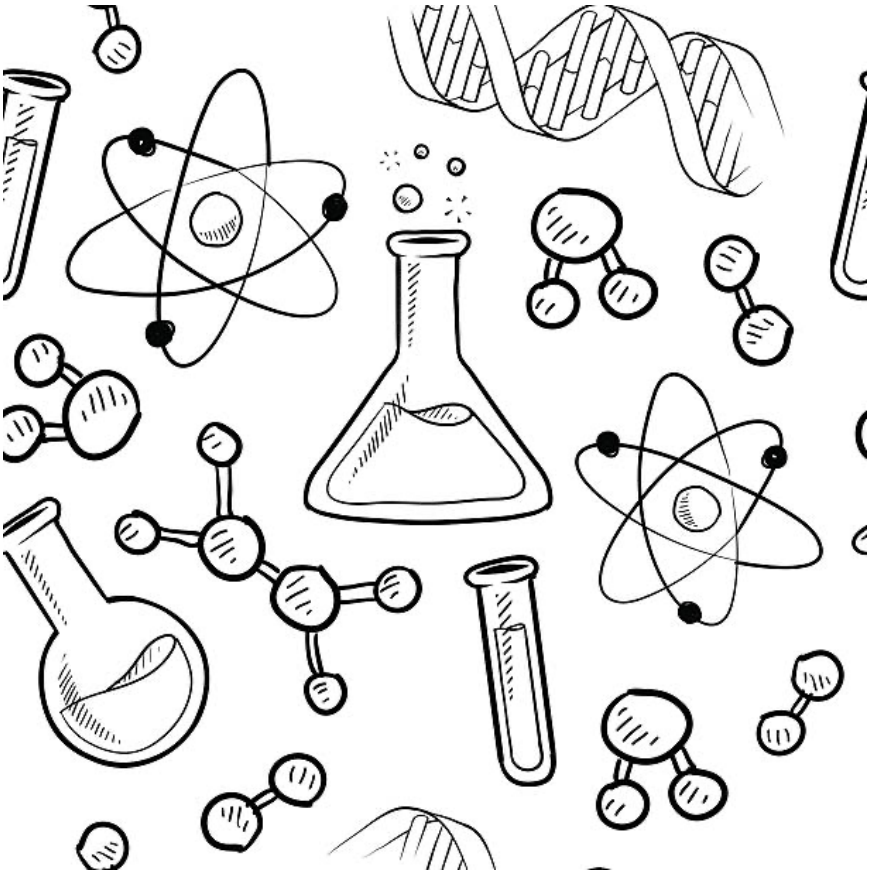
Research in the Chemistry and Biochemistry Department



2024

Research in the Dept. of Chemistry and Biochemistry

This booklet is aimed at students interested in conducting research in chemistry or biochemistry and highlights recent work in the department, the process of getting involved in research (both on- and off-campus), and available research projects for each department faculty member.

Mission:
As an inclusive community, we leverage the chemical sciences to promote scientific inquiry through interdisciplinary, experiential learning, and research.

Vision:
We aspire to create diverse and inclusive communities that contextualize the chemical sciences within both a liberal arts education and broader worldviews. We will innovate and apply evidence-based solutions for health, environmental, social justice, and other emerging local and global challenges.

Interested in a Summer Research Position?

Here are the steps for contacting a potential summer research advisor (see also the timeline for contacting below):

1. Draft an email with the following information. *Note that depending on availability, you may consider contacting 2-3 faculty members with research of interest.*

    a. Provide a brief biography including courses relevant to the research project. Be sure to check the 'required courses' listed under the advisor's research summary in this booklet.

    b. Include a description detailing your particular interests in certain project(s). You can list several projects in the order of interest if desired.

    c. Suggest several meeting times to chat more in person. If you don't receive a response within one week, send a follow up email.

Example of an email sent prior to Block 5:

Dear Professor Seaborg,

My name is Allison Smith. I am a second-year student with an interest in Chemistry. I have yet to declare my major, as I'm still weighing my options. So far, I have completed CH107, CH108 and CH250. I am enrolled in CH241 and CH251 in blocks 5 and 8 of this year. I plan to take CH275 and CH382 next year. After graduation, I am hoping to either pursue a graduate degree in Nuclear Chemistry or apply to medical school. I'm hoping a summer research experience will help me understand which route I would enjoy most.

After reviewing the different research projects described in the summer research booklet, I was very intrigued by your project of producing plutonium-239 through the bombardment of uranium. I am particularly interested in investigating new avenues for producing fissile materials that could be used for green energy production. I am also interested in your project investigating new methods of isolating neptunium and americium.

When you are available, could we talk more about the prospects of me participating in a research project with you this coming summer? I am free to meet on Tuesdays after 1pm, Wednesdays after 3:30pm, and any day after 4pm in the next two weeks. Please let me know if any of those times work for you. I look forward to talking more about research soon.

Sincerely,

Allison Smith

2. Meet the faculty member in person.

   a. Ask about project availability. If the project you are most interested in isn't available, are there other projects that would be a good fit?

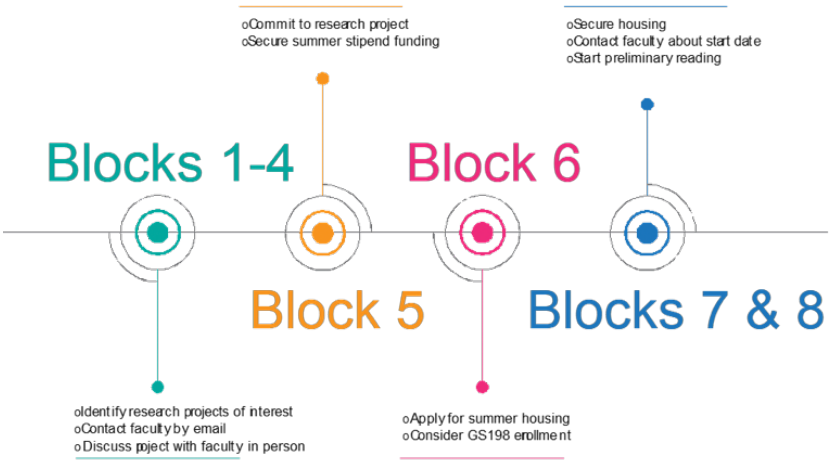
   b. Ensure you have completed any required courses for the project.

   c. Ask about funding options for the project including timelines for proposal submissions.

   d. Ask about this faculty's expectations of summer researchers, including time commitments, what a typical day looks like, start and end dates, etc. Be sure to discuss expectations/ outcomes of the specific project and any specific expectations for research presentation.

Timeline for Contacting Potential Research Advisors:

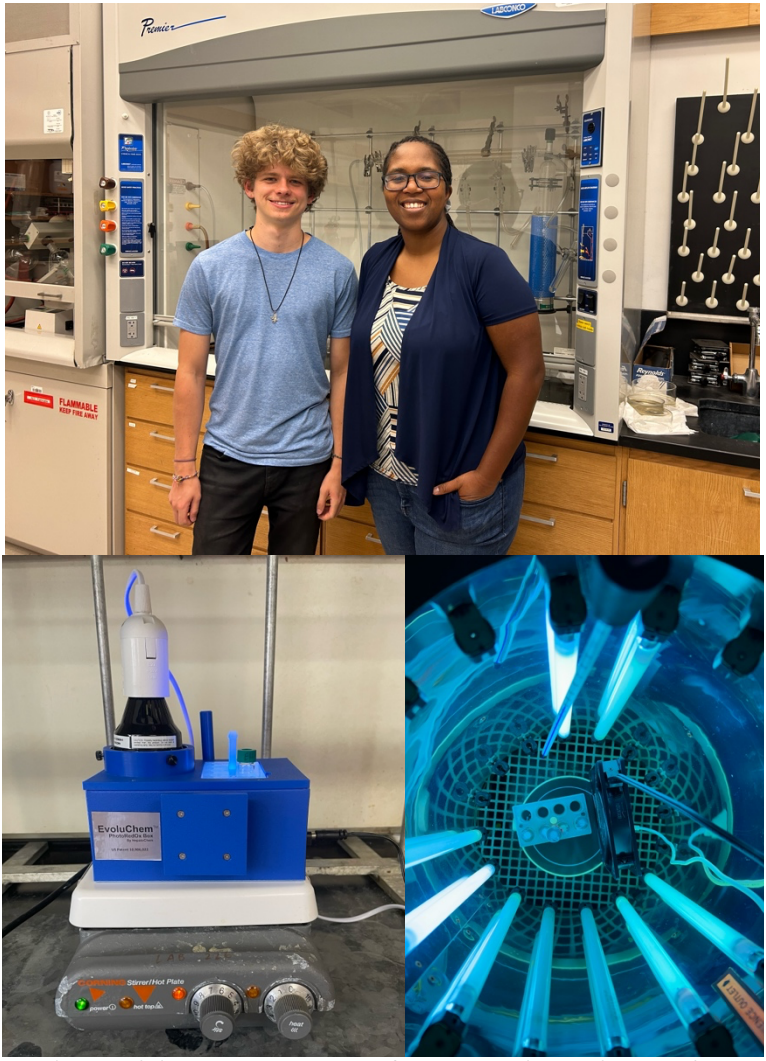
To ensure the best chances of securing a position, contact faculty prior to **Block 4**. By **Block 5**, commit to a research project/advisor. Talk with advisor about securing summer stipend funding. In **Block 6**, start thinking about summer housing. Discuss the option of enrolling in GS198. In **Blocks 7 & 8**, ensure you've secured summer housing. Discuss the start date with your advisor. Ask about any background reading required to get the project started.



