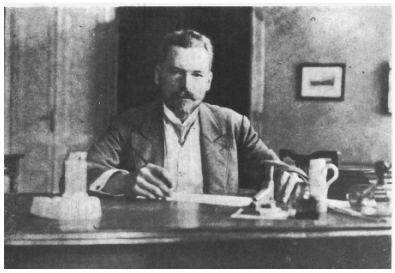

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Role of thermal fluctuations in gene expression

The role of thermal fluctuations is crucial in certain important biological processes, such as, transcription, translation, replication mechanisms, as they take place in very small scale systems.
We propose paradigmatic models for the transcription, i.e., DNA to m-RNA formation and DNA replication to see the effect of the environment on these important biological processes. We consider these processes as the copying of biological memory, where information is transferred from the parent DNA to its predecessor. We suggest that the sequence of bases in the strand of the parent DNA which is being copied to serve as the input signal for the process. The output is the base that binds to the parent DNA strand. Now, there are four possible outcomes as there are four conjugate bases present in the system. We consider these outputs to correspond to the minima of a four-stable potential. Thermal fluctuations have an important role when we consider systems of this scale. So, we propose that the output is described by the dynamics of a Brownian particle moving in a potential well having four stable minima. We consider both one-dimensional stochastic model and a four-state model and suggest that one of the minima gets lowered compared to the others when the system reads a particular signal. This minimum signifies the appropriate conjugate base of the corresponding base in the parent DNA strand. We allow the system to evolve for a finite-time and then examine whether the correct minimum corresponding to the given signal is occupied or not at the end of the process. When the output ends up in the correct minimum, we consider that as a successful process. Interestingly, we have found that this success rate shows a maximum at an intermediate value of temperature, i.e., the biological memory gets copied most efficiently at an optimum temperature. This result is encouraging as it is reported that for certain species, mutation rate which is just opposite to the success rate exhibits minimum at an intermediate temperature. We also intend to investigate the limit of the amount of information transferred from the parent strand to the nascent m-RNA or DNA strand.

Summary

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