17148. Influence of Environment on Preweaning Growth of the Rat. I. Dietary Regimen of the Young.*

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Evidence presented in a previous publication[2] indicated that the growth curve of preweanling rats in the authors' laboratory did not conform to the formulation of preweaning growth given by Zucker *et al.*[3,4] It was found with the Anderson and Smith[5] diet that Zucker's equation, $\log W = k \log t + \log C$, applied to the approximate postconception age periods, 22 to 34 and 43 to 50 days, but that there were changes in the constants of this equation at fairly definite ages. The first change at approximately 24 days was believed to be correlated with the birth-weight but the second change at about 29 days of age was tentatively ascribed to a change in growth pattern. The divergence of the curve from a straight line at about 34 to 43 days was assumed to be due primarily to some dietary influence.

These results were obtained under the usual breeding conditions wherein the mother and young were housed in a single cage and all had access to the diet. It is generally recognized that the young begin to ingest solid food coincident with the opening of their eyes at about 34 days after conception and it has been suggested[2] that this phenomenon may be associated with the divergence of the growth curve. The following experiments, fashioned after those of Kozlowska *et al.*[6] except that no mineral supplements were employed, were performed to elucidate the factors contributing to the observed divergence and to determine the pattern of growth when the young are restricted to the mother's milk.

Experimental. Seven pregnant Long-Evans strain rats were placed in individual breeding cages. The first group (3 rats) was fed the Anderson and Smith diet *ad libitum* in the breeding cages until the young were weaned. The second group (3 rats) was removed from the breeding cages (which contained no food) for 2-hour periods 3 to 4 times daily during the period 7:30 A.M. to 10:30 P.M. and allowed to eat the same diet *ad libitum* in separate cages. This procedure was continued until the young were weaned at 50 days postconception (28 days, post-natal). At this point the mother was removed from the breeding cage and the young were given the Anderson and Smith diet *ad libitum*. The third group (1 rat) was fed similarly except that separate feeding of the mother was discontinued at 43 days postconception and the diet was made available *ad libitum* in the breeding cage until the young were weaned at 50 days postconception.

Each of the litters was reduced at birth to 6 young divided, so far as possible, equally between males and females. The total weight of each sex in each group was determined daily and the total weights were divided by the number of males and females, respectively. The plot of the resultant averages is shown in the accompanying figures. These procedures afforded growth data on a total of 39 young (18, 15 and 6, respectively) in the 3 groups.

Results. The growth curves obtained for the male rats are shown in Fig. 1. Only the curves for the males are given inasmuch as the results were similar with the females. Since the growth data of the 10 males of

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1 Dunn, M. S., Camien, M. N., Eiduson, S., and Malin, R. B., in press.