Summer 2024 Research Highlights

Kisunzu Lab:

During Summer 2024, Ethan Bost worked with Dr. Kisunzu on a photochemical benzyne project. His main goal was to continue the process of reaction optimization by testing different solvents, photochemical conditions, reaction concentration, and other variables. For example, two different photoreactors can be seen irradiating reaction vials at wavelengths between 300-400 nm.



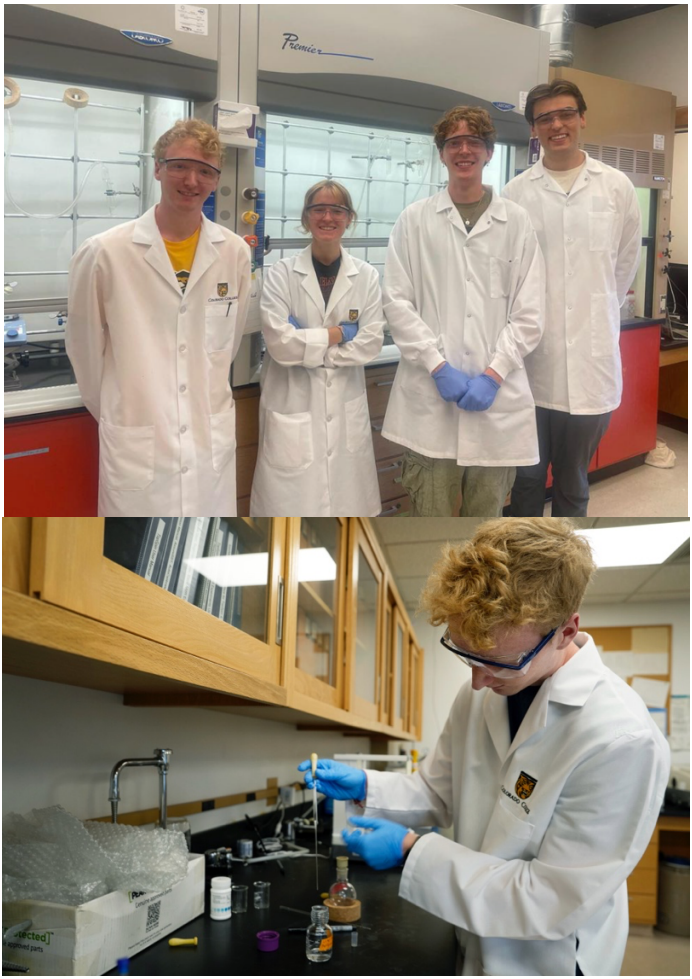
Top: Kisunzu lab group; Bottom Left: HepatoChem PhotoRedOx Box; Bottom Right: inside of Rayonet Photobox

Meyer Lab:
Maggie Nguyễn, Grace Nguyen, Gabe Katz, Cathy Xiao, and Estefanía Cerda worked with Dr. Meyer over the summer testing respiration, ventilation, and infiltration rate of CO_2. Cathy and Gabe wrote an equation which predicts the amount of CO_2 a person will generate in small spaces, like dorm rooms and study rooms. Grace researched the correlation between increased CO_2 inhalation and decreased cognitive function using a Stroop test. Maggie researched and tested how maximum room occupancy compared to safe levels of CO_2 on campus. Estefanía tested CO_2 levels and collected data in CC dorm rooms.

Meyer lab group

Brasuel Lab:
Eli Turovsky conducted research with Dr. Brasuel looking at the optimization of the extraction of phytochemicals from traditional herbal medicines. Working with valerian root and white sage, he made traditional tinctures, isolated essential oils using steam distillation, and extracted phytochemicals using supercritical CO_2. Eli also tested antioxidant capacity of these compounds.

Dounay Lab:
Trenten Chalik, Ollie Beland, Cate Rosenbaum, and Ty Kruger conducted summer research with Dr. Dounay. They worked on synthesizing a new antibiotic for the resistant bacteria P. aeruginosa, which affects immunocompromised people. They each worked on different aspects of the optimization process. Ty explored the use of microwave reactor to decrease the time required for the synthesis process. Ollie optimized the purification process. Cate researched less toxic and greener reaction solvents. Trenten researched the addition of a sugar probe for targeting an enzyme in the bacteria.



Top: Douany lab group; Bottom: preparing samples

Frequently Asked Questions about Summer Research

1. How long is a summer research position?

Positions are typically for 8 weeks over the summer. Start and end dates can vary depending on project and advisor. Shorter research projects may be available in some cases, but this depends on approval by the research advisor.

2. What is the summer research schedule?

Most projects/advisors will require a 40 hour/week research commitment. Specific allocation of that time over the week is project-dependent and may include laboratory experiments, reading of primary literature, paper writing, and other tasks.

3. Do I need previous research experience to be eligible for a summer research position?

Previous research experience is typically not necessary, although certain projects may require students to have completed particular courses. See each faculty member's research page in this booklet for required and suggested courses for research. This should be discussed directly in your first correspondence with the research advisor of interest.

4. How do Summer and Block research differ?

Block research is a graded research experience conducted over a single block with a faculty member in the department. Faculty in the department have one dedicated research block per academic year. Block research can be conducted at several levels (200-400) depending on level of experience. For more information about individual courses, see the Course Catalogue. Summer research is a non-graded and paid research experience over an 8-week summer period.

5. Do I get funded for the summer research position?

Summer research students are paid a $4800 stipend (pre-tax) for the 8-week duration. The stipend for research projects lasting less than eight weeks will be scaled according to the project duration at $600/week.

6. How do I get funded for summer research?

Summer research stipends are supported by either internal or external grants hosted by a particular faculty member. As a potential summer researcher, it is *your responsibility* to inquire with faculty about summer funding options. This often requires appealing to internal funding through small grants applications, such as the Faculty-Student Collaborative Grant. Most internal grant applications are due in Block 5. For that reason, it is critical that you discuss potential interest in summer research positions with faculty prior to Block 4 of the academic year in which you would like to conduct research. Failure to secure funding may result in an inability to support your summer research experience.

7. Can I volunteer (i.e. perform research without a stipend)?

Due to legalities of insurance coverage of you, of our instruments, and of other school property, and issues of equity we cannot allow you to volunteer for summer research.

8. Does the stipend include a meal plan subsidy?

The $4800 stipend does not include a separate meal plan subsidy. Students who elect to live on campus will be required to purchase a meal plan from their stipend for their housing period.

9. Where will I live throughout the summer research duration?

Students can elect to live either on or off campus during their summer research. A need-based housing scholarship is available for eligible students to reside on campus in a double occupancy room while completing their summer research.

10. Is there any additional financial help for international students participating in summer research?

The Center for Global Education & Field Study may offer additional housing and meal support for international students.

