DEPARTMENT OF CHEMISTRY & BIOCHEMISTRY
LIST OF FACULTY RESEARCH INTERESTS

Haley Beech (hbeech@calpoly.edu)
We are a polymer research group centered at the intersection of chemistry, materials science, and engineering. Research topics include:

- Precise polymer synthesis and functionalization
- The development of structure-property relationships using methods including rheology, light/x-ray scattering, and mechanical testing
- Polymer (re)processing and degradation
- Bio-synthetic composite materials

Daniel Bercovici (dbercovi@calpoly.edu)
Synthetic & Physical Organic Chemistry

1. Structure-Activity relationships in fragmentation reactions
    a. Synthesis and characterization of novel stimuli-responsive linkages
    b. Reaction kinetics by NMR
2. Development of new organic methodologies
    a. Hydroborations of unique alkynes – ynamides
    b. Diels-Adler reactions with vinyl boranes
3. Asymmetric Reaction development

Emily Bockmon (ebockmon@calpoly.edu)
Marine Chemistry

1. Characterization of the seawater carbon dioxide chemistry at the Cal Poly Pier.
2. Spatial and temporal understanding of the chemistry of Morro Bay estuary including freshwater sources of carbon and nutrients. This incorporates discrete sampling events as well as autonomously collected sensor data.
3. Instrumentation development for chemical characterization of seawater. Creating better, more accessible, cheaper instrumentation.
4. Ocean acidification and the dynamic relationship between seawater carbon, oxygen, and nutrients.

Seth Bush (sbush@calpoly.edu)

1. Studying the emergence of Science Faculty with Education Specialties
2. Developing and studying teacher professional development process
3. Improving teacher recruitment and training
4. Building and testing inquiry-based science toys, games and manipulatives

Tammy Campbell (tcampb06@calpoly.edu)

1. Nucleoside and oligonucleotide synthesis and evaluation
2. Peptides: catalysis, recognition and selection
3. Origins of life

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Jennifer Carroll (jacarrol@calpoly.edu)

1. Terrestrial and marine natural product isolation and characterization
    a. Rational collection of samples
    b. Screening extracts for biological activity
    c. Isolation of active components by chromatography (Flash and HPLC)
    d. Dereplication of known compounds by mass spectroscopy and literature review
    e. Elucidation of novel compounds by high field ID and 2D NMR techniques
2. Historical aspects of natural products and spectroscopic methods
    a. Development of NMR techniques
    b. Ara-C discovery and development

Jennifer Chik (jchik@calpoly.edu)

We are interested in identifying and characterizing multifunctional proteins that operate at the intersection of amino acid metabolism and chromatin regulation, two pathways that are critical for cellular and organismal wellbeing. Students will be working with a wide variety of biochemical, molecular biological, and genetic techniques in the budding yeast *Saccharomyces cerevisiae*.

Phil Costanzo (pcostanz@calpoly.edu)

Our research group focuses on the exploitation of simple and efficient chemistry to make novel materials for a wide range of applications. Members of the Costanzo research group will learn a wide array of technical laboratory skills as well as communication and writing skills. Technical skills include small molecule and polymer synthesis and various conditions (aerobic, anaerobic, cryogenic), experimental design and instrumentation maintenance. Writing skills include literature review, technical writing for peer-reviewed publication and proposal creation. No specific course work is required.

PRE_REQ:

1) Positive attitude;
2) Passion for knowledge and growth;
3) Strong work ethic.

For more information, please visit: costanzolab.com.

