

## Track Structure in Radiation Biology: Theory and Applications

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*Purpose:* A brief review is presented of the basic concepts in track structure and the relative merit of various theoretical approaches adopted in Monte-Carlo track-structure codes are examined. In the second part of the paper, a formal cluster analysis is introduced to calculate cluster-distance distributions.

*Method:* Total experimental ionization cross-sections were least square fitted and compared with the calculation by various theoretical methods. Monte-Carlos track-structure code Kurbusc was used to examine and compare the spectrum of the secondary electrons generated by using functions given by Born-Bethe, Jain-Khare, Gryzinsky, Kim-Rudd, Mott and Vriens' theories. The cluster analysis in track structure was carried out using the k-means method and Hartigan algorithm.

*Results:* Data are presented on experimental and calculated total ionization cross-sections; inverse mean free path (IMFP) as a function of electron energy used in Monte-Carlo track-structure codes; the spectrum of secondary electrons generated by different functions for 500 eV primary electrons; cluster analysis for 4MeV and 20 MeV x-particles and carbon ions.

*Conclusion:* There are a number of Monte-Carlo track-structure codes that have been developed independently and the benchmarking presented in this paper allows a better choice of the theoretical method adopted in a track-structure code to be made. A systematic benchmarking of cross-sections and spectra of the secondary electrons shows differences between the codes at atomic level, but such differences are not significant in biophysical modeling at the macromolecular level. Clustered-damage evaluation shows: that a substantial proportion of dose (~ 30%) is deposited by low-energy electrons; the majority of DNA damage lesions are of simple type; the complexity of damage increases with increased LET, while the total yield of strand breaks remains constant; and at high LET values nearly 70% of all double-strand breaks are of complex type.

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