2 Murphy, E. A., and Dunn, M. S., *Growth*, 1948, **12**, 311.

3 Zucker, L., Hall, L., Young, M., and Zucker, T. F., *Growth*, 1941, **5**, 399.

4 Zucker, L., Hall, L., Young, M., and Zucker, T. F., *Growth*, 1941, **5**, 415.

5 Anderson, W. E., and Smith, A. H., *Am. J. Physiol.*, 1932, **100**, 511.

6 Kozlowska, C. M., McCay, C. M., and Maynard, L. A., *J. Nutr.*, 1932, **5**, 61.

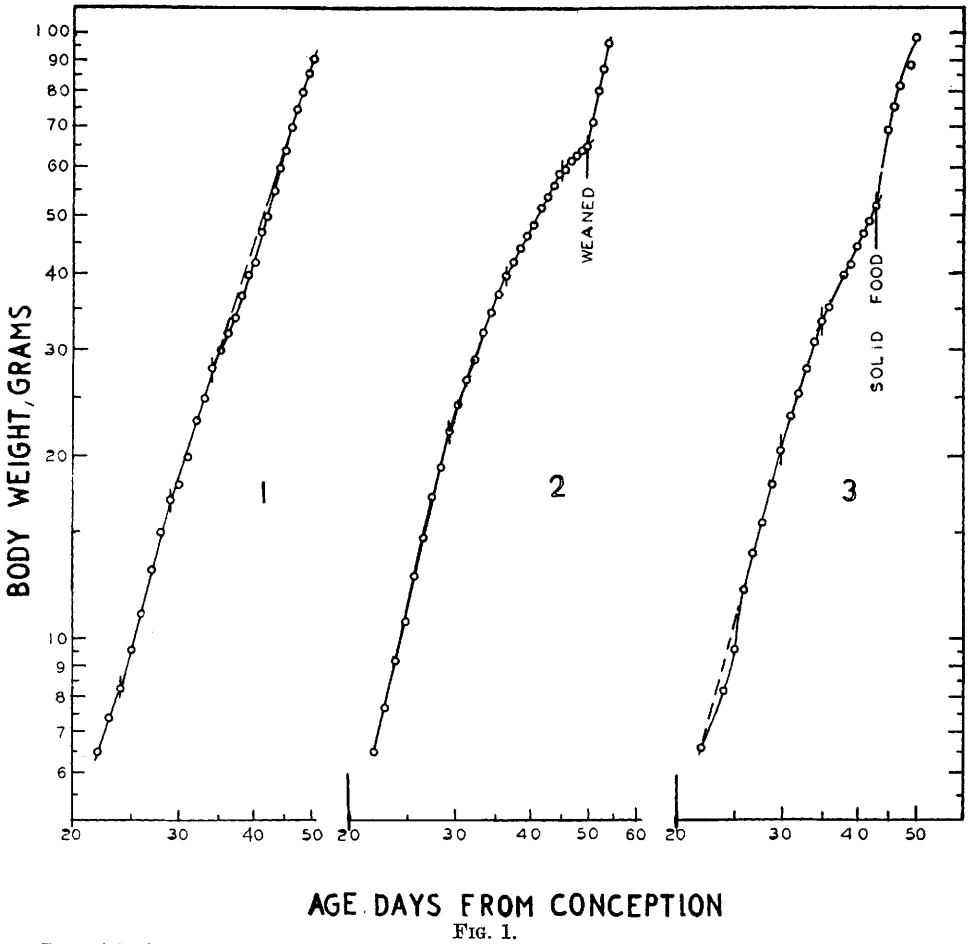

FIG. 1.

Logarithmic curves relating body weight and age of male Long-Evans strain rats under different dietary conditions.

Curve 1. Average of 33 rats, unrestricted feeding.
Curve 2. Average of 10 rats, restricted until weaning.
Curve 3. Average of 4 rats, restricted until 43 days of age.

Group 1 and those obtained previously were in close agreement the two sets of data were combined. The resultant curve (Curve 1, Fig. 1), therefore, represents the average growth of 33 males. The average curves representing the nine males of Group 2 and the 4 males of Group 3 are shown as Curves 2 and 3 of Fig. 1, respectively.

Discussion. It is apparent that the shape of the growth curve of the young, particularly from about 34 days of age (postconception) to weaning, is profoundly affected by the availability of solid food. The changes in slope of Curves 2 and 3 occurring between 34 days and weaning may reflect both the decreasing food value to the young rat and the decreasing volume of the mother's milk.[2] The insufficiency of the milk as a food source with increasing size of the young rat is emphasized by the abrupt increase in growth rate as soon as solid food became available. The correlation of these data is shown in Fig. 2 which was constructed by superimposing the curves for the male rats given in Fig. 1. This was accomplished by aligning the tracings so that point B and the line BC on each of the 3 curves coincided. In this way the curves are plotted approximately identically on the X scale (age) without regard for the Y scale (weight). The effect of environment on abso-

