Reimagining Higher Education

The 27th Annual Cottrell Scholar Conference
July 7-9, 2021

COTTRELL SCHOLAR CONFERENCE

RESEARCH CORPORATION *for* SCIENCE ADVANCEMENT

2021 Conference Planning Committee

Julio de Paula
Department of Chemistry,
Lewis & Clark College

Jordan Gerton
Department of Physics,
University of Utah

Gina MacDonald
Department of Chemistry and Biochemistry,
James Madison University

Maura McLaughlin
Department of Physics and Astronomy,
West Virginia University

Nicola Pohl
Department of Chemistry,
Indiana University Bloomington

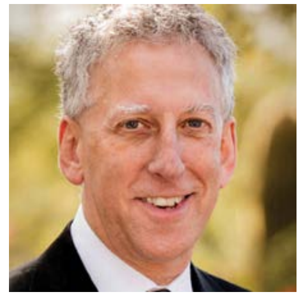
Jennifer Prescher
Department of Chemistry,
University of California, Irvine

Scott Shaw
Department of Chemistry,
University of Iowa

Tom Solomon
Department of Physics,
Bucknell University

Silvia Ronco, Chair
Senior Program Director,
Research Corporation for Science Advancement

Welcome from the RCSA President



As we come together in our second consecutive (and we hope last) virtual format for the annual Cottrell Scholar Conference, we have the opportunity to reflect on the many adjustments and innovations made over the past year, to recognize what worked well and where challenges emerged, and to draw on our experiences to design even more effective and inclusive approaches to teaching students in the classroom and in laboratory courses, and to leading them in research. Instead of simply going back to how we functioned as teachers and researchers in 2019, can we convert the lessons of the pandemic into sustainable, positive changes?

Among the challenges that arose, we saw that while the virtual environment can broaden the reach of academic programs, it also makes even more evident inequities in access to the latest technology. It seems likely that digital tools and materials will play even larger roles in pedagogy and scholarship in the future, so how can we ensure that everyone can use them?

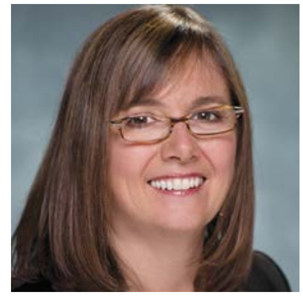
For the faculty, can shared and widely available resources make it simpler to adopt new approaches? Can Cottrell Scholars design better, online methods to evaluate student progress? Might the Cottrell Scholar community help faculty colleagues overcome any hesitancy to incorporate these improvements into their efforts?

Cottrell Scholars have an outstanding record of tackling issues in education, academic career development, and research together, and formulating creative interventions that can be applied within and beyond our community. I look forward to seeing what ideas emerge at this meeting for such collaborative projects.

I wish you all the best for an enjoyable and stimulating conference.

Daniel Linzer
President and Chief Executive Officer
Research Corporation for Science Advancement

Welcome from the Program Director



Welcome to the virtual 2021 Cottrell Scholar Conference!

What a year! I'm so glad that we can get together to share our experiences, reflect on the lessons learned during the pandemic, and to start healing as a community from a truly demanding and exhausting 2020-2021 academic year.

The theme of the 2021 Cottrell Scholar Conference is *Reimagining Higher Education*. The intent here is to offer a platform for thoughtful discussions on how to use the myriad of experiences gained this last year, together with increased awareness of inequities in science education, to plan for a more equitable academia. We are honored to have an exceptional speaker, Dr. Sean Decatur, 1996 Cottrell Scholar and current President of Kenyon College, who will challenge us to think big. In his presentation, Sean will review current challenges to achieving equity, identify clear action that individuals and institutions should take, and imagine more ambitious changes to create a more equitable future. As it is our tradition, a couple of breakout sessions in the conference theme will follow the keynote presentation. Hopefully, breakout discussions will trigger ideas for implementation in your campuses.

Continuing our long-standing tradition, the CS Conference is a celebration of the new class of Cottrell Scholars and the new ideas that emerge from formal and casual conversations. If you are a new Scholar, please know that you were selected not only for your impressive research and educational programs, but also for your strong potential for being an active member of the Cottrell Scholar family. In addition, if you are a returning Scholar, take some time to introduce yourself to new Scholars and welcome them to this worthwhile community. Effective communication begins with you. We encourage you to listen, speak up, and, above all, network with conference participants!

A great way to pursue new educational ideas with potential national impact is to participate in a project with the Cottrell Scholars Collaborative (CSC). A cross-disciplinary network begun in 2011, CSC's overarching goal is to improve science education at colleges and universities across the U.S. and Canada. CSC participation is also an excellent way to get know and network with members of the stellar Cottrell Scholar community. If you have questions about getting involved in CSC activities, please do not hesitate to reach out to me, my fellow RCSA program directors, or your CS colleagues.

We hope you find this event informative and stimulating. We are looking forward to hearing your ideas on how to create a more equitable environment to nurture a diverse, future workforce.

