glycuronic acid, (c) the formation of acetoacetic acid from fat, (d) the oxidation of reduced glutathione, (e) the oxidation of lipoids (*c. f.* their spontaneous decomposition in air). No doubt the effect is due to a combination of these factors.

6417

Resistance of Glucose Urea to Urease and Other Enzyme Action; Non-Absorbability of Glucose Urea from the Jejunum.

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In studying the mechanism of urease action, it would be of interest to find a derivative of urea that would be hydrolyzed in the presence of urease. Urease is very specific in its action and urea appears to be its only substrate. Closely related compounds such as amides or purines as well as simple derivatives of urea are not attacked by this enzyme. Armstrong and Horton[1] found that substitution in the urea molecule with methyl or ethyl groups invariably rendered the substituted urea inaccessible to urease. Schoorl[2] synthesized glucose-urea, in which one molecule of urea was united with one molecule of the sugar. This compound is very soluble in water and is stable in solution. When heated with acid it undergoes hydrolysis with the formation of δ-glucose and urea. Johnson and Bergmann,[3] in their recent researches on nitrogenous glucosides have prepared glucose urea, and Dr. Johnson generously placed at our disposal a very pure sample of glucose urea for investigation. We have studied the action of urease on this urea derivative.

Jack bean urease was found to have no ability to decompose glucose urea. There was no ammonia production in 10 minutes when urease was added to 0.2 M solutions of this compound. However, if glucose-urea was hydrolyzed by acid prior to the addition of urease, ammonia production occurred at a rate comparable to that observed when a 0.2 M solution of urea and glucose was exposed to urease. The results (Table I) clearly demonstrate that the inability of urease to split glucose urea must be ascribed to the chemical

[1] Armstrong, E. F., and Horton, E., *Proc. Roy. Soc.*, Series B, 1912, **85**, 109.

[2] Schoorl, M. N., *Rec. Trav. chim. Pays-Bas*, 1903, **22**, 1.

[3] Johnson, T. B., and Bergmann, W., *J. Am. Chem. Soc.*, 1932, **54**, 3360.

TABLE I.
Urease Action on Glucose-Urea. 5 cc. Substrate (0.2 M), 5 cc. KH_2PO_4 (0.1 M), 0.5 cc. Urease Solution.

Exp.	Substrate	T°	Time	NH_3 Formed
			min.	cc. 0.1 N
I	Glucose urea	22°	10	0.01
	" "	"	10	0.04
	Urea + glucose	"	10	10.68
	" "	"	10	10.55
II	Glucose urea	25°	7	—0.02
	Urea + glucose	"	7	3.26
	Hydrolyzed glucose urea	"	7	4.35
	" " "	"	7	4.36
	Control. Hydrolyzed glucose urea. No urease	"		0.31
III	Hydrolyzed glucose urea	27°	4	4.83
	" " "	"	6	6.93
	Urea + glucose	"	4	5.83
	" "	"	6	8.54
IV	Urea + glucose urea (0.2 M)	23°	8	8.01
	" " " (0.1 M)	"	8	8.24
	" "	"	8	8.21
	" "	"	8	7.78

make-up of the compound and cannot be the result of the presence, in the preparation, of substances that inactivate the enzyme. With the sugar group attached, urea cannot form a configuration which urease can attack. A substituting group, be it methyl, ethyl or glucose protects the urea from the enzyme. In the presence of glucose urea, urea decomposition by urease was not inhibited.

Glucose urea was also found to be unfermented by bakers' yeast. Neither emulsin (β glucosidase) nor yeast maltase (α glucosidase) caused any hydrolysis of glucose urea and no cleavage of this compound occurred in the presence of nucleosidase, prepared from pig kidneys by the method of v. Euler and Brunius.[4] In agreement with the results of Mayer,[5] we found that when this substance was injected into the blood stream of a rabbit it was largely (70%) excreted, unchanged, in the urine.

Glucose urea, despite its solubility and relatively low molecular weight, is not absorbed from an intestinal loop of a dog. The absorption of glucose urea was studied by inserting a solution of this compound in a Thiry loop of a dog's jejunum and after a suitable interval removing the contents of the loop. Through the courtesy of Drs. Ravdin and Johnston of this Medical School, an animal surgically prepared by them was used and their technique followed for carrying out absorption studies. After washing the loop with water, 20 cc. of a 0.09 M solution of glucose urea was inserted in

[4] v. Euler, H., and Brunius, E., *Ber. Chem. Ges.*, 1927, **60**, 1584.

[5] Mayer, P., *Biochem. Z.*, 1909, **17**, 145.

TABLE II.
Recovery of Glucose Urea from a Jejunal Loop of a Dog. 20 cc. of .09 M glucose urea, equivalent to 324.2 mg. of glucose remained in the loop 35 minutes.

Vol. fluid removed	Reducing Substances as glucose*		Glucose urea removed	Glucose urea hydrolyzed in the loop
	Before Hydrolysis	After Hydrolysis		
cc.	mg.	mg.	%	%
23	0	315	97	0

*Corrected for reducing substances removed from the loop during a control experiment.

the loop. At the end of 35 minutes, the contents of the loop were removed and the loop thoroughly washed, and analyzed for reducing sugar, before and after hydrolysis, by the Hanes method.[6] Correction was made for the small quantity of reducing substances that accumulated in the loop when 20 cc. of physiological saline was introduced into the loop for 35 minutes. The results of this experiment (Table II) show an almost quantitative recovery of glucose urea and are in marked contrast to results observed when a solution of glucose[7] or sucrose[8] was inserted into this loop. These sugars were rapidly and in large part absorbed in the course of a half hour. It may be concluded that glucose urea was not absorbed from the dog's jejunum. Further, no glucose urea was hydrolyzed during its exposure to intestinal enzymes.

The presence in blood or other tissues of any appreciable quantity of urea united with glucose, as glucose urea, seems unlikely since all the urea present in blood is decomposed by urease and the presence in blood filtrates of a non-fermentable substance that yields glucose on hydrolysis has not been demonstrated.

6418

Glycogen Content of the Rat Heart.

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The cardiac glycogen of albino rats has been determined under a variety of conditions. The figures quoted are for glycogen as glu-

[6] Hanes, C. S., *Biochem. J.*, 1929, **23**, 99.

[7] Unpublished results of Ravdin and Johnston.

[8] Unpublished results of the author.

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