

Purpose: Formulas linking Linear-Quadratic (LQ) cell survival parameters to double strand break (DSB) induction are derived from the Repair-Misrepair-Fixation (RMF) model for mixed radiation fields. Measured data for several cell lines irradiated by radiations of varying quality are used to examine the impact of proximity effects on intra- and inter-track binary misrepair.

Methods: With the RMF, estimates of alpha and beta for any particle type are determined by a well-defined physical parameter (mean specific energy), two biological parameters (theta and kappa) that are independent of radiation quality, and a biological parameter (sigma) that depends on radiation quality. To minimize the number of ad hoc adjustable parameters, we used the published Monte Carlo Damage Simulation (MCDS) to estimate sigma. The effects of radiation quality on alpha and beta were examined by performing a regression analysis of survival data for 55 and 250 kVp x-rays (V79 cells), for 55 kVp, 250 kVp and gamma-rays from ⁶⁰Co (CHO cells) and human kidney T-1 cells irradiated by x-rays, protons, deuterons and alpha particles with an LET up to 200 keV/um.

Results: In CHO, V79 and T-1 cells irradiated by widely varying types of radiation, the probability per unit time DSB formed by the same track interact in pairwise fashion is 100 to 300 times larger than the probability per unit time DSB formed by different tracks interact in pairwise fashion.

Conclusion: The RMF is a useful conceptual and mathematical framework to quantify the effects of radiation quality on intrinsic radiation sensitivity for monoenergetic charged particles and mixtures of charged particles of varying quality. Although not an especially important cell killing mechanism for low LET radiations, intra-track binary misrepair becomes the dominant one-track cell killing mechanism for intermediate and higher LET radiations.