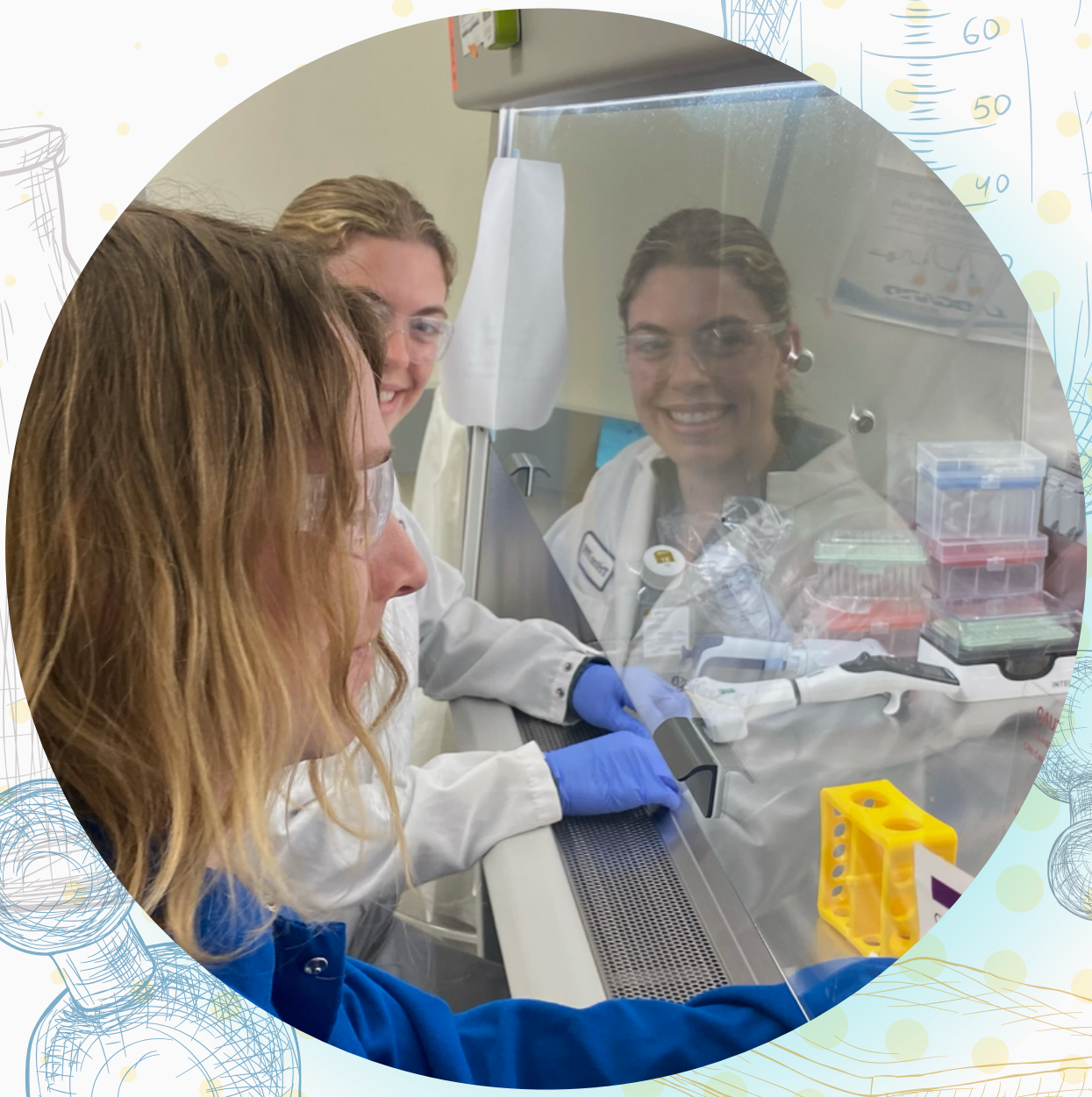
UC San Diego

Chemistry and Biochemistry



CHEMICAL BIOLOGY

RESEARCH

OVERVIEW

The Chemical Biology graduate program at UC San Diego is a vibrant hub of discovery, where the boundaries between chemistry and biology blur to reveal the intricate workings of life. This dynamic program leverages the department's interdisciplinary strengths, equipping students with the tools to delve into the molecular foundations of biological systems.

