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Dynamical control of protein concentration using synthetic two-component system

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To control cells using external input is useful for understanding biological function. For the analysis of the function, adding a time-invariant perturbation to a component is effective, but adding a time-variant perturbation is also effective. Dynamical control of protein concentration using external input (e.g. inducer or light) have been studied recently[1][2]. For dynamical control, a control system that converts external input into output like protein is required, and mathematical model of the system is desirable because of time dilation and noise. These studies are recently developed and it is necessary to increase variety of control systems. By using Cph8/OmpR two-component system that responds to a red-light stimulus and activate transcription of target gene, we controlled protein concentration tracking a desired value with mathematical model.

Cph8/OmpR two-component system has Cph8 as sensor protein and OmpR as regulator protein. Cph8 was synthesized by photoreceptor protein to be able to respond red light in E.coli[3]. In this study, Cph8/OmpR two-component system activates GFP expression under dark condition and can't activate it under red light condition.

Since the signal transduction mechanism of Cph8 is unknown, we constructed some mathematical models based on a few assumptions. In the process of parameter identification, we used time evolution of output (protein concentration) in response to dynamical switching of the input light. Finally, we dynamically controlled GFP concentration by changing input light pulse cycle. Mathematical model of the system is used to determine the optimum input. We show that Cph8/OmpR two-component system can be used for dynamical control of protein concentration. These studies would be useful for understanding biological function.

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