

Total Serum Protein Concentration and Total Weight of Circulating Protein in the Rat.

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The relation of total serum protein concentration and total weight of circulating protein to body size and sex were studied in the rat. The animals were used concurrently for estimation of blood and plasma volumes reported previously.¹

Methods. A total of 125 normal rats were used, 47 females and 78 males, ranging in weight from 48 to 308 g. The rats were divided into groups, each of approximately 10 animals. In each group, the weight range was less than 10% of the mean weight, in most cases considerably less.

Blood and plasma volumes were determined by the hemoglobin dye method previously described.¹ Serum from the rats in each group was pooled in aliquot portions, and the total serum protein concentration was measured by a modification of Kingsley's biuret method.²

Because hemoglobin was used in determining plasma volumes, it was necessary to correct the protein determinations. This was done by subtracting from the total circulating protein value the weight of hemoglobin injected, and by subtracting from the total serum protein concentration the calculated concentration of hemoglobin. The weight of hemoglobin injected was determined by the

colorimetric method of Evelyn and Malloy.³

In this paper, the previously reported individual values for blood and plasma volumes of the rats within each group were averaged. The mean values of these groups were related to body surface area, calculated from the formula of Carman and Mitchell.⁴

Results. The blood and plasma volumes (Fig. 1), total serum protein concentration (Fig. 2), and total circulating serum protein (Fig. 3) were plotted against body surface area. The results fitted a straight line reasonably well in each category. Regression lines

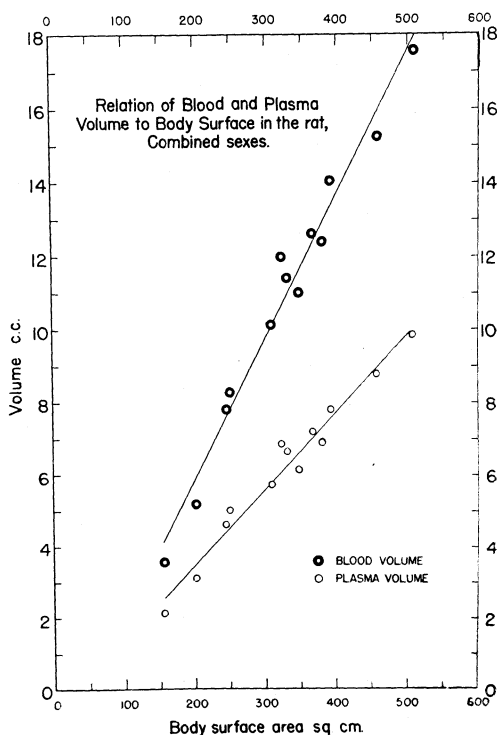


FIG. 1.

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¹ Lippman, R. W., *PROC. SOC. EXP. BIOL. AND MED.*, 1947, **66**, 188.

² Kingsley, G. R., *J. Biol. Chem.*, 1939, **131**, 197.

³ Evelyn, K. A., and Malloy, H. T., *J. Biol. Chem.*, 1938, **126**, 655.

⁴ Carman, G. G., and Mitchell, H. H., *Am. J. Physiol.*, 1926, **76**, 380.

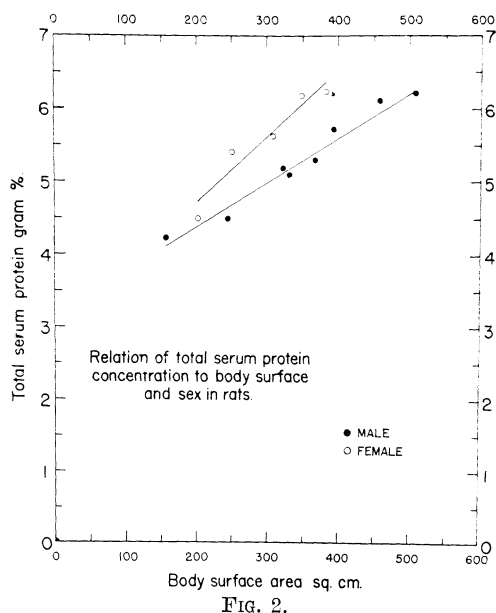


FIG. 2.

