

Dependence of the magnitude of stochastic fluctuations in prokaryotic gene expression on the transcription and translation initiation rates

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ABSTRACT

The kinetic model of prokaryotic gene expression has been formulated. The time evolution of the model was calculated by means of exact Monte Carlo simulations with Gillespie algorithm [1]. Results obtained for the model of LacZ gene were compared with detailed measurements available for this system and good agreement with experimental data has been achieved. In subsequent numerical experiments the rates of transcription and translation initiation were varied in the range of values reported for various prokaryotic genes. The magnitude of fluctuations in the number of protein molecules was calculated for each set of transcription and translation initiation rates and expressed as the ratio of standard deviation to the mean (variation coefficient). Variation coefficient was shown to converge to constant value if the simulations were performed in the time scales of several bacterial generations. Two dimensional phase plot of the variation coefficient calculated as the function of transcription and translation initiation rates has been calculated. For each point on the phase plot the speed of protein synthesis was also calculated. Results confirm, by more systematic approach, conclusions presented in the recent paper [2], that the same mean level of gene expression can be achieved by regulating the gene on the transcription or the translation level, but regulation on the transcription level induces much larger fluctuations. For the weak

promoters the protein is expressed in bursts rather than continuously. In contrast, the protein can be produced with a low and uniform rate if expression is regulated on the translation level. The sensitivity of these results to modeling assumptions such as the magnitude of fluctuations in the number of RNA polymerase and ribosome molecules and the protein degradation rate was also studied. All the calculations have been performed with the STOCKS (STOChastic Kinetic Simulator) [3] software which is available under GNU GPL license from anonymous ftp site:

<ftp://ibbrain.ibb.waw.pl/stocks>

REFERENCES

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