oscillated when two semi-batch reactors were interacted. The objectives of this study are to evaluate conditions causing the color cycle oscillation between the reactors and to study its oscillation mechanism.

The BR reaction solutions in different semi-batch reactors were mixed with a micro-tube pump. Flow rates, a reactor number, an initial amount of the solution, and an interval length were changed in order to clarify the mechanism of the color cycle oscillation.

As a result, though the color cycle oscillation was observed in case of the two semi-batch reactors, it was never observed in case of the three semi-batch reactors. When the three semi-batch reactors were employed, they were finally synchronized. The color cycle oscillation may depend on a flow rate, an initial amount of the solutions, and an interval length between reactors.

1P-253 反応複製系のエネルギー論

Energetics of a reproducing protocell with chemical reaction process

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Living systems are energy transducer in the sense that they get energy from environment for their maintenance and reproduction. They have potentiality for growth and reproduction, and in this sense, are distinguishable from conventional chemical engine to transducer energy that has been analyzed by thermodynamics. Here we take a simple cell system consisting of chemical reaction processes, with which external resources are flowed in, and transformed to other chemicals with which both the number of molecules and cell volume grow, and study the energetics for cell growth. In equilibrium condition with external environment, the internal reaction also reaches the equilibrium without cell growth. On the other hand, under flow of resources by nonequilibrium condition, the system can maintain an out-of-equilibrium condition for steady growth, depending on the internal reaction process. Through thermodynamic analysis, we analyze the ratios of energies consumed for growth and maintenance to the supplied energy, to elucidate their dependence on the resource flux to the cell system. By taking several types of models with reaction networks, we study the dynamics of the cellular state, and reveal its relationship with the above ratios of energy transduction.

1P-254 フラクタル様マイクロ流路を用いた生化学反応計測システム

Fractal-shaped micro channel system for kinetic analysis of biochemical reaction

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Microfluidic systems have been widely used to investigate the chemical and biochemical reactions in a small volume. They are designed to meet the time scale and detection scheme for specific reactions to be analyzed. However, time scale of the reaction dynamics may vary over a wide range depending on the type of reaction and concentrations used.

Here, we present the microchannel with fractal shape design is advantageous for measurement of the biochemical reaction with various time-scales. In this configuration, reaction at the discrete time periods is monitored at a single observation point. Moreover, timescale of the measurement can be changed by choosing the node of the fractal design. As a model reaction, we employed simple enzymatic reaction (enzyme β -galactosidase hydrolyzes the fluorogenic substrate resorufin β -D-galactopyranoside to liberate red fluorescent product). Aqueous solution containing each component (enzyme and substrate) was introduced by syringe pumps, and merged to initiate the reaction. The mixture was then encapsulated in water-in-oil emulsion to avoid the diffusion along the flow path. Time course measured at all nodes provides the detailed information of reaction kinetics, which gave the correct Michaelis constant of this reaction system. With the present system, measurement of variable biochemical reaction will become possible, including the stochastic behavior of single enzyme molecule by further miniaturizing the droplet size.

1P-255 蛍光偏光法を用いる新規 SNP 検出法の開発

Development of a Novel SNP Detection Method Using Fluorescence Polarization

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It is known that single nucleotide polymorphism (SNP) is one of the factors that determine individual genetic features. For the detection of SNP, a simple and high-throughput analysis method using a small quantity of sample is desirable. In recent years, many SNP analysis methods have been reported, however, these methods are not very suitable for high-throughput analysis because they require extremely time consuming processes. Here, we focused on fluorescence polarization analysis (FPA) as a candidate for single nucleotide polymorphism (SNP) detection method. In FPA, a fluorescently labeled molecule is excited with a polarized light, and the emitted fluorescence is depolarized due to the rotational Brownian motion of the labeled molecule. The degree of depolarization is strongly affected by the effective volume of the molecule. FPA is considered to be

better suited to high-throughput SNP detection than electrophoresis or solid phase methods.

In this research, we investigated the potential of FPA as a method for detection of SNP. We monitored the hybridization between DNAs with optimizing salt conditions for the hybridization and the length of target DNAs. Furthermore, for the target DNAs, which contain one base replacement in the sequence where the probe hybridizes, the features of the hybridization process were monitored with fluorescence polarization and compared with those for the non-mismatch target. We successfully detected a SNP using synthesized DNA as a target DNA with FPA. In the presentation, we will discuss the feasibility of SNP detection for the DNA, which is extracted from human cell and amplified using asymmetric PCR.

1P-256 定常流中の大腸菌速度の大腸菌サイズ依存性の理論的導出

The theoretical evaluation of the dependency of the velocity of *Escherichia coli* on their size in the stationary flow

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Background

Ca²⁺ ion is important for the cell-division of *Escherichia coli*. The size variation (related to the cell-division) dependent on the calcium concentration was observed with the fluorescence correlation spectroscopy (FCS) by Fujiwara *et al.* In order to analyse this result in detail, they measured the velocity of the spherical polystyrene bead with different size, which depends on their radius in the stationary flow.

Theoretical Method

Based on Fujiwara *et al.*'s experiments, we evaluate theoretically the dependency of the velocity of *E. coli* on their size using the following approximations.

We regard the form of *E. coli* as the prolate spheroid. The rotation of *E. coli* is neglected. We consider only the viscous resistance because of the slowness of the stationary flow.

In these approximations we can derive the terminal velocity of *E. coli* under the condition that three forces, the buoyancy, the gravity and the viscous resistance, are balanced.

We evaluate the dependency of the velocity of the spherical polystyrene bead in the same manner as of *E. coli*.

Conclusion

Comparing the results in the case of the spherical polystyrene bead, we can estimate the major radius and the minor radius of *E. coli* from their velocity in the stationary flow.

1P-257 原子間力顕微鏡による β ラクトグロブリン-抗 β ラクトグロブリン抗体に対する温度の影響の計測

Evaluation of temperature effect on interaction between beta-lactoglobulin and anti-beta-lactoglobulin antibody by AFM

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Intermolecular recognition such as interaction between antibody and antigen plays a crucial role in biological system. The interaction can be characterized by an energy landscape consisting of potentially energetic barriers along a reaction coordinate. Dynamic force spectroscopy (DFS), which consists of measurements of the binding forces between a molecule of interest and a complementary molecule at different loading rates by use of atomic force microscopy (AFM), is useful tool to investigate the energy landscape of the interaction at the single molecule level. We have previously reported the measurements of the binding forces between anti-beta-lactoglobulin antibody and beta-lactoglobulin at different temperatures and various loading rates using AFM. In the present study, we investigate the effect of temperature on the energy landscape of the interaction between the antibody and the antigen using previous results. The unbind rate at zero, the energy landscape roughness and the poison of energy barrier of the interaction, which are parameter of the energy landscape, were determined using Bell-Evans (Bell, 1978; Evans and Ritchie, 1977) and Dudko (Dudko *et al.*, 2007) model. Based on the results, we will report the temperature effect on the energy landscape of the interaction between the antibody and the antigen. This work is supported by Food Nanotechnology Project, MAFF.

1P-258 リン脂質膜で囲まれたマイクロメートルスケールの空間に閉じ込められた長鎖 DNA 分子の高次構造変化

Conformational transition on a long DNA molecule confined in a micrometer-scale space surrounded by a phospholipid membrane

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It has been established that a long DNA molecule (>20–30kbp) exhibits a conformational transition from a coiled state to a highly folded state under the presence of condensing agents such as polyamines. In a cell, DNA is placed in a