The absorption coefficient of various substances for γ-rays from ThC″ filtered through 6.8 cm. of lead is given in table B.

The lead absorber is of 0.682 cm. thick, and the thickness of other absorbers is approximately equivalent to this.

From the above table, it is seen that the value μ_e obtained by dividing the absorption coefficient μ by the number of external electrons per cc., increases with the atomic number, while according to the theoretical formulæ it should be constant. This might be explained by the following alternatives. (1) A part of the scattering may be due to electrons inside the nucleus as suggested by Professor Millikan in a report made to the National Academy in Nov., 1929, in which cosmic rays were shown to exhibit this same effect in still greater degree. (2) The scattering of a tightly bound electron of the atoms of high atomic numbers may be greater than that of a loosely bound electron. (3) There may still be some true absorption due to the photo-electric effect. At present, an investigation of the process of scattering is being carried on which might possibly throw some light on these questions.

I should like to express my gratitude to Professor R. A. Millikan and Professor I. S. Bowen for the suggestion of this experiment and their help in carrying it through, and also to Dr. H. N. McCoy who helped with the preparation of the Radio-Thorium.

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ON THE CONDITIONS OF ELICITATION OF CERTAIN EATING REFLEXES

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The behavior of an intact organism differs from the reflex activity of a "preparation" chiefly in the number of its independent variables. An unconditioned reflex requires, for example, not only a stimulus of adequate intensity but a facilitating condition within the organism. Similarly a conditioned reflex depends upon a facilitating condition peculiar to its underlying unconditioned reflex. The series of reflex acts by means of which an animal seizes, chews and swallows its food will serve as an example. In an adult rat this behavior is elicited by certain olfactory, visual or tactual stimuli. But these stimuli do not always evoke the behavior characteristic of them, and we say, among other things, that the rat eats only when it is hungry.

The resulting variability of behavior is typical of the sort which has led to protestations of the inadequacy of the reflex concept. But variability in the observed as against the predicted does not question the validity of a law if the variability is itself lawful. In this instance, for example, it should be possible, once having determined a measure of the "strength" of these reflexes, to investigate the conditions under which this strength changes and to eliminate the variability by describing it in a further law. Moreover, under the assumption that a facilitating condition within the organism is responsible for the variability, the laws of the variability are, *ipso facto,* the laws of the facilitating condition.

One meets at once the difficulty of measurement. In spite of the fact that the measurement of reflex strength is common practice, the dimensions of a reflex have never been critically examined. In general, the practice has been to choose a convenient measure of the action of the appropriate effector. Thus the reflex contraction of a muscle may be measured in energy developed per unit time, a reflex rise in blood pressure in millimeters of mercury, a glandular reflex in milliliters of secreted material and so on. If there is no warrant for the assumption that the response of an effector (or of a motor nerve) is directly proportional to the physiological strength of a reflex, it is at least the most convenient measure at hand. Accordingly, in the following experiments it is assumed that under constant conditions the amount of food eaten per unit time is proportional to the strength of the series of eating reflexes. If the size of the separate pieces of food is uniform, the amount of food per unit time reduces to the frequency with which the initial reflex (i.e., seizing a piece of food) is elicited. To obtain data on this frequency the following procedure was devised.

A white rat is placed in a sound-proof box in a sound-proof room. The box is 55 cm. × 50 cm. × 20 cm. and is continuously ventilated. Water is available at all times. Each rat is placed in the box at the same hour daily and eats its entire daily ration (with the exception of 5 grams of surface-dry lettuce leaf) before being removed. A feeding device permits the animal to obtain uniform pieces of a prepared food (20 pieces to the gram) in such a way as to make an electrical contact for each piece taken. The recording drum is in an adjoining room. A simple signal lever would suffice, but the records are more easily handled with a writing point devised to be lifted vertically one unit step for each contact. The record is a line running step-wise diagonally up the kymograph paper.

Since the time axis is traversed at a fixed rate (i.e., the speed of the kymograph), the slope of the line is determined by the frequency of the contacts, and the line is, indeed, a graph for this frequency.