Silvia Ronco
Senior Program Director
Research Corporation for Science Advancement

Statement on Promoting Diversity and Inclusion, and Avoiding Harassment

Research Corporation for Science Advancement fosters an environment for listening and considering new ideas from a diverse group, with respect for all participants without regard to gender, race, ethnicity, sexual orientation, age, or any other aspect of how we identify ourselves other than as fellow scientists.

RCSA does not tolerate any form of harassment, which could include verbal or physical conduct that has the purpose or effect of substantially interfering with anyone else's participation or performance at this conference, or of creating an intimidating, hostile, or offensive environment; any such harassment may result in dismissal from the conference.

2021 Virtual Cottrell Scholar Conference Agenda

Reimagining Higher Education

All times are PDT

Wednesday, July 7, 2021

8:30 – 9:00 am	**Welcome and Introductory Remarks** Silvia Ronco, CS Program Director Dan Linzer, RCSA President
9:00 – 10:00 am	**Introductions of 2021 CS and FCS** Lightning Talks *Who are you? What do you do? What is your dream goal in research and education?* Padlets from 2021 CS class members will be available throughout the conference.
10:00 – 10:10 am	**Break**
10:10 – 11:10 am	**Keynote Presentation** Sean Decatur, President, Kenyon College Cottrell Scholar 1996 **Q&A**
11:10 am – 12:10 pm	**Facilitated Breakout Session I**
12:10 – 12:25 pm	**Breakout Groups Report Out** Start planning collective action *Team forming and emerging themes*
12:25 – 12:30 pm	**Break**
12:30 – 1:00 pm	**Mixer and Networking**
4:00 – 6:00 pm	**Informal Virtual Lounge—Gather Town** *Bring your own drink!*

2021 Virtual Cottrell Scholar Conference Agenda

Reimagining Higher Education

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Thursday, July 8, 2021

7:00 – 8:00 am	**Informal Virtual Breakfast and Coffee Break**
8:00 – 8:15 am	**Reconvening and Planning the Day**
8:15 – 9:15 am	**Panel Discussion** Cottrell Scholar Collaborative Team Leaders *Start, goals, accomplishments, dreams, and on-going projects* **Q&A**
9:15 – 9:45 am	**Celebrating Our Outstanding Community** 2020 FRED Award *Cindy Regal, University of Colorado Boulder*
10:00 – 10:15 am	**Break**
10:15 – 11:15 am	**Facilitated Breakout Session II**
11:15 – 11:30 am	**Breakout Groups Report Out**
11:30 – 11:45 am	**Break**
11:45 am – 12:30 pm	**Update from Cottrell Scholar Program Committee**
12:30 – 1:00 pm	**Mixer and Networking**
4:00 – 6:00 pm	**Informal Virtual Lounge—Gather Town** *Bring your own drink!*

2021 Virtual Cottrell Scholar Conference Agenda

Reimagining Higher Education

All times are PDT

Friday, July 9, 2021

7:00 – 8:00 am	**Informal Virtual Breakfast and Coffee Break**
8:00 – 8:15 am	**Reconvening and Planning the Day**
8:15 – 9:15 am	**Celebrating Our Outstanding Community** 2021 IMPACT Award *Penny Beuning, Northeastern University* 2021 STAR Award *Tim Clark, University of San Diego* *Hanadi Sleiman, McGill University*
9:15 – 9:30 am	**Break**
9:30 – 10:15 am	**Team Formation** Encouragement to coalesce in a platform of their choice after the meeting ends
10:15 – 11:00 am	**General Facilitated Discussion**
11:00 – 11:30 am	**Conference Wrap-up** Proposal guidelines and ideas for engagement throughout the year

Keynote Speaker

Building More Equitable Colleges and Universities in the Aftermath of Covid

Sean Decatur
President, Kenyon College

Abstract: American colleges and universities have long positioned themselves as engines of economic mobility, providing educational opportunities to students facing socioeconomic disadvantage or racial discrimination. Yet these institutions often reify inequities by restricting access (either directly or through the barrier of high cost) or failing to address the needs of all students. The COVID crisis, combined with the national reckoning with systemic racism brought on by the murder of George Floyd, have brought the gap between the aspirations for equity and the reality of institutional operations. As we begin a return from the constraints of COVID, we are presented with an opportunity to build a foundation of equity into the new post-COVID normal. In this session, we will review the challenges to achieving equity, delineate clear action imperatives that individuals and institutions should take, and imagine more ambitious changes to create a more equitable future.

Bio: Sean M. Decatur became the 19th president of Kenyon College in 2013. Prior to that, he served as the dean of the College of Arts and Sciences at Oberlin College. He was also a professor of chemistry and biochemistry at Oberlin.

Dr. Decatur earned a bachelor's degree at Swarthmore College and earned a doctorate in biophysical chemistry at Stanford University in 1995; his dissertation was titled *Novel Approaches to Probing Structure-Function Relationships in Myoglobin*.

Dr. Decatur was a professor of chemistry at Mount Holyoke College, also serving as department chair from 2001-04. While there, he was appointed the Marilyn Dawson Sarles Professor of Life Sciences and was also an associate dean of faculty for science from 2005–08. On the faculty at Mount Holyoke, Dr. Decatur helped establish a top research program in biophysical chemistry. He also developed unique courses, including a race-and-science lecture series; a course exploring ethical, social, and political questions related to scientific topics; and a team-taught course that integrates introductory biology and chemistry.

