Laboratory of Biological Diversity

FUJITA Group

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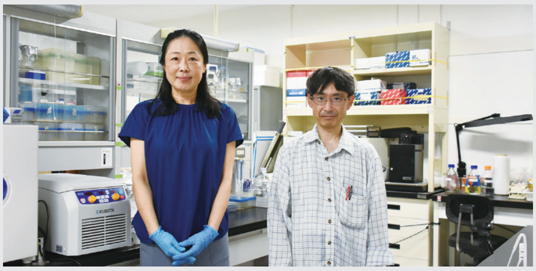

In nature, a variety of self-organized patterns, such as the galaxy and the snowflake, are found on a wide range of spatiotemporal scales. Particularly in living organisms, such self-organization of spatiotemporal patterns is both remarkable and essential. Therefore, we aim to elucidate the mechanism of generation and control of self-organized patterns in living systems with a particular focus on plants using both theoretical and computational approaches (Figure 1).

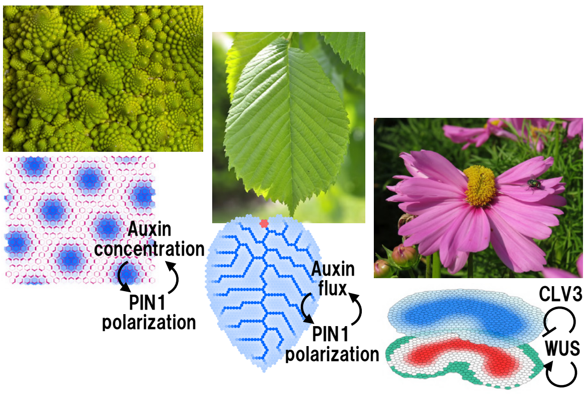

Figure 1. (Left) Phyllotaxis pattern is self-organized by the feedback regulation between auxin concentration and PIN1 polarization. (Middle) Leaf venation pattern is self-organized by the feedback regulation between auxin flux and PIN1 polarization. (Right) Shoot apical meristem (SAM) is self-organized by the interaction between WUS and CLV3.

I. Spatiotemporal self-organization of cell population

One well-known example of spatiotemporal self-organization in living systems is *Dictyostelium discoideum*, known as cellular slime mold. *D. discoideum* usually exists as a unicellular organism, but when stimulated by starvation, cells aggregate while forming a spiral pattern and develop a slug-like multicellular body. This remarkable self-organization is induced by chemotaxis to the signal molecule cAMP.

On the other hand, it is reported that *Escherichia coli*, which is a unicellular model organism, can self-organize spotted colony patterns (Figure 2B). This pattern formation is induced by the positive feedback between chemotaxis to aspartate (Asp) and Asp synthesis, and can be an excellent experimental system in the study of self-organization of cell populations. This stationary pattern of *E. coli* colony is formed under the condition of "spot inoculation", in which *E. coli* cells are inoculated in the center of soft-agar plates (Figure 2B). In order to further develop the research, we have newly developed an assay system "uniform inoculation", which causes a more dynamic self-organization in which colony spots initially emerge from the entire surface of agar medium, and they move and fuse with each other repeatedly (Figure 2C). Whereas experimental conditions in biological experiments are usually greatly restricted, the synthetic approach is a powerful research method that can control and modify the experimental conditions in a more flexible manner compared to the method used in standard experiments. Therefore, we try to apply the synthetic approach to *E. coli* to understand the principle of spatiotemporal self-organization of cell populations.

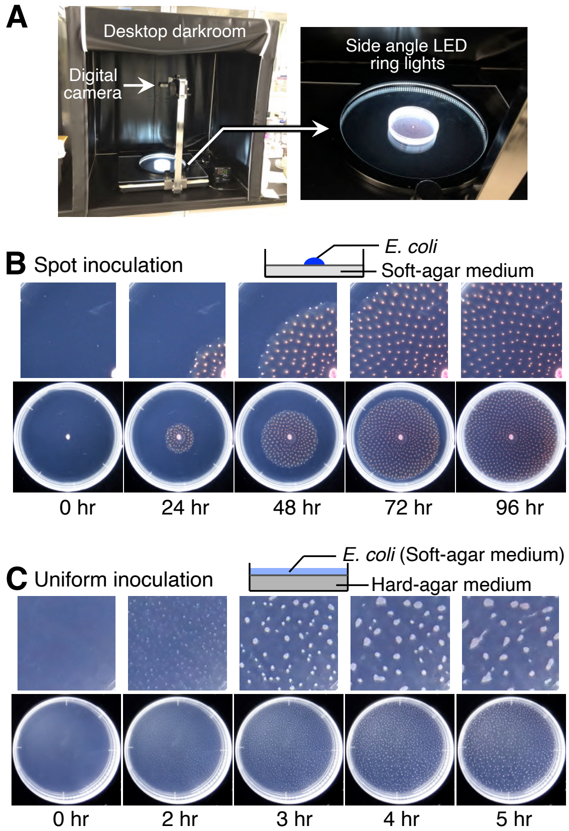

Figure 2. (A) A device system for photographs and time-lapse videos of spatiotemporal patterns of cell populations. (B) Spot inoculation; *E. coli* cells are inoculated in the center of soft-agar plates. The cell population spreads outward while forming a stable spot pattern. (C) Uniform inoculation; *E. coli* cells are evenly inoculated in soft-agar medium. The cell population shows a dynamic spatiotemporal self-organization in which colony spots initially appear from the entire surface of soft-agar medium (2 hr), and they move to fuse with each other repeatedly (2–5 hr).

Publication List:

〔Original paper〕

● Kataoka, K., Fujita, H., Isa, M., Gotoh, S., Arasaki, A., Ishida, H., and Kimura, R. (2021). The human *EDAR* 370V/A polymorphism affects tooth root morphology potentially through the modification of a reaction–diffusion system. Sci. Rep. *11*, 5143. DOI: 10.1038/s41598-021-84653-4