11. Can international students participate in summer research positions?

Students can participate in summer research regardless of national citizenship. As such, tax rates for the summer stipend may vary.

12. If I'm interested in a summer research position, how and when do I get involved?

See the 'How to Get Involved' and 'Timeline' sections of this booklet.

13. What year am I eligible for summer research?

Eligibility is not dependent on your academic year. Instead, it is specific to the project and advisor.

14. What are the expectations for communicating my research experience to broader audiences?

As a summer research student, you are expected to participate in the SCoRe Summer Research Symposium in either poster or oral format. The event highlights student-faculty collaborative research over Family & Friends Weekend at the college. Many summer researchers also have the opportunity to participate in discipline-specific regional or national meetings. This option should be discussed with your particular advisor.

15. Do I get credit for summer research?

Since summer research is a paid position, students will not receive academic credit. For those interested in recognition of their research on their academic transcript, they can enroll in GS198.

16. What is GS198? And do I have to take it?

GS198 is a *voluntary* course that summer research students can elect into allowing the summer research experience to be added to their academic transcript. The course is offered only as pass/fail. Students are required to keep a set of initial expectations, keep a research journal, and submit information through a GS198 Canvas portal. More information about GS198 can be obtained from Lisa Schwartz (lisa.schwartz@coloradocollege.edu) or Andrea Culp (andrea.culp@coloradocollege.edu).

17. As a Chemistry major, why should I conduct summer research?

Either on- or off-campus research experiences are essential for those interested in pursuing graduate studies in the chemical or medical sciences. It demonstrates your capacity to conduct research over an extended period which is important in the graduate school

application process. At the same time, it allows you to identify which components of the research you enjoy most (or least).

18. What if I'm not a Chemistry Major – can I still participate?

Eligibility does not depend on your declared major. Contact advisors of interest for more information.

19. What if I don't know what type of research I want to do?

Make sure you read through the available research projects for each faculty member in this booklet. If anything stands out as particularly interesting, contact that faculty member for more information.

20. What's expected of me as a student researcher?

You will be expected to think creatively, solve problems independently, and talk and write knowledgably about what you are researching. You are also expected to demonstrate the dependability, work ethic, attention to ethics, and awareness of safety required of a professional scientist.

21. What does a typical day look like as a summer researcher?

Specific allocation of that time over the week is project-dependent and may include laboratory experiments, reading of primary literature, paper writing, and other tasks. Typical days start at 9am and finish by 5pm.

Amanda Bowman

ASSOCIATE PROFESSOR OF CHEMISTRY & BIOCHEMISTRY

Areas: Inorganic, Organometallic, Art Conservation, Spectroscopy

Courses Required for Research: CH107/117 or CH275
Courses Helpful for Research: CH113, CH275, CH241, CH250, CH376

My research explores the synthesis of transition-metal based inorganic compounds, and explores their magnetic properties through spectroscopy and computational methods. I also apply spectroscopy to art conservation and investigation of artwork and cultural heritage objects.

Spin-Crossover Iron and Cobalt Complexes
The goal of this project is to synthesize iron- and cobalt-based coordination complexes that exhibit temperature-dependent spin-crossover behavior, evaluate their electronic structures, and investigate their potential applications. Spin-crossover (SCO) is a significant change in the spin-state of a transitional metal complex, generally from low-spin to high-spin. SCO complexes are of interest due to applications as molecular magnets and in the development of thermochromic materials (such as optical indicators of temperature in paint and ink, and in thin films as a means of regulating color and/or opacity of windows in response to heat and sunlight to promote energy efficiency). Projects can focus on designing and synthesizing these complexes, using spectroscopy to explore their magnetic behavior, or both. We use a variety of spectroscopy methods, such as UV-Vis, Raman, infrared, ^{1}H NMR, and magnetometry. Students working on this project will gain experience with air-free synthesis techniques. Projects can also use computational chemistry to investigate these complexes. *This project is ideal for students who are interested in synthetic chemistry and/or spectroscopy (CH275 recommended).*

Art Conservation Science
The goal of this project is to apply scientific techniques and spectroscopy to questions in the conservation of artwork and cultural heritage materials. Projects can focus on the investigation of a specific object, or focus on developing analytical methods that can generally be applied in art conservation and analysis. Current and recent projects have included the analysis and characterization of toners in cyanotype photographs using vibrational spectroscopy, detection of dye mordants in woven rugs using

X-ray fluorescence, and a complete study of Modigliani's painting *The Boy* including characterization of pigments, binders, varnish, and support materials used in the painting. Our projects sometimes involve collaboration with the Fine Arts Center museum. *This project is ideal for students who are interested in spectroscopy, as well as students interested in museum studies (CH113 or CH107/117 recommended).*

Cyanotype prints with (l to r) lead acetate toner, tannic acid toner, gallic acid toner, and no toner.

Selected Publications:

Bowman, A.; Smith, G.; Witkowski, L. *The Boy*. In *Modigliani Up Close*; Buckley, B.; Fraquelli, S.; Ireson, N.; King, A., Eds. Barnes Foundation, 2023.

Bowman, A. C.; Tondreau, A. M.; Lobkovsky, E.; Margulieux, G. W.; Chirik, P. J. "Structure and electronic structure diversity of pyridine(diimine)iron tetrazene complexes." *Inorg. Chem.* **2018**, *57*, 9634-9643.

Bowman, A. C.; Milsmann, C.; Bill, E.; Turner, Z. R.; Lobkovsky, E.; DeBeer, S.; Wieghardt, K.; Chirik, P. J. "Synthesis and electronic structure determination of *N*-alkyl-substituted bis(imino)pyridine iron imides exhibiting spin crossover behavior." *J. Am. Chem. Soc.* **2011**, *133*, 17353-17369.

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Murphy Brasuel

PROFESSOR OF CHEMISTRY & BIOCHEMISTRY

Areas: Analytical Chemistry, Bioanalytical Chemistry, Optical Properties of Nano-materials, Extraction and Characterization of Phytochemicals

Courses Required for Research: CH241 or CH250 with COI
Courses Helpful for Research: CH342, CH275, CH382

My research interests span from cell signaling to forensic analysis of art. Some ongoing projects are outlined below, but I open to exploring new avenues for the application of analytical chemical methods.

Ongoing Projects

Ongoing projects include the fabrication of nano-sensors for intracellular ion monitoring utilizing the optical properties of carbon quantum dots, development of rapid and portable assays for capsaicin (the pungent component of chili), nutritional analysis of croton nuts, determination of the phytochemicals responsible for the insecticidal properties of *Silphium integrifolium* (rosin weed) (collaboration with scientists at the Kansas Land Institute), VOC and nectar analysis of orchid subgenus species of Pleurothallis to identify subgenus species utilizing deceit pollination strategies (collaboration with Colorado College Professor Mark Wilson, Organismal Biology), nutritional analysis of the nuts of *Croton megalocarpus* (collaboration with Colorado College Professors Nate Bower and Eli Fahrenkrug) and forensic analysis of fakes and forgeries (collaborations with Colorado College Professors Amanda Bowman and Nate Bower, Chemistry and Biochemistry).

Selected Publications:

Brasuel, M. G., Bowman, A. C., *Blanchett, C. J. K., and Bower, N. W., "Minimally Invasive Sequential Analyses of Questioned Paintings: Six Experiments in Art Authentication," Journal of Forensic Science Education, Accepted, October, 2023,

Bower, N. W., Brasuel, M., Fahrenkrug, E., and Cooney M. D., "Insights into Geographic and Temporal Variation in Fatty Acid Composition of Croton Nuts Using ATR-FTIR," International Journal of Analytical Chemistry, vol. 2018, Article ID 4739759, 8 pages, 2018. https://doi.org/10.1155/2018/4739759.

Wise, W., and Brasuel, M., "The current state of engineered nanomaterials in consumer goods and waste streams: the need to develop nanoproperty-quantifiable sensors for monitoring engineered nanomaterials," *Nanotechnology, Science and Applications, 2011, **4**, 73-86.*

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Margaret (Peggy) Daugherty

ASSOCIATE PROFESSOR OF CHEMISTRY & BIOCHEMISTRY

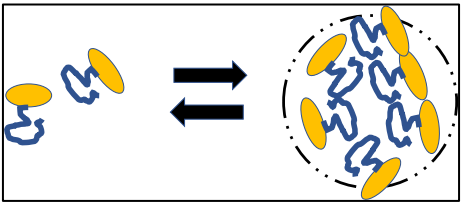
Areas: Protein Biochemistry and Molecular Biophysics

Courses Required for Research: CH107/8 or CH250/1 with consent, CH382
Courses Helpful for Research: CH241, CH383, and research blocks

Prof. Daugherty's current research is to investigate solution conditions that favor LLPS formation in proteins.

