

2025 Clapp Lecture

The Elements of Life: Decoding How Metal Nutrients Regulate Health, Behavior, and Disease

Metals are elemental nutrients acquired from our diets that are required to sustain all kingdoms of life, from the smallest single-cell organisms that we use to bake bread and brew beer up to every single human being on our planet. Indeed, these elements are like the chemical letters that make up the alphabet in the language of life, where chemistry not only provides the central science for decoding biological languages but also the ability to create new medicines and materials to enhance our daily lives. Our laboratory has pioneered new concepts for understanding the underlying chemistry of how metal nutrients contribute to life processes. Specifically, we develop molecular imaging probes to visualize the dynamic distributions of metal elements in living systems across space and time, revealing how they change under different situations in health, aging, and disease. These chemical reagents enable us to decipher metal-dependent signaling pathways that influence fundamental behaviors such as eating and sleeping, as well as identify new metal-dependent disease vulnerabilities in cancer, neurodegeneration, and metabolic disorders that can be treated with new precision medicines that target essential nutrients that we all eat on a daily basis.

Chemistry Colloquium

Activity-Based Sensing: Leveraging Chemical Reactivity to Decipher Single-Atom Chemical Biology

Traditional strategies for developing selective imaging reagents rely on molecular recognition and static lock-and-key binding to achieve high specificity. We are advancing an alternative approach to chemical probe design, termed activity-based sensing, in which we exploit inherent differences in chemical reactivity as a foundation for distinguishing between analytes that are similar in shape and size within complex biological systems. This presentation will focus on activity-based sensing approaches to visualize dynamic fluxes of metals and reactive oxygen and carbon species and their signal/stress contributions, along with activity-based proteomics probes to identify their biological targets. As representative examples of new biological lessons learned from these chemical probes, we have uncovered a new paradigm of transition metal signaling, where metal nutrients like copper and iron can serve as dynamic signals to regulate protein function by metalloallostery, as well as signal-atom signaling, where reversible redox interconversion between methionine and methionine sulfoxide reveals new biochemical pathways to accelerate the development of next-generation precision medicines that target redox vulnerabilities in cancer and neurodegeneration.



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Chris Chang was born in Ames, Iowa, and was raised in Indiana. He attended the California Institute of Technology for his undergraduate degree, where he studied chemistry. At Caltech, he worked with Harry B. Gray on the synthesis and characterization of metal salen complexes of manganese and vanadium, and nitrogen and oxygen transfer reactivity with these complexes, respectively.

Chris earned his B.S. and M.S. degrees in chemistry in 1997, after which he worked in the laboratory of Jean-Pierre Sauvage at the Université Louis Pasteur as a Fulbright Fellow. In 1998, he moved to the Massachusetts Institute of Technology as a NSF/Merck Graduate Fellow. During his doctoral studies, Chris worked in the laboratory of Daniel G. Nocera. After earning his PhD in inorganic chemistry in 2002, Chris remained at MIT, working with Stephen J. Lippard as a Jane Coffin Childs Fellow.