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**Relation Between Absorption and Utilization of Galactose.**

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Previous experiments<sup>1</sup> have shown that when galactose and glucose are absorbed together, the rate of absorption of galactose is greatly reduced. Folin and Berglund<sup>2</sup> had reported previously that in men the sugar excretion is less than one-tenth as great when a mixture of glucose and galactose (100 gm. each) is ingested as the excretion obtained from 100 gm. of galactose when taken alone. They suggested that the extent to which galactose is utilized in the human organism depends on the quantity of available glucose. Corley<sup>3</sup> administered glucose and galactose intravenously and obtained no evidence that the presence of an excess of glucose in the blood increased the ability of the rabbit to utilize circulating galactose. However, when Corley<sup>4</sup> administered glucose and galactose by mouth, the urinary excretion of galactose decreased, in confirmation of the results of Folin and Berglund. These observations made it desirable to establish a more definite relationship between the rate of absorption and the extent of utilization of galactose in the body. Such experiments were made 2 years ago and are now here reported.

*Experimental.* Each group, consisting of 4 to 6 rats, fasted previously for 48 hours, was fed a different amount of galactose by stomach tube, the amount introduced being known in each case. In one series of experiments galactose alone was fed, in a second series a galactose-glucose mixture of equal parts was given, and in a third series, galactose was presented to the rats in the form of lactose. The collection of urine was extended beyond the period of absorption in order to make allowance for any lag in sugar excretion. Figure 1 is a graphic illustration of the average values obtained in these experiments. The absolute amounts as well as the percentages of excretion and utilization corresponding to the varying amounts of galactose absorbed can be calculated from this graph. It will be noticed that in each of the 3 series of experiments the excretion of galactose, when plotted against the amount absorbed, falls on a straight line. The somewhat lower excretion in the beginning of absorption, represented by a slight break in the straight lines, is probably due to the establishment of the initial equilibrium between the galactose concentration of the blood and of the tissues. The re-

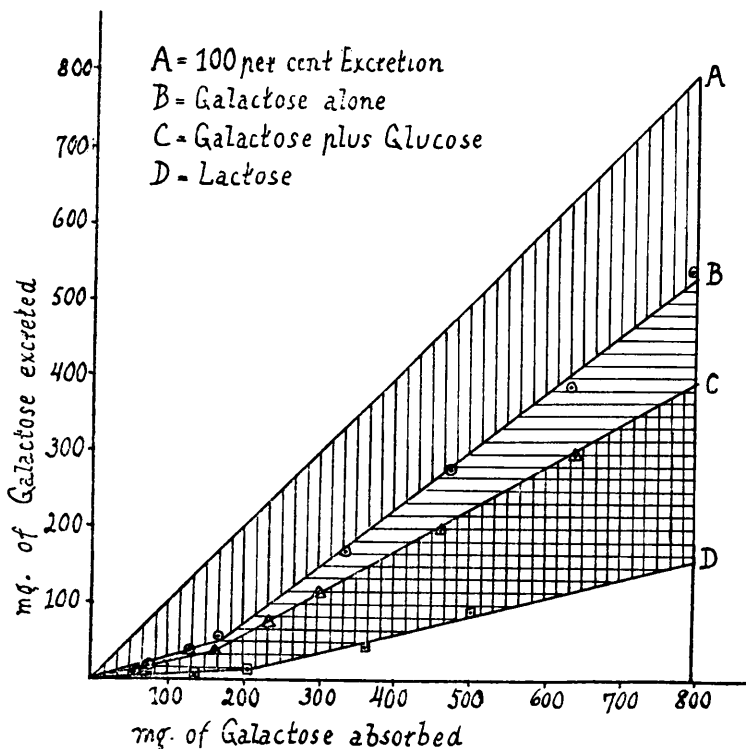


FIG. 1.