Chemical biology thrives at the crossroads of various disciplines. The program boasts faculty from organic and inorganic chemistry, molecular and structural biology, RNA and gene-editing, along with medicinal chemistry and chemoproteomics. This fosters a rich interdisciplinary environment, allowing student trainees to gain a comprehensive understanding of the chemical principles governing biological processes and desirable skill sets for careers in the thriving biotech industry of San Diego and beyond.

Graduate student trainees in the chemical biology track will also participate in our NIH-funded Chemistry-Biology Interfaces (CBI) Training Grant Program. Participation in this training grant program includes full financial support by the NIH during the second year of graduate training for domestic students, and customized training and professional development activities including monthly workshops, career and networking events, fellowship application preparation, mentorship, and grant writing assistance.

PROGRAM HIGHLIGHTS

During the first year, students take courses, begin their teaching apprenticeships, choose research advisors, and their thesis research. Beginning in the first summer, the emphasis is on research. In the second year, there is a Departmental Examination, which includes a written research prospectus and an oral presentation. In the third year, students advance to candidacy for the doctorate by presenting their preliminary findings and future research plans for their dissertation. Subsequent years focus on thesis research and defending the dissertation.

Coursework

Flexible coursework programs are tailored to the needs of individual students, based on their prior training and research interests to fuel the research-driven Ph.D. Students generally spend their first 3-quarters completing coursework.

Mentorship

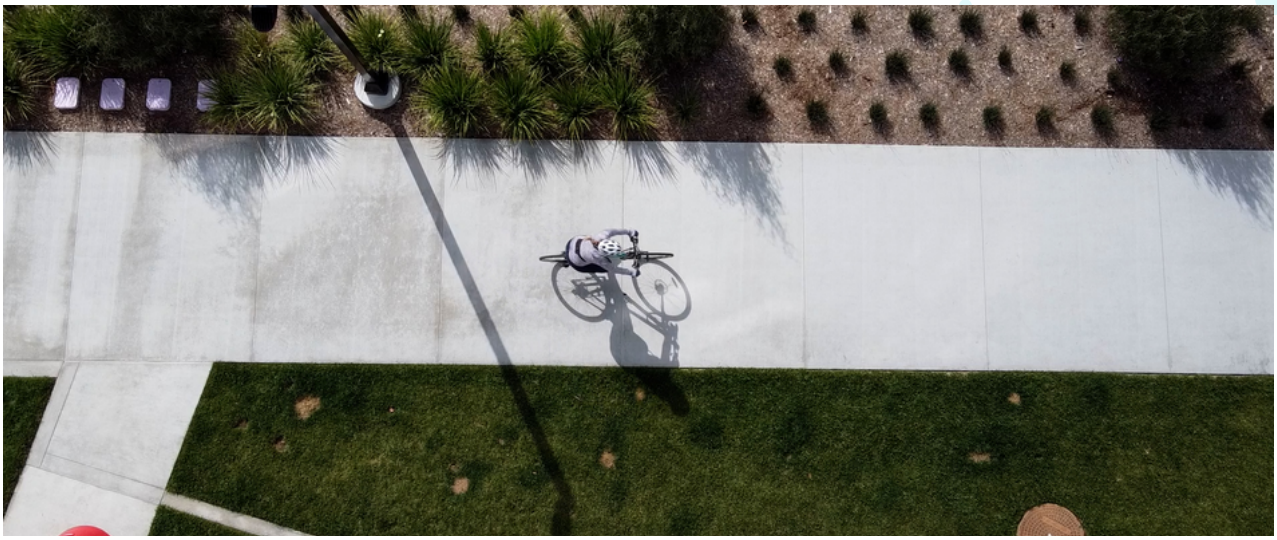
Students spend their first quarter in the program rotating with research groups to identify potential mentors and a research advisor. Annual Individual Development Plans (IDPs) are conducted each spring to foster proactive mentoring relationships.