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Scott Eagon (seagon@calpoly.edu)

Our research group focuses on the development of small molecule pharmaceuticals and probes, particularly those targeting infectious diseases and cancer. Students are involved in all aspects of drug synthesis and pre-clinical development. Our group is also interested in developing new synthetic methods to produce compounds quickly and with minimal purification in an effort to reduce development costs. Students majoring in Chemistry, Biochemistry, or related majors are welcome to join, but two quarters of organic chemistry lab are normally required to join due to the complexity of the chemistry involved. Current projects include the development of kinase-based chemotherapy agents, biological probes to better understand disease-related proteins, new treatments to combat *leishmaniasis*, the development of host-orientated compounds to combat anthrax and the Ebola virus, and the development of new classes of antibiotics to treat urinary tract infections. Please visit our research web page to learn more at https://eagonlab.github.io/

Ray Fernando (rhfernan@calpoly.edu)

1. Solar reflective wall coatings
2. Surface chemistry and rheology of latex-surfactant interaction
3. Industrial internships

Emily Fogle (efogle@calpoly.edu)

Mechanistic Enzymology. My research seeks to better understand the detailed chemical mechanisms that enzymes use. In particular, I am interested in pyridoxal phosphate dependent enzymes as well as oxidoreductases.

1. Methods used to gain insight into these enzymes include:
    a. Steady state kinetics
    b. pH rate profiles
    c. Kinetic isotope effects
    d. Site-directed mutagenesis
2. Other skills involved in these studies include:
    a. Overexpression of proteins
    b. Protein purification
    c. Basic molecular biology techniques

Derik Frantz (dfrantz@calpoly.edu)

Design and synthesis of non-natural molecular constructs possessing unusual structures

1. Constrained macrocyclic polyaromatic hydrocarbons
2. Extended π-systems for device applications

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Anya Goodman (agoodman@calpoly.edu)

1. Comparative genomics, genome structure and evolution: fruit fly genomes, annotation of genes in the oxidative stress pathways (collaboration with GEP https://thegep.org/) PRE-REQ: Bioinformatics Applications (Pre-req: BIO/CHEM441)
2. **Project CUREOS** (Characterizing Undergraduate Research Experiences and Outcomes in STEM); NSF-funded cross-disciplinary project. Current goals: analysis of quantitative data and communication of results to wide audiences (program reports and project website design https://www.cureos.org/).

Leslie Hamachi (hamachi@calpoly.edu)

Materials chemistry research. Please visit our group webpage to learn more
http://thehamachigroup.com

Project areas include:

1. Colloidal Covalent Organic Frameworks
    - Synthesis and surface chemistry
    - Electron microscopy and x-ray diffraction
2. Structural Color Pigments
    - Synthesis, characterization, and incorporation into architectural paint

John P. Hagen (jhagen@calpoly.edu)

1. Physical Chemistry: Structure property relationships of soluble and insoluble surfactants. Students would be working with the tensiometer, Langmuir trough, fluorescence microscope and Brewster angle microscope
2. Lab development, physical chemistry: Developing a physical chemistry lab experiment based on the kinetic salt effect
3. Educational research: How do novice and expert learners define “Polarity”?

Bonnie Hall (bhall10@calpoly.edu)

Studying protein functions helps solve problems in the real world. One focus in our lab is studying proteins with solved structures, but no assigned function, leveraging massive amounts of computational structural data now available. Another area of interest is engineering enzymes to modify or improve their functions for use in health, food production, and environmental remediation contexts. A new area of focus is leveraging machine learning to better understand protein function. Students will work with a wide variety of biochemical, molecular biology and computational tools as part of these projects.

Hall Research Group Website

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Justin Hancock
Our group studies crystalline inorganic solids. Such materials are essential to many modern technologies, such as semiconductors and Li-ion batteries. The interplay of composition and structure in these materials gives rise to many fascinating and useful properties. The two main projects in the group are the synthesis of 1) new Li-ion battery cathode materials and 2) environmentally friendly pigments for paints and structural coatings. We will study how the crystal structure of these materials relates to their properties. Students in the Hancock group will learn a variety of synthetic methods in solid-state chemistry and materials characterization techniques (electron microscopy and x-ray diffraction) to understand how the underlying atomic-scale and nano-scale structures influence the observed properties. No specific prerequisite coursework is required to join.

