Purpose:

To develop a nano-dosimetric Monte Carlo simulation package, TOPAS-nBio, based on the TOPAS (TOol for PArticle Simulations) framework that is being developed in a collaboration between the Massachusetts General Hospital (MGH), the SLAC National Accelerator Laboratory and the University of California, San Francisco. The goal is to incorporate biological processes on a sub-cell level that will provide the basis for a wide range of research in the field of radiobiology, such as bystander effects, biological dose calculations and effects of nano-particles on radiation therapy.

Methods:

The TOPAS framework has been utilized to extend the functionality of this tool for particle transport to include nano-dosimetry. The physics lists of TOPAS have been extended to include efforts by the Geant4-DNA group to model physics on nanometer scales, including chemical processes of the first millisecond after irradiation. TOPAS-nBio uses the functionality of TOPAS to score energy depositions on nanometer scales. A simulation of the setup of a cell culture irradiation experiment has been used as to test the feasibility of the project.

Results:

Track structures for an irradiation of a cell culture experiment were successfully obtained. Delta-electron distributions have been produced and single track delta electrons and their energy depositions were observed.

Conclusions:

This study is a first step in the development of TOPAS-nBio, a tool that aims at bringing nanometer scale radiation physics and biology together and make Monte Carlo simulations accessible for all radiobiology researchers. The results presented here show a first proof of concept for the development of TOPAS-nBio.