nificant part in ion transport and other processes associated with membrane function^{12,13}. Tewari and Bourne¹⁵ have also suggested such a role of the acid phosphatase in the synapses of the cerebral cortex of rat. Thus it seems likely that the lysosomes, after originating from the Golgi apparatus in the perinuclear zone, migrate to dendrites to play their parts in ion transport and other phenomena like pinocytosis, with the acid phosphatase mediating the processes.

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RADIOBIOLOGY

Cytotoxicity of Carbohydrates Heavily Irradiated in Solution

HEAVILY irradiated solutions of carbohydrates have been shown to influence the growth of cultures of bacteria¹, and plant² and mammalian cells³, as well as producing chromosomal abnormalities in mammalian cells⁴. Steward *et al.*⁵ have recently described the isolation from irradiated sucrose solution of a salt of formic acid which was characterized as sodium formate, and was shown to suppress the growth of carrot phloem explants.

In our earlier work on the effect of autoclaved and irradiated carbohydrate solutions on mammalian cells in tissue culture^{3,6}, we concluded that the compound most likely to account for the persistent toxicity of irradiated solutions was the radiolytic product glyoxal. It was shown that the gross cytotoxicity of irradiated carbohydrate solutions was closely reproduced in our experimental system by a solution of glyoxal equivalent in concentration to the glyoxal present in the appropriate irradiated carbohydrate solution.

The presence of formaldehyde in irradiated carbohydrate solutions is known from the work of Phillips⁷, but it is unlikely that it is itself cytotoxic for the reasons discussed in our earlier paper³. The recent observation of Steward *et al.*⁵ suggests that the oxidation of formaldehyde to formic acid, which might occur during irradiation or in the culture medium, results in the development of cytotoxicity. If this were so, glyoxal might similarly be converted to oxalic acid which must then be suspected as a potential cytotoxic agent. Because oxalic and formic acids are interconvertible, at least by chemical means, the gross effect of irradiated carbohydrate solutions might be accounted for by the system

This hypothesis was tested by the addition of formic and oxalic acids (as their sodium salts), glyoxal, or irradiated glucose solutions to the culture medium in which strain *L* mouse fibroblasts are grown. The culture

techniques have been described in detail in our earlier article³; the cells are grown attached to the glass surface of sealed bottles, collected by trypsinization, and the total growth after incubation at 37°C for 7 days counted electronically. The results are shown in Table 1, expressed as a percentage of growth in control cultures incubated simultaneously. Sodium formate exerts no cytotoxic effect, even at a concentration ten times higher than that shown by Steward *et al.*⁵ to be present in solutions of irradiated carbohydrates. Sodium oxalate is also much less cytotoxic than glyoxal. It can be calculated that, even if all the glucose transformed during irradiation with 2.5 Mrads were to appear as oxalic acid, the amount of acid produced would still not account for the observed cytotoxicity of the irradiated glucose solution.

Table 1. GROWTH OF STRAIN *L* MOUSE FIBROBLASTS

Ordinary growth medium plus:	Percentage of control growth in 7 days	Ref.
Autoclaved distilled water (control)	100	3 and present experiments
1 per cent solution, dextrose, B.P., filter-sterilized	104	3
1 per cent solution, dextrose, B.P., irradiated, 2.5 Mrads	1.3	3
1 per cent solution, dextrose, B.P., irradiated, 2.5 Mrads, stored for two years	2.2	Present experiments
Glyoxal, 0.0073 mg/ml.	100	3
0.022 mg/ml.	71	3
0.073 mg/ml.	34	3
0.22 mg/ml.	1.4	3
0.73 mg/ml.	0.8	3
Sodium formate, reagent grade		
0.0017 mg/ml.	106	Present experiments
0.017 mg/ml.	102	" "
0.17 mg/ml.	109	" "
Sodium oxalate, 'AnalaR'		
0.022 mg/ml.	79	" "
0.22 mg/ml.	37	" "
2.2 mg/ml.	2.2	" "

These results indicate that the cytotoxicity of the formate salt which has been demonstrated by Steward *et al.*⁵ is unlikely to be duplicated by the combined formic acid (which would appear as sodium formate in culture media for mammalian cells at pH 7.0–7.2) produced by radiolysis of carbohydrates in solution. This is also corroborated by the fact that labelled sodium formate is a common starting material used in the biological synthesis of a variety of compounds labelled with carbon-14. In these circumstances, oxidative processes involving the formation of formic and oxalic acids from formaldehyde and glyoxal cannot be expected to contribute to the cytotoxicity of heavily irradiated carbohydrate solutions.

Finally, the 1 per cent solution of glucose irradiated with 2.5 Mrads, which has been used in these studies, has been shown to retain its cytotoxicity for more than 2 years after irradiation.

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