

## Effect of Intestine Irradiation in the Absence of Sodium on the Oxygen Uptake \*

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The effect of X-irradiation (20.000 r) was studied *in vitro* in jejunum strips preincubated in medium without sodium over the posterior oxygen uptake of the tissue in medium with sodium, with and without glucose.

Irradiation under these conditions inhibits oxygen consumption by the tissue, the medium both with and without substrate, oxygen uptake reaching values much lower than those obtained with equal dosage of irradiation combined with medium with sodium. The inhibition produced by irradiation and that produced by preincubation in medium without sodium add their effects when these factors act simultaneously.

Previous investigations in this laboratory (2) showed that X-rays dosages of 20.000 r, administered *in vitro* over intestine strips, caused a reduction in oxygen and glucose consumption and had no effect on the amount of lactate present. These results indicated a clear inhibition of the oxidative utilization of glucose, since for a lower consumption of glucose similar quantities of lactase appeared, a higher quantity of glucose going toward lactate in the irradiate strips.

With preincubation of jejunum strips for one hour in the absence of sodium (this being substituted with mannitol) we

were able to prove effects very similar to those produced by irradiation (3).

On the other hand, effects of irradiation and preincubation in the absence of sodium over the active transport have been described (1, 4) and explanations have been proposed where inhibition at the lever of the respiratory chain or over system of transport itself is implicated.

In the present investigation experiments are performed where the tissue is simultaneously submitted to the both conditions: preincubation without sodium and irradiation.

### Materials and Methods

The experiments were performed using jejunum strips of Wistar rat. Procedures, medium composition, method of measurement of oxygen uptake and presentation

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Table I. *Effects of X-rays (20,000 r) on O<sub>2</sub> uptake ( $\mu$ M O<sub>2</sub>/100 mg w.w.) of jejunum strips.*  
 The strips were irradiated for a preincubation period of 60 minutes while in Krebs-Ringer-Tris/Man medium. The O<sub>2</sub> uptake was measured after irradiation in Krebs-Ringer-Tris/Na<sup>+</sup> medium with and without glucose 2.77 mM. Results are given as mean values  $\pm$  standard error; the numbers in parenthesis indicate the number of experiments. Statistics according to Student's *t* method. *P* < 0.001.

Time Hours:		1	2	3	4	5	6
Without glucose	Control	2.67 $\pm$ 0.09 (37)	4.59 $\pm$ 0.22 (25)	5.62 $\pm$ 0.28 (21)	6.85 $\pm$ 0.47 (17)	7.42 $\pm$ 0.70 (14)	
	Irradiated	2.18 $\pm$ 0.04 (30)	3.22 $\pm$ 0.17 (20)	3.63 $\pm$ 0.25 (20)	4.28 $\pm$ 0.31 (15)	4.03 $\pm$ 0.33 (10)	
	Differences %	26.54	29.84	35.40	37.51	45.68	
With glucose	Control	3.98 $\pm$ 0.20 (33)	6.48 $\pm$ 0.55 (26)	8.02 $\pm$ 0.39 (33)	9.92 $\pm$ 0.62 (18)	11.07 $\pm$ 0.78 (11)	12.27 $\pm$ 1.10 (12)
	Irradiated	2.95 $\pm$ 0.13 (35)	4.66 $\pm$ 0.23 (26)	5.12 $\pm$ 0.29 (33)	6.04 $\pm$ 0.33 (21)	6.52 $\pm$ 0.03 (11)	6.52 $\pm$ 0.38 (14)
	Differences %	24.93	28.08	36.15	39.11	45.07	46.86

Table II. *Comparison of the effects of irradiation in absence of sodium over oxygen uptake in rat jejunum strips.*  
 Those data corresponding to irradiation in KRT/Na<sup>+</sup> and effect of preincubation in absence of sodium taken from (2) and (3).

PREINCUBATED	Hours:				
	1	2	3	4	5
With Na <sup>+</sup>	4.52 $\pm$ 0.10 (106)	8.26 $\pm$ 0.15 (106)	10.56 $\pm$ 0.33 (89)	12.01 $\pm$ 0.62 (41)	14.64 $\pm$ 0.70 (38)
Without Na <sup>+</sup> with mannitol	3.98 $\pm$ 0.20 (33)	6.48 $\pm$ 0.55 (26)	8.02 $\pm$ 0.39 (32)	9.92 $\pm$ 0.62 (18)	11.07 $\pm$ 0.78 (11)
With Na <sup>+</sup> + irradiation	3.48 $\pm$ 0.12 (58)	5.48 $\pm$ 0.24 (44)	6.58 $\pm$ 0.29 (36)	7.28 $\pm$ 0.31 (26)	7.97 $\pm$ 0.25 (21)
Without Na <sup>+</sup> + irradiation	2.95 $\pm$ 0.13 (35)	4.66 $\pm$ 0.23 (26)	5.12 $\pm$ 0.29 (33)	6.04 $\pm$ 0.33 (21)	6.08 $\pm$ 0.03 (11)
Differences % as compared to control preincubated with Na <sup>+</sup>					
Without Na <sup>+</sup>	7.52	21.54	24.05	17.40	24.38
With Na <sup>+</sup> + irradiation	23.00	33.65	37.68	39.38	45.56
Without Na <sup>+</sup> + irradiation	34.70	43.50	51.50	49.70	59.10