Dr. Decatur's research was supported by grants from NSF, NIH, the Alzheimer's Association, the Dreyfus Foundation, and RCSA. He is the author of numerous scholarly articles and has received a number of national awards for his scholarship, including a CAREER award in 1999 and a Henry Dreyfus Teacher-Scholar Award in 2003. He was named a 1996 Cottrell Scholar, and an Emerging Scholar of 2007 by Diverse: Issues in Higher Education magazine.

Cottrell Scholar Collaborative Panel: 2020 Award Winners

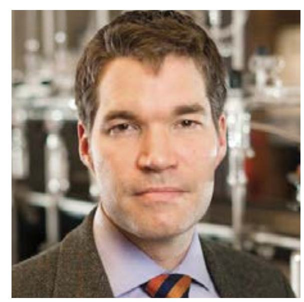
Diversity, Equity, and Inclusion in the Age of COVID-19

Shane Ardo
Cottrell Scholar 2017
Department of Chemistry, University of California, Irvine

Seeing is Believing: Enhancing the Visualization of Atoms, Molecules, and Materials Using Augmented and Virtual Reality

Katherine A. Mirica
Cottrell Scholar 2019
Department of Chemistry, Dartmouth College

Moving the Dial: A Network for Systematic Change



Rory Waterman
Cottrell Scholar 2009
Department of Chemistry, University of Vermont

2020 FRED Award Winner

Phononic Crystal Suspensions for Precision Mechanical Sensing

Cindy Regal
Cottrell Scholar 2014
Department of Physics, University of Colorado Boulder

Abstract: Mechanical detectors have played a surprising role in physics discovery of the past decades, from the atomic force microscope to gravitational wave detectors. Expanding understanding and control of extremely isolated mechanical modes will enable future discovery in both large and small-scale mechanical detectors. My group explores tensioned resonators at the microscale that we can bring to their quantum ground state of motion. I will present our studies within this class of micromechanical resonators that combine intriguing features such as dilution of dissipation through tensioned suspensions and shielding of acoustic loss through periodic mass arrays. I will discuss how pushing these vibrations to ultracoherent regimes may enable measurement of miniscule forces from precessing nuclear spins, detection of microwave photons in non-classical states, and broadened perspectives on acceleration sensing.

Bio: Cindy A. Regal is an American experimental physicist most noted for her work in quantum optics; atomic, molecular, and optical physics (AMO); and cavity optomechanics. Regal is an associate professor in the Department of Physics at the University of Colorado and JILA Fellow, and a Fellow of the American Physical Society (APS).

2021 STAR Award Winners

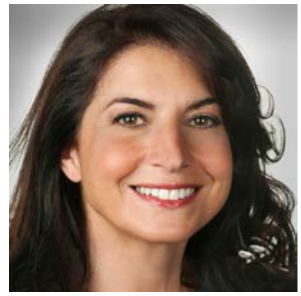
That's Boron Chemistry! Engaging Students in Chemical Research

Timothy B. Clark
Cottrell Scholar 2007
Department of Chemistry, University of San Diego

Abstract: This talk will focus on the chemistry and approach to engaging a diverse group of students in research, from training high school students to postdoctoral research associates, with a significant emphasis on undergraduate students. Challenges and successes of working with this group of students and highlights from the chemical results of organoboron chemistry will be discussed. In particular, the work of metal-catalyzed C-H borylation with amines and phosphines and copper-catalyzed borylation of carbonyls by the Clark group will be showcased.

Bio: Timothy B. Clark earned his BA in Chemistry at the University of San Diego in 2001. He completed his Ph.D with Keith Woerpel at UC Irvine in 2006, followed by a post-doc with Charles Casey at the University of Wisconsin. He joined the faculty at Western Washington University in 2007 and moved back to the University of San Diego in 2011. His teaching and research are focused on the areas of organic and organometallic chemistry. His passion lies in leading undergraduate students to an appreciation for the richness of chemical concepts and inquiry. Tim's research program has been funded by grants from the Research Corporation for Science Advancement, the American Chemical Society–Petroleum Research Fund, and the National Institutes of Health and the National Science Foundation, including an NSF Career award. He has received the Henry Dreyfus Teacher-Scholar Award, the University of San Diego's "University Professor" award, and Undergraduate Research Mentor Award.

DNA Nanostructures: From Design to Biological Function



Hanadi Sleiman
Cottrell Scholar 2002
Department of Chemistry, McGill University

Abstract: DNA is known to us as the molecule of life, the blueprint that defines who we are. But the very properties that make DNA such a reliable molecule for information storage also make it one of the most remarkable building materials. Over the past few years, our research group has taken DNA out of its biological context and has used this molecule to build nanostructures, for applications in biology and materials science. DNA structures can be precisely controlled in size, shape and presentation of molecules on their surface. They can load drug cargo and deliver on demand, in response to specific biological triggers. The applications of these DNA structures as drug delivery vehicles to cancer cells will be described. I will also discuss an initiative to establish a national training program in nucleic acid chemistry, focused on providing complementary skills for graduate students to be workplace-ready: for example, professional skills, entrepreneurial thinking, team management, multi-disciplinary internships, diversity training, and communication skills.

