Effect of Oxygen on the Frequency of Chromosome Aberrations Produced by X-Rays

MOTTRAM[1] demonstrated that the effect of gamma- and X-radiations in inhibiting the growth of *Vicia faba* root tips was materially reduced if the exposure was made under anaerobic conditions, and that the change in radiosensitivity could not be correlated with a change in the proportion of cells in division at the time of irradiation. Crabtree and Cramer[2] had previously shown a similar effect of anaerobiosis on the radiosensitivity of tumour cells.

We have confirmed Mottram's result by irradiating with X-rays (H.V.L. 1 mm. Cu) groups of beans with their roots in a 'Perspex' cell of water through which nitrogen was bubbled. The cell was placed in a cardboard box with small holes for the egress of the nitrogen to minimize back diffusion of air. The nitrogen was bubbled for ten minutes, the radiation was given in the next ten minutes, and the bubbling of the nitrogen, which had continued during the irradiation, was kept on for five more minutes. The beans were then returned to the culture tank, where they were always in darkness to avoid a daily mitotic rhythm. Doses of 320 r., 255 r., and 175 r. were given to three groups, while three other groups were treated identically, but air was bubbled instead of nitrogen. In no case did the temperature of the water drop by more than 2° C. from the 19° C. of the culture tank. The growth curves of the nine beans in a group have been averaged and are plotted in Fig. 1, which illustrates the striking effect of the anaerobiosis on the radiosensitivity.

Experiments are in progress here to test Gray's[3] hypothesis that the lethal effect of ionizing radiations on the growing tip of the *Vicia faba* root is due to the genetic abnormalities which result from the division of cells containing aberrant chromosomes.

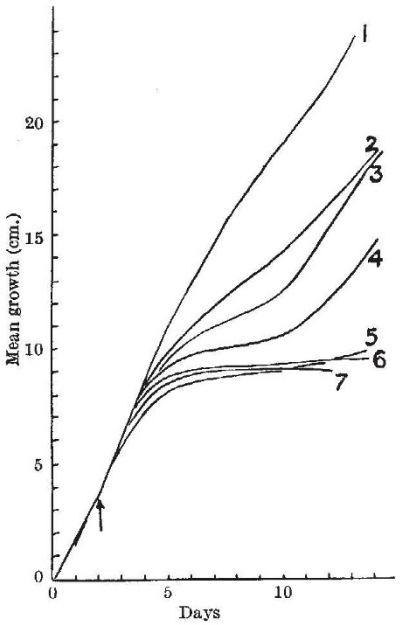

Fig. 1. EACH CURVE IS THE AVERAGE OF THE GROWTH CURVES OF A GROUP OF NINE ROOTS OF THE BROAD BEAN (*Vicia faba*) TREATED AS FOLLOWS ON THE SECOND DAY:

(1) 175 r. in nitrogen; (2) 255 r. in nitrogen; (3) 320 r. in nitrogen; (4) 175 r. in air; (5) 175 r. in oxygen; (6) 255 r. in air; (7) 320 r. in air

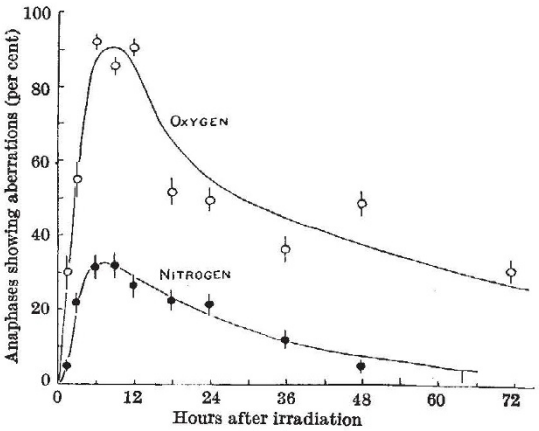

Fig. 2.
Upper curve—143 r. in oxygen; lower curve—143 r. in nitrogen

The results so far have been in agreement with this view, and it was therefore believed that the decrease in radiosensitivity of the root tips in nitrogen should be accompanied by a parallel decrease in the proportion of cells having chromosome aberrations. Groups of beans have therefore been irradiated, as described above, except that the exposure time was reduced to 4 min. to match earlier experiments. The dose was 143 r. In the case of half the groups nitrogen was bubbled, and for the other half oxygen (not air). Again the temperature did not drop by more than 2° C. Tips were fixed at intervals up to 72 hours after the exposure; Fig. 2 shows the percentage of anaphases in which there were visible bridges or fragments. All but two of the points are based on 100 anaphases studied in each of two root tips. The yield of chromosome aberrations is also strikingly less when the irradiation is done in an atmosphere of nitrogen. As a similar reduction of radiosensitivity, as measured by growth subsequent to irradiation, was observed when nitrous oxide, carbon dioxide, and hydrogen were substituted for nitrogen, it seems clear that the availability of oxygen is a very important factor in the production of chromosome aberrations. It is possible that the effect of temperature observed by Sax and Enzmann[4], and Catcheside *et al.*[5], and the effect of *p*H observed by Marshak[6] may, at least in part, be due to differences in the availability of oxygen. That the radiosensitivity of tumours is affected by oxygen supply has long been suspected. It now seems likely that this influence does act through the effect on the production of chromosome aberrations.

The details of these experiments and a full discussion will be published later. This preliminary report is given to direct the attention of those studying the production of chromosome aberrations by radiations to the importance of controlling the oxygen supply.

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[1] Mottram, *Brit. J. Radiol.*, 8, 32 and 643 (1935).
[2] Crabtree and Cramer, Imperial Cancer Research Fund Report No. 11, 75 (1934).
[3] Gray, British Empire Cancer Campaign Annual Report (1942).
[4] Sax and Enzmann, *Proc. U.S. Nat. Acad. Sci.*, 25, 75 (1939).
[5] Catcheside, Lea and Thoday, *J. Genet.*, 47 (2), 397 (1946).
[6] Marshak, *Proc. Soc. Exp. Biol. and Med.*, 38, 705 (1938).