Laboratory for Molecular Biophysics

Institute for Protein Research

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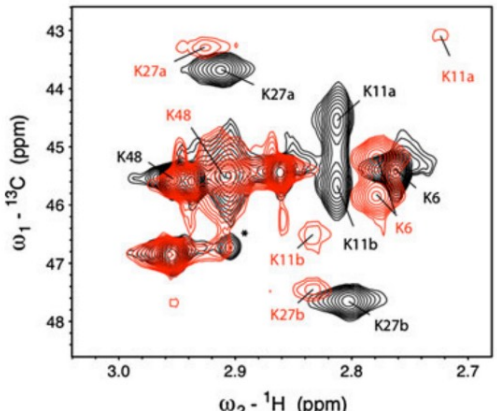
In our bodies, various energy and information transformations are carried out through biological membranes. The supramolecular systems that carry out these functions play an important role in the networking of biological activities. Currently, the structures of molecules with these functions are being revealed one after another. Our research aims to elucidate the function of proteins responsible for information and energy conversion on the basis of their three-dimensional structures, mainly using nuclear magnetic resonance (NMR).

Structure and function analysis of proteins by solid-state NMR

Solid-state NMR reveals structure and function of biologically important molecular complexes that not amenable to X-ray crystallography and electron microscopy. We are working on the structure and function analysis of molecular complex systems that are important for the signal transduction in living organisms. Specifically, these include proteins strongly bound to lipid bilayers and large molecular complexes in an amorphous state, such as rhodopsin, a membrane protein that transmits optical information, G proteins in complex with their receptors, and amyloid proteins. In addition, we are addressing structural and interaction analysis of proteins site-selectively in cells. As in biology, NMR experimental and analytical methods have also made great progress. We are developing experimental and data analysis methods for extracting more detailed information based on solid-state magnetic interactions.

Structure and function analysis of proteins by solution NMR

NMR is a very useful tool for analyzing the conformation and dynamics of proteins at the atomic level in the physiological solution states. In this laboratory, the 3D structures of proteins are mainly analyzed by NMR.



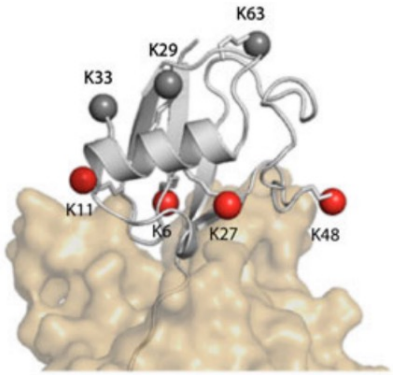


Fig. 1 Two-dimensional NMR spectra showing protein-protein interactions and the interaction between protein ubiquitin and YUH revealed by NMR.

Furthermore, we analyze how the protein interacts with other proteins or ligands to regulate its function at high structural resolution. We are also finding the correlation of the protein activity with the dynamics on relatively slow time scales, microseconds and milliseconds. Since the methodologies required for these analyses are still in the early stage, we are also developing such methodologies in NMR experiments and sample preparation such as isotope labeling.

Research Topics

1. Atomic resolution analysis of protein function and structure in cells
2. Structural and functional analysis of amyloid proteins
3. Structural analysis of membrane proteins for signal transduction
4. Development of NMR structural analysis based on selective isotope labeling
5. Analysis of protein structure and conformational change using paramagnetic probe molecules
6. Development of NMR structural analysis using bioinformatics
7. Development of ultra-highly sensitive NMR using terahertz waves and its application to biological systems

Figure 2 Ultra-highly sensitive DNP-NMR spectrometer. A superconducting magnet (left) and a terahertz-wave light source, a gyrotron (right), are used to observe NMR at cryogenic temperatures.

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