In Vivo Intestinal Absorption of Sugars and Electrolytes[1]

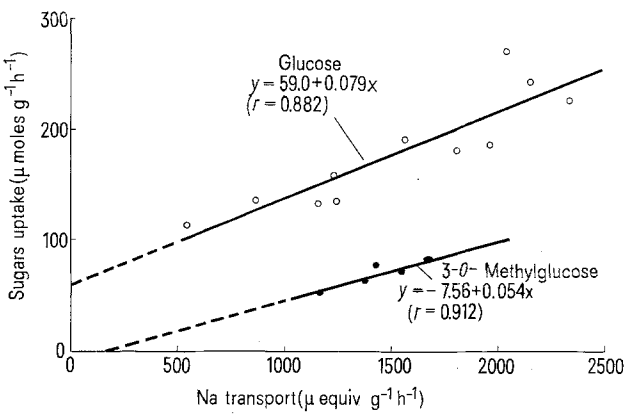
It is commonly accepted that actively transported sugars are first accumulated against a concentration gradient within the epithelial cell[2–4] and then they move passively towards the serosal side. This accumulation requires an outer Na concentration higher than that inside the cell and it has been suggested that this asymmetric distribution is responsible for sugar accumulation[4]. All these conclusions have been drawn from in vitro experiments.

In order to check the above conclusions also during the in vivo sugar absorption, we have perfused the lumen of the in situ jejunum of a surviving rat (Wistar strain) with a Krebs-Henseleit-bicarbonate solution added with a 2 mg/100 ml phenol red and glucose (5.5 or 13.9 mM) or 3-O-methylglucose (1.3 or 5.15 mM) according to the cases. The latter sugar is not metabolized by the rat[5,6] and when it was used, trace amount of ^{14}C-labelled compound was also added.

In the experiment in which glucose was perfused in the lumen, ^{14}C-polyethyleneglycole was infused into the jugular vein as a marker to determine the serosal extracellular space[7], whereas in the experiment in which 3-O-methylglucose (3MG) was perfused in the lumen, ^{3}H-Inulin and a concentrated solution of this sugar together with trace amount of ^{14}C-labelled compound, were infused into the jugular vein. The specific activity of ^{14}C-3MG present in the lumen was equal to that infused into the jugular vein. After 30 min experiment, the perfused intestine was removed, cut open along its mesenteric edge and the mucosal layer was scraped off at 0 °C as previously stated[8] in order to determine the wet and dry weight and the intracellular concentration of sugar and radioactivity (scintillation spectrometer). Samples of the initial and final luminal fluid and of serum were taken to determine both sugar and Na concentration and the radioactivity. The amount of fluid absorbed was calculated from the phenol red concentration at the end of the experiment.

The results so obtained show that there is a direct linear relationship between net Na transport through the epithelial layer (abscissa) and glucose uptake by the intestinal mucosa (Figure). The intercept value on the ordinate represents the amount of glucose metabolized by the intestine in the absence of Na transport.

It can be tentatively assumed that the amount of metabolized glucose does not vary appreciably along with the increase of Na transport; as a matter of fact, in the in vitro experiment the total lactic acid production is constant even if Na transport increases[9]. Therefore, the in vivo transepithelial glucose transport may be calculated by subtracting the intercept value from the mucosal glucose uptake.



Relationship between sugars uptake and Na transport across the in vivo jejunum of rat. Abscissa: Na transport (μequiv. $g^{-1}h^{-1}$). Ordinate: Glucose (open circles ○) and 3-O-methylglucose (solid circles ●) intestinal uptake (μmoles $g^{-1}h^{-1}$).

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Sugars concentrations, sugars and sodium transport across the in vivo jejunum of rat

Perfusing solution	Final lumen concentration (mM)	Final cell concentration (mM)	Final serum concentration (mM)	Sugar transepithelial transport (μmoles $g^{-1}h^{-1}$)	Na transepithelial transport (μequiv. $g^{-1}h^{-1}$)
Krebs-Henseleit bicarbonate + glucose 5.5 mM (11)	2.68 ± 0.21	2.95 ± 1.00	8.47 ± 0.59	122 ± 15	1536 ± 172
Krebs-Henseleit bicarbonate + glucose 14 mM (7)	7.55 ± 0.72	3.68 ± 0.84	11.53 ± 1.09	261 ± 51	1618 ± 262
Krebs-Henseleit bicarbonate + 3-O-methylglucose 1.3 mM (4)	1.14 ± 0.01	0.51 ± 0.03	1.08 ± 0.09	12 ± 1	652 ± 66
Krebs-Henseleit bicarbonate + 3-O-methylglucose 5.15 mM (6)	4.72 ± 0.05	2.70 ± 0.22	4.75 ± 0.26	70 ± 5	1358 ± 106

Transport values are referred to 1 g dry weight of intestinal wall. Values ± S.E.M. and number of experiments in parentheses are reported.