Bio: Hanadi Sleiman is a Professor of Chemistry and Canada Research Chair in DNA Nanoscience at McGill University. She received her Ph.D. from Stanford University, and was a CNRS postdoctoral fellow in Professor Jean-Marie Lehn's laboratory at the Université Louis Pasteur. She joined the faculty at McGill University in 1999, where her research group focuses on using the molecule DNA as a template to assemble nanostructured materials.

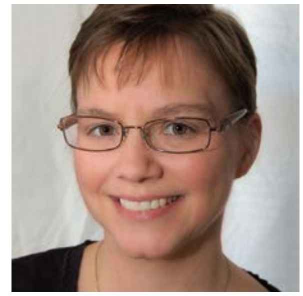
Sleiman is Fellow of the Royal Society of Canada (2016), Associate Editor of J. Am. Chem Soc., and Editorial Advisory Board member of J. Am. Chem. Soc., Chem., J. Org. Chem., and ChemBioChem.

Among her research recognitions are the Killam Research Fellowship (2018), Canadian Society of Chemistry R. U. Lemieux Award (2018), Netherlands Scholar Award in Supramolecular Chemistry (2018), Izatt-Christensen Award in Supramolecular Chemistry (2016), Swiss Chemical Society Lectureship (2012), Canadian Institute of Chemistry E. Gordon Young Award (2011), Canadian Society for Chemistry Strem Award (2009), NSERC Discovery Accelerator (2008), McGill Dawson Award (2004–13), Fellow of the Canadian Institute for Advanced Research (2004–12), and Cottrell Scholar (Research Corp., 2002).

Sleiman received the McGill Principal's Prize (2002) and the Leo Yaffe Award (2005) for Excellence in Teaching.

2021 IMPACT Award Winner

Developing the Next Generation



Penny Beuning
Cottrell Scholar 2009
Department of Chemistry and Chemical Biology, Northeastern University

Abstract: Effective mentoring and professional development can help advance diversity, equity, and inclusion by demystifying academia, providing a sense of belonging, and preparing students, trainees and junior faculty for success. Effective mentoring is also a skill that can be learned. By leveraging national initiatives, we are creating a culture of mentoring on our campus and in our region for students and professionals at all levels. In one example, a series of Future Faculty Workshops for Diversity in STEM fields has reached over 200 graduate students and postdoctoral scholars over three years. We found that Ph.D. students and postdocs greatly benefit from such organized support activities as well as the open discussion of potential challenges of academic careers, and many of these participants have gone on to academic careers. Numerous other formal and informal mentoring programs aim to support students and faculty, including mentor training for faculty and other mentors. This multi-level approach has been effective in bringing about departmental and institutional climate change.

Bio: Dr. Penny Beuning is Professor and Chair of Chemistry and Chemical Biology at Northeastern University. She completed her doctorate at the University of Minnesota in RNA biochemistry and conducted post-doctoral work at MIT in bacterial mutagenesis. Her research aims to determine how cells respond to DNA damage and maintain the accuracy of genetic information. As part of this work, she aims to develop DNA damage tolerance enzymes and DNA repair proteins as tools for biotechnology applications. Her lab also seeks to determine fundamental aspects of enzyme function that can be applied to protein engineering. She is active in the American Chemical Society in the Division of Chemical Toxicology, as well as through service on the Committee on Economic and Professional Affairs and the Graduate Education Advisory Board. She has been the recipient of the Camille and Henry Dreyfus Foundation New Faculty Award, a Cottrell Scholar Award, an American Cancer Society Research Scholar Award, and an NSF CAREER Award. In 2015, she received the Chemical Research in Toxicology Young Investigator Award and in 2020 was named an ACS Fellow.

Cottrell Scholar Collaborative Proposal Writing Rules

Successful proposals should have the potential to positively impact undergraduate and/or graduate science education in the classroom, at the departmental level or at the national level.

→ Up to four $25,000 awards will be given to teams of Cottrell Scholars working collaboratively.

→ Two-year awards are made to a team formed at this conference.

→ Members of the team are active or past Cottrell Scholars.

→ Award could be for a new project that will expand the impact of existing funded collaborative projects. New collaborative projects are also welcome.

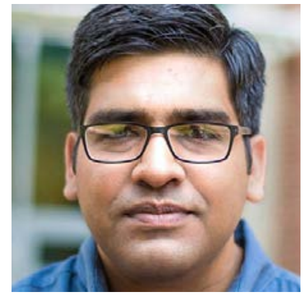
→ Proposal should briefly explain an innovative approach for projects with potentially broad impact.

→ Two-page proposal must be submitted through the RCSA online submission system by the end of the day on **July 26, 2021**.

→ Awards will be announced within a month of submission.

