POSSIBLE CARRIER MECHANISM FOR THE INTESTINAL TRANSPORT OF D-XYLOSE[1]

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Intestinal absorption of pentoses does not proceed against concentration gradients and is generally regarded as proceeding by "passive diffusion." However, it is now recognized that carriers may participate even if transport (here defined as a carrier-mediated process, without reference to details of the mechanism or the nature of the source of energy involved in the translocation) does not proceed uphill. Aspects of intestinal transport of D-xylose have been re-examined in vitro in an attempt to elucidate this question. Evidence is presented below which strongly suggests that transport of D-xylose and anaerobic transport of D-glucose in the surviving small intestine of guinea pigs is, in fact, carrier-linked.

Table I

Effect of Temperature on Transport of D-Xylose

Temp °C	0°	17°	27°	37°
Serosal D-xylose mg% ± S.D.	21 ± 4(3)	27 ± 6(6)	38 ± 4(6)	88 ± 11(6)
P ("t" test)		.05	< .10	< .001

Segments of small intestine of guinea pigs were incubated with the apparatus and in the medium described elsewhere (Salomon and Johnson, 1959a) under N_2. Initial mucosal concentration of D-xylose was 200 mg% in all experiments. Analyses were performed by the orcinol method (Ashwell, 1957). Numbers in parentheses indicate number of replicate tests. P = degree of significance for successive pairs of means.

In Table I, data are summarized which indicate a dependence upon environmental temperature much greater than is to be expected for simple diffusion of D-xylose through an aqueous system. However, it is recognized that com-

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parison of diffusion through cells (and possibly through interstices between cells) with diffusion through an aqueous medium may not be valid. From this point of view, the data of Table II are more diagnostic. These indicate substantial interference of D-glucose with the movement of D-xylose, and an apparent lack or relatively small degree of interference of the pentose with movement of D-glucose, and that these effects persist under anaerobic conditions. Participation of a single carrier in the movement of these carbohydrates, with greater affinity for D-glucose than D-xylose is thus indicated.

Table II

Competition between D-Glucose and D-Xylose in Transport

	Mucosal			Serosal		
No. of expts.	glucose mg%	xylose mg%		glucose mg% ± S.D.	xylose mg% ± S.D.	P*
			Aerobic (O_2)			
8	200	—	Controls	246 ± 27	—†	> .25
8	200	200		241 ± 24	—†	
3	—	200	Controls	—†	79 ± 2	< .01
3	100	200		—†	63 ± 4	< .005
4	300	200		—†	55 ± 4	
			Anaerobic (N_2)			
14	200	—	Controls	59 ± 9	—†	> .25
5	200	400		51 ± 7	—†	
6	—	200	Controls	—†	88 ± 11	< .005
3	300	200		—†	56 ± 8	

Experimental conditions as shown under Table I, except that temperature = 37°C, atmosphere as indicated above, and glucose determined enzymically (Salomon and Johnson, 1959b). The amounts of glucose here used do not interfere in the orcinol method in the determination of D-xylose (Ashwell, 1957).

*Comparison with mean of control experiments. †Not measured

It is also possible (Fig. 1) to show that addition of D-glucose inhibits the anaerobic uptake of D-xylose by segments of intestine of guinea pigs, whereas the addition of an isoosmolar quantity of NaCl does not.

With this information available, it was possible to apply the criteria of Rosenberg and Wilbrandt (1957) in an attempt to produce uphill transport of D-xylose, and adduce still more conclusive evidence for the involvement of a

