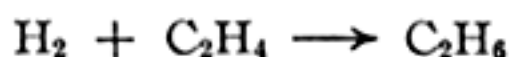


Foundation for advice in the construction of the photoelectric cell.) The design of the attachment of the cell to the spectrograph to make a photoelectric spectro-photometer will be recorded in another place.

The fact that hydrogen molecules, even with 3.78 volts will not react with ethylene is of much interest in reference to the activation theory of chemical reactions. The reaction



is itself exothermic and yet will not occur even with activation of the hydrogen amounting to 87,000 calories. It brings up the consideration, which has often been stated but not with such direct evidence, that the thermal activation of the reactants is in many cases of minor importance in causing reactions to take place; that it is the activation of some catalytic substance which may be present either as an impurity or "wall" which is the major factor in bringing them about.

This work was done while the writer was a National Research Fellow at The Johns Hopkins University, and he takes this opportunity of thanking those who made his year there one of pleasure and profit.

<sup>1</sup> Bates and Taylor, *J. A. C. S.*, 50, 771 (1928).

<sup>2</sup> Bates and Taylor, *Proc. Nat. Acad. Sci.*, 12, 714 (1926); *J. A. C. S.*, 49, 2438 (1927).

<sup>3</sup> Taylor and Marshall, *J. Phys. Chem.*, 29, 1140 (1925).

<sup>4</sup> Olsen and Meyers, *J. A. C. S.*, 48, 389 (1926).

<sup>5</sup> Tolman, *J. A. C. S.*, 42, 2506 (1920); 45, 2285 (1923).

<sup>6</sup> Stewart, *Z. Physik*, 32, 262 (1925).

<sup>7</sup> See Johnston and Andrews, *J. Inst. Metals*, 32, 285 (1924).

<sup>8</sup> Kaplan, *Phys. Rev.*, 31, 997 (1928).

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## THE INFLUENCE OF FOOD UPON LONGEVITY<sup>1</sup>

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Accepting the view that longevity is largely and perhaps chiefly determined by inheritance, it still remains possible that other factors may have more influence than has hitherto been clearly demonstrated. Thus if the mode of investigation is to inquire into the histories of people who have attained to noteworthy longevity, the ages reached by their parents and grandparents will usually stand out as clear-cut quantitative data while a correspondingly definite record of the kinds and amounts of foods consumed during a lifetime would be quite unobtainable. With man, one can neither control the food intake throughout a lifetime nor ensure

life-long uniformity of other factors for individuals whose food habits are different. These conditions can, however, be realized experimentally with suitable animals such as the familiar albino rat of the laboratory,<sup>2</sup> amenable to complete control, and having a life cycle not too long to permit of uninterrupted observation. It is also of interest that in general food habits and mode of metabolism of foodstuffs, as indicated by the end products appearing in the urine,<sup>3</sup> the rat is so much like the human as to justify considerable confidence that nutritional principles demonstrated in the one species will probably apply also to the other.

We have recently completed a somewhat extended experiment in which the influence of a single change in the food supply upon the longevity of rats of identical heredity, maintained under conditions uniform in all other respects, appears to have been fully demonstrated.

One of the groups of experimental animals received Diet A, a mixture of one-sixth dried whole milk and five-sixths ground whole wheat with table salt in the proportion of two per cent of the weight of the wheat, and distilled water *ad libitum*. The parallel group received Diet B, which differed from Diet A only in that the proportion of dried milk was increased to one-third, the wheat becoming two-thirds. We have previously outlined elsewhere<sup>4</sup> our mode of conducting such experiments and the evidence, from rates of growth and reproduction records, that Diet A is adequate but Diet B is better.

About two hundred animals, the exact numbers being 220 upon Diet A and 179 upon Diet B, were kept continuously upon each of the two diets until natural death.

With both males and females the average duration of life was almost exactly ten per cent longer upon Diet B than upon Diet A. The data are summarized in table 1.

TABLE 1  
COMPARISON OF LONGEVITY OF RATS ON DIETS A AND B

	DIET A		DIET B		DIFFERENCE OF LENGTH OF LIFE IN DAYS
	NUMBER OF CASES	LENGTH OF LIFE IN DAYS	NUMBER OF CASES	LENGTH OF LIFE IN DAYS	
Males	92	576 ± 10.0	80	635 ± 12.9	59 ± 16.0
Females	128	604 ± 11.4	99	664 ± 11.5	60 ± 16.2

The average lengths of life as given in table 1 are followed by estimates of their probable errors computed in the usual manner. It is realized that the validity of such computation of probable error might be questioned on the ground that it assumes a symmetrical frequency distribution which has not been actually demonstrated for data of this particular kind. It may be said, however, that the cases here summarized, while not sufficiently numerous to afford smooth diagrams, indicate at least an approximation to the symmetrical frequency distribution; and they belong to the general category of natural phenomena to which, according to Reitz and Mitchell,<sup>5</sup>

the usual calculations of probability may normally be expected to be applicable. Both for males and for females, the difference between the mean lengths of life upon the two diets is 3.7 times its probable error, as computed by the usual method. Assuming that this method is even approximately correct for the data here considered, this would mean that the chances that the differences found are truly significant and not accidental are about of the order of one hundred to one.