2021 Cottrell Scholars

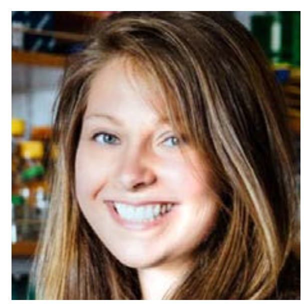
Vinayak Agarwal
Department of Chemistry and Biochemistry, Georgia Institute of Technology



Unlocking Marine Eukaryotic Natural Product Biosynthetic Schemes in Research and Education

Marine sponges, holobionts in which the sponge eukaryotic host is associated with a symbiotic microbiome, are engines for generating small organic molecules called natural products of tremendous diversity and complexity. Specifically, sponge-derived natural products of the pyrrole-imidazole alkaloid class have served as inspirational molecules for synthetic reproduction, facilitating method and catalyst developments along the way. This proposal seeks to access the genetic potential that is locked away in marine sponge holobionts for the construction of pyrrole-imidazole alkaloids. The challenge here is that biosynthesis of these natural products lies not within the microbiome, which can be interrogated using contemporary DNA sequencing and genome mining approaches, but within the eukaryotic sponge host which is impervious to these techniques. To address this challenge, an innovative new precursor-guided transcriptome mining approach is proposed which potentiates the discovery of the very first sponge eukaryote encoded natural product biosynthetic pathway, while also facilitating insight into the enzymatic construction of some of the most intricate natural product scaffolds. Pedagogic innovations proposed herein aim to address curriculum deficiencies in experimental chemical sciences at the host institution, Georgia Tech. The design and implementation of a new laboratory course at Georgia Tech is described which provides hands-on instruction to students in techniques in microbiology and metabolomics. Formative and summative assessment mechanisms have been constructed which includes academic leadership at Georgia Tech as well as an external examiner. Taken together, this proposal will result in new innovations in natural product biosynthesis and educate and train the next generation of scientists.

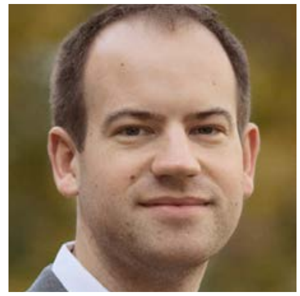
Jeanine Amacher
Department of Chemistry, Western Washington University



Investigating Sortase Enzyme Activity and Specificity Using Natural Sequence Variation and Ancestral Sequence Reconstruction

Bacterial sortase enzymes are powerful tools for use in protein engineering applications, due to their ability to recognize and cleave a sorting signal and then ligate two polypeptide chains together. However, relatively low catalytic efficiency and stringent target recognition limit their uses. Previous work in our lab used computational methods to identify a structurally conserved loop that can greatly enhance enzyme activity, target promiscuity, or both in Class A sortases (SrtA). We also utilized ancestral sequence reconstruction (ASR) to investigate natural sequence variation in SrtA enzymes. Preliminary studies revealed sequences with both reduced and enhanced activity. Our research proposal investigates the contribution of variant loop sequences to the activities and specificities of sortase enzymes in Classes B-F, biologically important proteins that are much less studied than SrtA enzymes, but which may also be important engineering tools. We will also characterize a number of additional ancestral SrtA proteins, and conduct ASR on SrtB enzymes. Our educational proposal addresses two challenges for students at our primarily undergraduate institution. First, we will expand the Life Sciences Symposium, first held in fall of 2019, which introduces our students to near-peer mentoring experiences with regional Ph.D students and postdocs. Second, we will establish an elective course in the Chemistry department that exposes students to faculty members and research labs, in order to ease barriers of an unspoken requirement of student-initiated contact in pursuing undergraduate research experiences. This is an equity, inclusion, and diversity issue, as these unspoken requirements disproportionately affect students from marginalized identities.

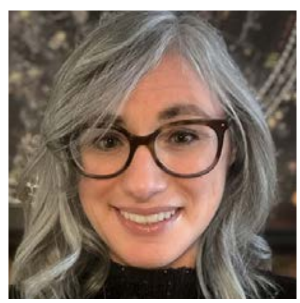
Jeffrey Bandar
Department of Chemistry, Colorado State University



Salt-Promoted Electron Transfer Processes for Reductive Cross-Coupling Reactions

There is a critical need for synthetic methodology that increases access to compounds desired in pharmaceutical, agrochemical, and other applied industries. New approaches to promoting fundamental mechanistic processes often have the largest impact since these strategies can be exploited to address a range of synthetic challenges. The objective of this research proposal is to use Lewis basic salts in combination with silane reagents to promote challenging electron transfer events and thus enable new coupling reactions. It is proposed that this approach can address longstanding challenges in organic chemistry, including development of a unified route for the monoselective C–F bond functionalization of trifluoromethylarenes and metal-free aromatic cross-coupling reactions. The proposed methodology will increase the scope and capabilities of established approaches to coupling reactions, such as transition metal catalysis, photoredox technology and electrochemistry. Modern Organic Chemistry I at Colorado State University (CSU) represents a major success gap for College of Natural Science students, ultimately decreasing the amount and diversity of those who complete STEM degrees. The objective of this educational proposal is to integrate smaller, topical Learning Groups into large organic classes as a way to relate course content to students' individual majors and career aspirations while providing increased peer and professional support. These groups will meet outside of lecture to engage in faculty guided active learning and collaborative work through the lens of their own academic interests. It is proposed that this learner-centered approach will improve motivation, learning, and support to help more students complete STEM degrees at CSU.

