

A QUANTITATIVE STUDY OF CELL POPULATIONS IN THE CIRCULATING BLOOD OF YOUNG ADULT ALBINO RAT*†

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In the course of quantitative studies of hematopoietic organs of the rat (*Monden*, 1955; *Osogoe et al.* 1957; *Osogoe*, 1958; *Osogoe and Awaya*, 1958; and *Monden*, 1958), it became necessary to make a similar study of the circulating blood of this animal. The present work is an attempt to calculate total cellular numbers of circulating blood in young adult albino rats on the basis of blood cell counts and measurements of circulating blood volume. Normal values for blood counts and circulating blood volume in the rat have been reported by a number of workers, but the published figures show discrepancies.

MATERIAL AND METHODS

Male albino rats from a subline of the *Wistar* strain weighing around 200 g ($\pm 2\%$) were chosen as the standard animals to be examined as in the earlier studies (*Monden*, 1955 and 1959). They were maintained on a standard laboratory diet consisted chiefly of unpolished rice, pressed naked barley and dried small sardines with a small amount of cod liver oil and minerals, supplemented once a week with cabbage or other vegetables.

Blood examinations were made of free flowing blood from the tail vein. For differential cell counts in blood smears, at least 500 cells were observed.

The circulating blood volume was measured by the method *Berlin et al.* (1949) using radioactive phosphorus (P^{32}), as described in the preceding paper (*Monden*, 1955).

RESULTS AND DISCUSSION

The results of blood cell counts on 50 standard rats are presented in Tables 1 and 2.

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Table 1. Differential counts of nucleated cells in the peripheral blood of the standard rat. Mean of 50 normal male rats with a mean weight of 201g.

Cell Type	Differential Counts in Smear (%)
Lymphocytes	70.05 ± 1.20*
Total Granulocytes	25.74 ± 1.33
Neutrophils	24.76 ± 1.14
Eosinophils	0.93 ± 0.17
Basophils	0.05 ± 0.02
Monocytes	4.22 ± 0.25

* Standard error.

Table 2. The estimated figures* for total numbers of different types of blood cells in the circulating blood of the standard rat (male rat weighing around 200g) and their coefficient of variation.

Cell Type	Average Number per mm ³ of Blood	Total Number in Circulating Blood** (× 10 ⁶)	Coefficient of Variation (%)
Erythrocytes	(10.37 ± 0.45) × 10 ⁶	114,400 ± 9,380	57.9
Total White Cells	17,100 ± 630	189 ± 14.1	52.5
Lymphocytes	11,970 ± 640	132 ± 12.0***	64.3
Total Granulocytes	4,400 ± 388	48.5 ± 6.1	88.8
Neutrophils	4,234 ± 350	46.7 ± 5.6	84.7
Eosinophils	159 ± 35	1.75 ± 0.45	181.0
Monocytes	722 ± 71	7.96 ± 1.06	94.0

* Mean ± Standard error.

** The mean value for circulating blood volume in standard rat is estimated to be 11.03 ± 0.44ml.

*** The corresponding value was reported to be (113 ± 28) × 10⁶ in the preceding communications (Monden, 1955; Osogoe et al., 1957; and Osogoe, 1958).

As reported previously (Monden, 1955), the circulating blood volume was estimated to be 11.03 ± 0.44ml* from a study of 10 standard rats.

From these data, the total number of each type of blood cells may easily be calculated. The results are given in Table 2,** together with variation in the values found for each type of blood cells.

The histograms of the frequency distribution of red cell counts and white cell counts on 50 animals each are shown in Figs. 1 and 2. It is of interest to note that the distribution of red cell counts is symmetrical, whereas that of white cell counts is asymmetrical and quite irregular.

* Standard error.

** The figures are slightly greater than those reported in the preliminary communications (Monden, 1955; Osogoe et al., 1957 and Osogoe, 1958), owing to increase in the number of observations.