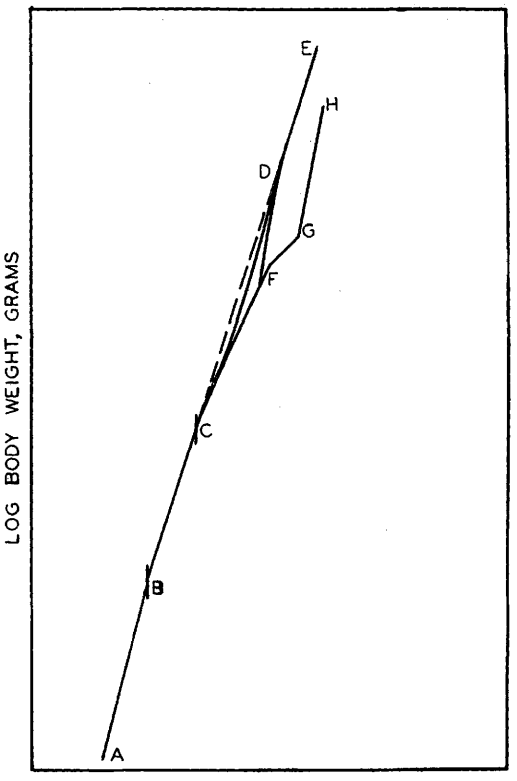

FIG. 2.

Superimposed logarithmic curves relating body weight and age of male Long-Evans strain rats under different dietary conditions.

Solid line, ABCDE—Curve 1 of Fig. 1. Unrestricted feeding.

Solid line, ABCFGH—Curve 2 of Fig. 1. Restricted, to 50 days.

Solid line, ABCFDE—Curve 3 of Fig. 1. Restricted, to 43 days.

lute size will be considered in a subsequent publication. In Fig. 2 the solid line, ABCDE, represents the growth of the males in Group 1 (unrestricted feeding); line ABCFDE represents the growth of the males in Group 3 (restricted to 43 days); and line ABCFGH represents the growth of the males in Group 2 (restricted to 50 days, weaning). It may be concluded from these results that the slopes of the segments CF and FG represent the rates of growth natural to the milk diet during these age periods and that the slope of segment DE is typical of the natural rate of growth on the solid diet after 43 days of age. The shape of the growth curve of the unrestricted males, therefore, would appear to be the resultant of the natural transition from the milk diet (CF) to that of the completely solid diet (DE) with the completion of the physiological ability to utilize fully the solid diet occurring at about 43 days (postconception). In this case the curve is naturally concave. Since, in the Group 3 animals there is present the physiological capacity to utilize the solid food, the resultant convexity of the curve is indicative of the "recovery" nature of the growth. This reasoning also accounts for the increase in slope of GH over that of DE.

Since the data of Group 1 agree very well with other similar data obtained earlier and with different groups of animals, they have reasonable reliability. That segments of the 3 curves have the same relative shape and are superimposable is further evidence supporting this view. It would seem to be a logical conclusion that the divergence from a straight line between about 34 to 43 days (illustrated by Curve 1, Fig. 1 and reported previously[2]) does not indicate necessarily a qualitative deficiency in the diet but may be a natural phenomenon arising because of the transition from a milk diet to one of solid food. Although this explanation was suggested by MacDowell *et al.*,[7] the present experiments appear to be the first to demonstrate its validity. That the causes were quantitative, rather than qualitative, in nature was indicated in previous experiments[2] with a limited amount of data. It was also shown earlier that the degree of divergence and/or its duration could be influenced by the quality of the diet.

Summary. The shape of the preweaning growth curve of the rat is profoundly affected by the lack or availability of solid food. The divergence from conformity to Zucker's growth equation of rats raised on the Anderson and Smith diet may be due to the natural transition from a liquid (milk) to a solid diet and does not appear to be explained by a qualitative deficiency in this diet.

[7] MacDowell, E. C., Gates, W. H., and MacDowell, C. G., *J. Gen. Physiol.*, 1930, **13**, 529.

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