Carson Hasselbrink
Organic and Materials Chemistry

1. Synthesis of ^{129}Xe MRI contrast agents using macrocyclic hosts and antibodies.
    a. Macrocycle synthesis and functionalization
    b. Protein conjugation and analysis
2. Development of macrocyclic hydrogel materials
    a. Hydrogel formulation
    b. Polymer and material analysis
    c. Kinetic uptake and release studies of small molecules

Taylor Haynes (mthaynes@calpoly.edu)
Organometallics method development

1. Expanding the synthetic utility of copper-catalyzed aerobic oxidations through the development of a series of tandem reactions
    a. Developments in this area have elucidated a divergent method that allows for the selective synthesis of either 1,3-diones or a,□-unsaturated ketones from a common set of starting materials
2. Studying the effects of a highly tunable ligand framework on the photophysical properties of Iron (II) complexes
    a. A Tridentate ligand core consisting of a pyridine and two N-Heterocyclic Carbenes that can be finely tuned by adjusting the steric and electronic parameters of each binding site and studying the subsequent effects on the electronic properties of Iron (II) complexes

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Mike Heying (mdheying@calpoly.edu)

1. Improving theoretical descriptions of the thermodynamic properties (pressure, density, chemical potential, etc.) and structures (pair distribution functions) of model fluids
    a. Utilizing these improvements to better understand and predict phenomena like phase changes in these systems
    b. Building (theoretically) more non-idealities into these "ideal" fluids to better mimic more realistic and more interesting systems
    c. Simulating model fluids (hard particles, soft potentials, etc.) in various ensembles as a way of providing comparative experimental data
2. Reactor Kinetics
    a. Continuous reactors, where reactors are continually fed in and products are continually removed are often used for large-scale production
    b. Investigating the kinetics of fermentation of beer through a set of continuous reactors as a way of potentially making what are complicated fermentation rate equations simpler and easier to study. We hope to use our kinetic equations to consider how we can make this process more advantageous, in terms of maximizing the rate of production while minimizing the concentration of off-flavor compounds

Chad Immoos (cimmoos@calpoly.edu)

1. Fluorescence detection of Reactive Carbonyl Species
    a. Synthesis of pre-fluorescent probes
    b. Investigation of fundamental reaction chemistry
2. Copper Complexes for Fluorescence Detection of Nitric Oxide
    a. Synthesis of pre-fluorescent probes
    b. Fluorescence bio-imaging in biological systems
3. Merging metallo-biomimetics and hydrophilic polymers
    a. Synthesis of transition metal catalysts to mimic biological reactivity
    b. Covalent attachment of catalysts in block co-polymers
    c. Investigation of reactions in polymers and at polymer surfaces

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Eric J. Kantorowski (ekantoro@calpoly.edu)

1. Mechanistic organic chemistry, synthetic methodology, organic synthesis
2. Cyclopropane chemistry: electrophilic- and radical-mediated ring opening of cyclopropanes and other strained systems
3. Synthetic methodology aimed at the preparation of bioactive natural products and analogs
4. Collaboration with external agencies to scout for compounds that show promise against Alzheimer's, autism spectrum disorder (ASD) and other disorders and diseases
5. Pedagogical innovation using modern technology

Jessica Karch (jmkarch@calpoly.edu)

Learning does not happen in a vacuum. Although chemistry and science learning is often framed as something that happens in one person's mind, external factors like interactions with peers, classroom rules and expectations, and norms and policies of a discipline influence how students learn and what kind of learning is seen as "valuable." To create equitable, student-centered chemistry learning environments, it is important to develop deep, empirically grounded understandings of how these contextual factors influence learning, as well as how these factors interact with each other. Current research projects undergraduates can join include:

1. Studying equity in graduate chemistry education policies
2. Meta-synthesis of DEIJ in interdisciplinary graduate education, focused on:
    a. Equitable practices and outcomes in interdisciplinary STEM
    b. Broadening participation in interdisciplinary STEM
3. Interview and policy analysis of interdisciplinary graduate programs

