Age Changes in the Total Number of Nucleated Cells in the Bone Marrow of the Normal Albino Rat*

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During a quantitative study of the normal age changes in the thymolymphatic tissues of the normal rats at different ages (A w a y a and O d a, 1964), the estimation of the total number of uncleated cells in the bone marrow has also been made of the same material using the cell-counting method described by A w a y a in 1962. By this we were able to establish a normal value and its physiological variations in the total cell counts within the marrow throughout the life cycle of a representative mammal, the rat. An analysis of the data obtained is the subject of this paper. Hitherto a little has been published on values obtained by using a quantitative method (F a n d and G o r d o n, 1957; B u r k e and H a r r i s, 1959).

MATERIAL AND METHODS

The same animals as those employed in the preceding study (A w a y a and O d a, 1964) served as material. These animals, consisting of 120 albino rats of a subline of the Wistar strain, were devided into twelve age groups as shown in Table 1. Five animals of each sex were studied in each of these age groups. The total number of nucleated cells in the bone marrow was estimated by A w a y a 's method. The method, in brief, consists of preparing the cell suspension of aproximately 10 to 20 mg of marrow tissue in 2 ml of the diluent (human plasma) and of making the hemocytometer count of nucleated cells. However, when the test animals were younger than 2 weeks of age and less than 10 mg of the sample is obtainable, the diluting fluid was reduced to 1 ml or even at times 0.5 ml. The sample was obtained from the right femoral marrow. This procedure has been elected because in the previous observations (A w a y a, 1962) we have observed that the femur, tibia and humerus contained similar numbers of nucleated cells, and the cellular density of the right femoral marrow served as the basis for estimating the total number of nucleated cells in the entire bone marrows of the

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animals body. The left femoral marrow was used for the cytological and histological observations.

RESULTS AND DISCUSSION

The chief results are shown in Table 1 and Figure 1.

The curves for the average values of the number of nucleated cells per mg of marrow showed the presence of very high values ($1.91-2.53 \times 10^6$/mg) till the 4th month. From 5 to 6 months the curves still maintained considerably high level ($1.81-2.02 \times 10^6$/mg), but thereafter declined slugishly ($1.20-1.66 \times 10^6$/mg). A distinct sex difference were not observed in this respect.

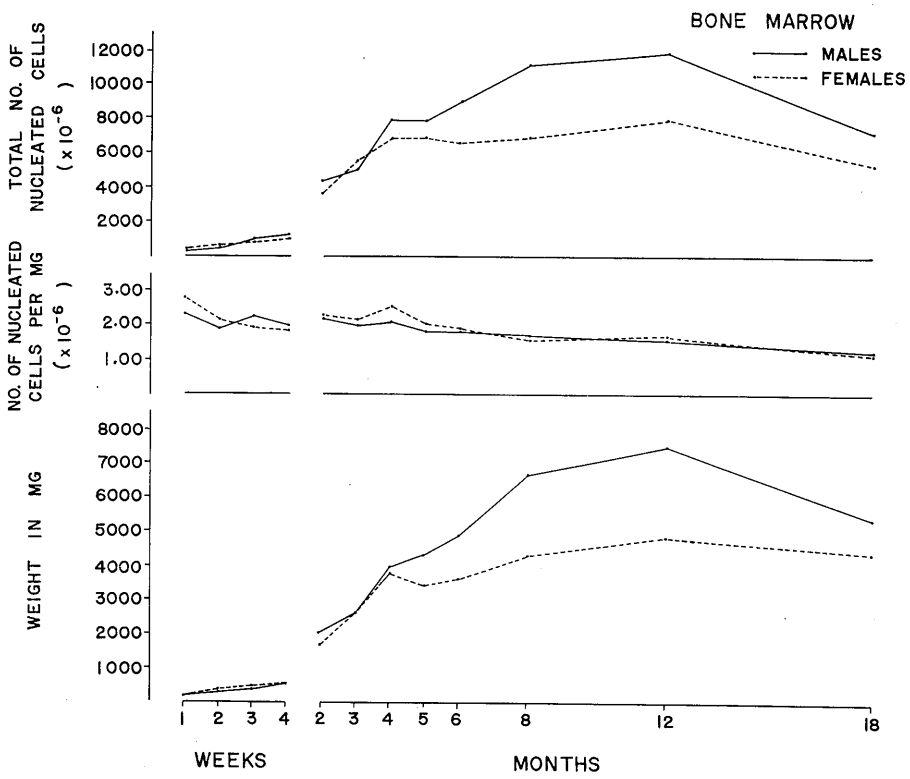

Fig. 1. Age changes in organ weight, cellular density (number of nucleated cells per mg) and total number of nucleated cells in bone marrow of male and female albino rats of a modified Wister strain. The weight of the bone marrow was expressed as 1.65% of body weight according to W a t a n a b e (1955).

