Changes in the sodium and potassium contents of cell nuclei after irradiation

The ability of thymus nuclei to retain sodium and potassium during isolation in aqueous media has been studied by ITOH AND SCHWARTZ[1] who concluded that sodium was the more firmly bound of the two elements. A connection between the release of nucleotides and potassium from isolated calf-thymus nuclei, and loss of the ability to perform nuclear phosphorylation was reported by OSAWA, ALLFREY AND MIRSKY[2]. In view of the marked radiosensitivity of nuclear phosphorylation[3,4], it seemed desirable to see whether radiation could also bring about this loss of nuclear potassium. In this connection it is of interest that changes have been described in the plasma and urinary electrolyte levels of irradiated animals[5,6], and a loss of potassium found to occur from the cells of the rat spleen 2 h after 1000 R of X-rays[7].

Rats of 80–120 g in weight were exposed to total-body X-radiation. The animals were killed by decapitation 1 h later, the spleen and thymus glands removed and nuclei prepared from them in buffered 0.25 M sucrose–0.0033 M $CaCl_2$ as described previously[4] except that the final centrifuging and resuspension were performed in medium containing no buffer. This was done to ensure a low sodium background. The sodium and potassium contents of nuclear preparations from the spleen and thymus glands were then determined by flame photometry of solutions of the residues of tissues which had been heated for 4 h with HNO_3. An oxy-acetylene flame was used, and corrections applied for the mutual interference of the sodium and potassium emissions[8]. DNA was estimated by the method of BURTON[9] and expressed as DNA phosphorus. It was used as a reference standard. It can be seen in Table I that there is a loss of both sodium and potassium from the nuclei of the irradiated tissues, but the control values themselves are rather variable.

TABLE I

CHANGES IN THE SODIUM AND POTASSIUM CONTENTS OF NUCLEI ISOLATED FROM TISSUES OF RATS EXPOSED TO TOTAL-BODY X-RADIATION 1 h PREVIOUSLY

Tissue	*Element*	*Control content µequiv./mg DNAP*	*Content of irradiated nuclei % control level*		
		Dose:	*25 R*	*50 R*	*1000 R*
Thymus	Potassium	5.55; 1.50; 4.16; 5.73	13, 21	27	34
	Sodium	3.90; 5.47; 2.04; 6.12.	56, 71	45	15
Spleen	Potassium	14.2; 5.17; 2.88; 6.52; 7.16	63, 69	113, 42	27
	Sodium	11.0; 8.77; 7.96	43,	33	17

To overcome the difficulty of this variation in the control values, we carried out irradiations *in vitro*. Nuclei were isolated from normal rat spleen, and portions of the suspensions exposed to γ-rays from a radium source (two 250 mC sources, dose rate calibrated by the method of MILLER[10]). After centrifuging these samples (completed within 5 min of irradiation), the sodium and potassium contents of the supernatants were determined, corrected for those of the un-irradiated suspensions and expressed as percentages of the total content of each nuclear preparation. These results appear in

Abbreviations: DNA, deoxyribonucleic acid.

Figs. 1 and 2 and show that loss of potassium from spleen nuclei occurs less readily than that of sodium, but that both elements are largely removed by doses of radiation of the same order as inhibit nuclear phosphorylation[4].

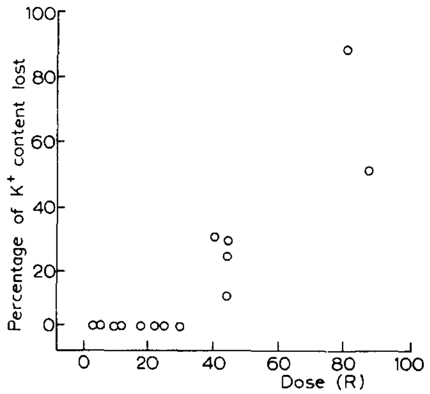

Fig. 1. The loss of potassium from isolated rat spleen nuclei as a function of the dose of γ-rays received. Losses are calculated as percentage of the total nuclear content lost into the supernatant 5 min after irradiation.

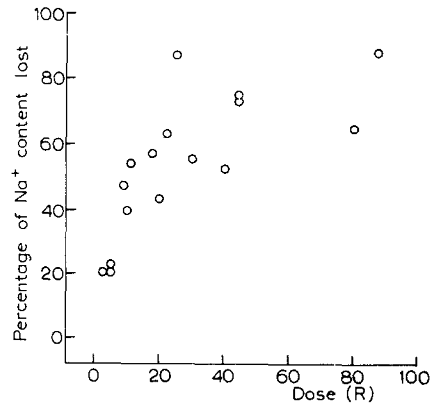

Fig. 2. The loss of sodium from isolated rat spleen nuclei as a function of the dose of γ-rays received. Losses are calculated as percentage of the total nuclear content lost into the supernatant 5 min after irradiation.

These observations suggest that the mechanism of the radiation lesion in nuclear phosphorylation involves the loss of bound sodium and potassium. The difference between the properties of nuclear and mitochondrial oxidative phosphorylation is emphasized by the fact that although the latter process is also dependent upon bound potassium[11], it is known to be very resistant to radiation *in vitro*[12].

I wish to express my thanks to Dr. L. A. STOCKEN for his interest and helpful suggestions during the course of this work; to Mr. M. J. CORP of the M.R.C. Radiobiological Research Unit, Harwell, for irradiating the animals and to Mr. R. HEMS for advice on flame photometry. I am also grateful to the Medical Research Council for a Training Scholarship and to the Rockefeller Foundation for grants towards the cost of apparatus.

Department of Biochemistry, University of Oxford (Great Britain) W. A. CREASEY*

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Received June 1st, 1959

* Present address: Department of Pharmacology, Yale University School of Medicine, New Haven, Connecticut, U.S.A.