DNA Looping and Regulation of Gene Expression

Jane Kondev

Physics Department and Program in Quantitative Biology
Brandeis University, Waltham, MA 018901, USA

Abstract. Gene expression is regulated by cells in response to internal and external signals. For example, in a bacterial cell such as *E.coli*, the *lac* genes, which are responsible for the digestion of the sugar lactose, can be turned on or off depending on whether or not lactose is the only food source present. Here we investigate the role of DNA mechanics in the regulation of gene expression, and in particular the effect that DNA looping has on the average, and on the fluctuations of the number of messenger RNAs produced from the *lac* genes. Following reference [1], we consider a thermodynamic model of the regulation of *lac* gene expression which explains experimental data obtained by the Muller-Hill group [2]. From the data which describes the change in expression as a function of DNA loop length, we compute the free-energy cost of DNA looping *in vivo* [3] and compare it to experimental results *in vitro*. Both seem to indicate that DNA is much more flexible at short lengths than was previously thought. In order to compute the fluctuations in mRNA number we develop a master equation approach, from which we compute a phase diagram of noise as a function of DNA-loop length. We show that depending on the loop length, DNA looping can either enhance or suppress noise in the expression of *lac* genes. Our theory provides testable predictions for experiments that measure the cell to cell variability of gene expression. Finally, we show that noise in gene expression can be tuned independently of the mean and speculate how regulation of noise might infer evolutionary advantage to a population of bacterial cells growing in a fluctuating environment.

REFERENCES

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