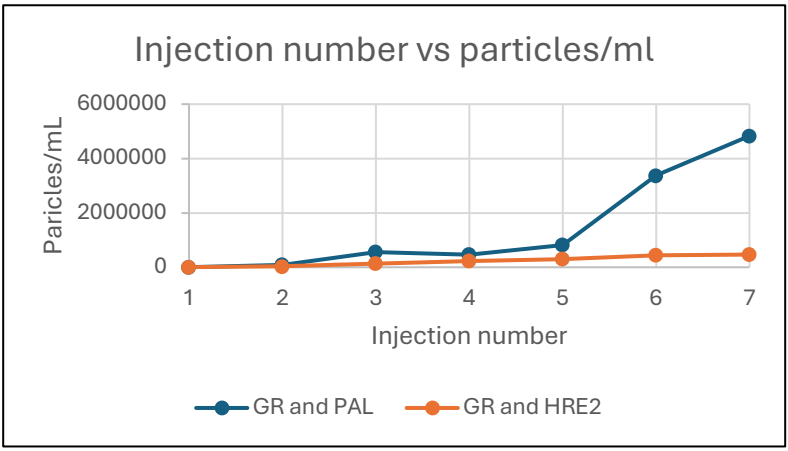
Solution conditions that favor LLPS formation in proteins

My laboratory is interested in characterizing solution conditions that favor liquid-liquid phase separation processes in oproteins. In the LLPS process, the protein is proposed to *reversibly* assemble via weak non-covalent interactions to form larger *particles*, essentially forming what has been referred to as a membraneless "compartment" in the cell, this is schematized in the figure to the right**.** The function of these compartments remains unclear, but has been proposed to play a role in protein localization and/or stabilization, sequestration of the protein with important biological partners (other proteins, nucleic acids, etc.) or to enhance its function, among other roles . Additionally, the LLPS process has been implicated in the progression of diseases including neurodegenerative diseases, cancer and SARS-CoV-2 infection. Much work has shown that assembly of these intriguing protein particles occur among interactions of non-structured parts of the protein and are controlled by altering solution conditions. As denoted by the arrows in Figure 1, formation of the LLPS particles are reversible, thus suggesting that these particles can be altered by environmental conditions.



Project 1: Research with the laboratory of Dr. David Bain (Department of Pharmaceutical Sciences, CU Anschutz) has been initiated on the three hormone receptor proteins, GR, ER and GRER, which we have shownt to undergo LLPS. We have initiated studies that investigate the solution conditions that favor the process, including how temperature, protein concentration, and solution conditions including different ions affect their

formation. Importantly, we have also looked at the role of different target DNA sequences in favoring these LLPS particles. Representative data is presented, showing that two different DNA sequences influence particle formation to significantly different extents (data collected by Nate Kesti '23).



Project 2: I am initiating studies on the human TATA-Binding protein, to investigate the potential for LLPS in this protein. Bioinformatic approaches suggest that the amino-terminal domain of the protein may be involved in LLPS formation. My laboratory has two variants of the protein, the full-length protein, and a version that just contains the sequence for the amino-terminal domain of the protein. I plan to express these proteins in bacteria, and characterize their propensity for LLPS formation.

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Amy Dounay

ASSOCIATE PROFESSOR OF CHEMISTRY & BIOCHEMISTRY

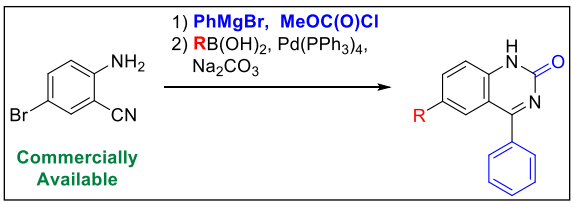
Areas: Organic Chemistry, Medicinal Chemistry, Drug Discovery for Neuroscience and Neglected Diseases, Chemical Education

Courses Required for Research: CH 250 and CH 251
Courses Helpful for Research: CH 351 and CH 410

Amy's research seeks to design and prepare new drugs for treatment of neglected diseases and to use green chemistry principles in drug synthesis

Design and Synthesis of New Drugs for African Sleeping Sickness

African sleeping sickness threatens millions of people in sub-Saharan Africa. Current treatments for this disease are inadequate due to their poor safety profiles, marginal efficacy, and complex dosing protocols. A safe, orally administered drug that is effective against early- and advanced-stage infections could pave the way for eradication of the disease. Through this program, students learn drug discovery strategies and techniques analogous to those used in the pharmaceutical industry. Our lab works with multiple collaborator labs at for biological testing of our new molecules. *Students will gain experience in design, synthesis, computational modeling (with collaborator labs), and characterization of new drug leads.*



Distributed Drug Discovery (D3): Global Collaborations

Through international collaboration, the D3 program links undergraduate chemistry education to research in antibiotic drug discovery. This program introduces students to drug discovery, solid-phase synthesis, and combinatorial synthesis. Students working on this program will help develop and validate new, greener protocols for use in organic chemistry instructional labs worldwide. These protocols must be simple and reliable to ensure that students in academic environments worldwide can contribute to preparing new drug leads for this program. Students may

also assist in screening new molecules for biological activity using simple bioassays. *Students interested in medicinal chemistry, drug design and synthesis, chemical education, and global health are encouraged to apply. Students may have opportunities for domestic and international travel to work with collaborators.*

Selected Publications (*undergraduate co-author)

Fuller, A. A.; Dounay, A. B.; Schirch, D.; Rivera, D. G.; Hansford, K. A.; Elliott, A. G.; Zuegg, J.; Cooper, M. A.; Blaskovich, M. A. T.; Hitchens, J. R.*; Burris-Hiday, S.*; Tenorio, K.*; Mendez, Y.; Samaritoni, J. G.; O'Donnell, M. J.; Scott, W. L. "Multi-Institution Research and Education Collaboration Identifies New Antimicrobial Compounds." *ACS Chem. Biol.* **2020**, *15* (12), 3187-3196.

Dounay, A. B.; O'Donnell, M. J.; Samaritoni, J. G.; Popiolek, L.; Schirch, D.; Biernasiuk, A.; Malm, A.; Lamb, I. W.*; Mudrack, K.; Rivera, D. G.; Ojeda, G. M.;Scott, W. L. "Globally Distributed Drug Discovery of New Antibiotics: Design and Combinatorial Synthesis of Amino Acid Derivatives in the Organic Chemistry Laboratory." *J. Chem. Educ.* **2019,** *96* (8), 1731–1737

Pham, T.;* Walden, M.;* Butler, C.; Diaz-Gonzalez, R.; Pérez-Moreno, G.; Ceballos-Pérez, G.; Gomez-Pérez, V.; García-Hernández, R.; Zecca, H.;* Krakoff, E.;* Kopec, B.;* Ichire, O.; Mackenzie, C.;* Pitot, M.;* Ruiz, L.M.; Gamarro, F.; González-Pacanowska, D.; Navarro, M.; Dounay, A. B. "Novel 1,2-dihydroquinazolin-2ones: Design, synthesis, and biological evaluation against *Trypanosoma brucei*," *Bioorg. Med. Chem. Lett.* **2017**, *27*, 3629-3635.

