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The rate of glycogen formation in the liver during glucose absorption.

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An attempt has been made to obtain data for a graphic representation of the normal rate of glycogen formation in the liver of the rat. If such a curve could be constructed with the desired degree of accuracy, a standard of comparison for even small changes in the rate of glycogen formation would be available.

Experimental.

Male rats were used, that were between two and three months of age and weighed between 120 and 150 grams. They were fasted for 48 hours in order to reduce the glycogen content of the liver. In one series glucose alone was given, in a second series 15 units of insulin per 100 gm. of body weight were injected simultaneously with the sugar feeding. The amount of sugar absorbed was determined on each rat.[1] The experiments were made at a temperature of 24° C. ± 2°.

Seven rats, fasted for 48 hours, showed an average of 0.397 per cent liver glycogen. This amount of glycogen was subtracted in each case in order to obtain the amount of glycogen formed.

The curve illustrating the normal rate of glycogen formation is S — shaped. The rate of glycogen formation increases gradually up to the second hour. Between the second and the third hour the rate is at its maximum. Between the third and fourth hour the rate diminishes until quite suddenly a definite glycogen maximum is reached after 4 hours. The curve for the insulinized rats shows how profoundly the rate of glycogen formation is influenced by a large dose of insulin. With a smaller dose of insulin the curve would be steeper, with a still larger insulin dose than was used in our experiments the curve would be still flatter.

Discussion.

When sugar is absorbed from the intestine, it passes through

[1] For the method used see the following report.

TABLE I.

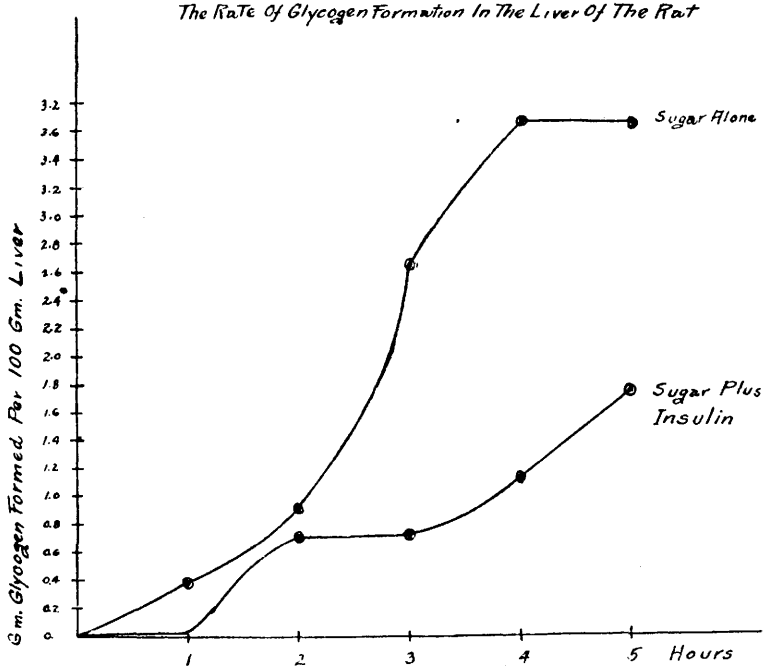
The rate of glycogen formation in the rat liver during the absorption of glucose from the intestine. A. after giving glucose alone. B. after giving glucose plus insulin. Each figure is an average of 5 to 6 experiments.

A. Glucose alone.					B. Glucose plus insulin.					
Liver in per cent of body weight.	Absorption coefficient.*	Blood sugar.	Glycogen formed per 100 gm. liver.	Percentage of sugar absorbed that is built up into glycogen.	Liver in per cent of body weight.	Absorption coefficient.*	Blood sugar.	Glycogen formed per 100 gm. liver.	Percentage of sugar absorbed that is built up into glycogen.	Remarks.
	gm.	mg.	gm.	per cent		gm.	mg.	gm.	per cent	Glucose absorption
2.96	0.183	169	0.38	6.07	3.00	0.169	73	0	0	1 hour
2.88	0.188	201	0.91	7.19	3.09	0.180	68	0.71	5.85	2 hours
3.13	0.176	189	2.66	15.84	2.89	0.175	60	0.73	3.73	3 hours
3.22	0.176	178	3.68	18.46	3.06	0.169	70	1.14	5.39	4 hours
3.24	0.175	173	3.65	13.70	3.20	0.189	71	1.77	6.01	5 hours

*The absorption coefficient is the amount of sugar absorbed per 100 gm. of body weight per hour.

Figure 1

The Rate Of Glycogen Formation In The Liver Of The Rat



the liver before it comes in contact with the other tissues of the body. In previous work on glycogen formation the amount of sugar passing through the liver was an unknown factor. Nor was it posible to know whether the control animals and the injected animals absorbed the same amount of sugar. Furthermore, most authors confined themselves to the determination of one point out of the whole curve of glycogen formation. Since different authors chose different points of the curve, certain discrepancies in the results were bound to occur. The advantage that is gained when rats instead of large laboratory animals are used is obvious. Rats can easily be bred in sufficient numbers so that animals of uniform stock, age and nutritional condition can be used for the experiments.

Our experiments show that the insulinized rats, which absorbed the same amount of sugar as the controls, deposited decidedly less liver glycogen. Lesser[2] found that mice, which re-

[2] Lesser, E. J., *Die innere Sekretion des Pancreas*, in *Oppenheimer's Handbuch der Biochemie*, 1924, 2d ed., vol. ix, 159.

ceived glucose and insulin intraperitoneally, formed glycogen 3 times as fast as the controls. Our experiments do not contradict his results. The important factor is the relation of the sugar content of the cells to the amount of insulin present. In Lesser's experiments, where sugar was injected intraperitoneally, an excess of sugar entered the blood and the tissues in a short time.[3] Consequently, the sugar content of the tissues relative to the insulin dose was great. In our experiments, where sugar was absorbed from the intestine, the relation was reversed. The normal rat, with the aid of its own insulin production, is able to metabolize the sugar at the same rate at which it enters the blood from the intestine. In other words, the relation of insulin to the amount of sugar available is optimal with respect to the rate of glycogen formation. Therefore, the injection of even a small insulin dose will create an excess of insulin over the amount of sugar available. On 8 rats, not recorded in Table I, 1 unit of insulin instead of 15 was injected, with the effect that within two to three hours less glycogen was deposited than in the respective controls.

Summary.

1. A curve for the normal rate of glycogen formation in the liver of rats during glucose absorption has been constructed.

2. Large doses of insulin decrease the rate of glycogen formation in the liver very markedly.

[3] The rate of absorption of glucose from the peritoneal cavity of mice has been determined by us on a former occasion. PROC. SOC. EXPER. BIOL. AND MED., 1925, xxiii, 122.