Mixed strains, 100-300g. /14/ Cheviot, blackface, grayface strains.

2. RELATIVE VISCOSITIES, BLOOD, PLASMA, SERUM

	Animal	Temperature of Meas. ($^{\circ}$C)	Relative Viscosity[1]		
			Blood[2]	Plasma[3]	Serum[3]
	(A)	(B)	(C)	(D)	(E)
1	Man	38	4.7	1.8	1.5
2	Cat	38	4.2		
3	Dog	38	4.7		
4		37	5.5		
5	Goat	20	4.0		
6	Horse	20	4.1	1.9	1.7
7	Ox	20	4.6		
8	Pig	20	5.9		1.6
9	Rabbit	37	3.4		1.4
10	Sheep	20	4.3	1.6	1.5
11	Frog	15	2.8[4]		1.5
12	Turtle	20	2.2[4]		

/1/ Relative to water at the temperature of measurement. Absolute viscosity = relative viscosity x absolute viscosity of water. Absolute viscosity of water in poises (=dyne-seconds/cm^2), accurate to within 2%, is 0.00680 at 38°C, 0.00692 at 37°C, 0.0101 at 20°C, and 0.0114 at 15°C. /2/ Apparent viscosity as measured in capillary tube viscosimeters with radii greater than 0.05cm, length greater than 150 radii, and at apparent Reynolds numbers in the range 50-800 (apparent Reynolds number = urd/v' where u = mean velocity, r = tube radius, d = density, and v' = apparent viscosity, all expressed in c. g. s. units). Apparent viscosity of blood varies inversely with the temperature of measurement, directly with the protein content, and with the hematocrit. Hematocrits for above values not available in original reports. Hematocrit differences may be the chief reason for variations among species and between the sexes. /3/ Calculated from protein concentration in g/100ml plasma or serum (=c) and fluidity lowering constant (=k) where apparent viscosity = 100/(100-kc); k = 5.8 for coordinates 1D, 4.8 for 1E, 7.0 for 6D, 6.1 for 6E, 5.7 for 8E, 5.3 for 9E, 6.5 for 10D, 5.8 for 10E. For values of c, see table on Plasma Proteins, Laboratory and Farm Animals. /4/ Corrected for defibrination (=10% less viscous than whole blood).