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Eli Fahrenkrug

ASSISTANT PROFESSOR OF CHEMISTRY & BIOCHEMISTRY

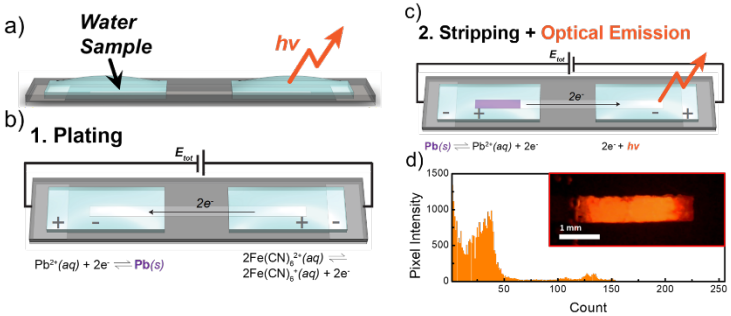
Areas: Analytical Chemistry, Materials Science, Lab-on-a-Chip, Electrochemistry, Nanoscience

Courses Required for Research: None
Courses Helpful for Research: CH107/8, CH250/1, CH241, CH266, PC241/2, CH342, CH275

Our research ethos is centered on democratizing access to chemistry. *We take an interdisciplinary approach to problem-solving, anticipating that the best solutions are often found at the interface of traditional disciplines. Contributing research students have come with diverse interests spanning chemistry, physics, journalism, history, biology, CS, and EV.*

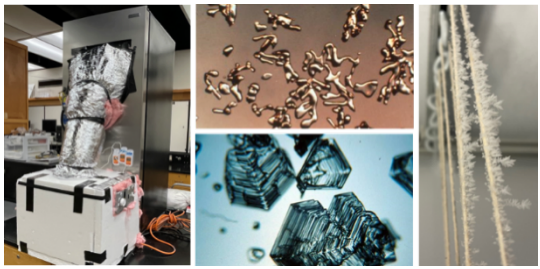
Accessible Water: *New Open-Source Sensors*

In low-resource settings, meeting the need for high-quality environmental chemical testing requires overcoming challenges of harsh transportation and storage conditions, non-technically trained users, limited infrastructure for support and maintenance, and an economy that cannot afford expensive solutions. **We develop and employ a suite of new electrochemical sensors for truly simple, open-source, high-quality, low-cost water quality diagnostics for heavy metal ions and PFAS compounds.**



Dust on Snow: *Chemical Evolution of Snow Grains*

Deposition of **dust** onto snowpacks in the mountain West has increased 300% in 20 years. As a result, the intensity of snowmelt water results in much lower retention in our reservoirs. **The goal of this work is to develop a laboratory model of snowpack metamorphism to monitor how and where specific impurities migrate through the snow grain crystal structure under controlled thermal and radiative perturbation.**



Selected Publications:

Miranda, J.; Humphrey, N.; Kinney, R.; O'Sullivan, R.; Thomas, B.; Mondaca Medina, I. E.; Freedman, R.; **Fahrenkrug, E.** On-Chip Optical Anodic Stripping with Closed Bipolar Cells and Cathodic Electrochemiluminescence Reporting. *ACS Sensors* **2021**, *6* (11), 4136–4144.

Fahrenkrug E., DeMuth, J., Ma, L., Maldonado, S., Electrochemical Liquid Phase Epitaxy (ec-LPE): A New Methodology for the Synthesis of Crystalline Group IV Semiconductor Epifilms. *J. Am. Chem. Soc.,* **2017**, 139, 6960-6968.

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Neena Grover

PROFESSOR OF CHEMISTRY & BIOCHEMISTRY

Areas: Nucleic Acid Biochemistry; Small RNA Thermodynamics, RNA-Magnesium Binding

Courses Required for Research: CH107/8
Courses Helpful for Research: Biochemistry, RNA

The research in our laboratory examines thermodynamic properties of small RNA with an emphasis on quantifying magnesium-nucleic acid interactions.

Small RNA Motifs

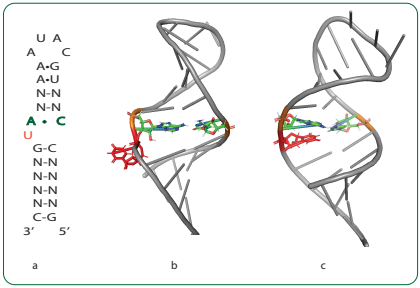
RNA structures are modular and dynamic. Our laboratory studies small structural units that are likely to form in many RNA structures. These motifs are likely to have certain sequence requirements, and associated stability, that are relevant to its function. We are currently investigating sequence and stability of small RNA in various small loops regions of RNA. We are particularly interested in RNA structures in which metal ions are implicated in structure formation and/or in the function.

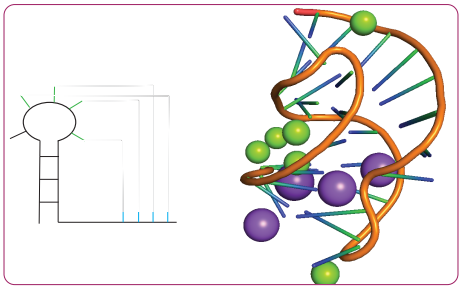
The RNA we study are often derived from functional regions of large RNA. We often choose RNA that are well characterized. The projects start by designing small RNA and various control RNA and DNA. This requires learning about RNA in general and reading literature on a given RNA. Then we measure the energy it requires to form the structures using methods such as thermal denaturation and isothermal calorimetry. We also use techniques such as fluorescence spectroscopy and native PAGE experiments to understand RNA structures. We are planning new explorations of RNA structures using circular dichroism and Raman spectroscopy.

Students who enjoy explorations and are self-motivated to do research will enjoy developing experiments that elucidate the rules of RNA structures. Once the rules of RNA structures are clear, scientists could potentially predict structure and function of all RNA, including coronavirus. Thus, it is theoretically possible to stop a virus using our knowledge of RNA structures and functions. In the past year, several students have started working on projects related to Coronavirus, some are studying the structures of RNA and others are examining ways to inhibit the coronavirus by designing small RNA-based inhibitors. Along with learning

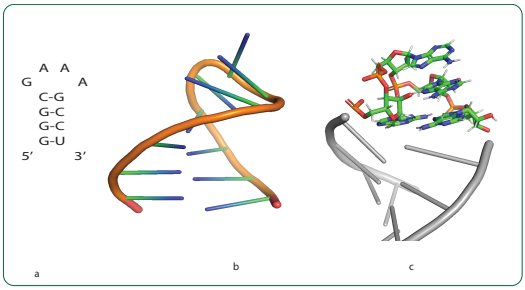
about the RNA, students also participate in outreach efforts to share their knowledge about RNA and science with the broader community.

Example of motifs that are currently being studied in the laboratory:





U6 snRNA *RNA Pseudoknot*



Hairpin Loops

Representative Student Publications:

Allison O'Connell, Jared Hanson, Darryl Cole McCaskill, Daniel Lewis, Ethan Moore, Neena Grover (2019) Thermodynamic examination of pH and magnesium effect on U6 ISL 1x2 internal loop in RNA and DNA constructs. RNA 25:1779-1792.

Shane Strom, Evgenia Shiskova, YaeEun Hahm, Neena Grover (2015) Thermodynamic examination of 1- to 5-nt purine bulge loops in RNA and DNA constructs. RNA 21: 1312-1322.

Ian Carter O'Connell, David Booth, Bryan Eason, Neena Grover (2008) Thermodynamics Examination of trinucleotide bulged RNA in the context of HIV-TAR RNA. RNA 14:2550-2556.

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Jessica Kisunzu

ASSOCIATE PROFESSOR OF CHEMISTRY & BIOCHEMISTRY

Areas: Organic Chemistry, Methodology Development, Strained Intermediate Reactivity, Photochemistry, Natural Product Synthesis

Courses Required for Research: CH250, CH251
Courses Helpful for Research: CH351

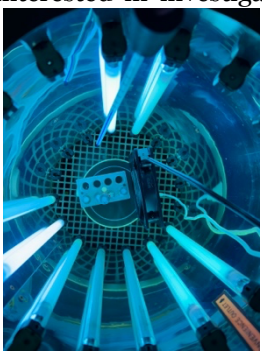
Dr. Kisunzu's research explores the formation and application of highly strained, reactive organic intermediates.

