15A-07 細胞膜の形成の分子機構とその制御

The bacterial flagellum is a filamentous organelle made up of about 30 proteins with their copy numbers from a few to a few tens of thousands. Since the flagellum extends from the cytoplasm to the cell exterior, most of the component proteins are exported to the distal end of the growing flagellum through the flagellar type III protein export apparatus. The export apparatus is composed of the export gate made of six membrane proteins (FHa, FlhD, FltQ, FlfP, FlfQ, FlfR) and three soluble proteins (FlhF, FlhG, FlhI), which assemble on and disassemble from the gate during the export cycle. Recent studies revealed that the export process is regulated by a small number of multifunctional substrate-specific chaperon proteins (FlgN, FlgM, FlgK, FlgW). By forming a 1:1 complex with their substrates, they prevent their substrates from premature aggregation in the cytoplasm, and facilitate the export of the substrates through the direct interaction with the export apparatus. After release of their substrates, the free chaperons regulate flagellar protein gene expression. Thus the flagellar gene expression and flagellar assembly stage are linked by the export chaperones. In this symposium, we will show the role of chaperones on the flagellar construction process based on the recent biophysical, biochemical and genetic works and discuss the molecular mechanisms of the protein export and flagellar gene expression.

15B-01 DNAの構造と機能～二次構造転移が生み出す時間空間秩序
Synergy between Stiffness and Softness on DNA: Spatiotemporal Order Organized through the Higher-Order Structural Transition of DNA
Yoshiko Takenaka (Nanosystem Research Inst., AIST)

Genomic DNA is a semi-flexible polymer chain, which has longer persistence length (~50 nm) than the diameter of a chain (~2 nm) and much longer total length (100 μm to 1 cm) than the persistence length. That is, DNA behaves as a flexible chain over μm scale and a rigid chain in nm scale. Different from short oligomeric DNA, long DNA exhibits the property to undergo a discrete structural transition induced by the change in pH, temperature, concentration of polycation, ATP, RNA, etc. We call this kind of structural transition as higher-order structural transition of DNA. In the presentation, we propose a novel hypothesis to interpret the informational cascade from DNA to macromolecular spatio-temporal order in multi-cellular systems, based on the unique property of genome-sizes DNA as a semi-flexible polymer.

We will present a hypothetical gene network model, in which the higher-order structural transition of DNA plays an essential role in regulating stable on-off switching and/or the oscillation of a large number of genes under the fluctuations in individual living cells. This model can explain the robust and broad transcriptional response in a genetic assembly against fluctuations.

We will also interpret the mechanism of the spatiotemporal pattern in somitogenesis. We will stress the importance of spatial discreteness, i.e., actual size of cells, on the reliable theoretical model. With this model, we can produce stationary patterns, which are similar to those of somitogenesis.

15B-02 Protein as Mechanical Transducer

"Human body has mechanisms for transducing mechanical stress (deformation and motion by force) into biochemical reactions, which is considered the basis for producing the dynamics of the body," stated Miyaoka et al. in Seikagaku (81, 494-501, 2009). They further stated that the mechanical stress would include 1) shear, 2) hydrostatic pressure, 3) pulling, compressing and pushing, and 4) vibration. We have been studying structural, dynamic and thermodynamic properties of proteins on pressure-axis by NMR spectroscopy using hydrostatic pressure as variable. We have found that proteins are highly sensitive to pressure perturbation and change their equilibrium populations from the basic sub state often to an excited and functional sub state with increasing hydrostatic pressure (Akasaka K., Chemical Reviews 106: 1814-35, 2006). Experimentally, a uni-axial mechanical stress applied to a protein solution is used to produce a thermodynamically excited state of the protein with a higher chemical reactivity. Namely, mechanical stress to a pump (uni-axial) -- hydrostatic pressure (isotropic) -- protein conformational transition (thermodynamics) -- activation of reactivity (chemical reaction, function) is a similar scheme as above found also in living systems? What is the relationship of the above scheme with the apparently non-uniform stress to human body like pulling, compressing, shearing and vibrating?