RED BLOOD CELL COUNT

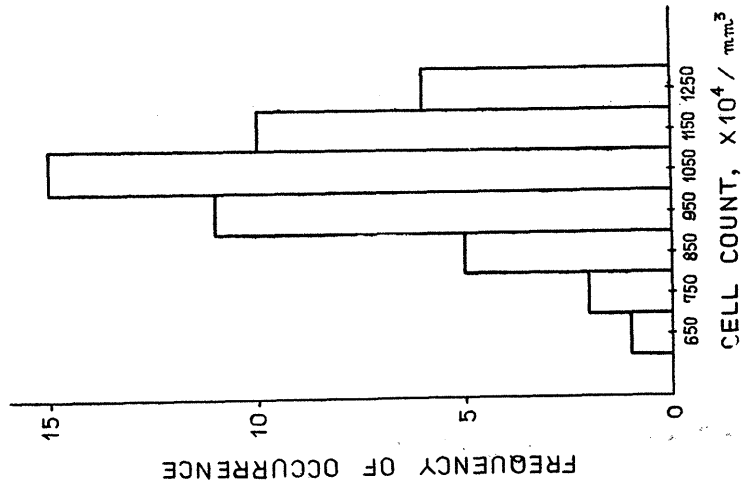


Fig. 1. Histogram of the frequency distribution of red blood cell counts on 50 normal male rats weighing around 200g.

WHITE BLOOD CELL COUNT

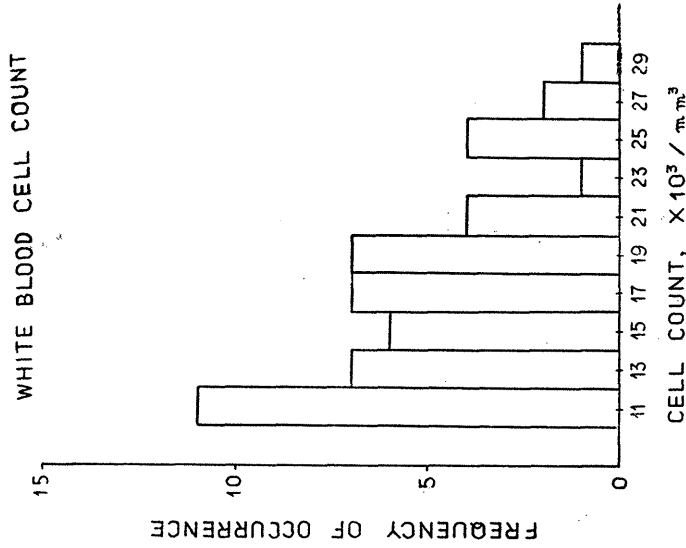


Fig. 2. Histogram of the frequency distribution of white blood cell counts on 50 normal male rats weighing around 200g.

Table 3. Comparison of the values* reported for blood cell counts in the rat, including the figures obtained in the present study.

Reference	Age or Body Weight	Number of Observations	R B C Count per mm ³ ($\times 10^6$)	W B C Count per mm ³	Lymphocyte Count per mm ³ or Differential Count
Kindred, 1942	200 g	8	8.95 ± 0.85	6,600 ± 650	5,350 ± 700
Andreasen, 1943	216 g (164-273 g) (♂)	10	7.7 (6.5-8.4)	6,578 (1,640-14,640)	5,863 (1,600-13,200)
Endicott & Ott, 1945	More than 60 days old (♂, ♀)	22	—	14,570 $\pm 1,470$	10,840 ± 920
Cameron & Watson, 1949	4 months or older (♂)	69-71	8.50 ± 0.106	21,400 ± 727	81% (70-89%)**
"	"	200	8.70 ± 0.069	20,400 ± 580	81% (70-89%)**
Rosenthal et al., 1951	200-300g (♂, ♂)	6	—	<i>Tail vein blood:</i> 21,100 \pm 1,470 <i>Heart blood:</i> 16,300 \pm 890	<i>Tail vein blood:</i> 17,330 \pm 1,500 <i>Heart blood:</i> 14,490 \pm 780
Albritton (ed.), 1952	—	—	8.9 (7.2-9.6)	14,000 (5,000-25,000)	10,200 (7,000-16,000)
Meineke & Crafts, 1957	3-4 months old (♀)	15	8.31 ± 0.08	21,900 $\pm 1,600$	—
Table 2, this paper	210 g (♂)	50	10.37 ± 0.45	17,100 ± 630	11,970 ± 640

