

University of Michigan
DEPARTMENT OF CHEMISTRY

CHEMICAL BIOLOGY

Graduate Program



Chemical Biology

Chemical Biology studies the fundamental chemical principles that govern all biological systems. The Chemistry department at Michigan is home to an exciting multidisciplinary program at the interface between Chemistry and Biology. Synthesis, measurement, and theory of biological molecules are important components of the program. Particular areas of expertise are Biological Catalysis, Biomolecular Structure & Function, Chemical Genetics, Chemical Imaging & Sensors, Metallo-Biochemistry, Nanobiology and RNA Biochemistry. Laboratory rotations of choice allow students to explore their individual areas of interest before choosing their thesis mentor. Students may also participate in the unique and NIH funded Chemistry & Biology interface, Molecular Biophysics, Cellular Biotechnology, Pharmacological Sciences and Microfluidics in Biomedical Sciences training programs of the University that span all science and engineering colleges and can include internships in industrial settings. We also offer a dynamic Future Faculty Program funded by the US Department of Education.

Biological Catalysis

Understanding how nature catalyzes the chemical reactions that occur in living organisms is a problem central to the field of chemical biology. Several research groups are using combinations of physical, chemical, and genetic approaches to investigate the reaction mechanisms of protein and RNA enzymes. Members of the department are studying a wide range of biologically important chemical reactions, including the modification of proteins by lipid, carbohydrate and other chemical groups, the generation of free radicals by enzymes, and how RNA molecules are specifically cleaved and processed in the cell.

Biomolecular Structure & Function

Biological macromolecules have precise three-dimensional structures that are essential determinants of their biological function. The exploration of the relationship between structure and function is key to understanding the chemical reactivity and molecular recognition properties of biological molecules. At Michigan, interests include: determination of the high resolution structure of macromolecules using spectroscopic and crystallographic methods; investigation of the molecular determinants of catalytic activity and molecular recognition; exploitation of macromolecules for the development of therapeutic agents, biocatalysts, biomaterials, and biosensors and understanding the role of natural and manufactured particles in cell inflammation and toxicity.



Proc Natl Acad Sci U S A. 2004 Oct 19;101(42):15064-9.
Crystal structure of a eukaryotic zinc-dependent histone deacetylase, human HDAC8, complexed with a hydroxamic acid inhibitor. Vannini A, Volpari C, Filocamo G, Casavola EC, Brunetti M, Renzoni D, Chakravarty P, Paolini C, De Francesco R, Gallinari P, Steinkühler C, Di Marco S.

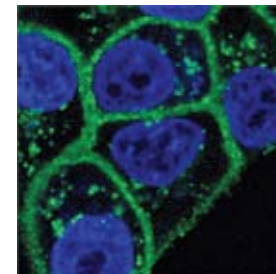
Chemical Genetics

In chemical genetics, cell permeable compounds are used as molecular probes to study intracellular processes, such as posttranslational modifications. Natural products often provide lead structures as the starting points for these agents. At Michigan, compounds with exquisite specificity for the treatment of genetic diseases have been obtained through the use of both rational design and combinatorial chemistry.

Chemical Imaging & Sensors

Imaging and sensing molecules is a central problem in areas ranging from the environmental to the biomedical sciences. Researchers in the Chemistry department, in collaboration with the Medical School, the School of Public Health, and the School of Engineering, are pioneering the design and synthesis of ultra-small de-

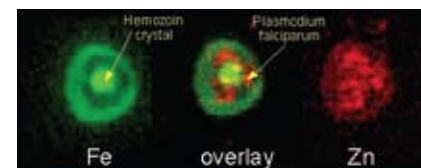
PAMAM dendrimers with folic acid targeting ligands bind to KB cells (green fluorescence). The cell nuclei have been stained with DAPI (blue fluorescence).



vices for the detection of minute amounts of clinically relevant analytes and pathogens to probe biological pathways and to diagnose and treat diseases. On a more fundamental level, the chemical and catalytic properties of single biomolecules are studied.

Metallo-Biochemistry

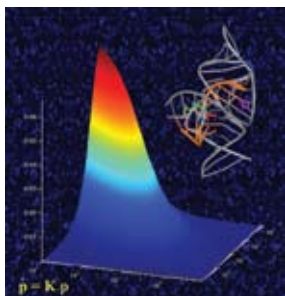
It is estimated that one-third of all proteins contain a tightly bound metal ion. Metallo-Biochemistry explores the roles of metal ions in biological samples. At Michigan, interests range from the synthesis of small-molecule mimics for enzyme active sites to the structural, spectroscopic, and enzymologic characterization of metal sites in proteins and nucleic acids. A central theme guiding these studies is the effort to relate metal-ion structure and reactivity to biological function. The faculty at Michigan are also developing novel tools to analyse the function, localization and concentration of intracellular metal ions.