Kevin B. Kingsbury (kkingsbu@calpoly.edu)

1. Polymer Chemistry
    a. Novel Hydrogels with controlled architectures using RAFT and 'Click' Chemistry
    b. Semiconducting polymers for Polymer LED's
2. Organometallic and Organic Chemistry
    a. Polymerization catalysts
    b. Transition metal carbynes
3. Development of 'Green' Laboratory Experiments for Inorganic and Polymer Chemistry

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Alan Kiste (akiste@calpoly.edu)

1. Development of highly innovative chemistry and transdisciplinary curricula
2. Development, assessment, and evaluation of new pedagogical interventions
3. Development and evaluation of new inquiry learning laboratory experiences

Corinne Lehr (clehr@calpoly.edu)

1. Isolation and identification of polyphenolic compounds in honey that have potential health benefits.
2. Trace analysis of iron uptake by *E. coli* to aid in the development of novel antibiotics.
3. Revision of the Chem 1110 curriculum including new inquiry-based labs

Elahe Mahdavian (emahdavi@calpoly.edu)

My current research combines publicly available biological data, data analytics, and computational modeling to uncover how anticancer drugs work and why some cancer cells respond better than others. We use datasets containing basal and drug-induced genomic, proteomic, and pathway information to identify potential drug targets and mechanisms of action.

As proof of concept, I developed an undergraduate-friendly research workflow using imatinib, a well-characterized cancer drug, as a model system. Students can then apply these same approaches to experimental anticancer compounds, including synthetic fusarochromanone, a primary focus of my research, to predict how they may kill cancer cells and propose experiments to test those predictions.

This interdisciplinary research brings together cancer biology, bioinformatics, computational chemistry, and drug discovery while giving undergraduate students meaningful experience with approaches used in modern biomedical research. Ultimately, this work may help identify new drug targets, useful biomarkers, and promising strategies for developing more effective cancer treatments.

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Andres Martinez (awmartin@calpoly.edu)

My research is focused on the development of simple and portable diagnostic tests that could be useful for diagnosing diseases or detecting analytes in the field. My group works primarily with devices made from paper and studies everything from capillary wicking of fluids in paper to the shelf life of reagents stored on paper-based devices. Students in my research group learn about qualitative and quantitative chemical analysis, fabrication, fluid dynamics, and global health (and we get to work with cool tools like a liquid dispensing robot, a laser cutter, a 3D printer and an environmental chamber). PRE_REQ: Creativity, curiosity and strong work ethic. No specific coursework is required.

Lauren Manck (lmanck@calpoly.edu)

Microbes carry out many metabolic functions that are the primary drivers of elemental cycles in the marine environment including photosynthesis, respiration, and nitrogen fixation. Many of these metabolic pathways require trace metals, such as iron, as enzymatic cofactors, yet low concentrations of these elements in seawater mean that they are often a limiting nutrient of these fundamental life processes. As such, the availability of bioactive trace metals can fundamentally shape marine microbial communities and the large-scale cycling of carbon and other macronutrients. Both field- and lab-based research in our lab focuses on understanding molecular pathways that marine microorganisms use to acquire nutrients like iron, carbon, and nitrogen using a wide variety of biochemical, molecular biology, and analytical chemistry techniques.

Ashley McDonald (armcdona@calpoly.edu)

Our research group uses computational techniques to study molecular interactions in complex chemical contexts. We look at how small molecules bind to big ones and how that affects intermolecular signaling, reaction mechanisms, and biological processes. Note that our group is 100% computational chemistry; we do not do any wet lab chemistry. While no particular computer skills or courses are required to get started, you must have an interest in developing computational skills and learning to use specific computational chemistry software. Most projects also require some level of coding skills, though again, you don't have to have these skills before you join the group. To learn more, visit our website at https://armcdona.github.io/.