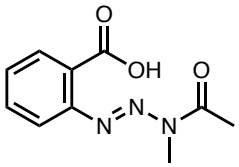
We study how specific strained alkynes derived from benzene, called "benzynes" (**1**), react. In general, compounds in the family of aromatic alkynes are called "arynes".

benzyne, **1**

Photochemical Benzyne Chemistry

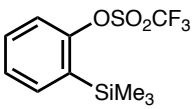
One way to generate benzynes is to use ultraviolet (UV) light. We are interested in investigating the way that these photochemical reactions work and how they can be applied to develop new chemical methods. Students have been studying the reactivity of a known compound (**2**, which has the abbreviation AMTBA) that forms benzyne when exposed to UV light. The resulting benzyne can then participate in different reactions (e.g., bond insertions, additions, and cycloadditions). Photochemical conditions are not used as often as other methods of benzyne formation, so our goal is to develop new efficient and reliable ways that they can applied. *Students working on this project will explore organic synthesis, photochemistry, radical reactions, and structure determination and analysis.*



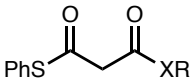


AMTBA, **2**

Investigations of Aryne Reactivity with Various Functional Groups



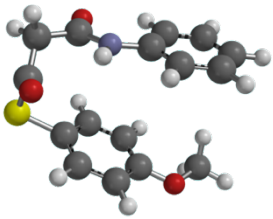
silyl triflate, **3**



X = O, R = alkyl, aryl; ***MTM***, **4**
X = N, R = alkyl, aryl; ***MTMA***, **5**

We are also interested in expanding the understanding of benzynes generated using a base (like from ortho-silyl triflates, **3**) by reacting them with different molecules or functional groups. For example, certain families of sulfur, oxygen, and nitrogen-containing b-dicarbonyl compounds have not been studied in relation to benzyne chemistry, therefore their reactivity is unknown. Of current interest are monothiomalonates (MTMs, **4**) and monothiomalonamides (MTMAs, **5**). Thioesters, esters, amides, and substituted rings are abundant in nature, and the development of new methods can be useful in the synthesis of biologically or medically relevant small molecules. This project also includes the study of other functional groups with benzynes. *Students will gain practice in organic synthesis, developing new reactions, and structure determination and analysis.*

Computational Analysis of Arynes



Density Functional Theory (DFT) methods have been used to analyze angle sizes, relative energies, and electron density around aryne rings. Students use programs like Gaussian and Spartan to model our reaction intermediates and how they interact with other compounds. Students also become more familiar with the opportunities that computational modeling has to offer. Computational analysis will be combined with statistical methods to predict and understand reactivity. Incorporation of computational tools and data science is also supported by participation in the NSF Center for Computer-Assisted Synthesis. *This project is great for students who are interested in the connection between organic synthesis and computational methods for molecular modelling. Prior knowledge of the computational programs is not required.*

Selected Publications:

Rigling, C.; Kisunzu, J. K.; Duschmalé, J.; Häussinger, D.; Wiesner, M.; Ebert, M.-O.; Wennemers, H. Conformational Properties of a Peptidic Catalyst: Insights from NMR Spectroscopic Studies. *J. Am. Chem. Soc.* **2018,** DOI: 10.1021/jacs.8b05459

Kou, K. G. M.; Pflueger, J. J.; Kiho, T.; Morrill, L. C.; Fisher, E. L.; Clagg, K.; Lebold, T. P.; Kisunzu, J. K.†; Sarpong, R.† A Benzyne-Insertion Approach to Hetisine-Type Diterpenoid Alkaloids: Synthesis of Cossonidine. (†Corresponding authors) *J. Am. Chem. Soc.* **2018,** *140*, 8105-8109.

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Sally Meyer

PROFESSOR OF CHEMISTRY & BIOCHEMISTRY

Areas: Physical, Computational

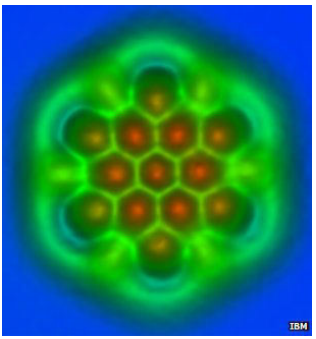
Courses Required for Research: No required courses for Project 1, PC441 or CH367 required for Project 2
Courses Helpful for Research: Any physics, chemistry, math and computer science course

Modeling Home Energy Improvements

This project involves learning how to do an energy audit of an existing house. The information gathered will be used to model the cost and benefit of different improvements to the house. After learning how to do the audits students will write computer code to model the physics of energy waste within the house. The goal of this research is to improve the process of auditing houses and help make it available to everyone. *Students interested in chemistry, physics, environmental science, math and computer science are encouraged to apply.*

Non-Born Oppenheimer Quantum Chemistry

It is impossible to solve the Schrodinger equation exactly for any molecule without using the Born-Oppenheimer approximation. This approximation was introduced in 1927 and since then has been considered valid for most chemical systems. Recently it has been discovered that for some systems of interest this approximation is not valid. The goal of this research is to find ways to solve Schrodinger's equation for these systems without the approximation, which is challenging and requires large computers and efficient codes. Students interested in quantum chemistry, math and/or computer science are encouraged to apply.



References:

1. https://www.ulb.ac.be/cpm/people/bsutclif/bornopn_corr.pdf
2. https://pubs.acs.org/doi/10.1021/cr200096s

Selected Publications:

Wierzba, A.L.; Morgenstern, M.A.; Meyer, S.A.; Ruggles, T.H.; Himmelreich, J.; Energy Efficiency, 4 4) Page: 587-597, 2011 "A Study to Optimize the Potential Impact of Residential Building Energy Audits".

Morgenstern, Mark; Meyer, Sally; Whitten, Barbara and Reuer, Matt. Jour. of College Science Teaching, 37(5), 2008: "The Energy Retrofit of a Building: A Journey Through Bloom's Learning Domains".

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Habiba Vaghoo

ASSOCIATE PROFESSOR OF CHEMISTRY & BIOCHEMISTRY

Areas: Organic Chemistry, Organofluorine Chemistry

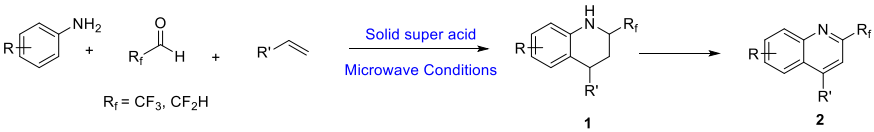
Courses Required for Research: CH 250, CH 251
Courses Helpful for Research: CH 351

Habiba Vaghoo is an organic chemist whose research interests are in the area of organofluorine chemistry. She works on developing new reactions to introduce fluorine and fluorinated groups to small organic molecules of biological interest using microwave technology.

Microwave-Assisted Solid Acid Catalyzed Multicomponent Synthesis of Fluorinated Heterocylces

Multicomponent reactions (MCR) are synthetically very useful as they allow the construction of an extensive collection of complex molecules rapidly. In general, these reactions involve three or more reactants that react sequentially in one pot to afford the desired product with high atom economy and selectivity.[i] MCRs play an important role in the synthesis of biologically important compounds and their fluorinated derivatives are attracting more attention due to the increased interest in fluorine from the medicinal chemistry communit.[ii] Thus, the need for new methodologies for the incorporation of fluorine in small molecules is an area of active research. In addition, Microwave-assisted organic synthesis (MAOS) is becoming more appealing for the synthesis of small organic molecules for its efficiency in terms of reagents, time, and energy. This project enables the use of MCR, microwave technology and commercially available solid acids to synthesize biologically important molecules via an environmentally friendly and synthetically efficient route. The first MCR that we are interested in developing involves the in-situ formation of a CF_3/CF_2H aryl-aldimine and its subsequent reaction with styrene via the Povarov reaction to afford fluorinated tetrahydroquinolines and eventually the corresponding quinolones derivatives (Scheme 1).

Tetrahydroquinolines and quinolones in general are important scaffolds that are present in both natural products and pharmaceuticals as they have interesting biological properties.[iii] Fluorinated quinolines have also been studied and shown to exhibit important biological properties such as antimalarial activity.[iv]



Scheme 1. One pot synthesis of 2-CF_3/CF_2H-Tetrahydroquinoline/ quinolone derivatives.

Mefloquine, sold as Larium, is a major antimalarial drug that is used for both prevention and treatment of malaria. On the other hand, fluorinated tetrahydroquinolines have not been widely explored for their biological properties; the reason for which may be attributed to the fact that methodology to synthesize these compounds are limited. Nevertheless, given the importance of fluorinated heterocycles and the academic quest to develop new synthetic methodology, these class of compounds make interesting and worthwhile targets.

