【Grant - in - Aid for Scientific Research on Innovative Areas(Research in a proposed research area)】
Biological Sciences

Title of Project : Evolutionary theory for constrained and directional diversities

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Research Project Number : 17H06384 Researcher Number : 00178089

【Purpose of the Research Project】

Living organisms do not evolve perfectly in random directions, but we recognize unevenness and directionalities in phenotypic variations and evolutionary changes. Thus far, however, these directionality or evolutionary constraints have never been dealt with scientifically. In this project, we aim at detecting them at various hierarchical levels, to understand the relationships or correlations between phenotypic changes observed in a short time scale (like adaptive responses) and those observed in a longer scale as evolution, to look for mechanistic and causal logics linking between the two, and finally to establish a theoretical framework to deal with the patterns of evolution, involving classical natural selection and neutral theories.

【Content of the Research Project】

1. To quantify the phenotypic response towards environmental and developmental perturbations, and to speculate the mode of correlation between the responsive gene expression levels and the responding phenotypic variations based on the fluctuation-response theory already developed in the field of physics. Thus, we will describe and measure the correlation between responses of gene regulation and phenotypes, and fluctuating embryonic morphological patterns and resultant phenotypic variations. Variations in epigenetic regulation will also be the target of the analyses.

2. To speculate the existence of constraints in the process of phenotypic generation during evolution, by means of comparison of phenotypes among various species, and to analyse, behind the fluctuating phenotypes, how the responsible genes' expressions and developmental patterns can fluctuate. Using simple models, we aim at performing experimental evolutionary analyses (*E. coli*), to identify and quantify genetic factors (structure of gene expression networks) behind the constrained phenotypes.

3. Based on the results obtained in 1 and 2, and by integrating the simulation analyses using simple models as well, we aim at exploiting methodologies to analyse the relationship between phenotypic variations and evolutionary changes, as the bases for applying to multiple systems at different hierarchical levels including complicated body plans and host-parasite symbiosis. Eventually, we will try to establish a new theoretical framework to deal with evolutionary directionality and constraints.

【Expected Research Achievements and Scientific Significance】

One major aspect of this project is the fact that it involves concepts of statistic physics to deal with so far untouchable questions in the evolutionary biology, namely, the causal and mechanistic nature of evolutionary directionalities and constraints. We also aim at establishing an integrative theory that can deal with evolutionary phenomena at various, multiple hierarchical levels like, from molecules and cell to the complex anatomical traits or ecological level evolution. The hint is already given from the field of physics and theoretical biology (fluctuation-response evolutionary theory; Kaneko and Furusawa, 2006). Not a while ago, even the quantum physics could never imagine that the field would ever be related by itself directly to the evolution of the entire universe, but now it does. Integration of the theory and observation has connected the two different worlds, which used to look so distantly related from each other. In the present project also, it is aimed at jumping over different hierarchical levels of phenomena, to show how a simple and integrative rule governs the entire world of organismal evolution and perplexing diversity surrounding us.

【Key Words】

Evolutionary biology, Evo-Devo, Evolutionary morphology, Experimental evolutionary biology, Ecology, Physics, Theoretical biology.

【Term of Project】 FY2017-2021

【Budget Allocation】

1,230,800 千円 Thousand Yen

【Homepage Address and Other Contact Information】

http://constrained-evo.org/