DNA computer-based rational construction of artificial genetic circuits in cell model vesicles containing cell-free protein synthesis system

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In the field of synthetic biology, the construction of artificial genetic circuits is aimed for understanding natural biological systems and designing new biological parts. However, the rational construction of artificial genetic circuits large enough to be of practical value is not easy at all. No effective method for the rational construction has yet been developed. Here, we report a DNA computer-based approach to the construction of artificial genetic circuits, which may have the potential for the rational construction of large artificial genetic circuits of practical value. In this study, a simple artificial genetic circuit was constructed based on a framework of RTRACS, which is a modular DNA computing system comprised of modules communicating with each other by using input and output RNA strands (Phys. Rev. E, 78:041921, 2008). The simple circuit receives input RNA for two inputs and produces output mRNA coding green fluorescent protein (GFP) as a consequence of the AND operation on the two inputs (Fig. 1). The constructed circuit was encapsulated into a Giant Unilamellar Vesicle (GUV), which is an artificially-prepared phospholipid-bilayer vesicle and has been recognized as a model to study biological cells. Expression of GFP gene controlled by input RNA strands was observed by green fluorescence emitted from GFP translated (synthesized) from the output mRNA using a cell-free protein synthesis system in a GUV. It was confirmed that the genetic circuit worked successfully in a GUV (Fig. 2). The present work would be the first small but important step toward the rational construction of more sophisticated artificial genetic circuits of practical value working in cell model vesicles.

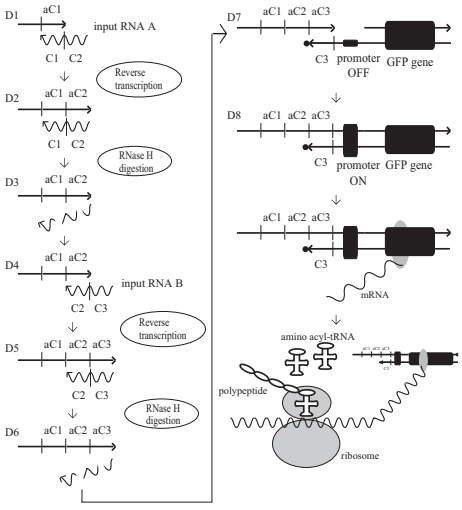

図 1　Reaction scheme of constructed module.

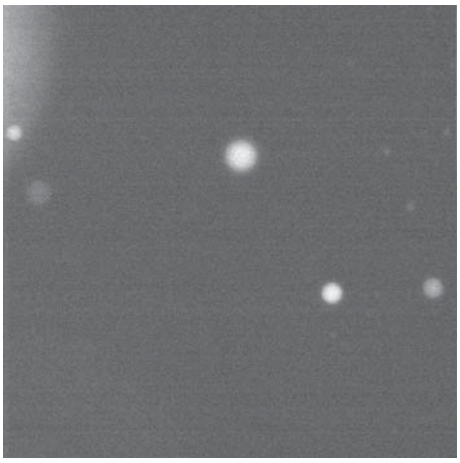

図 2　FM observation of GFP-expressed GUVs.