XXIX. THE EFFECT OF EXCESSIVE RADIATION WITH ULTRA-VIOLET LIGHT UPON THE GROWTH OF RATS.

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A SERIES of experiments was made in this Institute [Chick and Roscoe, 1926] in which the vitamin A content of milk was titrated by a method based on that of Steenbock, Nelson and Black [1924]. In this method the milk doses were given after growth had ceased upon the defective diet, but the vitamin D requirement of the rat was satisfied by means of daily irradiation with ultra-violet light for 10 minutes or longer. This irradiation was continued during the test period.

It was found that the growth which had been restored by addition of milk to the diet, tended to diminish after 3 to 4 weeks, and more quickly if the time of irradiation was increased from 10 to 20 minutes daily. At the same time the rats developed conjunctivitis with purulent secretion.

An excessive dose of irradiation was clearly deleterious, and it was suggested to me by Dr Chick that it might be worth while to determine whether the effect was entirely due to the conjunctivitis, and also whether it was enhanced when the animals' diet was defective.

The following two experiments were therefore designed to determine:

(1) whether there is a maximum period of time and intensity up to which irradiation with ultra-violet rays is beneficial to growth, and beyond which it is deleterious;

(2) whether the presence or absence of vitamin A in the diet has any influence on the supposed deleterious effects of prolonged exposure to such irradiation.

TECHNIQUE.

Young rats of 40–50 g. weight received a diet, "F" diet [Chick and Roscoe, 1926], complete in all other respects, but devoid of fat-soluble vitamins. In exp. 1 this was supplemented in some cases by daily doses of pasture-fed butter, to provide vitamin A. In exp. 2 the rats received the same diet without supplement of butter.

The mercury vapour quartz lamp was made by the Hewittic Electric Co., with a straight burner 10 cm. in length; on a 200 volt circuit it was using a current of 4 amperes. It had been in use for about 2 years at the beginning

of the experiment. The rats were exposed at a distance of 42 cm. from the lamp.

Exp. 1. The rats were divided into groups receiving irradiation from the lamp for 2', 5', 10' and 30' respectively. Each group contained 6 rats of which 3 received 0.2 g. of butter daily, and 3, 0.5 g. In addition there was a group of 2 rats receiving 1.0 g. of butter and 30' irradiation and control rats which received 0.5 g. of butter and were not irradiated.

The first experiment was begun without arranging for protection to the rats' eyes. After about 12 days, traces of purulent secretion were observed in the eyes of some rats receiving 10 to 30 minutes' irradiation, and steps were at once taken to shield them. This was effected by means of a small circular wash-leather mask with a hole in the centre. The snout was passed through the hole. The mask covered the rats' eyes. A bag of wide-meshed mosquito-net was stitched to the mask and tied firmly behind the head and also behind the fore-legs with strings of narrow tape threaded through the meshes of the mosquito-net. The open end of the bag was secured firmly by safety-pins behind the hind-quarters and this prevented the rats from wriggling out.

With this protection the condition and the eyes improved rapidly and in the course of a week or 10 days the appearance was again normal. Later on, after 4 to 6 weeks, it was noticed that the eyes became sore and showed a blood-stained purulent secretion. The time of onset did not appear to depend upon the length of daily exposure to the ultra-violet radiation; but it was noticed that the rats affected were those whose eyes had been unprotected at the beginning of the experiment, the others continuing to show healthy eyes. This affection of the eyes may have been due to a slightly incomplete supply of vitamin A, but the deficiency must have been very slight, especially in the case of rats receiving the larger doses of butter. The exposure of the eyes at a previous period seemed to have rendered them hyper-sensitive to some slight defect.

It is conceivable that this abnormality may have been concerned with an insufficiency of vitamin B. McCollum, Simmonds and Becker [1925] describe an ophthalmia indistinguishable from that caused by vitamin A deficiency, but which they attribute to an insufficiency of vitamin B, combined with a badly balanced salt mixture in the diet. Hume (verbal communication) has also observed a slight degree of ophthalmia in rats on diets well supplied with vitamin A, which she attributes to an insufficiency of vitamin B.

There was no significant difference to be detected in the first experiment as regards growth in weight between the animals in the different groups, with the exception of the male control which was considerably below the average weight of the irradiated male rats. Disregarding a few exceptions evenly distributed in the various groups, growth was sustained throughout the observation, which lasted 12 to 13 weeks, and there was no failure in the case of rats receiving the largest doses of irradiation. The smallest dose of butter (0.2 g.) appeared to be as effective as the larger doses.

Exp. 2. The rats were divided into three groups, one group of 2 rats receiving no irradiation and two groups of 3 rats receiving daily irradiation for 2' and 30' respectively. These rats received no supplement to the "F" diet. The eyes were protected during irradiation of the animal from the beginning of the observation.

As was to be expected, the irradiated rats grew better than the controls but there was no significant difference in this respect between the two groups of irradiated animals. Seven out of the eight rats displayed a more or less marked degree of xerophthalmia, the onset of which was earlier in the majority of the irradiated rats than it was either in their own controls or in the irradiated rats receiving butter (exp. 1). The difference was not however very striking and as the one rat in which the eyes remained normal was an animal receiving the maximum dose of irradiation, the experiment does not seem to suggest that these symptoms of vitamin A deficiency were aggravated by exposure to ultra-violet light.

SUMMARY AND CONCLUSIONS.

(1) Previous observations in which ultra-violet radiation had exercised a deleterious effect upon the health of experimental rats are confirmed but the effect is found to be due to the conjunctivitis from which the animals suffered.

(2) Provided that the eyes were shielded, exposure of young growing rats to ultra-violet radiation for periods up to 30' daily was found to have no deleterious effect upon the growth and well-being of the rats (although this dose was found to be 15 times the adequate dose for male rats). It was also found that exposure for 30' to the lamp had no more beneficial results than exposure for the shorter periods.

(3) When using the biological method for the titration of vitamin A it is preferable to provide vitamin D by the inclusion of an irradiated vitamin-free rat in the diet, than by direct irradiation of the test rats.

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