# The Concentration of Oxygen Dissolved in Tissues at the Time of Irradiation as a Factor in Radiotherapy



L. H. Gray, M.A., Ph.D., , A. D. Conger, Ph.D., , M. Ebert, Dr. Rer. Nat., , S. Hornsey, B.Sc., , and O. C. A. Scott, M.B., B.Ch.,

Radiotherapeutic Research Unit, Hammersmith Hospital, London

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## Abstract

The sensitivity of tumour cells to X rays has been shown to be about three times as great when irradiated in a well-oxygenated medium as under anoxic conditions. The manner in which sensitivity depends on oxygen tension closely resembles that found by other workers for plant and insect tissues. The sensitivity of the tumour cells to fast neutron radiation is only slightly affected by oxygen tension.

Consideration is given to the supply of oxygen to tissues as a factor in radiotherapy, and it is concluded on the basis of existing knowledge that in certain circumstances the effectiveness of X-ray treatment might be increased if the patient were breathing oxygen at the time of irradiation.

The Ehrlich ascites tumour cells used in the *in vitro* experiments were grown as a solid tumour and exposed to X rays while the mice were inhaling various mixtures of oxygen and nitrogen at 1 atmosphere pressure and above. In all cases, except when the tumour was very large at the time of irradiation, the regression produced by a given dose was greater when the inspired gas was oxygen than when it was air. The effect of oxygen treatment on the response of the tumour was much greater than on that of skin and hair, as would be expected if these tissues are normally well supplied with oxygen. In the most satisfactory experiment so far made, 1000 r administered to mice breathing oxygen at 1 atmosphere produced about the same tumour regression as 1500 r delivered to mice breathing air.

Cell degeneration produced by exposing chick fibroblasts to X rays *in vitro* showed a dependence on oxygen tension of the same general type as the tumour cells and other tissues, but the exact form of this relation between radiosensitivity and oxygen tension remains to be determined.

Two chemical model systems have been examined, and in one of them the amount of chemical change produced by a given dose of X rays was found to vary with the concentration of dissolved oxygen in a manner rather closely resembling the biological systems.

Reasons are given for believing that oxygen exerts an important influence on biological response by affecting the chemical changes produced directly in the cell by the radiation. We would like to emphasise that these investigations are still only at an early stage, but the information to hand seemed to us to show that the influence of oxygen tension as a factor in radiotherapy merits much fuller investigation.

It would not be possible, on the basis of our experiments, to predict that any particular human tumour would respond more favourably to X-ray treatment if the patient were breathing oxygen at the time of irradiation. We believe, however, that the possibility of substantial differential gain in effectiveness of the radiation with respect to tumour tissue relative to well-oxygenated normal tissue is inherent in any

situation in which regions of partial anoxia occur in a human tumour.