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Javin Oza (joza@calpoly.edu)

Our group applies biochemical principles to engineer biochemical systems. We do this to achieve a variety of goals:

1. To harness the genetic code in a test-tube
2. To develop Bio-inspired materials
3. To bring biotechnology into our classrooms to enable learn-by-doing for our students

We pursue these goals through the integration of biological engineering tools with hypothesis driven science.

New students do not need any special skill or training. Students who succeed in our group generally show a high-level of commitment and an interest in making meaningful contributions

HH Palandoken (hpalando@calpoly.edu)

1. Broad field of Organic Synthesis
2. Bioorganic chemistry
    a. Design and synthesis of alkoxyamine investigator reagents (AIR) to examine glycosylation of biomolecules which is a crucial step in biological processes
    b. Design and synthesis of antibody drug conjugates
3. Polymer chemistry
    a. Study of the alkoxyamine (RONH2) functional group in new materials as versatile ligating sites for carbonyl (i.e., aldehyde/ketone) substrates
    b. Synthesis and characterization of alkoxyamine polymers
    c. Testing the alkoxyamine polymers for the selective immobilization, molecular presentation and controlled release of various carbonyl compounds (e.g., pharmaceuticals, biomolecules)

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Erik Sapper (esapper@calpoly.edu)

Our research group works at the intersection of coatings and polymer science, surface chemistry, and materials informatics. We are interested in understanding how formulation and material properties control performance, and in developing new experimental and computational tools to design better materials more efficiently. A common theme across our work is the integration of fundamental materials science, experimentation, and computation to move from trial-and-error formulation toward predictive materials design.

Current research interests include:

- Coatings and polymer formulation – understanding relationships between composition, structure, processing, and end-use performance.
- Materials informatics and inverse design – using machine learning, optimization, and genetic algorithms to accelerate formulation development and identify materials that meet multiple performance targets.
- Durability and service-life prediction – connecting accelerated testing, degradation mechanisms, and data-driven models to predict long-term materials performance.
- Surface and interfacial science – investigating adhesion, wetting, contamination, and other phenomena that govern interactions between coatings, surfaces, and their environments.
- Sustainable materials and formulations – developing approaches to reduce environmental impact through renewable raw materials, lower-VOC formulations, improved durability, and more efficient use of experimental data.
- Digitalization of formulation science – developing tools for extracting, organizing, searching, and learning from complex formulation and testing datasets.

Gregory Scott (gscott02@calpoly.edu)

1. Characterization of nanomaterials via scanning probe microscopies (scanning tunneling microscopy and atomic force microscopy)
2. Identification of the relationships between morphological, electrical, and optical properties of nanomaterials
3. Development and assessment of immediate feedback tools for use in teaching and learning
4. Measurement of conceptual expertise in chemistry

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Elizabeth Vaughan (ebvaugha@calpoly.edu)

Our research group investigates the pedagogical practices that undergraduate students encounter in STEM courses, and the impacts that these practices have on student and instructor experiences. Particularly, the Vaughan Research Group is currently interested in investigating the impact of popular, novel, and/or innovative pedagogical practices used in undergraduate chemistry classrooms. Current research interests include:

1) Investigating students' affective experiences (e.g., self-efficacy, motivation) related to grading practices in chemistry courses
2) Investigating chemistry instructors' perceptions and implementations of traditional and alternative grading practices
3) Exploring the impact of laboratory course delivery styles (e.g., studio, traditional, course based undergraduate research experiences) on students' meaningful learning in chemistry

Sandra Ward (sward07@calpoly.edu)

The Ward group is interested in designing, synthesizing, and studying responsive materials. After synthesizing the organic building blocks, we prepare nanoparticles and hydrogels and study the properties, stability and degradation kinetics in different chemical environments. We are particularly interested in developing our stimuli responsive materials for applications in antibacterial coatings and sustained agrochemical delivery.

