ferent subjects for the same cereal. An average of all the subjects for all the cereals indicated that at the end of one hour 35 to 45 per cent of the ingested cereal protein had passed out of the stomach, at two hours about 75 per cent and at three hours the average stomach was empty. Oats protein tended to leave more rapidly during the early part of digestion but was delayed in the later part.

Reliable data on rate of absorption were obtained from two subjects in connection with work and dynamic action experiments. The nitrogen of the milled wheat product regularly appeared sooner than the nitrogen from ingested oats. This was confirmed for the carbohydrate of the cereals by its effects upon the respiratory quotient.

Figures on the extent to which the cereal proteins are absorbed in the entire alimentary tract were obtained from experiments in which the fecal nitrogen and its metabolic fraction were known. From these data and the figures for ingested nitrogen the percentage absorption or utilization of the cereals are as follows: Milled wheat product 99.5 per cent, whole wheat product 87.2 per cent, oat product 86.7 per cent. These figures apparently verify the generally accepted opinion that roughage, necessary as it is, decreases the percentage of utilization.

3013

The rate of glycogen formation in the liver during absorption of fructose and galactose.

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The rate of glycogen formation in the liver of the rat during the absorption of glucose from the intestine, and the influence of insulin on the rate of glycogen formation has been studied on a former occasion.[1] It seemed of interest to repeat these experiments during the absorption of fructose and galactose.

[1] PROC. SOC. EXP. BIOL. AND MED., 1926, xxiii, 286.

EXPERIMENTAL.

The method used has been described in our previous publication.[1] Five male rats were killed 1, 2, 3, 4, and 5 hours after feeding fructose by stomach tube. The amount of sugar absorbed from the intestine and the amount of liver glycogen formed was determined on each animal. The average amounts of glycogen formed per 100 gm. liver were as follows: After 1 hour, 0.48 gm.; after 2 hours, 1.60 gm.; after 3 hours, 2.79 gm.; after 4 hours, 3.95 gm.; and after 5 hours, 4.23 gm If these values are represented in the form of a curve and compared with the curve that has already been published for glucose, it will be noted that the curve for fructose shows a steeper rise and reaches a higher glycogen maximum than the curve for glucose.

If one calculates the percentage of the total amount of sugar absorbed that is retained in the liver in the form of glycogen, this exceeds, as an average, 30 per cent for the 2, 3, 4, and 5 hour absorption periods. In some individual experiments as much as 45 or even 50 per cent of the absorbed fructose was converted into liver glycogen. This is a surprisingly large amount if one considers that the liver of rats fasted for 48 hours constitutes only 3 per cent of the body weight. In the former experiments with glucose[1] only 14 to 18 per cent of the absorbed glucose was built up into liver glycogen. The lower percentage of glucose that is retained as liver glycogen is mainly due to the fact that glucose is absorbed twice as fast as fructose. The liver, from a quantitative standpoint, plays a much more important role in removing fructose from the blood stream than glucose. There is also evidence that the kidney threshold for fructose is very low. These two factors might explain why the tolerance for ingested fructose has been found a suitable test for liver function.

Insulin has a stronger inhibiting influence on the rate of glycogen formation from fructose than from glucose. In the first three of fructose absorption no glycogen is formed, when 10 to 15 units per 100 gm. of body weight are injected simultaneously with the sugar feeding. After 4 or 5 hours a small amount of glycogen is deposited. Hypoglycemic symptoms were absent in these animals. During the absorption of glucose glycogen was already formed in the second hour of insulin action.

The experiments with galactose indicate that this sugar is converted very slowly into glycogen, and that a large part of this sugar is excreted in the urine. The average amounts of glycogen formed per 100 gm. liver were as follows: After 2 hours, 0.52 gm.; after 3 hours, 0.68 gm.; after 4 hours, 1.36 gm. The excretion of galactose in the urine shows many striking features and needs further investigation. The percentage of the absorbed galactose that is excreted increases more and more the longer the absorption proceeds, in spite of the fact that the rate of absorption remains constant. Thus, in one hour 27 per cent of the absorbed galactose appears in the urine, in two hours 41 per cent, in three hours 51 per cent and in four hours 60.5 per cent.

SUMMARY.

1. The rate of glycogen formation in the liver during the absorption of fructose is slightly greater than during the absorption of glucose and leads to a higher glycogen maximum.
2. The liver plays a larger role in removing fructose from the blood stream than glucose.
3. Large doses of insulin almost completely suppress the glycogen formation from fructose.
4. Galactose is very slowly converted into glycogen and is excreted to a large extent in the urine.

3014

The influence of insulin on the tolerance for intravenously injected glucose and fructose.

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It has been found previously[1] that non-fasting male and female rats during amytal narcosis show no glycosuria, when glucose is infused at a rate between 2.2 and 2.5 gm. per kilogram per hour. Woodyatt's[2] figure for the intravenous tolerance limit of rabbits, dogs and men was only 0.85 gm. glucose per kilogram per hour.

[1] PROC. SOC. EXP. BIOL. AND MED., 1925, xxii, 127.

[2] Woodyatt, R. T., Sansum, W. D., and Miller, R. M., *J. Am. Med. Assn.*, 1915, lxv, 2067.