

【Grant-in-Aid for Transformative Research Areas (A)】

Section IV



Title of Project : Advanced mechanics of cell behavior shapes formal algorithm of protozoan smartness awoken in diorama conditions.

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【Purpose of the Research Project】

Intelligence broadly describes an ability to adapt to the environment. In this sense, single-celled organisms like protists (eukaryotic unicellular organisms) have a prototype of intelligence, or rather they can demonstrate skillful behavior in complex field environments due to their sophisticated evolution over hundreds of millions of years. This behavioral ability seems to be inherited as ‘single-cellular’ behavior in multicellular organisms (sperm motility during fertilization, cell motility in the internal environment, etc.).

In this Research Area, we define ‘proto-intelligence’ as the fundamental adaptability to the environment that single-celled organisms potentially possess. We name such artificial conditions as ‘diorama environments’, where organisms can show their potential proto-intelligence. Diorama environments may mimic the complexity of a habitat but in a setup designed for testing proto-intelligence. For example, one such instance is that of an amoeboid organism of slime mold, which displays the ability to find the shortest path in a maze of diorama environments. Since the mechanisms of proto-intelligence can often be formulated using coupled kinetic equations of cell motion and the environment, such environment-coupled mechanics will be thoroughly applied.

We will challenge and advance the algorithms (heuristics) of proto-intelligence, based on considering how the model works for solving the problem. More concrete objectives are (1) to make a wide search for proto-intelligence, and (2) to formulate the proto-intelligence by a mechanical model.

【Content of the Research Project】

‘Ethological dynamics in diorama environments’ is short for the full name of this research project, which is ‘Ethological dynamics to formulate proto-intelligence exerted in diorama environments’.

The Planned Research consists of four groups (diorama ethology, diorama implementation, mechanical modeling, algorithmic evaluation). Firstly, this focuses on the two main areas of (1) single sperm behavior (the smallest scale) and (2) collective motion of a red tide (the largest scale) in order to survey a wide range of scale for ethological dynamics. Secondly, the scope of investigation will be expanded to include the behavior of ciliates, flagellates, algae, and bacteria, and the ciliary movement in multicellular organisms. In Publicly Offered Research, we expect to expand our research target to various species and cell types, and through active research exchange within the Research Area, we will establish ethological dynamics in diorama environments.

In this way, we will elucidate the mechanisms of proto-intelligence that transcend the boundaries between species and cell types.

【Expected Research Achievements and Scientific Significance】

By collecting and organizing instances of proto-intelligence, we will establish ‘ethological dynamics in diorama environments’. This will provide a new perspective on the capabilities and diversity of cellular behavior.

We will formulate a model for agglomeration behavior and diurnal vertical migration of red tide algae and delving into their mechanisms will lead to improvement of the prediction accuracy of red tide.

Formulation of the environment-dependent swimming behavior of sperm in several species will reveal how sperm respond to disturbances in the real environment to reach the egg. It is also expected to have a ripple effect on the maintenance of ecosystems and cultivated fisheries.

We expect to lead to the acquisition of unknown proto-intelligence algorithm by understanding the performance and mechanism of environment-dependent self-organization of body shape and movement, observed in pseudopodial motile and ciliated (flagellated) motile cells in unicellular and multicellular organisms.

【Key Words】

Proto-intelligence: the fundamental adaptability to the environment that single-celled organisms potentially possess, and the capacity of environment-dependent movements shown at cellular level.

Ethological dynamics: the mechanical modeling for cell behaviors that describes the interaction with the environment in which the cell is placed.

Algorithm of proto-intelligence: to evaluate the mechanical model of cell behaviors as a method of problem-solving, or the method obtained by the evaluation.

【Term of Project】 FY2021-2025

【Budget Allocation】 1,064,300 Thousand Yen

【Homepage Address and Other Contact Information】

<http://diorama-ethology.jp>