Excretion and utilization of galactose, when galactose alone, galactose plus glucose, and lactose is fed.

lation between excretion and utilization is indicated by the shaded areas. The vertically shaded area between lines A and B serves as an index of the amount of absorbed galactose which is utilized in the body, when galactose alone is fed, while the area included between B and the abscissa corresponds to the amount excreted. The area between A and C represents utilization of galactose, when a galactose-glucose mixture is fed and the horizontally shaded area between B and C corresponds to the increment in utilization (or decrease in excretion) with a galactose-glucose mixture as compared with galactose alone. What is the explanation for the phenomenon that for an equal amount of galactose absorbed, the utilization of galactose is lowest when galactose is being absorbed alone, intermediate when a galactose-glucose mixture is fed, and highest when lactose is ingested? We believe that this phenomenon is explained by different rates of absorption of galactose in these 3 cases. In Table I the ratio in the rate of absorption of galactose alone, or galactose from a galactose-glucose mixture and of galactose from lactose is of

TABLE I.  
Mg. of sugar absorbed per 100 gm. rat.

	1 hour	2 hours	3 hours	4 hours	Average blood sugar
Galactose alone <sup>†</sup>	184	358	534	744	328
Glucose alone <sup>†</sup>	183	376	528	704	176
<i>Galactose-glu- cose mixture</i>					
Galactose	60	148(1)	264		220
Glucose	114	216(1)	309		
<i>Galactose-fruc- tose mixture</i>					
Galactose		256			247
Fructose		182			
Lactose	56	104	162		128
Lactose from milk	48	92	129		118

the order 100:41:15, while the ratio in the amounts utilized, as calculated from Fig. 1, is of the order 100:153:240, respectively. It is obvious that the rate of absorption of galactose is inversely proportional to the amounts of galactose utilized in the body.

The values recorded in Table I, with the exception of those indicated by quotation figures, are averages of unpublished experiments. The rate of absorption of galactose alone remains constant from hour to hour. When galactose and glucose are absorbed together, the rate of absorption of galactose increases each hour, while the rate of absorption of glucose diminishes. This is due to the fact that glucose is absorbed faster from the mixture than galactose. Consequently, the molecular ratio between the 2 sugars in the intestine changes in favor of galactose as the absorption proceeds. From a galactose-fructose mixture the former sugar is absorbed faster than the latter. This is of interest in view of the results recorded by Bodansky,<sup>5</sup> who found that fructose in contradistinction to glucose, had only a slight effect on galactosuria. The low rate of absorption of lactose as compared with the rate of absorption of the galactose-glucose mixture must be due to the fact that the disaccharide is split rather slowly into its components by the intestinal lactase and that the disaccharide as such does not seem to be absorbed from the intestine of the rat. It is of interest that the absorption of lactose from milk proceeds at a still slower rate and that under these conditions practically no galactose is excreted in the urine. The lower rate of absorption from milk is probably due to the simultaneous absorption of amino acids.<sup>6</sup>

The blood sugar concentrations in Table I reflect the varying rates of absorption of galactose under the different conditions. The

blood sugar values in Table I are for total blood sugar, that is, for galactose plus glucose plus residual reduction. It seemed of interest to determine galactose and glucose separately in order to find out whether there was a rise in the glucose concentration of the blood during galactose absorption. Such a rise would indicate that galactose is converted in part into glucose. Considerable time has been spent in working out a method for the determination of glucose and galactose in the same blood sample. The method consists in the determination of the reducing power of the blood by means of the Hagedorn and Jensen method before and after treatment with yeast. In the meantime a method based on the same principle has been published by Corley,<sup>8</sup> who found that the recovery of added galactose ranged from 90 to 104%, the low results having been obtained with small amounts of galactose. Our recoveries were somewhat better, ranging from 96 to 102%, probably because the ferricyanide of the Hagedorn and Jensen method is more sensitive to small amounts of galactose than the Shaffer-Hartmann reagent. Table II indicates that during the absorption of galactose there is no rise in the glucose concentration of the blood. The same conclusion can be drawn from Corley's experiments.

TABLE II.

