FURTHER EXPERIMENTS ON THE INFLUENCE OF FOOD UPON LONGEVITY*

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THE available data regarding noteworthy cases of longevity in man have given the impression that this depends almost entirely upon inheritance. The limitations of the method of investigation in such cases, however, may quite conceivably have tended to obscure or minimize the importance of food, and perhaps of other factors. In compiling the available facts regarding a person who has attained to great age, the ages reached by parents and grandparents will usually stand out as clear-cut quantitative data; while it will be quite impossible to obtain equally clear-cut and quantitative data as to the food consumed throughout a life-time.

This latter factor can, however, be studied experimentally by the use of such a laboratory animal as the rat; and the suitability of this species for use in studies of nutritional problems of human importance has been fully discussed by Osborne and Mendel (1), while further evidence is afforded by the work of Folin and Morris (2) which showed close similarity of the end products of metabolism in the two species.

McCollum and others (3) have repeatedly shown that the normal length of life of experimental animals (rats) may be shortened in almost any desired degree by dietary deficiencies of varying degrees of severity.

Our own problem has been to determine whether, starting with a food supply and nutritional condition already adequate and normal, it is possible by improvement of the food to induce a definite increase in longevity.

In the present experiments the original diet (Diet A) consisted of a mixture of one-sixth dried whole milk and five-sixths ground whole wheat, with table salt and distilled water. Families of experimental rats are still thriving after 21 successive generations on this diet. This is probably an unprecedentedly rigorous test of the adequacy of a food supply and shows beyond question that this original diet was certainly adequate.

Simultaneously, parallel lots of animals, of the same heredity, have been fed a diet differing only in that the proportion of milk powder in the food mixture was increased to one-third (Diet B).

While Diet A was clearly adequate, Diet B proved to be better, and

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induced, in addition to other evidences of improved nutrition (4), *both* a decrease in infant mortality *and* an increase of ten per cent in the average length of life of the adults.

The two groups of animals, which as already mentioned were of the same heredity, were kept under identical conditions in all respects except for the difference in food. The higher proportion of milk in Diet B means chiefly, in chemical terms, a richer intake of calcium, of vitamins A and G, and of certain of the amino acids. Experiments designed to determine to which of these chemical factors the increase of longevity is attributable are now in progress but not yet sufficiently advanced to permit of final conclusions. From the results thus far obtained it seems probable that the increased intakes of calcium, of vitamin A, and of vitamin G may all have contributed to the higher degree of health and the increased length of life.

That the increase of longevity was real and not accidental is made clear both by simple statistical treatment of the data and also by grouping them in such manner as to afford a series of comparisons (of the animals on the two diets) in terms of the percentages attaining to different degrees of longevity. The evidence as assembled in these two ways is briefly summarized in Tables I and II, respectively.

A part of this evidence was presented in a preliminary report of about a year ago (5). Since that time the numbers of animals compared have been considerably increased and the findings have become more conclusive.

TABLE I
COMPARISON OF LONGEVITY OF RATS ON DIETS A AND B

	Diet A		Diet B		Difference of Length of Life in Days
	Number of cases	Average Length of life in days	Number of cases	Average Length of life in days	
Males	135	571±8.0	124	635±8.5	64±11.7
Females	196	603±8.0	163	669±7.8	66±11.2

The average lengths of life and the differences of these averages, as given in Table I, are followed by estimates of their probable errors computed in the usual manner. While it is true that such computation is based upon an assumption of symmetrical frequency distribution and therefore may or may not be precisely accurate for data of this particular kind, yet, inasmuch as these data belong to the category of natural phenomena to which, according to Reitz and Mitchell (6) the usual calculations of probability may normally be expected to be applicable, there is good reason

to believe that the quantitative relations thus computed are at least approximately correct. This being the case, and the increase of longevity being 5.6 and 5.9 times its probable error, for males and females respectively, it follows that, speaking mathematically and from the standpoint of this mode of interpretation alone, the chances are about ten thousand to one (10,000:1) that the increase in longevity here found is a true difference due to the food, and not an accidental difference nor due to unknown causes.

The findings are established with still greater certainty when our basis of scientific judgment is broadened to include a further consideration of the data from the point of view summarized in Table II. This makes possible a series of nine comparisons, and in every one of these the greater longevity attained upon Diet B than upon Diet A is clearly apparent.

TABLE II

INFLUENCE OF FOOD UPON ATTAINMENT OF DEFINITE AGES

Percentage of Lives Longer than:	Males		Females	
	On Diet A	On Diet B	On Diet A	On Diet B
600 days	42.9	65.3	54.1	73.0
700 days	14.8	32.3	27.6	43.6
800 days	2.9	10.5	12.2	15.9
900 days	0.0	1.6	2.6	5.5
1000 days	—	—	0.5	1.2

Hence it may be regarded as established beyond any reasonable doubt that, starting with a diet which is already clearly adequate, it may still be possible to induce a very significant improvement in longevity by enriching the diet in certain of its chemical factors.

REFERENCES

1. Osborne, T. B., and Mendel, L. B., Publication No. 156, Carnegie Institution of Washington (1911) and subsequent papers in the *Journal of Biological Chemistry*.
2. Folin, O., and Morris, J. L., *Jour. Biol. Chem.*, 1913, XIV, 509–515.
3. McCollum, E. V., Simmonds, N., and Parsons, H. T., *Jour. Biol. Chem.*, 1921, XLVII, 111–246. McCollum, E. V., and Simonds, N., "The Newer Knowledge of Nutrition," 3rd Ed. 1926.
4. Sherman, H. C., and Campbell, H. L., *Jour. Biol. Chem.*, 1924, LX, 5–15.
5. Sherman, H. C., and Campbell, H. L., *Proc. National Academy of Sciences*, 1928, XIV, 852–855.
6. Reitz, H. L., and Mitchell, H. H., *Jour. Biol. Chem.*, 1910–11, VIII, 297–326.