第47回生命の起原および進化学会学術講演会
The 47th SSOEL Annual Meeting

Synthesizing a minimal cell with artificial metabolic pathways

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A “synthetic minimal cell” is a cell-like artificial vesicle reproduction system in which a synthetic information polymer regulates a chemical and physico-chemical transformation network. Very recently, we synthesized such a minimal cell consisting of three subsystems: energy production, information polymer synthesis, and vesicle reproduction [1,2]. Supplied ingredients (D-glucose and oxygen) are converted to energy currencies (H_2O_2) which trigger the synthesis of an information polymer (polyaniline emeraldine salt form, PANI-ES), where the vesicle membrane plays the role of its template. The information polymer promotes the uptake of membrane molecules from the environment, leading to vesicle membrane growth. The growing vesicles show recursive reproduction over several generations by tuning the membrane composition and permeability to osmolytes.

Our synthetic minimal cell, for the first time, achieved the “complete reproduction cycle” of vesicles consisting of (i)membrane growth, (ii)deformation, (iii)division, and (iv)volume recovery. Furthermore, our “synthetic minimal cell” greatly simplifies the scheme of contemporary living cells while keeping their minimal essence. The chemical pathways and the vesicle reproduction pathways are well described by kinetic equations and by applying the membrane elasticity model, respectively. This study provides new insights to understand better the differences and similarities between non-living forms of matter and life.

[1] Reproduction of vesicles coupled with a vesicle surface-confined enzymatic polymerisation.
Kurisu, M. et al. *Communications Chemistry* **2**, 117 (2019).
[2] From vesicles toward protocells and minimal cells.
Imai, M., Sakuma, Y., Kurisu, M. & Walde, P. *Soft Matter* **18**, 4823-4849 (2022).