The reality of the observed differences in longevity is also confirmed in other ways.

If the median length of life be compared, instead of the mean, both males and females again show the distinct difference in favor of Diet *B*.

Furthermore, if we compare the percentages of individuals attaining to definite degrees or standards of longevity, we find that such cases of longevity are distinctly more frequent upon Diet *B* than upon Diet *A*, as may be seen from the data summarized in table 2.

TABLE 2  
INFLUENCE OF FOOD UPON ATTAINMENT OF DEFINITE DEGREES OF LONGEVITY

	PERCENTAGE OF RATS LIVING OVER 800 DAYS	PERCENTAGE OF RATS LIVING OVER 900 DAYS
Males		
Diet A	4.3	0.0
Diet B	13.8	2.5
Females		
Diet A	17.2	3.9
Diet B	20.2	9.1

Here it will be seen that when the results are so arranged as to test the influence of food upon the attainment of definite degrees of longevity there is, in each of the four comparisons, again a distinct difference in favor of Diet *B*.

Infant mortality is not included in the data discussed in this paper; if it were, the differences in favor of Diet *B* would be still further accentuated.

It is especially worthy of emphasis that the influence of food upon longevity, as here recorded, was manifested well within the bounds of normal and adequate nutrition. Reference has been made above to an earlier paper<sup>4</sup> giving numerous data which establish the adequacy of Diet *A*, and it may also be said in this connection that we now have rat families in our colony which are still thriving upon this diet in the twenty-first generation.

Diet *A* is therefore adequate, but not optimal. Diet *B* is better than Diet *A*, but is doubtless still capable of further improvement. Hence it is probable that further studies will reveal possibilities of a more extended influence of food upon longevity than that here recorded.

The precise determination and relative evaluation of the individual chemical factors involved will doubtless require prolonged investigation.



<sup>1</sup> This paper is published as Contribution No. 589 from the Department of Chemistry, Columbia University.

<sup>2</sup> For discussion of the rat as a laboratory animal for nutrition investigations, see Osborne, T. B., and Mendel, L. B., Publication No. 156, Carnegie Institution of Washington (1911).

<sup>3</sup> Folin, O., and Morris, J. L., *J. Biol. Chem.*, 14, 509-515, 1913.

<sup>4</sup> Sherman, H. C., and Campbell, H. L., *J. Biol. Chem.*, 60, 5-15, 1924.

<sup>5</sup> Reitz, H. L., and Mitchell, H. H., *J. Biol. Chem.*, 8, 297-326, 1910-11.

## THE INTERFEROMETER U-GAUGE WITH CLOSED AUXILIARY RESERVOIRS

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1. *Both Reservoirs of the U-Gauge Closed.*—In the doubly closed gauge either shank becomes a region for the measurement of small pressures, provided the temperature differences can be adequately stated. To facilitate this, the air space  $v$  (figure 1, insert  $g$ ) and the air space  $v'$  are severally connected with identical Dewar flasks of relatively large volumes,  $D$  and  $D'$ , each provided with a sensitive thermometer  $T$ ,  $T'$ , reading at least to  $0.01^\circ\text{C}$ .

Since the micrometer of the interferometer is adjusted to indicate pressure on the  $v'$  side, if its readings increase, the equation heretofore\* used now becomes

$$dh + h(dh/2l + d\tau/\tau) = \Delta h + h(-dh/2l + d\tau'/\tau),$$

$dh$  being the total change of head when the level falls in  $v'$ ,  $\tau$  denoting absolute temperature (rising in both cases),  $h$  the mean barometer height and  $l$  the modified depth of the volumes  $v$ ,  $v'$ , computed to include the volumes of  $D$  and  $D'$  for the same diameter of gauge level at  $m$  and  $m'$ . Hence

$$\Delta h = dh + h \left( \frac{d\tau - d\tau'}{\tau} + dh/l \right) = 0,$$

since  $dh$  is the whole head of mercury as stated and there is no pressure-producing reaction in  $v'$ . Thus  $\Delta h$  is here an indication of the degree of accuracy with which the temperatures  $\tau$ ,  $\tau'$  have been measured.

2. *Data.*—In figures 1 and 2 I have given examples of the results of four runs taken on successive days between 9 A.M. and 6 P.M., as shown by the abscissas. The curves  $a$  summarize the temperature changes in the lapse of time, where  $\tau' - \tau$  was always positive and  $d\tau' - d\tau$  also as a rule and hence the quantity  $(d\tau' - d\tau)/\tau = \Delta\tau/\tau$  has been plotted