Physics of gene regulation – Looking at genome from the viewpoint of soft matter physics and chemical reaction researches

Tetsuya Yamamoto
Specially Appointed Associated Professor
Affiliation: ICReDD, Hokkaido University and PRESTO, JST
e-mail: tyamamoto@icredd.hokudai.ac.jp
Specialty: Biological physics and soft matter physics

ABSTRACT

Recent development of experimental techniques, such as super-resolution microscopes and next generation sequencing techniques, has revealed highly organized structure of genome in the nucleus of eukaryotic cell. The structure and dynamics of genome is involved in the regulation of gene expression. For example, heterochromatin, which is highly condensed region of chromatin, coexists with euchromatin, which is relatively dilute region of chromatin[1]. Transcription, which is the first step of gene expression and is one of the important chemical reactions in life, is suppressed in heterochromain and is active in euchromatin. Enhancers, which are regulatory DNA sequences, are located at a few kb away from promoters of the target genes. Transcription machineries, such as RNA polymerase II, transcription factors, and mediators, form so-called transcriptional condensates by liquid-liquid phase separation and enhancers regulate the expression of target genes by localizing these genes at the proximity to the transcriptional condensates[2]. The structure and dynamics of genome as well as nuclear bodies, such as transcriptional condensates, can be treated by using an extension of soft matter physics. It is of interest to understand how gene expression is regulated by the structure and dynamics of genome as well as the interaction with other structures in nucleus, such as nuclear bodies and nuclear membranes, by combining the soft matter physics and the kinetics of biochemical reactions involved in gene expression.

In this talk, I will introduce our attempt to understand the mechanism of the assembly of paraspeckles[3-4] by the fusion research between (experimental) RNA molecular biology and (theoretical) soft matter physics, as an example of providing new understanding of biological systems by looking these systems from the viewpoint of soft matter physics and chemical reaction researches.

REF.

1. T. Yamamoto, T. Sakaue, and H. Schiessel, Phase separation of chromatin brush driven by enzymatic reaction dynamics of histone posttranslational modifications, **bioRxiv**, (2020).

2. T. Yamamoto, T. Sakaue, and H. Schiessel, Slow chromatin dynamics enhances promoter accessibility to transcriptional condensates, **Nucleic Acids Research**, 49, 5017-5027 (2021).

3. T. Yamamoto, T. Yamazaki, and T. Hirose, Phase separation driven by production of architectural RNA transcripts, **Soft Matter,** 16, 4692-4698 (2020).

4. T. Yamazaki, T. Yamamoto, H. Yoshino, S. Souquere, S. Nakagawa, G. Pierron, T. Hirose, Paraspeckles are constructed as block copolymer micelles. **EMBO J,** e107270 (2021).