Study of the Action Principle of Multicellular Systems

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Tissue formation of multicellular organisms is an important subject in biology. Modeling study has highly contributed to the understanding of the mechanism of tissue formation. For example, cellular dynamics theory has elucidated the aggregation mechanism of cellular slime mold. Our ultimate goal is to apply the cellular dynamics theory to the aggregation of the multicellular organism and to uncover fundamental tissue formation mechanism of mammals including human.

In the chapter one, we propose a new stochastic individual-based model as a mesoscopic theory that clarifies the consistency between the macroscopic reaction diffusion theory and the microscopic cellular dynamics theory. Our model is able to handle individual cells much like the cellular dynamics theory and approximate the diffusion term of the reaction diffusion theory. Here, we adopt predator-prey systems which is easy to model as a test case and we verify the validity of the model.

In the chapter two, we present a new scheme for the external control of mutually coupled oscillators which adopts a receptor scheme instead of a conventional linear coupling scheme. Our scheme can achieve both mutual and external synchronization much more effectively. It is also expected to apply our scheme to the distributed PLL (phase locked loop) networks which resolves clock delay or to the highly fault-tolerant electrical circuit design.

In the chapter three, we present a cell model which includes many mitochondria instead of a conventionally used single mitochondrion. Our study has demonstrated that the glycolysis and the multi-mitochondria develop the distributed processing system for the ATP production and that it can maintain homeostasis within the cell.

These researches are based on the concept of multi scalability to elucidate the tissue formation mechanism of multicellular organisms and expected to serve as an important step toward the study of the action principle of multicellular systems.