References:

(1) Van der Heijden, G.; Ruijter, E.; Orru, R. "Efficiency, Diversity, and Complexity with Multicomponent Reactions." *Synlett*. **2013**, *24(6)*, 666.
(1) Wu, J.; Cao, S. "Multicomponent Reactions based on Fluoro-Containing Building Block." *Curr. Org. Chem.* **2009**, *12*, 1791.
(1) (a) Sridharan, V., Suryavanshi, P. A. and Menéndez, J. C.," Advances in the chemistry of tetrahydroquinolines". *Chem. Rev*. **2011**, 111, 7157.
(1) (a) Lutz, R. E.; Ohnmacht, C. J.; Patel, A. R. "Antimalarials. 7. Bis(trifluoromethyl)-.alpha.-(2-piperidyl)-4-quinolinemethanols". *J. Med. Chem*. **1971**, 14, 926; (b) Grellepois, F.; Grellier, P.; Bonnet-Delpon, D.; Begue, J.-P." Design, synthesis and antimalarial activity of trifluoromethylartemisinin-mefloquine dual molecules." *ChemBioChem*. **2005**, *6*, 648.

Selected Publications:

Prakash, G. K.; Narayanan, A.; Nirmalchandar, A.; **Vaghoo, H**.; Paknia, F.; Mathew, T.; Olah, G. A. "Direct synthesis of 2-/3-(trifluoromethyl)thiochroman-4-ones: Superacid-induced tandem alkylation-cyclic acylation of benzenethiols using 2-/3-(trifluoromethyl)acrylic acid" *J. of Fluo. Chem*. **2017**,*196*, 63.
Vaghoo, H.; Prakash, G. K.; Narayanan, A.; *Choudhary, R*.; Paknia, F.; Mathew, T.; Olah, G. A. "Superelectrophilic Activation of Crotonic/Methacrylic Acids: Direct Access to Thiochrom-4-ones from Benzenethiols by Microwave-Assisted One-Pot Alkylation/Cyclic Acylation." *Org. Lett*. **2015**, *17*, 6170.

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Research Opportunities Outside of Colorado College

National Science Foundation (NSF) Research Experience for Undergraduates (REU): The Research Experiences for Undergraduates (REU) program supports active research participation by undergraduate students in any of the areas of research funded by the National Science Foundation. REU projects involve students in meaningful ways in ongoing research programs or in research projects designed especially for the purpose. NSF funds a large number of research opportunities for undergraduate students through its REU Sites program. An REU Site consists of a group of ten or so undergraduates who work in the research programs of the host institution. Each student is associated with a specific research project, where he/she works closely with the faculty and other researchers. Students are granted stipends and, in many cases, assistance with housing and travel. Undergraduate students supported with NSF funds must be citizens or permanent residents of the United States or its possessions. An REU Site may be at either a US or foreign location.
See: https://www.nsf.gov/crssprgm/reu/

Summer Undergraduate Research Fellowship Program (SURF, SURP): SURF is a national program hosted by many institutions across the country. SURF is modeled on the grant-seeking process. Students collaborate with a potential mentor to define and develop a project. Applicants write research proposals as part of the application process. Faculty review the proposals and recommend awards.
See:
https://www.aamc.org/members/great/61052/great_summerlinks.html

DAAD-RISE Program: A German scientific internship for undergraduate students studying at a North American University/College with a major in biology, chemistry, computer science, physics, earth sciences or engineering. Internships are hosted at a variety of German academic institutions covering a wide range of project topics. Students are matched with a host university or institute according to their area of interest. DAAD provides students a monthly stipend for three months to help cover living

expenses. German language is not required and the working language will be in English.
See: https://www.daad.de/rise/en/rise-germany/

SCI Scholars Internship Program: The Society of Chemical Industry (SCI), American Institute of Chemical Engineers (AIChE), and the American Chemical Society created the SCI Scholars Summer Internship Program to introduce chemistry and chemical engineering students to careers in the chemical industry. Exceptional sophomores and juniors majoring in chemistry and chemical engineering can apply for a prestigious SCI Scholars summer internship. Students are selected based on the strength of their application, statement of interest in an industrial internship, and letters of recommendation.
See:
https://www.acs.org/content/acs/en/education/students/college/experienceopp/scischolars.html

Amgen Scholars Program: The Amgen Scholars program provides students the opportunity to conduct research in biology, chemistry, and bio-technical related fields under the guidance of seasoned research mentors. The goal of the program is to provide research opportunities to students interested in pursuing a Ph.D. or M.D./Ph.D. program in STEM fields. The program is also committed to providing research opportunities to students traditionally underrepresented in STEM fields and to those who attend schools where undergraduate research is limited. Amgen Scholars receive a $6,275 stipend for the ten-week period. See http://www.amgenscholars.com/us-program

University of Colorado SMART Program: The SMART program is intended for undergraduate students who are interested in preparing for graduate degrees in science, math and engineering. SMART offers students the opportunity to conduct research under the guidance of a faculty mentor, and participate in workshops designed to strengthen scientific writing and oral presentation skills. SMART interns earn upper-division undergraduate credit in independent study, and receive a stipend, room and board, and travel expenses.
See: https://www.colorado.edu/smart/undergraduates/smart-program-information

Big 10 Universities Summer Research Opportunities Program (SROP): A summer research program that provides undergraduate students from populations underrepresented in graduate study with an opportunity to explore careers in research. The program provides students with an experience that will help strengthen their knowledge, skills, and understanding of graduate school. Since 1986, Summer Research Opportunities Program (SROP) has brought talented undergraduate students from across the US and its territories, such as Puerto Rico, as an introduction to graduate study, research, and the admission process. The many activities offered through the SROP gives participants an opportunity to establish important relationships with faculty in their respective fields of study and conduct graduate-level research under the supervision of a renowned faculty member. Participants will also become acquainted with the culture of graduate school and learn what is needed and expected of them as graduate students in their discipline.
See: http://www.btaa.org/resources-for/students/srop/introduction

Kansas University Undergraduates Studying Pharmaceutical Chemistry: The Department of Pharmaceutical Chemistry offers a 10-week summer undergraduate research program. Students perform independent research under the supervision of faculty members, applying chemical principles to problems involving drugs and related molecules. In pharmaceutical chemistry, the emphasis is on promoting the therapeutic effects of the drug or minimizing toxicity, or controlling delivery of the drug to specific sites of action. This involves increased attention to physical-organic, physical and analytical chemistry. Participants receive basic instruction in laboratory and research techniques, including laboratory safety, effective use of major university science library, and instruction in first-hand use of specialized laboratory instrumentation of importance to a given research problem. The program is designed to provide an opportunity for students to evaluate the possibility of entering a graduate program in the pharmaceutical sciences. Accordingly, students are provided the opportunity of engaging in a full-time research experience in close collaboration with faculty members and graduate students. As a direct result of the summer undergraduate research experience, many of our former participants have entered graduate schools and successfully completed doctoral degrees.

See: https://pharmchem.ku.edu/undergraduate-research-programs

Summer Internship in Biomedical Health (SIP) at the National Institutes of Health (NIH): Summer programs at the National Institutes of Health (NIH) provide an opportunity to spend a summer working at the NIH side-by-side with some of the leading scientists in the world, in an environment devoted exclusively to biomedical research (At the NIH "biomedical sciences" includes everything from behavioral and social sciences, through biology and chemistry, to physics, mathematical modeling, computational biology, and biostatistics). The NIH consists of the 240-bed Mark O. Hatfield Clinical Research Center and more than 1150 laboratories/research groups located on the main campus in Bethesda, MD, and the surrounding area as well as in Baltimore and Frederick, MD; Research Triangle Park, NC; Hamilton, MT; Framingham, MA; Phoenix, AZ; and Detroit, MI. Internships cover a minimum of eight weeks, with students generally arriving at the NIH in May or June. The NIH Institutes and the Office of Intramural Training & Education sponsor a wide range of summer activities including lectures featuring distinguished NIH investigators, career/professional development workshops, and Summer Poster Day.
See: https://www.training.nih.gov/programs/sip

MIT Summer Research Program (MSRP): The MIT Summer Research Program (MSRP) seeks to promote the value of graduate education; to improve the research enterprise through increased diversity; and to prepare and recruit the best and brightest for graduate education at MIT. MSRP began in 1986 as an institutional effort to address the issue of underrepresentation of African Americans, Mexican Americans, Native Americans, and Puerto Ricans in engineering and science in the United States. Today, this program's goal is to increase the number of underrepresented minorities and underserved (e.g. low socio-economic background, first generation) students in the research enterprise. MSRP seeks to identify talented sophomores, juniors, and non-graduating seniors who might benefit from spending a summer on MIT's campus, conducting research under the guidance of MIT faculty members, postdoctoral fellows, and advanced graduate students. Students who participate in this program will be better prepared and motivated to pursue advanced degrees, thereby helping to sustain a rich talent pool in critical areas of research and innovation.