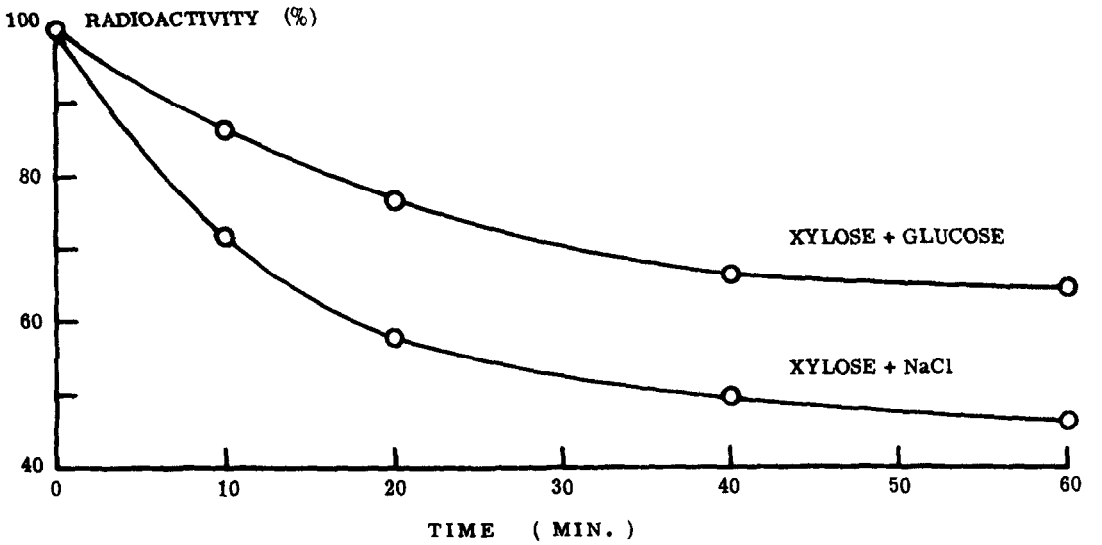

Figure 1. Empty everted sections of small intestine were tied off at both ends. Exactly equal weights of tissue (5.00 gm) were incubated and analyses of mucosal medium performed as shown under Fig. 2. Segments 1, 4, and 6 were added to one flask, segments 2, 3, and 5 to the control flask (no glucose) to offset possible regional differences in uptake of pentose. Initial volume was 3.25 ml, containing 0.975 mg of D-xylose and 0.5 μc of D-xylose-1-C^{14}, plus 11.7 mg of D-glucose or 1.9 mg of NaCl, and incubated in air at 37°C. 100% = initial radioactivity in cpm/.01 ml of mucosal medium.

carrier. The results of several such experiments are shown in Fig. 2. D-xylose was incubated with an entire small intestine until equilibration had occurred. Isoosmolar amounts of D-glucose or of NaCl in high concentration were then added. Provided that a carrier mechanism common to both D-xylose and D-glucose exists, D-xylose must then exit from the cell, and do so necessarily against its own concentration gradient. Uphill movement of the pentose on addition of D-glucose did invariably occur because of the successful competition of the hexose for the sites of the carrier, while addition of a solution of NaCl in no case resulted in uphill transport of D-xylose. This is considered to be conclusive evidence for the presence of a mobile carrier system (Rosenberg and Wilbrandt, 1957; Crane, 1960). Furthermore it is in direct agreement with all other data presented above.

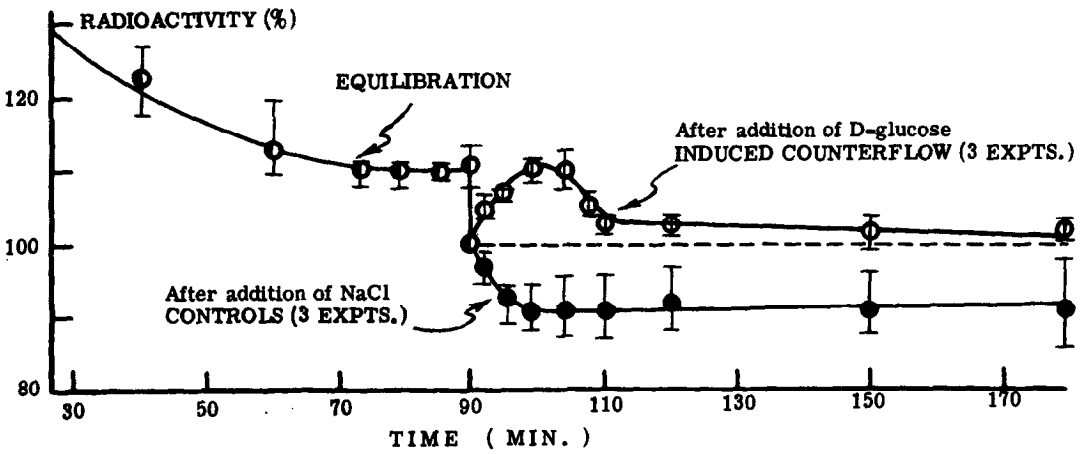

Figure 2. The entire empty everted small intestine of a guinea pig was incubated under air in an initial volume of 6.5 ml containing 1.95 mg D-xylose and 1.00 μc of D-xylose-1-C^{14} until equilibration was essentially complete. Into the 4.5 ml remaining after periodic removal of samples, 0.5 ml of cold 2M glucose or 1M NaCl was added. Aliquots were counted as $BaC^{14}O_3$. Temperature = 37° from 0 to 75 min, and 0° thereafter. 100% = calculated level of radioactivity after additions were made. Identical results were obtained in two earlier experiments with unlabelled D-xylose. For these runs, xylose was determined by the phloroglucinol method which corrects for large amounts of glucose (Dische and Borenfreund, 1957).

It is felt that these experiments provide evidence for the participation of a carrier in the transport of D-xylose and anaerobic transport of D-glucose in a process which might be designated "thermal transport" (as distinct from "active transport"). Because of the evident difficulties involved in subjecting this theory to rigorous tests in vivo, supporting evidence derived under this condition is, unfortunately, unavailable.

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