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# From microdosimetry to nanodosimetry

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Radiation-induced damage to living cells or genes is governed, to the greater part, by the pattern of inelastic interactions of ionizing particles in sub-cellular targets (segments of the DNA, nucleosomes, or segments of the chromosome fibre). In consequence, the effectiveness and quality of ionizing radiation should be defined more in terms of quantities which are directly related to the track structure of ionizing radiation than in terms of macroscopic quantities like absorbed dose and linear energy transfer (LET). At the same time, these quantities should be measurable by physical means.

To tackle this challenge to radiation metrology, a track-structure based concept of radiation damage has been developed assuming that the initial damage to nanometre-sized volumes like the DNA is mainly due to the number of ionizing processes of single particles within a target volume or in its near neighbourhood. This number of particle interactions (the so-called ionization-cluster size) is measurable in gases using single-ion or single-electron counting techniques, and serves as a measure of the degree of radiation damage; the corresponding cluster-size frequency then serves as a measure of the radiation-induced damage probability. Radiation damage is described, therefore, in terms of particle interaction probabilities in nanometric volumes (nanodosimetry) instead of micrometric volumes (microdosimetry). In this way the traditional description of radiation damage in terms of LET and absorbed dose is exchanged by a probabilistic description of cluster-size formation which characterizes the interaction pattern of ionizing radiation in nanometric volumes and, thus, the particles'track structure.

To check the validity of the track-structure-based concept of radiation quality, experimental radiobiological data are compared with nanodosimetric quantities derived from cluster-size frequencies calculated by Monte Carlo simulations for ionizing particles at different radiation qualities assuming nanometre-sized liquid-water targets as substitutes of short segments of the DNA. This comparison shows a clear relation between track-structure-based nanodosimetric quantities and radiobiological data, which can also be expected if ionization-cluster-size frequencies are measured in gaseous target volumes filled, for instance, with molecular nitrogen or propane at low gas pressure.

**Primary author:** Prof. GROSSWENDT, Bernd (PTB (retired))

**Presenter:** Prof. GROSSWENDT, Bernd (PTB (retired))

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