The straight line of the relationship between 3-MG and Na transport starts close to the origin of the coordinates (Figure 1). This agrees with the well-known fact that 3-MG is a non-metabolized sugar and means that its uptake corresponds to the transported amount across the intestinal wall.

As far as the intracellular sugar concentration is concerned (Table), we can see that it is always lower than that of the lumen and the serum.

If we assume that the non-absorbing cells of the intestinal epithelial layer are not the most part of the epithelial cells and that the intracellular concentration in these cells of non-metabolizable sugars (3MG) is not too much lower than the blood concentration, a sugar concentration lower than that of the serosal space also in the absorbing cells, must be admitted.

This fact seems to demonstrate that in the in vivo experiment sugars enter the cell downhill and that they are pumped out towards the subepithelial serosal space by an active mechanism. The apparent absence of an intracellular sugar accumulation was postulated by other authors[2]. Therefore, Na asymmetry between the two sides of the brush border in vivo could be responsible of an enhanced entrance of sugars but not of their uphill accumulation.

The drag effect of net water flux on sugars at the level of the serosa facing membrane, as suggested by CRANE[4], can be presumably disregarded because of the low passive permeability of sugars[10].

The lower intracellular sugar concentration in in vivo experiment could be due to the fact that the sugar extrusion into the serosal space is higher in this condition than in the in vitro one. As a matter of fact the transepithelial glucose transport in the isolated intestine at the optimum temperature of 28 °C is only a fraction[11] of that found in vivo. Also the Na pump is noticeably lower[11] in vitro in comparison with the in vivo condition.

Riassunto. Nell'intestino tenue di ratto in vivo è stato osservato che la concentrazione intracellulare di glucosio o di 3-*O*-metilglucosio, durante l'assorbimento di questi zuccheri, è sempre minore che nel siero. Ciò lascia presumere che esista una pompa per l'estrusione degli zuccheri a livello della membrana serosale delle cellule assorbenti intestinali.

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Heart Tissue Catecholamines in the Grey *Ratus norvegicus*[1]

Albino rats submitted to long term exercise were reported to develop heart hypertrophy if the exercise was repeated daily[2–5]. No such hypertrophy could be detected in the intermittent physical training[6,7]. The 'athletic' animals were reported to have bradycardia[8], increased cardiac tissue acetylcholine content[9], and a decreased heart tissue catecholamine concentration[7]. These elements were obtained by exercizing the albino laboratory rats in artificial conditions such as running on a threadmill, in a rotating cage or by swimming.

To our knowledge, no studies have been performed dealing with the heart sympathetic neurotransmitter content of the wild grey *Ratus norvegicus*. It was felt to be interesting to examine the effects of exercise and activity resulting from a normal psychological motivation such as would occur in the wild grey rats, and to compare these results with the same species of animals living in confined conditions.

Materials and methods. Wild young male and female grey *Ratus norvegicus* weighing approximately 50 g were caught in traps. They were housed in laboratory cages, fed with standard food and received water ad libitum. They lived in colonies and were submitted to 10 h of light and 14 h of darkness a day. All sensory and emotional

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Table I. Values of body weight, heart weight, and heart: body weight ratio in wild and lab *Ratus norvegicus*

	Wild	Lab	*F* ratio
No. of animals	15	17	
Body weight (g)	276 ± 22	292 ± 21	0.28
Heart weight (mg)	988 ± 158	914 ± 58	0.56
Heart: body weight ratio × 100	3.498	3.260	4.47

Values are means ± S.E.M

Table II. Heart weight, tissue catecholamines and proteins in wild and lab *Ratus norvegicus*

	Wild	Lab	*F* ratio
No. of animals	10	16	
Catecholamines (μg/g)	0.498 ± 0.031	0.709 ± 0.039	14.55
Total heart catecholamines (μg)	0.452 ± 0.033	0.639 ± 0.044	9.02
Heart proteins (mg/g)	73 ± 0.02	72 ± 0.01	0.002
Heart weight (mg)	911 ± 77	914 ± 57	0.0009

Values are means ± S.E.M.