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Two Stochastic Resetting applications to Biophysics

Biophysics is a growing field that involves mathematical modelling and data analysis to study biological, medical and ecological processes. In this presentation we show two applications of stochastic resetting to understand drug resistance development and RNA transcription.

Drug resistance development is the process in which the current therapy against an infection is decreased in efficacy, when that occurs a therapy needs to be changed. A change in the therapy can occur either during periodic visits, after a detection of a decrease in the number of healthy cells during another medical procedure or after the appearance of a drug with less secondary effects. We model the mutations of the infection as a random walk in genotype space leading to drug resistant phenotypes and the therapy changes are described as a stochastic resetting that transports the infection resistance phenotype to its initial state.

Transcription is a key process in gene expression, in which RNA polymerases produce a complementary RNA copy from a DNA template. RNA polymerization is frequently interrupted by backtracking, a process in which polymerases perform a random walk along the DNA template. Recovery of polymerases from the transcriptionally inactive backtracked state is determined by a kinetic competition between one-dimensional diffusion and RNA cleavage. Here we describe backtrack recovery as a continuous-time random walk, where the time for a polymerase to recover from a backtrack of a given depth is described as a first-passage time of a random walker to reach an absorbing state. We represent RNA cleavage as a stochastic resetting process and derive exact expressions for the recovery time distributions and mean recovery times from a given initial backtrack depth for both continuous and discrete-lattice descriptions of the random walk. We show that recovery time statistics do not depend on the discreteness of the DNA lattice when the rate of one-dimensional diffusion is large compared to the rate of cleavage.

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