Mathematical modeling of DNA repair

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Studying of the repair of radiation-induced DNA lesions is one of the important problems of radiation biology. Along with experimental research, computational methods have become increasingly important in recent years in this area. They allow modeling of specific aspects ofbiophysical systems responsible for DNA recovery which cannot be assessed by experiments.

Aim of the project

It is planned to acquaint students with quantitative approaches used in system biology for modeling ofDNA repair systems in living organisms.

Description

The project considers the repair of DNA double-strand breaks (DSB) induced by ionizing radiations in mammalian and human cells.This is the most harmful type of DNA lesions, which can lead to various negative effects, such as the inductionof chromosomal aberrations, genomic instability, cell death, etc.

In particular, the project deals with the major eukaryotic DSB repair system represented by non-homologues end joining (NHEJ). The feature of NHEJ is that it can be realized without any DNA homology in the cell, so it can take place in any phase of the cell cycle. Thepurposeof this study is to develop a mathematical model of the NHEJ repair pathway in the mammalian cell after exposure to radiations of different quality.

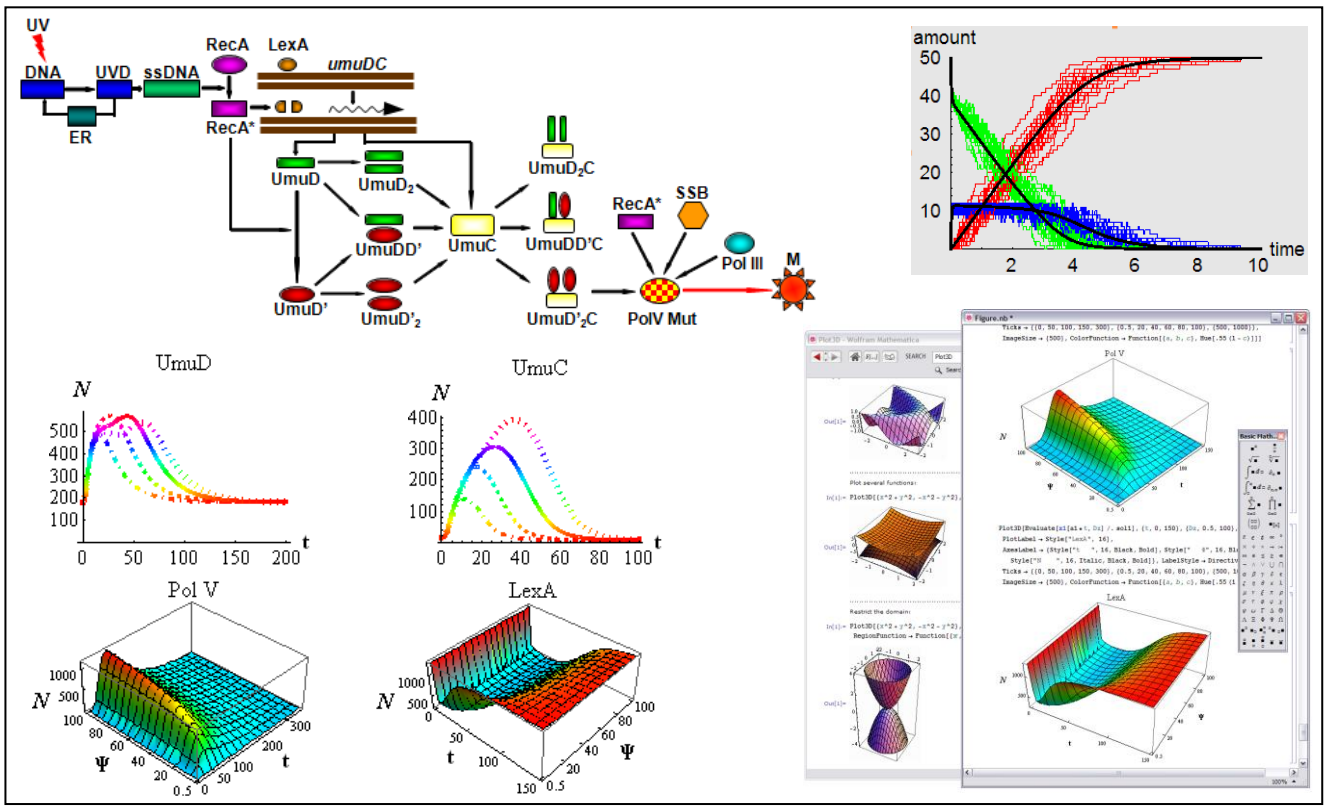
The calculation technique reviewed in the project is based on using of non-linear kinetics for simulations of enzymatic reactions. As an example of earlier application of this approach, the model of bacterial induced mutagenesis is considered [1, 2].

Practical tasks for students

1. On the basis of the published experimental data, determine the major processes contributing to the functioning of the selected DNA repair system.
2. Develop a phenomenological model the repair system.
3. Construct a mathematical model of the chosen DNA repair system using the deterministic and stochastic approaches.
4. Define the numerical values of the model parameters.
5. Obtain and analyze solutions of the model.

Experience

Required courses: General Radiobiology, Differential Equations and at least one of the following courses: DNA Damage and Repair, Biophysics, Biochemistry. Experience in using Wolfram Mathematica and MATLAB software.



Anexample of studying of the SOS repair system in Escherichia coli bacterial cells

Number of participants

The number of participants is limited to two.

Recommendedliterature

1. Belov O.V., Chuluunbaatar O., Kapralov M.I., SweilamN.H. The role of the bacterial mismatch repair system in SOS-induced mutagenesis: A theoretical background // J. Theor. Biol. – 2013. – Vol. 332. – P. 30-41.
2. Belov O.V., Krasavin E.A., ParkhomenkoA.Yu.Model of SOS-induced mutagenesis in bacteria Escherichia coli under ultraviolet irradiation // J. Theor. Biol. – 2009. – Vol. 261. – P. 388–395.

Project supervisor

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