Rachel S. Bezanson
Department of Physics and Astronomy, University of Pittsburgh



Building Bridges in the Steel City: Leveraging the Nearby to Follow Galaxies Across Cosmic Time

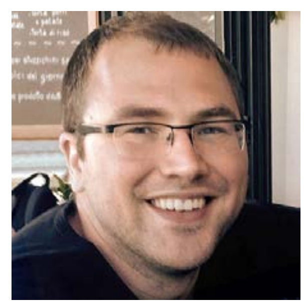
Understanding how galaxies form and grow throughout cosmic time requires simultaneous analysis of a vast array of datasets, from detailed maps of the nearby Universe to glimpses of the youngest galaxies in the distant Universe. For this project, my team will build outwards, leveraging the detailed multidimensional maps of nearby galaxies to simulate current and future observations of galaxies in the distant Universe. By moving the nearby further away, these mock observations will facilitate fair comparisons between diverse datasets to robustly characterize how populations of galaxies evolve through cosmic time and reveal the physical processes driving that evolution. Furthermore, this project will leverage the wealth of existing data to prepare for future observations, like those provided by the James Webb Space Telescope, to optimize community use of this invaluable, but limited resource. In a parallel effort, I will build stronger interpersonal bridges, rethinking undergraduate and graduate student mentoring and bolstering the nascent APS Bridge Program within the Physics and Astronomy Department at the University of Pittsburgh. Through these combined efforts, we will recruit a strong cohort to significantly increase the number of Physics degrees awarded to students from underrepresented minority groups and create a strong mentoring framework to support and launch their professional careers.

Laura Blecha
Department of Physics, University of Florida

The Making of a Gravitational Wave Source: Probing the Role of Galaxy Assembly in Black Hole Binary and Triple Formation

Our synergistic proposals will advance research and education goals in computational physics, including gravitational wave (GW) source predictions and new opportunities in research computing for underrepresented minority (URM) high school and undergraduate students. LIGO detections have opened the GW universe, and we are now on the cusp of the next frontier: supermassive black hole (BH) binaries may soon be detected at nHz to mHz frequencies by pulsar timing arrays and LISA. However, we still lack robust theoretical models that illustrate how observables can distinguish between BH formation and evolution channels. We propose to address a crucial knowledge gap in this area: How does the formation of BH multiples and GW sources depend on galaxy assembly? We will use a suite of cosmological and galactic-scale simulations, currently in development with the AREPO magnetohydrodynamics code. For the first time, we bring together (i) a cutting-edge galaxy formation model (SMUGGLE) for a self-regulated, multiphase ISM and (ii) a novel method that will enable us to resolve the Bondi accretion radius around multiple BHs. We will calculate BH binary formation timescales in the dynamical friction phase, identify where triple BH systems are most likely to form, and constrain their impact on GW sources. We will also expand the UF Gator Computing Program into a residential summer program for URM high school students, and we will implement a Computational Physics curriculum for UF undergraduates. URM students will be recruited from the summer program and the physics course to conduct research in my group.

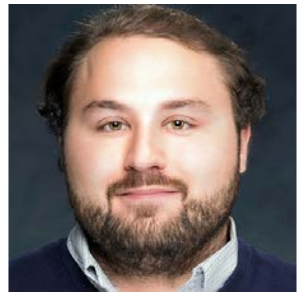
Justin R. Caram
Department of Chemistry and Biochemistry,
University of California, Los Angeles



Chemical Physics Informed Design of SWIR Emissive Molecules

The design of shortwave infrared (1000-2000 nm) fluorescent molecules represents a foundational challenge for chemists, that if achieved may open many exciting applications. To design such chromophore systems requires a detailed understanding of the fate of photoexcitation and methods to systematically design brighter, more emissive species. This proposal aims to study how to mitigate non-radiative decay pathways while enhancing radiative pathways, through the design of the local vibronic and photonic environment. The PI also proposes new methods to enhance undergraduate chemical education through the design of an enhanced nonmajor's general chemistry course that replaces remedial chemistry, through the use of intensive peer learning.

Joel F. Destino
Department of Chemistry, Creighton University

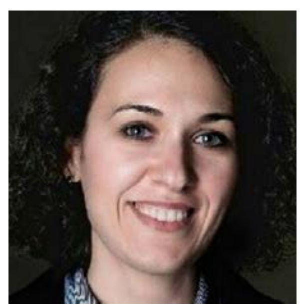


Bottoms Up: Investigating the Growth and Glass-Forming Properties of Germania-Containing Colloids

Conventional melt quench processes limit glass and optical system design but are poised for a fundamental paradigm shift as chemistry takes center stage. Bottom-up sol-gel chemistry creates new design space, including the advancement of additively manufactured (AM) glass materials. Amorphous sol-gel-derived silica colloids and their glass-forming properties have been studied for decades. Germania, germanium dioxide, is an excellent glass former by traditional melt quench methods like its northern neighbor on the periodic table, silicon as silica. However, stable sol-gel-derived amorphous germania is challenging to synthesize, inhibiting its use in preparing glass from the bottom up. The proposed research asks the question: what underlying chemistry drives amorphous sol-gel germania colloid growth and subsequent crystallization? Mechanistic insights gleaned will facilitate the design and synthesis of stable amorphous germania colloids, enabling us to study a second research question; how do germania-silica colloid structure and morphology influence their glass-forming properties?