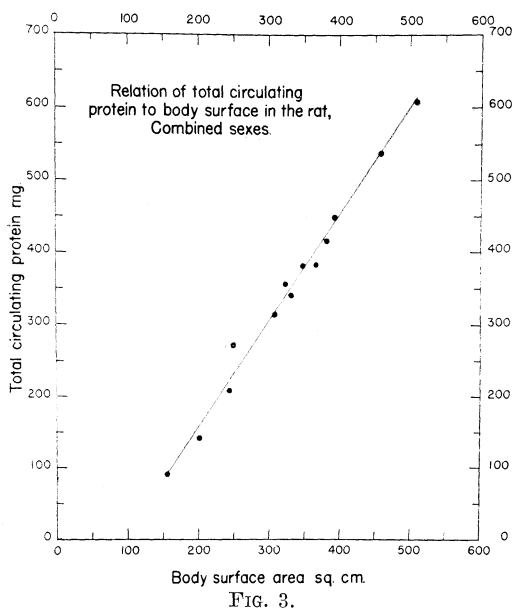


FIG. 3.

were calculated and the constants are given in Table I. There were slight sex differences in the regression constants for blood and plasma volumes and for total circulating protein, but as these did not appear significant for the purposes of this paper, the data were combined and are given in a single regression line. A significant sex difference in total serum protein concentration was found, and 2 re-

gression lines are presented (Fig. 2).

Discussion. Few previous studies of the total serum protein concentration or the weight of total circulating serum protein in the rat have been made. Comparison is difficult, as different methods have been used to express results.

Cutting and Cutter⁵ determined circulating plasma protein and plasma protein concentrations in rats. Their data were not segregated by sex, and they divided the rats into only 2 groups: "large" (292-395 g) and "small" (188-213 g). Their results, given in Table II, demonstrate a difference in the plasma protein concentration between the 2 groups. In addition, they found that the total circulating plasma protein in the large adult rats was greater in terms of surface area than in the smaller adult rats. Because female rats of the colony used by Cutting and Cutter rarely grow to weights over 300 g, it may be assumed that their "large" group consisted of male rats.

Metcoff and Favour⁶ determined the total plasma protein concentration and total circulating plasma protein of rats, and likewise did not segregate their data by sex. They divided the rats into 3 groups: adult (119-335 g), pubescent (73-89 g), and prepubescent (40-68 g). Their total plasma protein concentrations were somewhat higher than other values reported, and they attributed this difference to the copper sulfate method of determination, which they used. However, their range of difference in total plasma protein concentration, between small rats and large rats, is similar to that which we found. They also found that the total circulating plasma protein increases in terms of body surface up to puberty, after which it remains relatively constant.

Our data, segregated by sex and into narrow weight ranges, appear to demonstrate a constant relationship of total circulating serum protein and serum protein concentration to body surface area over a wide range of weight which includes the range of puberty.

⁵ Cutting, W. C., and Cutter, R. D., *Am. J. Physiol.*, 1935, **113**, 150.

⁶ Metcoff, J., and Favour, C. B., *Am. J. Physiol.*, 1944, **142**, 94.

TABLE I.
Relation of Blood Volume, Plasma Volume, Total Circulating Serum Protein, and Total Serum Protein Concentration to Body Surface Area.
General equation: $f(x) = A + Bx$
where x is body surface area in sq cm.

$f(x)$	Sex	A	B
Blood volume (cc)	♂	— 1.59	0.0385 ± .0032
	♀	— 1.90	0.0380 ± .0048
	Combined	— 1.91	0.0390 ± .0016
Plasma volume (cc)	♂	— 0.570	0.0211 ± .0026
	♀	— 0.316	0.0192 ± .0026
	Combined	— 0.710	0.0211 ± .0008
Total circ. protein (mg)	♂	—150.	1.50 ± .04
	♀	—147.	1.54 ± .06
	Combined	—142.	1.49 ± .04
Serum protein conc. (g %)	♂	3.15	0.00617 ± .0024
	♀	2.85	0.00920 ± .0026

TABLE II.
Previously Reported Values for Plasma Protein Concentration and Weight of Total Circulating Plasma Protein.

Author	Wt group	Total plasma protein conc. g %	Total circ. plasma prot. mg/100 sq cm
Cutting and Cutter	Large (292-395 g)	6.88	108
	Small (188-213 g)	6.30	82
Metcoff and Favour	Adult (119-335 g)	8.07	190
	Pubescent (73-89 g)	6.60	172
	Prepubescent (40-68 g)	5.62	118

This apparent discrepancy between our observations and those previously reported may be explained by the fact that the regression lines do not intercept the x -axis at 0, so that the ratio $f(x)/x$ increases as x increases. Although the lines are valid over the observed range, the relationship must change in extremely young rats, as it must ultimately pass through the point of origin.

We have related our results to body surface area of the rat, although we realize the imperfections of body surface as a reference measure. Kleiber⁷ has clearly discussed the

errors of body surface area calculations and relates metabolic rate to the 0.75 power of body weight. Our blood and plasma volume data exhibit a closely similar relationship.¹ We have used the relation of variables to body surface area here because it affords some comparison with other discussions in the literature.

Summary. 1. The total circulating serum protein and the serum concentration of total protein in the rat are shown to be related to body surface area over a wide range. 2. The sex difference in total serum protein concentration is of sufficient magnitude to require its consideration in experiments.

⁷ Kleiber, M., *Physiol. Rev.*, 1947, **27**, 511.