Final report

Contract: Bi7-040 **Sector: B11**

Title: Specification of radiation quality at the nanometre level.

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I. Summary of Project and Global Objectives

Research concerning the best way of specifying radiation quality for radiobiology and radiation protection by physical parameter expressing the track structure-target structure relation remains a central task of microdosimetry. Since both molecular biology and radiobiological analysis (track segment method) suggest for cellular radiation effects, critical target sizes of few nanometre, the imperfection of present microdosimetric simulation of volumes in the micrometer range have become evident. For all ionizing particles or particle configuration (e.g. Auger cascade) which produce a high concentration of deposited energy on the nanometre scale, but having ranges much smaller than the micrometer dimensions, the spatial resolution of present microdosimetric detectors is inadequate. The project has four main aims.

1. Track structure studies for nanometer targets

AIM

To establish the approximated constancy of the delta-ray contribution to the energy deposition fluctuation in a nanometer target. To establish the constancy of the ratio of restricted LET to linear primary ionisation.

Track structure studies, based on computer simulation, recent cross section updates and adequate statistical concepts such as distribution parameters, pattern recognition and target modelling, will provide the physical basis for the validation of the proposed quantities linear primary ionisation or restricted LET. The phenomenon of d-ray cutoff at nanometre target boundaries will need further study and the proposed close correlation of these quantities with lineal energy in simulated nanometre volumes will have to be substantiated. The work will include updated cross-sections and genomic target structure.

2. Biological validation of the best suited parameter

AIM

To select bench-mark sets of survival, chromosome aberration and molecular lesion data to test and confirm the ability of linear primary ionisation and restricted LET to determine their variation with radiation quality.

The ultimate decision concerning the suitability of the new radiation quality parameters must be provided by their ability to predict the dependence of radiobiological yields on radiation quality. This work, already started by the cooperating groups in promoting linear primary ionisation or restricted LET, needs further effort in broadening the biological data base and stepping forward from retrospective analysis to predictive approach.

3. Experimental studies of associate detector systems

AIM

Measurements of the ionisation pattern around charged particles tracks and study of a portable device able to simulate T.E. volumes of few tens of nanometres in size.

The actual experimental studies, which aim to determine the lowest simulation limit of a TEPC, will continue with the use of slow ions as probes to explore the avalanche characteristics of single-wire and field-grid TEPC. A tissue-equivalent multistep parallel plate avalanche chamber will be manufactured to measure single ionisations in order to study the correlation between primary ionisation and restricted LET. The possibility to manufacture a small cylindrical avalanche chamber will be studied. In parallel with the gas-filled detectors, a feasibility study will be carried out with the object of simulating the biological response to radiations in nanometre dimensions in condensed phase detectors. The optimum method will be selected, guided by the biological analysis, and work will begin on a device.

4. Quantification of indirect action from single tracks.

AIM

To conduct an experimental study of the yield and spatial distribution of paramagnetic free radicals formed in the wake of individual tracks by measurement of relaxation time and using ESR technique. To compare the experimental results with the predictions of a semplified theoretical model of biological effectiveness.

ESR measurements will be used to explore the spatial distribution, mean life times and reaction rates of free radicals generated by charged particle tracks in nucleic acids, proteins, aminoacids from cell cultures and possibly whole tissues. Measurement of radical density is based upon the dependence of the saturation value of microwave magnetic fields upon the spin-spin relaxation time. The possibility of adapting simplified theoretical methods, developed for enzyme inactivation by indirect action, will be explored in an attempt to obtain a more meaningful model of radiation action for radiation protection purposes.