of the results are the same as described in previous papers (2, 3). Irradiation of the intestine strips took place while the tissue was preincubated in Krebs-Ringer-Tris medium without sodium, this being substituted in its osmotic effects with mannitol (KRT/Man medium). Sixty minutes after this preincubation the strips were taken to ordinary medium with sodium (KRT/Na<sup>+</sup>) in order to measure oxygen uptake.

## Results and Discussion

Irradiation (20,000 r) while preincubation (60 minutes) in medium without sodium (KRT/Man) produces an inhibition in oxygen uptake as posteriorly measured in a medium where sodium is restored (KRT/Na<sup>+</sup>). In the first hour this inhibition is of the order of 25% as compared

to the strips submitted to the same preincubation in absence of sodium but not irradiated (Table I, Fig. 1). Furthermore, the irradiated strips, as opposed to the others, practically do not respire after two or three hours, both when there is glucose in the medium and when there is not, the inhibition increasing as time passes (approximately 35% after three hours).

The relative effect of irradiation under these conditions is also of the same order as that observed over oxygen uptake when irradiation takes place during preincubation in medium with sodium (KRT/Na<sup>+</sup>) as compared with controls preincubated in this same medium but not being irradiated (2).

Since preincubation in medium without sodium (KRT/Man) causes itself a reduction in oxygen uptake, when besides the intestine strips being submitted to preincubation are also irradiated, oxygen uptake in KRT/Na<sup>+</sup> medium following these procedures is very much lower than that observed in tissue preincubated in medium with sodium (KRT/Na<sup>+</sup>) but not irradiated. The inhibition of oxygen uptake by irradiation in the absence of sodium is, after three hours, of the order of 50% as compared to the control strips, neither preincubated in medium without sodium nor irradiated (Table II). These results indicate that the inhibitory effects showed by each of these two factors (preincubation in KRT/Man and irradiation) are added when these factors act simultaneously.

Both irradiation and preincubation in absence of sodium cause a reduction in the oxidative utilization of glucose (2, 3, 5). Both factors, on the other hand inhibit the active transport of glucose through the intestine *in vitro* (1, 4). When there is glucose in the medium oxygen uptake may diminish as an effect of the lower availability of the substrate and as a more direct effect over its oxidative utilization. But since in absence of glucose oxygen

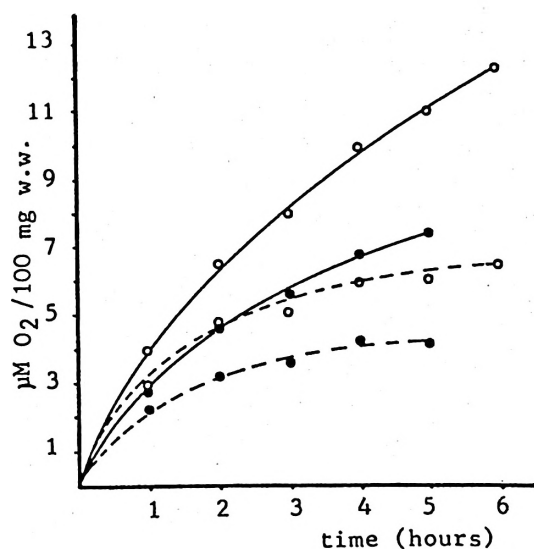


Fig. 1. Comparison of the effects of Irradiation in absence of sodium over oxygen uptake in rat jejunum strips.

The data of Table I. Oxygen uptake in a medium with glucose (○); oxygen uptake in a medium without glucose (●). Irradiated (----); controls (—).

consumption is inhibited in a similar proportion, it can be inferred that the metabolic alteration is more important than that of sugar transport.

The synergic character of the effects of irradiation and preincubation in medium with mannitol can be explained as both factors having different points of action over the oxidative metabolism or as acting together in the same alteration.

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