15B-03 身体細胞動態（受動メカニカルモデル解説、細胞を生み出す細胞の多様性、構造と機能）
Body-cell dynamic mechano-mechanical linkage: softness, flexibility, fluctuation and controllability derived from ECM environment as "niche for cells in our body"
Yoriko Atomi1, Miho Shimizu2, Eri Fujita3, Tomaoki Atomi2, Noboru Hirose4, Katuya Hasegawa4 (1Radioisotope Center The University of Tokyo, 2Dept. of Mechnano-Informatics, Univ. of Tokyo, 3Teikyo University of Science, 4JAXA)

After 3.11, we all need re-think the science based on the principle of living human body. Furnio-Obasa has already discerned that biological macro molecules such as F-actin in muscle is more flexible/fluactuate in action, suggesting that all physical activities may promote flexibility at the molecular levels. We humans belong to eukaryote as multi-cellular organism. Sixty trillions cells in our body are soft and sticky compared with yeast cells, which have hard cell wall like plant. In addition, we should think about specificity of multicellular organism in our body, which cells can communicate each other with mechano-mechanical linkage and also using paracrine and autocrine, and/or secretion of ECM molecules. Acquiring controllability of the human body is essential to receive a benefit from cellular activity-dependent manner, which is a principle of life. Rapid progress of stem cell technology shed light on an importance of a special microenivornment termed the "niche" (ECM), a relation between the cells and our own body as a niche at macro-level is mysterious. Various phenomenological results from exercising/immmobilized knee, unweighting/gravity loading muscle, heat loading muscle cells, and solubilized eggshell membrane treated yeast which give "Knowledge" of life and the science of life sciences are included in this topic. Enhanced adaptability for wellbeing brought by soft and flexible fine-tuned extracellular matrix will link body-to-cell and solve many problems in aged society where people live with unstable body under the gravity.

15B-04 多分野立位を可能にした身体の冗長性：柔らかさの制御と機能
Flexibility of human body with multi-segmental structure enabling bipedal standing
Tomaoki Atomi1,2, Noboru Hirose3, Miho Shimizu2, Yoriko Atomi3 (1Teikyo Univ. of Sci., 2Grad. Sch. Univ. Tokyo Metropolitan, 3Univ.of Tokyo)

Human body movements are restricted by the shape/structure of the human body parts, like bones, muscles, etc. The spatio-temporal function relationship of the body is deduced from dynamic protein structures/ interactions at macro cellular level, and from bone shapes of the joint which affects how body moves at macro level. In principle, life has been evolved to the species survival and preservation. If we look at the individual humans, a system to control the gravity center of the body within an appropriate range away from a possible danger of falling down is essential for life survival. Gravity center of the body is affected by the shape of the segments primarily consisting from bones, and soft tissue consisting of diartrodial joint. Intrinsically unstable bipedal human being controls gravity center of the body at relatively higher position compare to four-legs animals. Possible compatibility of multi-segmentality and stability shows that close relation exists between regulation systems of physical movement and physical property of soft tissue, and gravity center of the body. The present study is focusing on body elasticity (material) and balance regulation (controllability) to the physical movement which affects the shape alterations of the body figure (eg. standing, crouch down, lay down, etc.).

15B-05 人工制御した細胞膜の柔らかさと制御の確立
Softness of the artificial cell niche and its active interplay of forces
Miho Shimizu1, Yuki Katsumura2, Toshiyuki Watanabe2, Eri Fujita3, Tomaoki Atomi3, Noboru Hirose4, Katuya Hasegawa4, Yoriko Atomi3 (1Dept. of Mechano-Informatics, Univ. of Tokyo, 2Tokyo Univ. of Agri. & Tech., 3Teikyo University of Science, 4JAXA, 3Radioisotope Center The University of Tokyo)