Professional Development

Students receive training on effective teaching practices (CHEM 509) and responsible conduct of research training (CHEM 250) during their formal coursework requirements. Through the Student Success Center, Teaching + Learning Commons, and research conference travel awards, students have numerous opportunities to network and build career-enhancing professional skills.

OUR FACULTY

Our faculty's research is highly interdisciplinary, spanning biochemistry; biophysics; inorganic, organic, physical, analytical, computational, and theoretical chemistry; surface and materials chemistry; and atmospheric and environmental chemistry. Please refer to the faculty pages for full descriptions of the on-going research in our department. State-of-the-art facilities and laboratories support these research programs.



Our faculty are more than just respected colleagues and captivating lecturers; they're scientific powerhouses. They consistently garner prestigious awards for their groundbreaking research. But recognition isn't their only metric of success. They also command millions in federal and private research grants, a testament to the boundless potential and rigorous academic training environment cultivated.

At UC San Diego, chemists and biochemists are part of a thriving community that stretches across campus and out into research institutions throughout the La Jolla and San Diego area, uniting researchers in substantive interactions and collaborations.

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CHEMICAL BIOLOGY

Prof. Fleur Ferguson

Research in the Ferguson laboratory applies organic synthesis, medicinal chemistry, chemoproteomics and cell biology towards the goal of developing new therapeutic strategies in oncology and neurodegenerative disorders.

To do so, we harness proximity-mediated pharmacology to develop targeted protein degraders, molecular glues, and new modalities, to rewire cell signaling. We cultivate a multidisciplinary and highly collaborative approach to science to tackle fundamental questions in disease biology and drug discovery.

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Prof. Alexis Komor

The long-term goal of Komor Lab research is to combat the variant interpretation problem that is hindering precision medicine progress: there are currently over 685 million human single nucleotide variants (SNVs) identified from human sequencing data, and less than 1% have a defined clinical interpretation. This issue is particularly endemic to rare genetic variants and those discovered in minoritized populations and indigenous people, highlighting the need for a significant increase in studies that functionally assess human genetic variation in a more equitable manner.

Specifically, new laboratory-based methods that enable functional characterization of SNVs will help to diminish this healthcare inequity and allow for the identification of new therapeutic strategies in the field of precision medicine in a more equitable manner. To address this issue, we develop new precision genome editing methodologies, mechanistically study how these tools work (from both enzymatic and cellular DNA repair perspectives) in order to improve them, and apply these tools to functionally interrogate how specific SNVs contribute to human disease.

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CHEMICAL BIOLOGY

Prof. Seth Cohen

Chemical Biology research in the Cohen Laboratory is focused on the study of metalloenzyme inhibitors, as well as the study of bioactive metal complexes. Metalloenzymes are involved in nearly every aspect of human health, from oncology to viral disease.

For nearly two decades, our laboratory has been a leader in the discovery of small molecule inhibitors of metalloenzymes. We combine principles of bioinorganic and medicinal chemistry and apply them to fragment-based drug discovery (FBDD) to discover best- or first-in-class metalloenzyme inhibitors. Recently, we have started exploring the use of small metal complexes as inhibitors of enzymes. In these Chemical Biology studies, we employ a wide range of methods including organic synthesis, high-throughput screening, structural biology, and others.

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Prof. Galia Debelouchina

The Debelouchina lab uses chemical biology tools and nuclear magnetic resonance (NMR) to study proteins involved in gene regulation and Alzheimer's disease. In particular, we use techniques such as native chemical ligation, intein chemistry, unnatural amino acid incorporation, and bioconjugation, to understand how protein post-translational modifications influence cellular decisions regarding which genes to turn off and on and how these processes go wrong in disease.

We combine these studies with solution and solid-state NMR spectroscopy, which allows us to elucidate how post-translational modifications influence protein structure and interactions. We are also developing sensitivity-enhanced NMR spectroscopy methods to study these questions in cells.

