Laboratory of Bioinorganic Chemistry

Graduate School of Science

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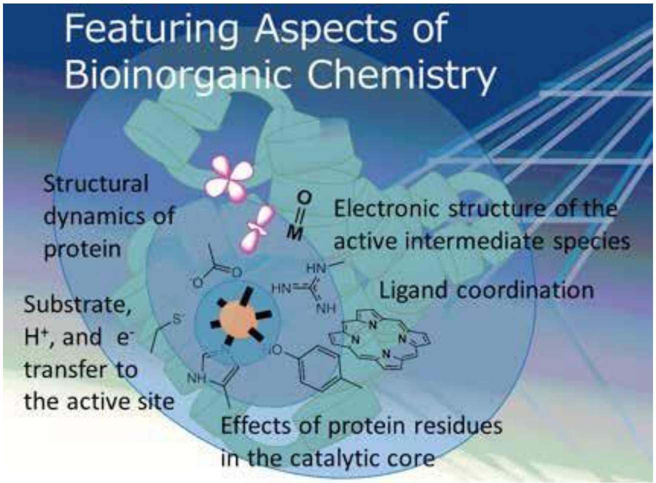
In biological processes such as energy transfer and metabolism, photoexcitation, electron transfer, and molecular conversion reactions are smoothly carried out. In the narrow space of metalloproteins, which are responsible for these reactions, there are reaction-active metallic sites, and these sites are the center of the reactions.

Metalloproteins and artificially synthesized metal complexes share the same properties of their central metal ions. Furthermore, some metal complexes exhibit pharmacological activity in vivo. Our research is focused on understanding the relationship between metals and life, and on developing functional complexes and artificial metalloenzymes that contain related metals.



Molecular activation of metal active centers

Transition metal-containing proteins include those involved in respiration, photosynthesis, and associated electron transfer, as well as enzymes with catalytic functions. For example, the reduction of oxygen molecules to water at the end of the respiratory chain by transporting and storing small molecules of oxygen is carried out by a group of metalloproteins. There are also numerous metalloenzymes that activate oxygen molecules to oxidize various substrates and scavenge reactive oxygen species. Transition metals are essential cofactors in the active sites of these metalloenzymes, including heme- and non-heme iron, type II and type III copper, and manganese. Manganese clusters also catalyze the reaction that generates oxygen from water in photosynthesis. Zinc-containing metalloenzymes are also used to catalyze carbon dioxide release in respiration and protein hydrolysis in digestion, respectively. Thus, we are interested in the function of transition metals in the active site of proteins, which activate oxygen, hydrogen, nitrogen, and their related compounds and other substrate molecules.

Photoexcitation and electron transfer

In photosynthesis and respiration, the transfer of energy necessary for biological activities first takes place using electrons as carriers. For example, in the light reaction of oxygen-evolving photosynthesis, photoexcited electrons move through proteins to produce NADPH. On the other hand, holes are transferred to the manganese cluster and annihilated by water oxidation to produce oxygen. Both processes contribute to the proton concentration gradient and also promote ATP synthesis. Intermediate electron transfer in the Z-scheme is carried out by a series of electron-transfer proteins containing transition metals such as redox-active heme iron and iron-sulfur clusters and type I copper. These electron and proton transfer processes depend not only on the dynamics of the protein structure but also on quantum effects such as tunneling, which is the subject of our research.

Development of Artificial Metalloenzymes

By studying metalloproteins from the above perspective, one of our first goals is to elucidate the correlation between function and structure of metalloproteins. Life has actively incorporated metals as essential elements since the beginning of its development.The study of proteins also leads to an understanding of the origin of life and subsequent molecular evolution.

On the other hand, the active sites of natural metalloproteins and artificially synthesized metal complexes share similar chemical properties, and some of them have acquired the photosensitizing ability necessary for the utilization of light energy. We are also working on the development of new functional complexes containing metals related to metalloproteins and artificial metalloenzymes.

Synthesis of metal complexes with anticancer activity

We are developing a metal complex as an anticancer drug that causes apoptosis of metastasizing cancer cells by inhibiting the intracellular signal transduction mechanism.

We welcome energetic people who are willing to take on challenges.

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