Preliminary Results Simulating Direct and Indirect Neutron-Induced DNA Damage With Repair Mechanisms

Nicolas Desjardins[1] and John Kildea[2]

[1]*Dept. of Physics, McGill University, Montreal, QC, H4A 3J1, Canada*
[2]*Medical Physics Unit, McGill University, Montreal, QC, H4A 3J1, Canada*

INTRODUCTION

- High-energy radiotherapy patients (>10 MeV) and astronauts in deep space are subject to **neutron radiation** which can lead to **carcinogenesis** [1-2].
- The risks associated with neutron radiation are **energy dependent** [3-4].
- Previous studies have used Monte-Carlo simulations to study this energy dependence but **none included repair mechanisms** [5-6].

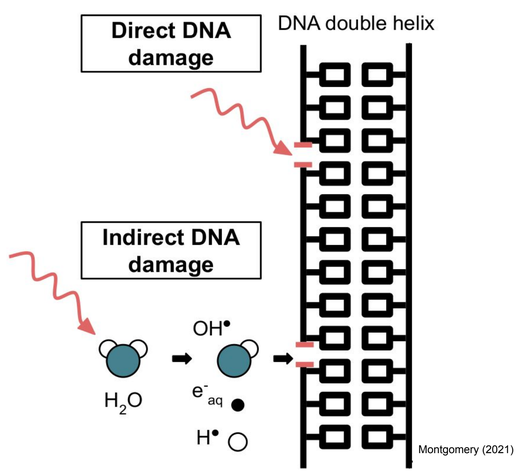
OBJECTIVES

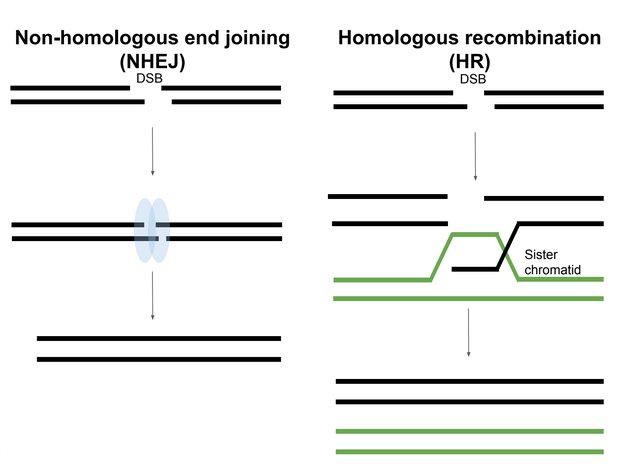
- Overall goal: Better understand **how neutrons cause cancer.**
- Specific goal: Estimate the neutron **relative biological effectiveness** by simulating DNA damage and repair mechanisms.

The **relative biological effectiveness** tells us how the effects of a given radiation compare to those of a reference radiation, which is typically 250 keV photons.

METHODS

- Our team had already acquired data on the secondary particles of neutrons using Geant4 simulations [7].
- Using those data, direct and indirect damage were simulated on a DNA model by TOPAS-nBio using the TOPAS toolkit [8-9].
- Non-homologous end joining was simulated using the DaMaRiS framework adapted to TOPAS [10]. Homologous recombination will be included in future work.



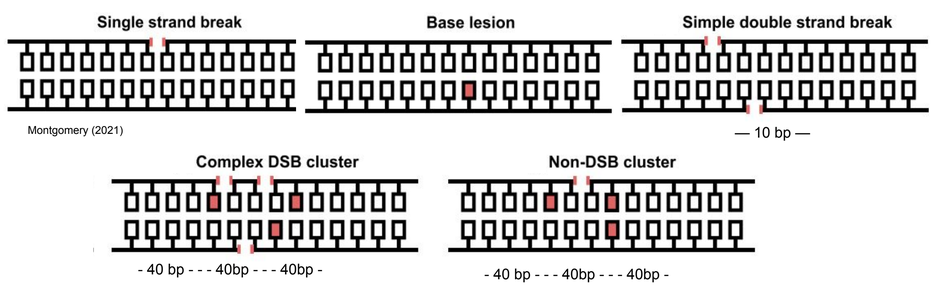


NHEJ (Simulated)

- Prone to errors
- Faster
- Always available
- Does most of the repairs

HR (Future work)

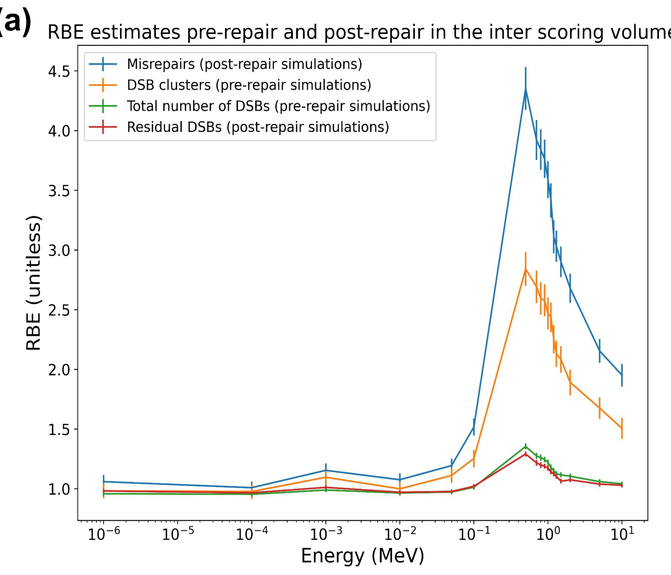
- Fewer errors
- Slower
- Only available during replicating stage
- Less used than NHEJ



CURRENT RESULTS

- **Result (a):** The estimated RBE peak is more significant for mis-repairs than it is for residual DSBs post-repair. This is to be expected given that mis-repairs are believed to be caused by DSB clusters.
- **Result (b):** The pre-repair damage results from this study compared to the results obtained from a similar study using a different DNA model. The differences may be due to different physical constructors and DNA models.
- **Results (c):** The post-repair RBE estimates compared to the published neutron quality factors. The quality factors are judgment values used to evaluate the risk associated with neutron radiation.

(a)



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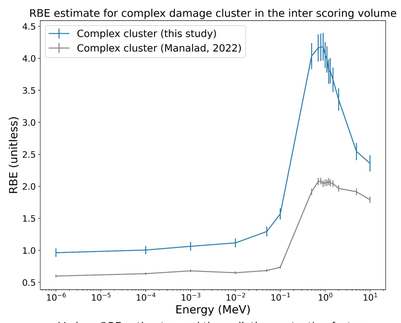
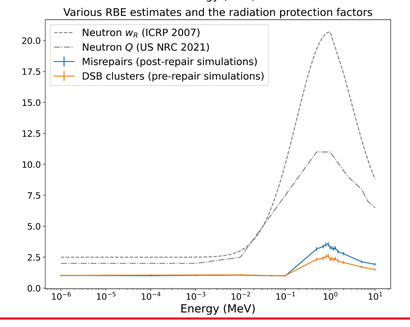


(c)



CONCLUSION

- The addition of the NHEJ mechanism to Monte-Carlo simulations seems to increase the peak of our estimated RBE compared to DSB clusters.
- These results are preliminary and more analysis is required to conclude anything significant.
- Future work will incorporate homologous recombination.

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