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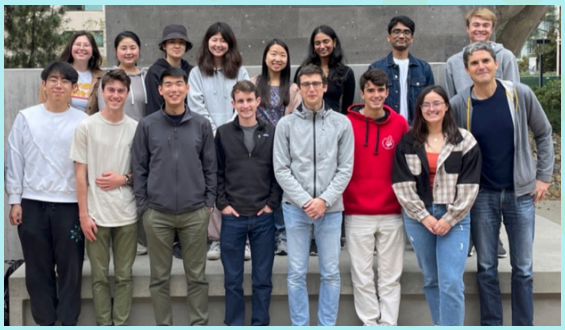
CHEMICAL BIOLOGY

Prof. Akif Tezcan

Chemical Biology research in the Tezcan Group involves the design, construction, and characterization of novel proteins, enzymes, and protein-based materials. Proteins and protein assemblies are the primary drivers of the chemical complexity in biological systems, and fulfill essential functions both as biochemical machines (e.g., enzymes, molecular motors) or as materials with advanced properties (e.g., cytoskeletal filaments, cage-like proteins). Yet, despite the remarkable properties of these natural systems, their functions are ultimately limited by cellular and evolutionary constraints.



The Tezcan Group develops new chemical methods and combines them with computation to engineer novel proteins and protein assemblies with new-to-nature functions, and incorporates them into living systems. Our research employs a wide variety of tools, including X-ray crystallography and cryo-EM for structure determination, advanced spectroscopic tools for characterizing reactive metal centers, organic synthesis to develop chemical agents to control protein self-assembly, and various computational methods for rational or ML-based protein design.

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Prof. Michael Burkart

Our group is involved in natural products biosynthesis and development. We focus on non-ribosomal peptide, polyketide, and fatty acid biosynthesis, and applications of these molecules. For their biosynthesis, all require the participation of a carrier protein (CP), a small four-helix bundle protein that covalently tethers all substrates and intermediates and interacting with both tethered substrates and partner enzymes. We have developed unique molecular tools to trap, visualize, and modify these protein•protein and protein•substrate interactions. Through the complimentary and collaborative application of chemical, structural, and computational biology, we are can understand the complexities of CP-dependent biosynthesis for the development of next-generation therapeutics, biofuels, renewable materials, and fine chemicals. Our research is highly interdisciplinary, involving the tools of organic synthesis, biochemistry, structural biology, and materials science, and collaborative.

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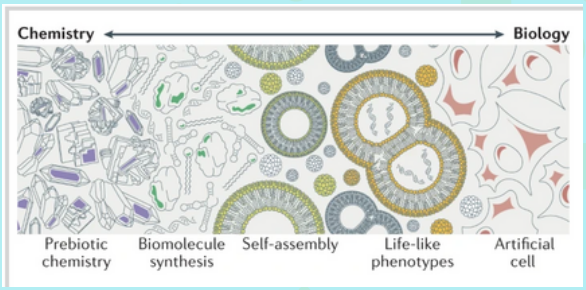
CHEMICAL BIOLOGY

Prof. Neal Devaraj

Lipid membranes in cells are fluid structures that undergo constant synthesis, remodeling, fission, and fusion. The dynamic nature of lipid membranes enables their use as adaptive compartments, making them indispensable for all life on Earth. Efforts to create life-like artificial cells will likely involve mimicking the structure and function of lipid membranes to recapitulate fundamental cellular processes such as growth, transport, and signal transduction. As such, there is considerable interest in chemistry that mimics the functional properties of membranes, with the express intent of recapitulating cellular phenomena while also providing clues to how life might have originated. Our lab aims to mimic some of the remarkable dynamic properties of living membranes. We have developed methods for the abiotic synthesis of membrane-forming lipids from basic starting materials. While initial investigations from our laboratory primarily yielded non-natural lipid analogs, our recent efforts have shifted towards the development of methodologies for synthesizing membranes composed of lipids identical to those naturally occurring in biological systems providing insights into how particular lipid compositions can influence cellular function.



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Prof. Colleen McHugh

Therapeutics targeting cancer cell growth and development have mainly focused on protein transcription factors and protein-mediated signaling pathways. Bioinformatics studies have identified a set of cancer-associated non-coding RNAs with expression linked to metastasis and decreased long-term patient survival. We are using a combination of chemical biology and genomics tools to examine the molecular interactions and functions of cancer-associated non-coding RNAs in cell growth control.

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YOUR JOURNEY
HAS BEGUN

Let's Grow Together

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