【Grant-in-Aid for Scientific Research (S)】

Broad Section J

Title of Project： **AutoMatter: Toward creation and expansion of programmable micro-active matter**

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Research Project Number: 20H05701 Researcher Number：50372446
Keyword：Automatter, Artificial cell, Self-replication, Mass production, Electro-molecular interface

【Purpose and Background of the Research】

Research on the construction of artificial cells has been attracting a great deal of attention in recent years, both for providing an example of how life can emerge from materials and as a key technology that may provide a basis for new material production systems based on lessons learned from living organisms. While the reconstruction of natural cells is a challenging task, the limitations of artificial cells, which aim to reproduce themselves as copies of cells, are also similar to those of living organisms. In recent years, self-assembled soft matter and self-organized active matter, which shows spontaneous motion in energy flow, have been extensively studied. If new materials can self-replicate and their motion can be controlled both molecular and electronically, it is expected that new materials will be able to perform tasks from the molecular scale to the macroscopic level. In this project, we aim to develop and integrate elemental technologies for realizing programmable and controllable "Auto matter", which are different from natural cell mimicry, by utilizing different principles and principles.

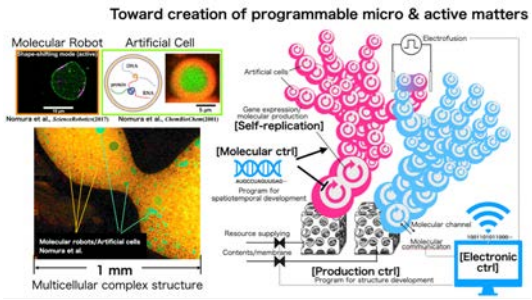

Figure 1 Schematic illustration of the project.

【Research Methods】

We have four sub-topics to realize, **1)** self-replication capability, **2)** molecular control, **3)** automated mass production, and **4)** electronic control-molecular interface, as the elemental technologies of this project. We will address this issue by integrating our knowledge of artificial cell construction and control technologies, molecular robots, the PURE (reconstituted gene expression) system, and the regulation of cellular functions by artificial molecules, all of which have been independently demonstrated by our research team. **1)** We aim to construct a system of simultaneous expression of about 100 protein species, including factors of the translation system, using PUREsystem. **2)** We aim to construct a spatio-temporal control system that regulates PURE expression of specific molecules in response to external miRNA signals using RNA programming techniques. **3)** We aim to construct a generator that continuously outputs artificial cellular structures by controlling the supply of material molecules of artificial multicellular bodies. **4)** Designing the molecular environment of multicellular structures to make the structures themselves act as chemotaxis and electrokinetic sensors. We will develop and integrate these elemental technologies (i.e., build prototypes) and nurture them as the core of "Automatter technology".

【Expected Research Achievements and Scientific Significance】

The newly developed technologies and knowledges (a basic set of artificial cell solutions for self-replicating cells, controlling technology for gene expression/repression by a molecular program, the basic technology for electron-molecule signal conversion, and technology for mass production control of artificial cells) would help to cooperate between life- and materials science via informational science. We also would like to expand our research to develop molecular systems for an application that production of the desired materials with efficiency comparable to that of natural cells and for the basic science that models of life that are different from life on earth.

【Publications Relevant to the Project】

- Sato, Y. *et al.*, ***Science Robotics***, 2(4), (2017), eaal3735.
- Hayase, G., Nomura, S.-i. M., ***Langmuir***, 34 (37), (2018), 11021–11026.
- Nomura, S.-i. M. *et al.*, ***Journal of the Robotics Society of Japan***, 28-10, (2010), 28-29.
- Nomura, S.-i. M. *et al.*, ***ChemBioChem***, 4, (2003), 1172-1175.

【Term of Project】 FY2020-2024

【Budget Allocation】 150,300 Thousand Yen

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