A pin was attached at right angles to the prong of a 100 dv. tuning-fork, and its tip vibrated in a cork. By pulling a strip of adding-machine paper over the cork while the tuning-fork was in operation, the fork punched timing holes as accurately as it ever traced a curve. An electric bell, with the gong removed, and with a pin on its arm, likewise will give a series of perforations for as long as the circuit is closed. Thus any method of closing the circuit through the electric bell for an instant or for long times will give a record.

Mr. Joe Alexander, a graduate student in the psychology of athletics, has applied this principle to a study of reaction and total time in running. He records the firing of the gun, the start and the finish, by making contacts which momentarily close the circuit of the electric bell interrupter. The 100 dv. fork gives him his finer measures, and a one-second timer the grosser. He can record all six runners in the 100-yard dash at the same time.

This basic method of recording by perforating may be used to replace many types of fountain pen and pencil recordings, and may especially be used in reaction time work. There are no adjustments or refillings of any kind to the recording instruments, and our present device is relatively fool-proof.

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SPECIAL ARTICLES

THE STIMULATION OF METABOLISM BY ALCOHOL

THE foods serve several functions in the body. One of the functions is to be oxidized to give rise to heat and energy, and another to increase metabolism, or oxidation. The animal body is continually producing heat and giving it off to the surrounding air.. Previous to the time of Lavoisier (1780) it was a most difficult problem to explain this heat production by an animal. Lavoisier solved the problem when he showed that the heat of the body is derived from the oxidation of the food materials.[1] How this oxidation is brought about in the body seems to be as perplexing now as was the problem of how heat was produced in the body before the time of Lavoisier. Lavoisier also showed that the ingestion of the food increased oxidation and heat production. Rubner[2] found that the ingestion of protein increased metabolism more than sugar or fat. Lusk found that the amino acids increased heat production, and he attributed the stimulating effect of proteins to the amino acids resulting from the digestion of the proteins.[3] Later, however, he attributed it to the organic acids resulting from the deaminization of the amino acids.[4]

It is already recognized that alcohol can serve at least one function of the foods, namely, that of being oxidized in the body to give rise to heat. In fact, alcohol is more easily oxidized than ordinary foodstuffs, and for this reason it is used in critical periods of sickness and in weakened conditions of the body. The object of this investigation was to determine if alcohol can also serve another function of the foods, namely, that of stimulating metabolism, or more specifically, sugar metabolism.

The respiratory quotient is the index usually used to the amount of sugar metabolized in the body, a rise in the quotient indicating an increase in sugar metabolism; and a fall, a decrease in sugar metabolism. In this investigation sugar utilization, as well as the effect of alcohol and the foodstuffs on this utilization, was determined directly. This was done by adding these materials to sugar solutions in which were placed goldfish and making sugar determinations from time to time. A mixture of glycerole with equal portions of sodium palmitate, stearate and oleate was used for the fat. The alcohol used was ethyl alcohol. Instead of protein a mixture of equal portions of the following amino acids was used: glycine, dl-leucine, dl-valine, d-glutamic acid, dl-isoleucine, l-tryptophane, l-cystine, l-tyrosine, l-leucine, dl-alanine, arginine, dl-phenylalanine and l-aspartic acid. Three cubic centimeters of alcohol were used. One cubic centimeter was added at the beginning of the experiment and one half cc was added subsequently at intervals of five hours until 3 cc in all had been added. One hundred mgs of the mixture of fatty acids and glycerole as well as a hundred mgs of a mixture of the amino acids were used.

The following is the description of a typical experiment. Five hundred cubic centimeters of 0.1 per cent. dextrose solution were prepared, sterilized and divided into four portions of 125 cc. Each portion was introduced into a 200 cc beaker. Two goldfish of approximately the same size and with a combined weight of approximately 5 gms were introduced into each beaker. Air was bubbled through the sugar solutions to insure an adequate supply of oxygen to the

[1] A. L. Lavoisier, "Memoire sur la Chaleur," Mem. Acad. Sc., 355–424. 1780.

[2] M. Rubner, "Die Gesetze des Erergieverbrauchs bei der Ernährung," 322–323. 1902.

