Robustness is a fundamental feature of biological systems which allows a system to maintain its functions despite external and internal perturbations. It facilitates evolvability, and evolution selects robust traits.It can be achieved by four basic mechanisms : system control, alternative (or fail-safe) mechanisms, modularity and decoupling ,[1]which need to be organized into coherent architecture to be effective at the level of the organism.

Biological robustness can be seen in many biological phenomena.For example,the use of negative feedback helps improve the bacteria's ability to follow a chemical gradient in bacterial chemotaxis.Bacterial chemotaxis refers to a kind of directional movement of bacteria, which is a basic function of bacteria to adapt to environmental changes and survive. It makes bacteria have the ability to find food sources and escape toxic environment, and has competitive advantages in survival. Bacteria can adapt to the change of chemical inducer in a wide range of concentration, and always adjust their behavior according to the change of chemical inducer concentration.This process is achieved by the feedback loop shown in the figure1.[2]

Chemotactic ligand combines with specific receptor MCP to form a stable complex which is composed of protein CheA and CheW. CheA is a phosphorylation regulator enzyme. CheY binds to the flagellar motor and makes changes. The ligand attached to the receptor is modified by the kinase of CheA to change the frequency. The receptor is also reversibly methylated. Methylation promotes the activation of the enzyme and adapts to the concentration change of the ligand. In the adaptive process of two proteins, one is CheR methylation and the other is CheB demethylation. The feedback mechanism of CheA indirect CheB phosphorylation promotes demethylation.[2]

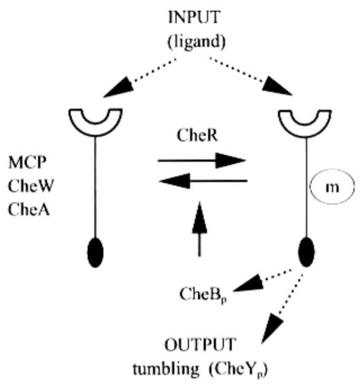

Fig.1 Chemotaxis system of *E. coli*[2]

When it comes to the significance of biological robustness,I have to admit that robustness is a fundamental feature of systems.It enables complex systems to evolve, and that evolution may probably increase the complexity of organisms through successive addition of regulatory systems, such as diverse regulation, signal-transduction pathways, RNA regulation[3][4][5]and histone modifications[6], to enhance robustness against specific environmental perturbations and to allow exploration into unoccupied niches[7],thus making living organisms have a greater probability of survival.

Although biological robustness can make organisms against external and internal perturbations, the introduction of various control feedback loops generates trade-offs by causing instability when unexpected perturbations are encountered, leading to catastrophic failure, which is called biological fragility.

Biological Fragility is the phenomenon that systems which have been evolved to be robust against general perturbations are extremely fragile against certain types of unexpected perturbations[8][9].As is said before,bacteria should be able to swim faster without negative feedback, but this would sacrifice their precision in following a chemical gradient.The experiments have verified that the use of negative feedback improves the bacteria's ability to follow a chemical gradient at the same time sacrificing the swim speed. [2]Therefore,fragility can cause robust systems much more vulnerable when the system's fragility is exposed.

Introduction

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