X-ray fluorescence nanoprobes image of the distribution of Fe and Zn in a red blood cell infected with *Plasmodium falciparum*.

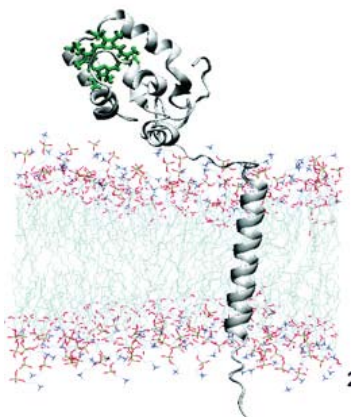
RNA Biochemistry

Non-protein coding RNAs are involved in a multitude of cellular processes ranging from protein synthesis, regulation and processing of genetic information to viral defense through RNA interference. At Michigan research on RNA Biochemistry includes ribozyme catalysis, RNA structure and dynamics, as well as molecular level dissection of the role of proteins required for ribosome assembly and RNA transcription.



Catalysis by the hairpin ribozyme (stick figure) is monitored in real-time by single molecule fluorescence microscopy (background); the enzyme is accelerated by tertiary structure formation (3-D plot). Rueda, D., Bokinsky, G., Rhodes, M.M., Rust, M.J., Zhuang X., and Walter, N.G. (2004) Proc. Natl. Acad. Sci. USA 101, p. 10066-10071.

Atom-level imaging of membrane proteins using NMR spectroscopy. Durr, U.H., Yamamoto, K., Im, S.C., Waskell, L., Ramamoorthy, A. (2007) J. Am. Chem. Soc. 129, p. 6670-6671



The University of Michigan and Ann Arbor

The University of Michigan offers a rich intellectual environment. Opportunities for research collaborations outside chemistry are enhanced by other top-ranked programs in chemical biology, medicine, engineering, physics, applied physics, biology, biochemistry, mathematics, and computer science. The many institutes, laboratories, centers, and libraries provide excellent facilities in a wide range of academic endeavors. Resulting from the strength of its many research programs, the University is currently ranked second in overall research funding in the nation.

The University is located in Ann Arbor, a city of 110,000, which combines the comfort and charm of a college town with the vivid cultural life of a large city, including live music, theater, dance, a top-ranked college sports program, outdoor cafes etc.

Further Information

For more information about specific research interests see www.umich.edu/~michchem or contact a faculty member directly:

Hashim al-Hashimi	hashimi@umich.edu
Mark Banaszak Holl	mbanasza@umich.edu
Charles L. Brooks III	brookscl@umich.edu
Kate Carroll	katesc@umich.edu
Dimitri Coucouvanis	dcouc@umich.edu
Carol A. Fierke	fierke@umich.edu
Gary D. Glick	gglick@umich.edu
Kristina Hakansson	kicki@umich.edu
Katrin Karbstein	kkarbst@umich.edu
Raoul Kopelman	kopelman@umich.edu
David M. Lubman	dmlubman@umich.edu
Anna K. Mapp	amapp@umich.edu
Neil Marsh	nmarsh@umich.edu
Mark E. Meyerhoff	mmeyerho@umich.edu
Michael D. Morris	mdmorris@umich.edu
Vincent L. Pecoraro	vlpec@umich.edu
James E. Penner-Hahn	jeph@umich.edu
A. Ramamoorthy	ramamoor@umich.edu
Roseanne J. Sension	rsension@umich.edu
David H. Sherman	davidhs@umich.edu
Nils G. Walter	nwalter@umich.edu

How to Apply

Application to the Chemistry Graduate Program at the University of Michigan is online at www.umich.edu/~michchem/graduate/

For questions regarding admission, see www.umich.edu/~michchem or contact the department by

Website:	www.umich.edu/~michchem
Email:	ChemAdmissions@umich.edu
Phone:	toll free 888-999-2436 or 734-764-7278
Fax:	734-647-4865

cover: Overall view of the PAPS reductase-Trx1 complex in the cocrystal structure. Chartron, J.; Shiau, C.; Stout, C. D.; Carroll, K. S. (2007) Biochemistry 46: 3942-3951.

Chemistry at the University of Michigan

Chemical Biology