* Mean \pm Standard error.

** No sex difference was noticed in the differential counts of lymphocytes.

As shown in Table 3 which survey values for blood cell counts in the rat reported up to the present time, the published figures do not show much variation in the values for red cell counts, which lie between 7.7×10^6 and 8.95×10^6 . The mean value from the present observations (10.37×10^6) is greater than the highest values previously reported. In contrast, the reported figures for total white cell (WBC) counts vary from 6,578 to 21,900 per mm^3 . The mean value from the present observations (17,100) lies between these extremes. The values reported by *Kindred* (1942) and *Andreasen* (1943) for total white cell counts are exceedingly low as compared with the figures of the other workers. Although the reason for this discrepancy is not apparent, it is probable that strain differences and variations in diet are partly responsible.

As regards the blood cell counts, it is of particular interest that the leukocyte count of heart blood is much lower than that of tail blood (cf. Table 3, the figures of *Rosenthal* et al.). Since the present calculations are based solely on the examinations of tail blood, the estimated figure for total number of leukocytes in the circulating blood would probably be an overestimate.

The accuracy or reliability of the calculations on the total number of circulating blood cells also depends upon whether the estimated figure for circulating blood volume is quite reasonable or not. Regarding the blood volume in the rat, divergent values are reported in the literature, varying from 4.1 to 10.7 ml per 100 g of body weight (*Monden*, 1955 and *Belcher* and *Harris*, 1957). However, according to *Belcher* and *Harris* (1957) who have made an extensive study on young growing rats, the total blood volume per 100 g of body weight decreases with advancing age, from 7.59 ml in rats weighing 26–50 g to 5.10 ml in rats weighing 226–250 g. In the rats weighing around 200 g, the total blood volume is estimated to be either 10.54 or 11.36 ml according to these workers. Either figure is in good agreement with the figure used in the present study (11.03 ± 0.44 ml). It can be stated therefore that our figure is quite reasonable.

Finally, the author wishes to compare the figures obtained in the present study for total cellular numbers of circulating blood with the corresponding values reported by *Kindred* (1942), who made a quite similar calculation based on a study of 8 albino rats weighing approximately 200 g each. The value used by *Kindred* for circulating blood volume was 14.76 ± 0.27 ml per 200 g of body weight, and the following figures were obtained: $(136,000 \pm 3,800) \times 10^6$ for red cells; $(104 \pm 2.9) \times 10^6$ for total white cells; $(86.6 \pm 5.2) \times 10^6$ for lymphocytes; and $(17.4 \pm 1.9) \times 10^6$ for total granulocytes in the circulating blood. From a comparison of these figures with the values given in Table 2, it is seen that the figures of *Kindred* for leukocytes (lymphocytes and granulocytes) are much smaller than the corresponding values obtained in the present study. This is attributable to a large extent to the fact that the total white cell count was exceedingly low in the animals used by *Kindred* as compared with that in our material (cf. Table 3).

SUMMARY

On the basis of the cell counts of tail blood from a total of 50 standard rats (male rats weighing around 200g from a subline of the *Wistar* strain) and the measurements of total circulating blood volume on 10 standard rats using radioactive phosphorus, an attempt has been made to calculate total cellular numbers of circulating blood and the results are presented.

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