Katharine Watts (krwatts@calpoly.edu)

Our research explores how bacteria make biologically active natural products and how their genomes can guide us toward new chemistry. We combine microbiology, molecular biology, genomics, and natural products chemistry to discover microbial metabolites, uncover their biosynthetic pathways, and understand the enzymes responsible for building complex molecules. Students can contribute at many stages of this process—from growing bacteria and analyzing genomes to cloning genes and isolating new compounds.

- Natural product discovery from bacteria
- Genome-guided discovery of antibiotics from ancient microbes
- Connecting natural products to biosynthetic gene clusters
- Cloning and characterization of biosynthetic pathways
- Isolation and structure elucidation of natural products
- Understanding biosynthetic enzymes

Learn more at https://krwatts.wixsite.com/wattslabcalpoly

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Steven Wilkinson (spwilkin@calpoly.edu)

1. Protein stabilization mediated by small molecule "osmolytes"
    a. Development of structure-and-activity based biochemical assays of protein stability
    b. Characterization of osmolyte-dependent protein stability for multiple protein models
    c. Investigation of stabilization mechanisms
2. Biochemical characterization of proteins potentially involved in antibiotic-resistance mechanisms in Clostridium difficile
    a. Cloning, overexpression and purification of putative gene regulatory proteins
    b. Characterization of DNA-and-ligand-binding properties
    c. Analysis of molecular mechanisms and gene regulatory functions

Sarah Zeitler (szeitler@calpoly.edu)

Our research group aims to provide sustainable methods for breaking down and building up commodity plastic materials through mechanochemistry. Accessing more environmentally conscious depolymerization and polymerization methods through mechanical force provides a unique solution to the world's concerning plastics problem. In addition to developing new methodology for polymerizations and depolymerizations, we are also studying small molecule models to provide improved understanding of polymer mechanochemistry. If you have an interest in organic chemistry, polymer chemistry, or sustainability (or all three!), our research projects may be a great fit for you!

Shanju Zhang (szhang@calpoly.edu)

Our group focuses on synthesis and characterization of functional polymers and coatings for emerging applications in energy, water and biology. Currently available projects are:

1. Conducting polymers for energy: we use supramolecular synthesis and liquid crystal design to prepare polymer complexes with controlled nanostructures and mixed ion-electron conduction
2. Polymer membranes for water treatment: we incorporate metal organic frameworks (MOFs) into polymer membranes for advanced nanofiltration
3. Functional coatings for food packaging: we utilize a bio-based polymer binder to formulate mechanically robust coatings with multifunctionalities
4. Chemical recycling of plastic waste: we apply the synthesized catalysts to depolymerize plastic waste into the constituent monomers that can be polymerized to regenerate the original plastics
5. Blended BS + MS in Polymers and Coatings Science

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David Zigler (dzigler@calpoly.edu)

We are interested in using light from the sun or LEDs to start chemical reactions, a process more generally called photochemistry. We can use light to turn air into fuels and fertilizers. We can use light with molecular therapeutics to treat localized diseases. We can use light to make molecules that cannot be made using traditional methods of mix and stir chemistry.

In our group, students try different flavors of chemistry. They might:

1. Synthesize and characterize new light absorbing compounds
2. Design and analyze photochemistry experiments to learn how the reactions happen
3. Use computer programs to understand spectra and reactivity
4. Use advanced analytical methods to measure ultra-fast processes and electrochemistry

If you are interested in joining our team, come chat. There are no specific pre-reqs.

Matt Zoerb (mzoerb@calpoly.edu)

Atmospheric Chemistry and Aerosol Particle Composition

1. Wildfire Emissions: Chemical Composition and Physical Properties
    a. Dependence on fire fuel/source
    b. Changes with age and distance from emission
    c. Smoke transport and exposure
    d. Impacts on air quality
2. Organic Aerosol Sources and Reactivity
3. Ambient Aerosol Measurement, Instrumentation, and Method Development