The educational component of this proposal addresses three barriers that insulate chemistry from the real world. The first aim tackles physical boundaries between chemistry laboratories and our everyday lives through the development and implementation of hands-on, at-home laboratory experiments. The second aim proposes new analytical chemistry curricula that remove conceptual barriers that decouple chemistry from social justice and inequity issues. The third aim addresses equity and opportunity in chemistry research by developing and implementing a sustainable recruitment, training, and mentorship program to serve first-generation and underrepresented high school and undergraduate researchers building on the PI's journey from first-generation college graduate to a faculty position.

Daniela Fera
Department of Chemistry and Biochemistry, Swarthmore College

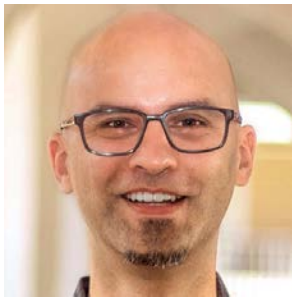


Dissecting the Interactions and Conformations of Protein Kinases to Understand Biochemical Signaling

Protein kinases act as molecular on/off switches in the cell. Their functions vary from controlling cell growth to controlling immune responses. The proposed research will engage undergraduate research and upper-level biochemistry laboratory course students in the study of a protein kinase, called Lyn, which is critical in B-cell development and activation. B cells are the specialized cells that produce antibodies in the human body. Lyn mediates signaling pathways in B cells that differentiate the production of antibodies against foreign antigens as desired, versus "self" which would lead to autoimmunity. A detailed atomic-level picture of how Lyn is regulated or how it interacts with other proteins is not yet available and would be important for understanding how B cells produce antibodies against the correct targets. The proposed research will involve performing a molecular "dissection" of Lyn, using standard biochemistry and specialized biophysical and structural biology approaches, to understand important interactions and structural features within Lyn and their effects on activity. These studies will provide a proof-of-concept for studying other kinases and their complexes and help us better understand the fundamental principles of signaling. This work has implications in understanding how B cells behave when faced with pathogens, and pave the way for learning what causes autoimmune disease. Through this work, research, and course students will engage in authentic research, gain skills that will help them in future scientific endeavors, and make important contributions to science. Results from this work will be published and disseminated, thereby expanding the impact beyond Swarthmore College.in organic chemistry class to pursue STEM careers by introducing real-life application-based interactive learning modules in an active learning class; (3) inspiring students of all backgrounds to consider chemistry and STEM career paths by offering a 3D printing workshop with a focus on interdisciplinary collaboration with a culture of inclusion.

2021 Cottrell Scholars Continued

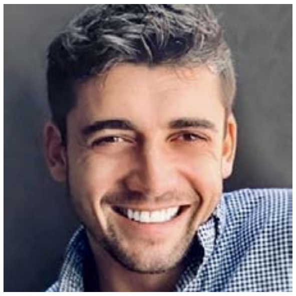
Alex Frañó
Department of Physics, University of California, San Diego



Creating Artificial Angstrom-scale Periodic Potentials Using X-ray Standing Waves and Enhancing Creativity in Physics Education

The physics of solids and their band structures are governed by a simple yet profound principle: electrons are in a spatially periodic potential. Means of controlling the shape and spacing of the potential could render a new era in condensed matter physics, where arbitrary band structures could be designed. Interfering laser beams forming optical lattices produce such periodic potentials, but their wavelength is too large for electrons. The objective of this proposal is to create an analogous lattice using x-ray beams that modify electrons at the Angstrom scale. Using x-ray standing waves and modern x-ray free-electron lasers, we will design an experiment in which electrons inside a metal will be exposed to a periodic potential and thus open gaps at certain momenta values of their Fermi surface. If successful, this ground-breaking experiment will render a new paradigm in which electronic band structures can be created with arbitrary periodicities and shapes. In the education plan, we intend to develop new classroom teaching and grade assessment techniques that enhance the role cognitive creativity in physics. Our current approach to undergraduate physics education is too narrowly focused on solving textbook problems and does not cultivate the creative process involved in actual research. The methods we will develop to enhance creativity will be published in a peer-reviewed article, with particular focus on a new format for a graduate admissions test. This approach will give students from underrepresented gender and socioeconomic groups a chance to display skills that our current approach is prone to ignore.