See: http://odge.mit.edu/undergraduate/msrp/

Woods Hole Fellowship in Oceanography for Minority Undergraduates: Summer Student Fellowships are awarded to undergraduate students who are completing their junior year at colleges or universities and are studying in any of the fields of science or engineering including but not limited to the fields of biology, chemistry, engineering, geology, geophysics, mathematics, meteorology, physics, oceanography, and marine policy. Students must have at least a tentative interest in the ocean sciences, oceanographic engineering, mathematics, or marine policy. Persons from underrepresented groups are encouraged to apply. WHOI actively recruits underrepresented minorities in ocean science as defined by the National Science Foundation (African-, Hispanic- and Native-Americans, and Pacific Islanders) in all of our education programs, as well as programs of the Woods Hole Diversity Initiative, such as the Woods Hole Partnership Education Program.
See: http://www.whoi.edu/page.do?pid=8065

Research Intensive Summer Experience (RISE) at Rutgers: a nationally acclaimed summer research program for outstanding undergraduates from diverse backgrounds. Scholars participate in 10 weeks of cutting-edge research in the biological, physical, and social/ behavioral sciences, math, engineering, and exciting interdisciplinary areas under the guidance of carefully matched faculty mentors. A comprehensive professional development component, including GRE preparation, complements the research.
See: https://www.rise.rutgers.edu/

Binghamton Louis Stokes Alliance for Minority Participation (LSAMP) Summer Research Internship: The LSAMP Summer Research Internship Program is an 8 week paid summer internship here at Binghamton University, during which you will work as a Research Assistant on a faculty-designed research project, at least 30 hours a week. LSAMP is funded to increase the number of underrepresented minorities (African-American, Latino, Native American, Alaskan Native, Hawaiian Native, and Native Pacific Islander) who pursue careers in science, technology, engineering and mathematics.
See: https://www.binghamton.edu/lsamp/summer-research.html

University of North Carolina, Summer of Learning and Research (SOLAR): A summer undergraduate research program at UNC in the biomedical sciences for rising college juniors and seniors from diverse groups. an intensive 10-week experience designed to prepare diverse students for graduate research and careers in science. The program is open to rising juniors and seniors from 4 year colleges and universities around the country, particularly those from minority serving institutions (MSIs). Our goal is to provide undergraduate students interested in careers in biomolecular research with an opportunity to carry out independent research projects under the guidance of a UNC faculty mentor. This intense summer research experience will introduce you to cutting-edge research and will provide you with a realistic view of graduate school and biomedical research careers. You will be immersed in the research process, including the design of a research project, methods for conducting controlled experiments, data collection, data analysis, and team-work. We will help you develop strong scientific communication skills and you will have the opportunity to present your work in the cross-campus summer research poster session at the end of the summer.
See: https://www.med.unc.edu/oge/stad/solar/

Nuclear Forensics Undergraduate Summer School (NFUSS): NFUSS is a six-week course, sponsored by the Department of Homeland Security (DHS), designed to provide undergraduate students with comprehensive, experimental, hands-on training in topics essential to nuclear forensics. This program will be held June 11 to July 20 at the University of Utah campus in Salt Lake City. Through laboratory experiments and complementary lectures, students are introduced to the practice and technical aspects of nuclear forensic science. The program will also include a field trip to Oak Ridge National Laboratory (ORNL).
See: https://orise.orau.gov/nfuss/

Naval Research Enterprise Internship Program (NREIP): Provides an opportunity for college students to participate in research at a Department of Navy (DoN) laboratory during the summer. The goals of NREIP are to encourage participating college students to pursue science and engineering careers, to further education via mentoring by laboratory personnel and their participation in research, and to make them aware of DoN research and technology efforts, which can lead to employment within the DoN. NREIP provided competitive research internships to

approximately 560 college students last summer. Participating students spend ten weeks during the summer conducting research at approximately 38 DoN laboratories.
See: https://nreip.asee.org/

Department of Energy (DOE) Science Undergraduate Laboratory Internships (SULI): The Science Undergraduate Laboratory Internship (SULI) program encourages undergraduate students to pursue science, technology, engineering, and mathematics (STEM) careers by providing research experiences at the Department of Energy (DOE) laboratories. Selected students participate as interns appointed at one of 17 participating DOE laboratories/facilities. They perform research, under the guidance of laboratory staff scientists or engineers, on projects supporting the DOE mission. The SULI program is sponsored and managed by the DOE Office of Science's, Office of Workforce Development for Teachers and Scientists (WDTS) in collaboration with the DOE laboratories/facilities. Applications for the SULI program are solicited annually for three separate internship terms. Internship appointments are 10 weeks in duration for the Summer Term (May through August) or 16 weeks in duration for the Fall (August through December) and Spring (January through May) Terms. Each DOE laboratory/facility offers different research opportunities; not all DOE laboratories/facilities offer internships during the Fall and Spring Terms.
See: https://science.energy.gov/wdts/suli/

Nakatani RIES Fellowship for U.S. Students: The Nakatani RIES Fellowship for U.S. Students is a 13-week, summer research internship in science & engineering that is open to freshman and sophomore engineering students from universities nationwide. This summer program seeks to cultivate interest in science & engineering research among young U.S. undergraduate students, especially those from underrepresented groups, and encourages such students to pursue future graduate study. To be eligible students must be U.S. citizens or permanent residents. Up to 12 students will be selected to participate annually.
See:
http://nakatani-ries.rice.edu/u-s-fellows/about-u-s-program/

Oak Ridge National Laboratory (ORNL): Oak Ridge National Laboratory has two internship programs that support summer research, the Nuclear Engineering Science Laboratory Synthesis

(NESLS) and the Higher Education Research Experiences (HERE). NESLS provides nuclear engineering research opportunities and associated activities for undergraduate students through cooperative research with mentors at the national lab. The program is open to full- or part-time student enrolled at an accredited U.S. college or university in a nuclear engineering, science, or eligible related degree with a cumulative GPA of 3.0. US citizenship is not required. The internship duration is flexible, with a suggested minimum of 10 weeks in summer with a required poster session. HERE provides research opportunities and associated activities for undergraduate students. The program is designed to complement academic programs by utilizing the unique resources of ORNL to enhance science, technology, engineering, and mathematics (STEM) education, encourage careers in science and technology, and improve scientific literacy, while at the same time contributing to the Laboratory mission. Participating students must Be currently enrolled as an undergraduate student at a U.S. accredited institution and have a cumulative GPA of 2.5. The internship duration is flexible. Students must be a U.S. Citizen or Legal Permanent Resident at the time of application to be eligible.
https://orise.orau.gov/ornl/nesls/default.html
https://orise.orau.gov/ornl/hereatornl/undergraduates.html

National Renewable Energy Lab (NREL): Undergraduate students have the opportunity to join the NREL team as an intern while gaining valuable mentoring experience, participating in the lab's research and development programs, and establishing ongoing collaborations through NREL's Research Participant Program. Full-time undergraduate students currently enrolled in a U.S. college or university who have successfully completed at least the sophomore year of school by June of the current year and plan to continue full-time enrollment during the following fall term are eligible for NREL's Research Participant Program internships. Students must have a minimum cumulative GPA of 3.0 in the last completed semester to be eligible. The internship term is flexible, with up to 40 hours per week in the summer.
https://www.nrel.gov/careers/nrel-internships.html