Based on the value of 1.65 gm per 100 gms of body weight (as given by W a t a n a b e in 1955) the marrow weight and the total number of nucleated cells contained in the total bone marrow of the whole body were roughly esti-

Table 1. Nucleated cell number in the bone marrow of albino rats at various ages. Means±Standard errors. (n = 5).

Age and Sex	per mg ($\times 10^{-6}$)	per organ ($\times 10^{-6}$)	per 100 gm body weight ($\times 10^{-6}$)
1 week ♀	2.31±0.23	363.1±61.21	3808.2±554.22
♂	2.76±0.47	413.0±64.83	4554.0±861.36
2 weeks ♀	1.91±0.12	541.2±20.32	3158.1±191.97
♂	2.18±0.19	732.7±75.13	3590.4±309.59
3 weeks ♀	2.25±0.17	975.1±103.00	3719.1±277.71
♂	1.94±0.12	906.5±74.10	3204.3±194.84
4 weeks ♀	1.96±0.10	1111.3±85.32	3237.3±163.04
♂	1.89±0.07	1073.0±89.06	3121.8±116.13
2 months ♀	2.18±0.07	4443.2±313.21	3590.4±119.62
♂	2.22±0.07	3662.1±119.74	3659.7±108.75
3 months ♀	1.98±0.09	5120.2±413.60	3273.6±155.36
♂	2.16±0.14	5505.9±416.35	3564.0±231.00
4 months ♀	2.06±0,23	7996.4±568.82	3394.4±381.42
♂	2.53±1.26	6859.2±438.02	4174.5±463.94
5 months ♀	1.81±0.10	7854.9±566.32	2986.5±166.90
♂	2.02±0.08	6869.0±473.77	3331.7±196.33
6 months ♀	1.85±0.05	9012.7±470.29	3052.5±78.44
♂	1.87±0.11	6642.5±495.44	2593.0±452.30
8 months ♀	1.66±0.08	11238.5±1118.74	2745.6±138.99
♂	1.60±0.06	6958.6±341.25	2640.0±102.65
12 mouths ♀	1.59±0.06	11903.9±913.82	2620.2±90.89
♂	1.66±0.14	8011.0±530.66	2735.7±238.57
18 months ♀	1.34±0.07	7279.2±1000.2	2206.9±112.19
♂	1.20±0.11	5364.2±671.67	1973.4±188.17

mated. The values for both, in both sexes, increased rapidly from 2 to 4 months. After this, the curve for males continued to rise till the 12th month while the curve for females ran fairly horizontally till the 12th month. By 18 months of age the values in both sexes markedly decreased. It should be noticed that the red marrow, which is composed of myeloid tissue and plays a role in hemopoiesis producing the erythrocytes and the granulocytes, is gradually replaced by the yellow marrow with its fat cells with advancing age. However, the relative amount of the fatty marrow being unknown in this study, the materials were tentatively assumed to contain the red marrow only. For this reason, the values presented here seem to be overestimated especially in the 5th month on, when the hematopoietic elements are replaced to more or less extent by fat. These values will, therefore, require some correction. Thus, the hemopoiesis in the

bone marrow may be said to be most vigorous from 2 to 4 months of age. This fact also is clearly shown in the table 1 in which the relative number of nucleated cells per 100 gm body weight are listed. Quantitative analysis in the preceding study (A w a y a and O d a, 1965) showed that the growth of the mesenteric lymph nodes and spleen were most vigorous from 2 to 4 months of age while the thymus, after reaching its maximal growth at the 2nd or 3rd week, underwent a rapid involution. Thus, it was observed that there occurred an active hematopoiesis in the bone marrow almost coincident with the vigorous growth of the lymph nodes and spleen.

Studies of bone marrow smears revealed that the marrow of young rats was characterized by an increase in nucleated red cells associated with decreased numbers of granulocytic series, and that with advancing age there was the decline in the number of erythrocytic elements and the concomitant increase of granulocytes. In addition, histologically the bone marrow showed a progressive fatty infiltration with advancing age. The decline of the cellular density in the marrow of the aged rats mirrored such an increase of fat in response to aging. These cytological and histological observations will be discussed separately.

SUMMARY

Using quantitative method the cellular density in the bone marrow, the weights and the total number of nucleated cells in the total marrow of the whole body were estimated in the normal rats from 1 week to 18 months of age. These average values are shown in Table 1. The data indicate that an active hemopoiesis occurred between 2 and 4 months of age.

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