*Galactose and glucose content of blood during galactose absorption (in mg. %).*

	0 hours	1 hour	2 hours	3 hours
<i>Rats</i>				
Galactose	—	233	256	268
Glucose*	97	96	81	101
<i>Cat</i>				
Galactose	—	84	45	39
Glucose*	78	87	91	89
<i>Rabbit</i>				
Galactose	—	99	172	134
Glucose*	96	91	87	102

\*Glucose plus residual reduction.

*Summary.* For an equal amount of galactose absorbed, the utilization is highest with lactose, intermediate with a galactose-glucose mixture, and lowest with galactose. This is ascribed to the different rate of absorption of galactose in the 3 cases, the rate being lowest with lactose, intermediate with a galactose-glucose mixture and highest with galactose. During the absorption of galactose there is no rise in the glucose content of the blood.

<sup>1</sup> Cori, C. F., *PROC. SOC. EXP. BIOL. AND MED.*, 1926, xxiii, 290.

<sup>2</sup> Folin, O., and Berglund, H., *J. Biol. Chem.*, 1922, li, 213.

<sup>3</sup> Corley, R. C., *J. Biol. Chem.*, 1927, lxxiv 19.

<sup>4</sup> Corley, R. C., *J. Biol. Chem.*, 1928, lxxvi, 23.

<sup>5</sup> Bodansky, M., *J. Biol. Chem.*, 1923, lvi, 387.

<sup>6</sup> Cori, C. F., *PROC. SOC. EXP. BIOL. AND MED.*, 1926, xxiv, 125.

<sup>7</sup> Cori, C. F., *J. Biol. Chem.*, 1926, lxx, 577.

<sup>8</sup> Corley, R. C., *J. Biol. Chem.*, 1927, lxxiv, 1.

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### The Rate of Excretion of Galactose.

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It has been shown in a previous paper<sup>1</sup> that the percentage of absorbed galactose that is excreted in the urine of the rat increases with increasing length of absorption, in spite of the fact that the rate of absorption remains constant from hour to hour. Thus in 1

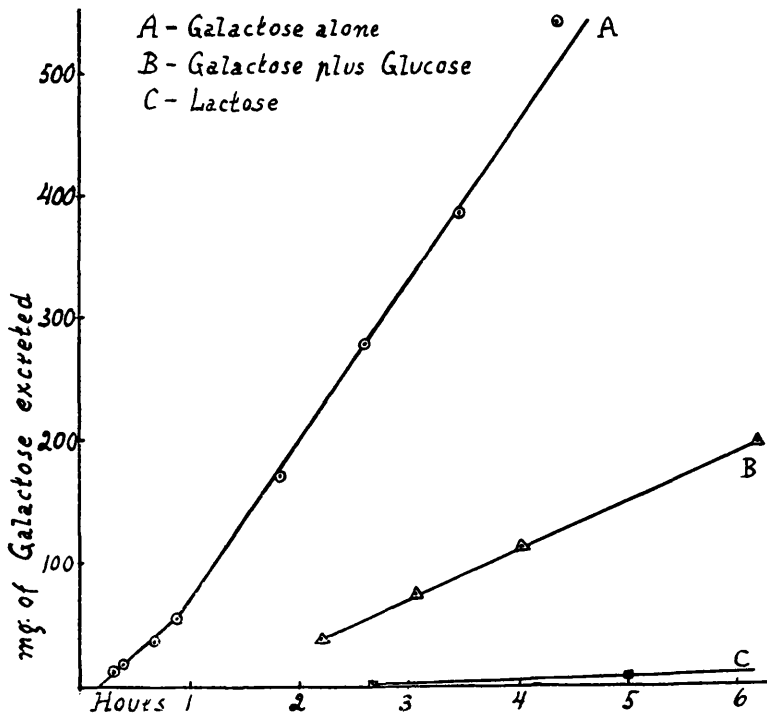


FIG. 1.

Rate of excretion of galactose, when galactose alone, galactose plus glucose, and lactose is fed.