Life Science:


"Nadeshiko"- *Fringed Pink*

Synchrotron radiation is a fundamental technology in macromolecular crystallography which reveals three-dimensional structures of biomolecules at atomic and molecular levels. Because of this importance, a national structural biology research project started five years ago, the 'Target Protein Research Program' (TPRP) has totally supported structural biology research in the aspects of scientific research and infrastructure development, and has produced many fruitful results. Although this project terminated at the end of the 2011 fiscal year, as the successor to the part of infrastructure development in the project, the 'Platform for Drug Design, Discovery and Development' will start in the 2012 fiscal year. This is a response to the expanding need and importance of the analytical technologies for innovative research including drug discovery. This concept is similar to the 'Instruct' program started in the European Union: "Instruct is the dynamic hub of structural biology providing an integrated infrastructure of cutting edge technology, scientific expertise and pioneering training." In the next five years, the user support system for the structural analyses and upgrading beamlines will be established.

Again this year, many outstanding results have been reported, particularly in the research field of bioenergy and membrane protein. We briefly introduce each article.

Photosynthesis is the greatest energy source for biological activity and produces organic compounds including sugar from water and carbon dioxide with light energy of the sun. Oxygenic photosynthesis causes charge separation of water by light reaction, resulting in the production of molecular oxygen, protons and electrons. The proton gradient, produced by this reaction and successive electron transport chain, enables the synthesis of ATP, a major and common biological energy currency, utilized for organic compound production in cyanobacteria and plants. Umena *et al*. revealed the high resolution structure of photosystem II and the secret of the reaction center for the charge separation reaction.

Oxygen evolution by the photosynthesis reaction maintains an aerobic condition in the atmosphere. Heterotrophic organisms, which depend on complex organic substances including sugar for nutrition, produce ATP by oxidizing the organic substances. For the oxidizing reaction, cellular respiration, i.e. the use of oxygen uptaken by breathing, is essential and it is coupled with the reduction of molecular oxygen obtained from atmosphere. However, in an ancient era where atmospheric oxygen was rarefied before the photosynthesis machinery was established, anaerobic respiration, where an electron acceptor other than oxygen is used, was rather common. Shiro *et al*. determined two anaerobic respiratory enzymes and discussed their evolutionary processes.

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The recycling of oxygen and carbon is a closed loop because of the existence of plants and heterotrophs in an aerobic environment. On the other hand, the recovery of electron acceptors is crucial in anaerobes. Hydrogenases directly catalyze the reversible oxidation involving molecular hydrogen and water with electron acceptors including biological cofactors of NAD and quinones. This enzyme is also of interest in the synthesis of molecular hydrogen useful in power fuel cells. However, the enzymes produced by anaerobes are generally ineffective in an aerobic environment. Shomura *et al*. revealed a hydrogenase structure that is effective even in an aerobic environment.

A membrane is the border between self and the outer world, where membrane proteins play an important role as gates. The exporting of protein from inside of the cell, i.e., secretion, is an essential activity in the modification of the outer world by a living organism. However, unlike smaller molecules such as sugar, protein is too large to permeate the cell border. Tsukazaki *et al*. determined the protein secretion machinery and revealed its dynamical structure.

Protein export is also necessary for an extracellular structure such as a flagellum used for bacterial swimming. This biological machinery penetrates membranes and tightly connected to the flagellar motor protein. Thus the export apparatus for flagella should be assembled in concert with the flagellar motor protein. Imada *et al*. determined the flagellar export apparatus and compared it with another bacterial protein export apparatus, injectors of virulence factors in pathogenic bacteria.

As described above, structures of membrane proteins clarify the fundamentals of many biological functions. However, due to their amphipathic character, the preparation of purified specimens is often laborious work. Wada *et al*. successfully utilize an effective protein production system, a cell-free system, to produce a membrane protein, marine alga rhodopsin. Its structure is also of interest in the proton pumping mechanism driven by light energy.

Cellular motility is a biological kinematic process and related to essential biological processes of cell division for example. Cytoplasmic dynein can walk on a microtubule, that is, a cellular skeleton, and carries large cargo such as organelles and chromosomes. This dynamical action is supported by its ATP-dependent motor action. Kon *et al*. determined the functional full-length motor domain of dynein.

Flowering, a successor process to fruition, is a key step also in agricultural applications. This process is known to be regulated by the hormonal protein 'florigen', whose protein family is distributed in a wide variety of organisms, but its functional detail has not been known. Ohki *et al*. determined the ternary complex of florigen with a transcription factor and scaffold protein and clearly depicted the activation mechanism of the flowering signal.

The centromere is the attachment site of spindle fibers for cell division and the part of a chromosome that links sister chromatids, which is another copy of the chromosome resulting from DNA replication earlier in the cell cycle. To reveal the unique DNA packaging structure at the centromere, Kurumizaka *et al*. determined the structure of centromere specific histone CENP-A complexed with DNA.

A wire shows various topological structures such twisting and winding. The long strand that stores genetic information, DNA, also exihibits topological changes. The wound form of DNA is useful to compactly package DNA, but conversely, the unwound form is essential for DNA transactions including replication and transcription. The enzymes of DNA topoisomerase/gyrase contribute to the regulation of the dynamics of DNA topology. Wu *et al*. determined the complex structure of topoisomerase, TOP2, using inhibitory drugs.

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