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Simulation of radiation interactions in the cell interior-Review

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The specific radiation energy absorbed in the main cell compartments in radiobiology experiments are usually estimated by calculations. Radiation dose in individual cells is typically modelled using analytical calculation or Monte Carlo simulation codes which model each radiation interaction with cellular components. Cellular mechanisms responsible for the dose enhancement effect achievable by the inclusion of metallic nano-particles in cells are generally not understood. In order to gain the maximum benefit in radiotherapy, the physical, chemical, and biological processes involved in the irradiation of cells should be investigated in more detail. It has been modelled the structure of Gold-nanoparticles on a nanometre scale. The simulation consisted of a macroscopic distribution of gold spheres within a spherical water medium. Although results were promising, this model lacked the geometrical complexity of a real cell. Then a virtual 3D randomized model of a cell containing key regions has been developed using realistic elemental compositions which was the first computational model using realistic cell geometry. In another study, electron tracks within different cell geometries (spherical, ellipsoidal) and an irregular shape has been simulated. After that, a simple cellular model consisting of a spherical cell, which contains nucleus and elliptical mitochondria, was implemented. Other researchers used elemental compositions derived from experimental measurements in a Monte Carlo simulation study to determine the energy deposition of two different cases: a homogeneous cell composed and a compartmentalized. And in a very recent findings, realistic phantoms has been built based on deconvolved wide field fluorescent microscopic images of the mitochondria of cells by importing the phantoms into Geant4 as tessellated volumes taking into account the geometrical complexity of these organelles. These are forward steps in the direction of producing more sophisticated and detailed simulations of the cell's interiors which would enable better understanding of radiation induced damage at the microscopic level.

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