IS THERE A TEMPERATURE COEFFICIENT FOR THE DURATION OF LIFE?

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In 1908 one of us raised the question whether there is a definite temperature coefficient for the duration of life.[1] This might be expected if the duration of life depended upon the presence of certain substances which were used up during life; or if the duration of life were limited by the cumulative injurious effects of certain products of metabolism. Thus, Metchnikoff[2] has mentioned the possibility that the duration of the life of the moth of the silk worm is limited by the retention of certain poisonous substances contained in the urine. The rapidity of consumption of the necessary substance in the case of the first or the velocity of the accumulation or action of injurious substances in the case of the second hypothesis should increase with the temperature according to a certain law.

It seems that there exists for each species a pretty definite duration of life in spite of the fact that injuries of various types may shorten the life of the individual. The annual plants, the sequoia of the sierras, the human, the insects, have their characteristic duration of life. On the other hand, it was shown by Leo Loeb that the cancer cell is immortal and he pointed out that this might be the case for all cells. Then the problem arises, what is the cause of the fact that each species has a limited duration of life the magnitude of which is characteristic for the species? If the answer to this question is given by one of the two hypotheses mentioned in the first paragraph of this paper, it may be expected that there should be found a temperature coefficient for the duration of life of the order of magnitude of that of chemical reactions. A search for such a temperature coefficient can only be attempted on a form with a naturally short duration of life. We have selected for this purpose the fruit fly *Drosophila*.

Newly hatched flies were put into large Erlenmeyer flasks kept in thermostats 34°, 31°, 28°, 24°, 14°, and 9°. Each flask contained on the average about 100 flies. The number of dead were counted each day and the surviving flies were put into fresh flasks every two days. Each determination of the duration of life was based upon at least two and often as many as twelve cultures of about 100 flies each. The values for the mean length of life of the flies in the separate cultures, at a given temperature, was averaged and this value taken as the average duration of life for that temperature.

Three series of experiments were made. In one the flies were provided only with water, in the second with a 1% cane sugar solution, and in the third with fermented banana. In the third series the results were less regular than in the first two series, probably on account of differences in the nature of microorganisms present in the food. We intend to repeat these experiments with sterile cultures of flies which we are now raising, and will report on these experiments in a later publication.

The following table gives the average duration of life for different temperatures.

TEMPERATURE	DURATION OF LIFE IN DAYS	
	With H_2O	With 1% cane sugar
°C.		
34	2.1	6.2
28	2.4	7.2
24	2.4	9.4
19	4.1	12.3
14	8.3	
9	11.9	

If we consider the figures for temperatues between 28° and 9° for the cultures in water and in sugar we find that there exists a temperature coefficient for the duration of life of about the order of magnitude of that of chemical reactions, namely, of about 2 for a difference of 10°C. We find also that the coefficient is greater for the lower range of temperatures. The same temperature coefficient was also found by previous authors for the time required for the development of the eggs of animals and incidentally also by us for the larval period of these flies; with this difference only, that in the latter case the coefficient is more regular.

These experiments therefore show that the duration of life in the cases examined has a temperature coefficient of that order of magnitude which is characteristic for life phenomena and for chemical reactions in general.

[1] Loeb, J., *Arch. ges Physiol.*, **124**, 411 (1908).
[2] Metchnikoff, E., *Ann. Inst. Pasteur*, **29**, 477, (1915).