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Radiation Damage: Particle Interactions in Nanometre-sized Volumes, a Challenge for Radiation Physics and Life Science

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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, and 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*). To tackle this challenge for 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 cluster size) serves as a measure of the degree of radiation damage, and the cluster-size frequency as a measure of the radiation-induced damage probability. Radiation damage is described, therefore, in terms of particle interaction probabilities in nanometric volumes (nanodosimetry), and 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 and, thus, the particles' tack structure. The same concept should also be applied to describe the radiation damage to complex structures other than those of living cells such as complex systems of electronic circuits if the sizes of the radiation sensitive components of the system are of the order of a few nanometres.