Circadian Oscillation and Stochastic Noises

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Keywords: Biobje, simulation, Drosophila, circadian rhythm

1 Introduction

Various organisms (microbes, plants, and mammals) have own circadian rhythm and an endogenous timekeeping. All organisms have approximately 24 hours periodic rhythm, although the mechanisms and factors for oscillation production are different [1]. Even in the same cell, the expression level of genes should be different and amount of the proteins should stochastically differ [3]. To keep the precise rhythm, cells should have the system to overcome the stochastic noises. In order to identify this maintenance mechanism of the circadian oscillation, we tried extensive simulation of *Drosophila* circadian oscillation using a biological simulator, "Biobje" [4].

2 Method and Results

2.1 Simulation

We applied "Biobje", which was an original simulator based on a stochastic random walk model for the *Drosophila* circadian oscillation. We inserted the two interlocked negative feedback loops has the circadian machinery consist of 10 factors as proposed by Nick R.J. *et al.* [2, 5] into this simulator. All the parameter sets were tuned based on biological information [1, 2]. Each condition was used to examine simulation at least 10 times, and the total values from simulation results are plotted.

2.2 Results

In this model, the circadian oscillation became unstable, when it was hypothesized that the lifetimes of mRNAs are shorter than 5 hours, suggesting that the lifetime of mRNA is the key parameter for maintenance of precise oscillation. (Fig. 1 A, B) Under conditions, this periodic wave was maintained for longer than 700 hours with about 24hours cycles. (Fig. 1C)

3 Discussions

This model system composed of ten independent regulators which were stochastically produced, moved around and made reactions in the cells, could keep the precise oscillation cycle for longer than 700 hours. Our simulation showed the possibility that lifetime of each mRNA is the key parameter for maintenance of *Drosophila* circadian rhythm. The long lasting mRNA can produce the protein steadily and the accumulation of regulatory proteins seemed to make the oscillation more stable. Thus, our simulator "Biobje" could suggest us a hypothetical key regulation which could be examined on bench.

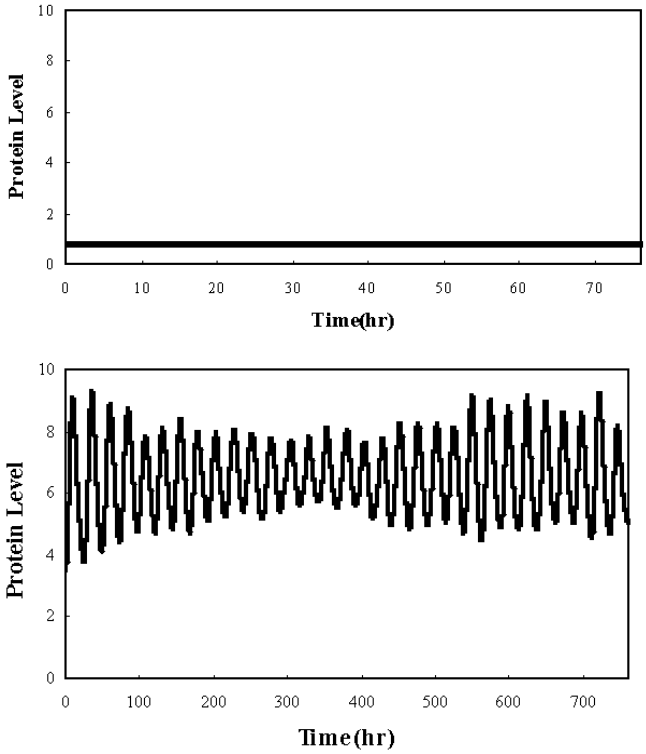

Figure 1: Each simulation is repeated more than 10 times in the same parameter set. The total amounts of proteins and mRNAs of per, tim, clock, and cycle were calculated and then protein levels of tim in different conditions are plotted. mRNA lifetime of each factors was hypothesizes as 2.5 hours (A) and 5 hours. (B), respectively.

References

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