[3] G. Lusk, "The Influence of the Ingestion of Amino Acids Upon Metabolism," *Journal of Biological Chemistry,* 13: 155–183. 1912–1913.

[4] G. Lusk, "An Investigation into the Causes of the Specific Dynamic Action of the Foodstuffs," *Journal of Biological Chemistry,* 20: 555–617. 1915.

fish. Into one of the beakers, 100 mgs of the mixture of the amino acids were introduced; into another, 100 mgs of the mixture of the fatty acids and glycerole; to the third, 1 cc of 100 per cent. ethyl alcohol was added, and the fourth and fifth beakers to which nothing was added served for controls. Small amounts of the sugar solutions were removed immediately from each beaker and sugar determinations were made according to the method of Benedict. Sugar determinations were also made again after thirty hours at the end of the experiment. Six series of such experiments were made and the following is the average for the six experiments. The average amount of sugar used by the controls in thirty hours was 36 per cent.; the fish to which the alcohol was added used 57 per cent.; those to which the fatty acids and glycerole were added, 58 per cent., and the fish to which the amino acids were added used 62 per cent. of the sugar. By comparing these figures it will be seen that alcohol increased sugar utilization almost as much as the fat and protein or the amino acids. It should be stated that the increase in the sugar utilization produced by these substances was fairly uniform and constant in all the experiments.

SUMMARY

(1) The effect of ethyl alcohol, fat and protein, or the amino acids, on sugar metabolism was determined directly.

(2) It was found that alcohol stimulated sugar metabolism almost as much as fat and protein.

(3) From this it is concluded that alcohol, in addition to serving as a source of heat and energy, may also serve another function of the foodstuffs, namely, that of stimulating metabolism.

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A RELATION BETWEEN THE MEAN DISTANCES OF THE PLANETS FROM THE SUN

IN 1772 Bode drew the attention of the scientific world to an empirical law, previously discovered by Titius, relating the mean distances of the planets from the sun. If we write the following number series: 0, 3, 6, 12, 24, 48, 96, 192, 384, and add 4 to each member of the series we obtain the following numbers, which are very nearly proportional to the mean distances of the planets from the sun: 4, 7, 10, 16, 28, 52, 100, 196, 388.

The first term of this series, which corresponds to the planet Mercury, does not belong to the series but should have the value 5.5 instead of 4. Moreover, the actual distance of Neptune is less than four fifths the expected distance. Nevertheless, Bode's law has served a useful purpose inasmuch as it suggested the existence of an unknown planet in the fifth position and thereby led to the discovery of the host of asteroids.

The writer has discovered another simple relation between the planetary distances, and so far as he is aware this relation has not been reported hitherto. It suggests the possibility that the orbits of the planets may be "quantized" somewhat after the manner of the electronic orbits in the Bohr atom. For this reason it may prove to have some theoretical importance.

The mean distances of the planets from the sun are proportional to the squares of simple integral numbers. The four innermost planets are represented by four successive integers, *viz.*, 3, 4, 5 and 6. The space between Mars and the average mean distance of the asteroids (taken as 2.7 astronomical units) corresponds to a difference of 2 between the corresponding integers, that between the asteroids and Jupiter to a difference of 3, that between Jupiter and Saturn to a difference of 4, that between Saturn and Uranus to a difference of 6, and that between Uranus and Neptune to a second difference of 6. The last two planets do not fit into the law quite as well as the others, but on the whole the agreement is good, and can scarcely be accidental.

The following table gives the data upon which the preceding statements are based. The numbers given in the third column of the table are obtained by dividing the mean distances in astronomical units by 0.0425, and extracting the square roots of the quotients.

TABLE

Planet	Distance from sun in astronomical units	Square root of comparative distance	Nearest integer	Percentage deviation
Mercury	0.3871	3.018	3	+0.60
Venus	0.7233	4.125	4	+3.13
Earth	1.0000	4.851	5	−2.98
Mars	1.5237	5.988	6	−0.20
Planetoids	2.7(?)	7.97	8	−0.4(?)
Jupiter	5.2028	11.06	11	+0.59
Saturn	9.5388	14.98	15	−0.13
Uranus	19.1910	21.25	21	+1.19
Neptune	30.0707	26.60	27	−1.50

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