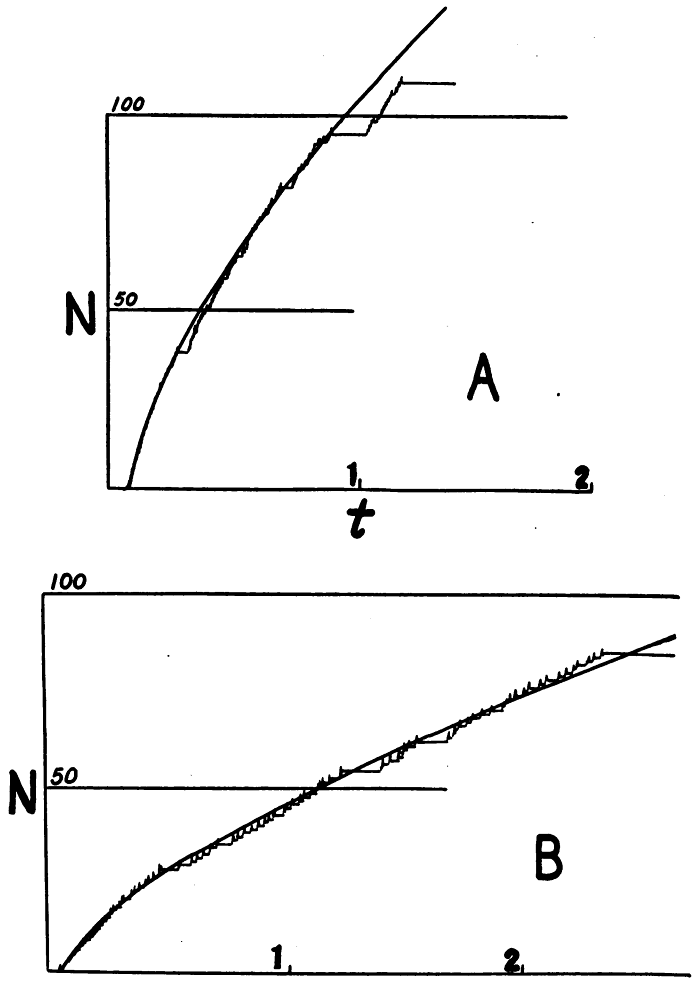

FIGURE 1

Sample records for two rats. Ordinates: number of pieces of food eaten; abscissae: time in hours from the beginning of the eating period. The theoretical curves are for the equation $N = Kt^n$, where N is the amount of food eaten at time t. In both curves $n = 0.68$. In A, $K = 3.87$; in B, $K = 1.75$.

Figure 1 gives sample records chosen at random for two rats. Without regard to the theoretical curves which have been drawn through the data, it is apparent that the frequency with which the rat repeats a series of eating reflexes diminishes in an orderly way throughout the eating period.

The average time required to eat ten pieces of food at the beginning of the period is much less than, say, at the end of one hour. The transition from one rate to another is gradual. The regularity of the change is broken only by occasional periods when no eating takes place. These interruptions are capable of quantitative description, which must be delayed until further experiments are completed. For the present it may be noted that

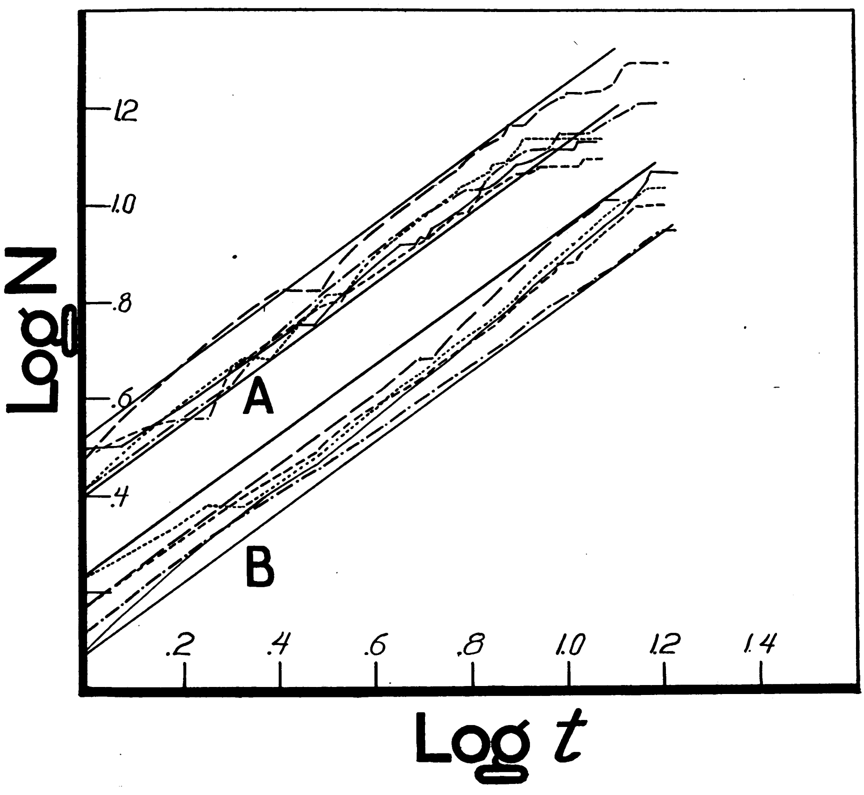

FIGURE 2

Five records for each of the animals in figure 1, plotted on logarithmic coördinates (units arbitrary). The slope of the four limiting straight lines is for $n = 0.68$.

