Life Science :

It is interesting to see how eager biologists are to make use of new experimental techniques. Some even develop novel techniques for a particular experiment. In addition to benefiting their own research, these efforts promote significant advances in biological sciences. The biological problems tackled by these scientists are often long-standing fundamental ones, and SPring-8 has been benefited by the efforts of these innovative biologists. The four reports in this section are good examples.

Iwamoto and Yagi of SPring-8/JASRI used an ultra-high speed CMOS camera to record the diffraction from muscle proteins in a bumblebee during a wing beat. Although the strong X-ray from a SPring-8 undulator beamline has been available for some years, an X-ray detector fast enough to capture a wing beat has not. The new CMOS camera is capable of recording 5,000 frames per second. When it is coupled to an X-ray image intensifier with a short-decay phosphor, it works as an ultra-high speed X-ray detector. They also used the same camera to observe the motion of wings to find a correlation with the time-resolved X-ray diffraction data, which is related to the molecular structural changes in the muscle cells. The motion of one wing triggers the motion of the other wing in an alternating fashion. The triggering mechanism seems to be similar to that in other types of muscles, including human muscles.

Medical Biology

In eukaryotic nuclei, the long genetic DNA is folded into compact chromosomes. The organization of DNA in chromosomes has been a matter of debate for many years. It is generally assumed that a long strand of DNA must be folded regularly to make a compact packing. However, although there have been reports on regular repeats in chromosomes, the precise structure has never been revealed. Maeshima *et al.* used X-ray scattering techniques to investigate this long-standing question. Using an ultra-low angle scattering technique, they demonstrated that such a regular structure does not exist in human mitotic chromosomes. This surprising finding suggests that irregular folding is actually important for the dynamic function of cells.

Nango and his colleagues are interested in the high-resolution structure of bone. There is a tubular structure in bone called the canaliculi with a diameter of about 0.25 μm. They used two types of X-ray microscopes with a zone plate to study bone at this structural level. One type utilizes a defocused condition, which causes edge-enhancement in the image that helps visualize the fine structure of the canaliculi. The other is Talbot interferometry, which uses a pair of gratings to obtain a phase-contrast image, allowing the high-density resolution necessary to estimate bone matrix mineralization. Combining these two techniques for CT (Computed Tomography) provides three-dimensional structural information, and changes in the mineralization of the regions surrounding the osteocyte canalicular network were elucidated.

NRVS (Nuclear Resonance Vibrational Spectroscopy), which is specific for the displacement of Fe atoms, is a novel method to study the chemical states of metal atoms, especially Fe, in proteins. The technique, which was developed by Prof. S. Cramer's group (University of California, Davis), has been demonstrated in various metalloproteins. A group led by Prof. Solomon of Stanford University has applied this technique to mononuclear non-heme iron (NHFe) enzymes, which play important roles in human cells. Analysis of the NRVS spectra of these proteins and theoretical computations led to the elucidation of an intermediate state of a quadrivalent iron atom bound with oxygen. This novel approach to evaluate protein function will be applied to many metalloproteins in the future.

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