there is usually a compensating increase in rate after an interruption, so that an even course is approximated. In many records (which are not, however, typical) no significant interruption occurs for as long as two hours. It will be noted that a limiting factor brings each record to an end, either suddenly or after a short period of reduced frequency, but that the rate has not closely approached zero when the animal stops eating.

The analysis of a large number of these records has demonstrated that they closely resemble curves for a power function and are to be described by the equation

$$N = K t^{n}, \tag{1}$$

where N = amount of food eaten at time t (counted from the beginning of the eating period), and K and n are constants. The smooth curves in figure 1 are for this equation. If this relationship holds, the data should plot as straight lines on logarithmic coördinates. In figure 2 five records for each of the individuals in figure 1 are so plotted. The approximation to a straight line is in each case surprisingly good in view of the fact that deviations due to errors of recording or to incidental disturbances in the experimental box are additive throughout the record.

In solving for the constants in equation (1) the procedure has been to take values from the straight line which appears most closely to fit the data when plotted logarithmically. In all of the records so far examined n has been of approximately constant magnitude (0.67 to 0.71). This is evident in figure 2, where the two sets of data (with slopes determined by n) are parallel. The constant K, given by the intercept on the log N axis, has so far been found to vary: (1) between animals (see Fig. 2); (2) with the amount of food eaten on the previous day (i.e., with the degree of "hunger"); (3) with the conditions of the experimental procedure (for example, with the size of the pieces of food) and (4) of course, with the units chosen. If any three of these conditions are held constant, the order of variation of the fourth can be easily investigated.

It has not been possible to vary the magnitude of n by varying any of the conditions of the experiment. It is the important constant in the equation so far as the *kind* of function is concerned, and its complete independence of experimental conditions indicates that it is, in effect (and as our assumption would imply), the description of a process. We can come directly to the characteristics of this process in this way:

It follows from (1) that the rate of eating at any time t is given as

$$\frac{dN}{dt} = K n t^{n-1} \tag{2}$$

Letting $K' = Kn(n - 1)$ and $n' = n - 1$, the second derivative of (1) appears as

$$\frac{d^2N}{dt^2} = K' t^{n'-1} \tag{3}$$

which is the rate at which the rate of eating varies with time. It thus describes the rate at which the facilitating condition changes.

Equation (3) is also for a power function (but in which the exponent is negative). The values of the constants are easily obtained from the data. Here again the constant which describes the character of the process is found experimentally to be practically invariable (about -0.3) over a wide range of conditions and with different animals.

Discussion of the process underlying the conditions of facilitation of these eating reflexes (other than to note that it must obey the power law) may be delayed until the possibilities of this method have been more fully utilized.

THE ENERGY REQUIREMENTS OF INTENSE MENTAL EFFORT

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The popular tradition that fish is a brain food has given way to the idea that mental effort demands calories. It is the experience of nearly every one that intense, sustained mental effort results in a feeling of profound fatigue, not only in mind but likewise in the entire body. The disposition instinctively to seek fresh air, to open a window and to stretch the limbs after a period of mental work is pronounced. Is the effect of mental effort upon the general vital processes in any sense commensurate with this subjective feeling of profound fatigue? The problem has been an alluring one and contributions have been made to it intermittently for thirty or more years. At the present day, although the results are most divergent, the consensus of critical opinion is that mental work has somewhat of an influence upon the metabolism, that the effect varies with the intensity of the work, and that there is a great difference in the effect produced by various kinds of mental effort. The factors most readily and most clearly studied in their relation to mental effort are the pulse rate, the respiration rate and, indeed, the entire mechanics of respiration, the carbon-dioxide production and the oxygen consumption. Measurement of these last two factors gives a direct means for computing the total energy transformation or the metabolism.

In any experimental procedure the ideal situation would be to measure the metabolism when the subject is in digestive repose, i.e., 12 hours after the last meal, perfectly quiet, muscularly relaxed, and as nearly as possible in a state of mental vacuity. Upon this basal condition should then be superimposed the factor of intense mental activity. Since this super-