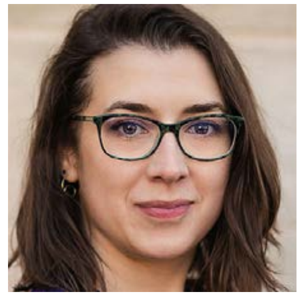
Thomas L. Gianetti
Department of Chemistry and Biochemistry, The University of Arizona



Developing a Photo-Rechargeable and Symmetrical Organic Redox Flow Battery

Technological advances progressively allow society to transition to sustainable sources of energy; however, efficient batteries to store and redistribute electricity remains a key challenge. Recently, redox flow batteries (RFBs) have gained considerable focus to solve transient energy grid-level storage. In RFBs, energy stores in liquid electrolyte solutions in an electrochemical cell. While vanadium-based RFBs and other metal-based electrolytes have successfully shown high durability, they have high toxicity and cost issues. In contrast, redox-active organic materials are an attractive alternative for low-cost and large-scale RFBs thanks to sustainable, synthetically tunable, and inexpensive raw materials. As a Cottrell Scholar, my overarching research goals are to: 1) synthesize new carbenium-based electrolytes with high electrochemical features; 2) develop carbenium-based organic RFBs prototypes with high energetic density and high cyclability that are symmetrical to avoid cross-contamination and chargeable regardless of the current direction; and 3) create the first photo-rechargeable organic RFB. My overarching educational goal is to enhance communication between scientists and policymakers who advance public policy, through a new community of undergraduate students with the skills to fully contribute to the policy process. As a Cottrell Scholar, I will expand and enhance a pilot curriculum at the University of Arizona for a larger community of students with classes of up to 50 undergraduates. With more instructors, the plan is two or three sections per semester. The ultimate goal is to offer this class to 100–200 students per year in a model readily translatable to other higher education institutes.

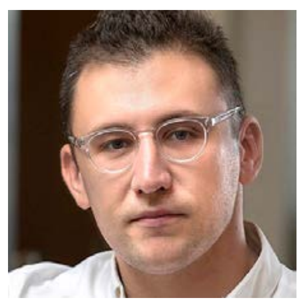
Natalie Gosnell
Department of Physics, Colorado College



Constraining the Complexities of Stellar Activity with Sub-Subgiant Stars

Our understanding of stellar evolution is the foundation of modern astrophysics, built upon a rich interplay between observational studies and theoretical models. As our knowledge of stellar evolution unfolds, the complexities introduced by magnetic stellar activity become more apparent. One example is seen in sub-subgiants, magnetically active stars with starspots that sit below the subgiant branch and red of the main sequence. Starspot covering fractions, a helpful proxy for stellar activity, are predicted in models but are difficult to constrain observationally. With the advent of Gaia and TESS, we can now identify a population of field subsubgiants to serve as a key observational sample for model comparisons. In this research proposal, we will constrain starspot covering fractions for these field sub-subgiants using a novel spectral decomposition and light curve analysis. The results will anchor surface conditions of active stellar models, allowing us to test interior structure parameterizations. This work is an important step in advancing magnetically active stellar models to bring in the next era of stellar astrophysics. The educational proposal addresses a lack of retention of underrepresented students in undergraduate Physics through developing innovative embedded creativity exercises within the introductory physics sequence. This creativity curriculum is designed as an intervention to acknowledge creative processes as an important aspect of a student's physics identity, reduce isolation and increase belongingness, and provide new ways to engage with subject material that reinforces foundational knowledge—all factors that are linked to positive classroom culture as well as student persistence and resilience in Physics.

Christopher H. Hendon
Department of Chemistry, University of Oregon



Inorganic Eefects in Metal-organic Frameworks

The research goal of this proposal is to examine the electronic properties arising from inorganic defects in metalorganic frameworks, a family of materials composed of organic linkers supporting Earth-abundant metal clusters. Using a computational approach borrowed from conventional semiconductor physics, we will elucidate the emergent properties of vacancies and adatoms at the inorganic anion sites in these clusters. This work will provide a foundational understanding of how inorganic defects can be used to access unusual metal oxidation states and novel local coordination environments—key design principles for catalyst development. The methods and tools developed herein will more broadly enable defect simulations in molecular solid-state materials. The educational goal of this proposal is to develop a comprehensive online General Chemistry laboratory course, to be performed using homemade analytical tools—a spectrometer and electrochemical cell, in addition to a simple titration kit. The class will minimize both risk and cost, thereby enhancing access to tertiary level education, while removing the limitations imposed by conventional in-person General Chemistry practical classes. To do so, the PI will leverage his extensive work in the coffee industry—who already have these devices—to develop a coffee-related fundamental science curriculum. While this objective will immediately increase scientific literacy in the public, it will also yield an exciting curriculum that will lay the foundation for a Freshman level remote laboratory classes. The content will then be expanded and globally offered via open-source distribution, and the educational platform will be implemented at the freshman level at UO and beyondcourse at the University of Michigan.

2021 Cottrell Scholars Continued

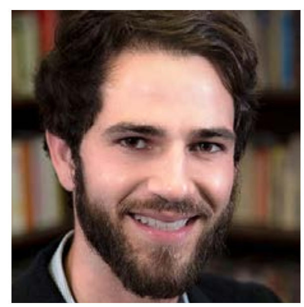
Alexis C. Komor
Department of Chemistry and Biochemistry, University of California, San Diego

Harnessing Precision Genome Editing Tools to Study DNA Repair Proteins in Live Cells

Research abstract: DNA repair is a fundamental process that is necessary for all life on earth; as such, a deep mechanistic understanding of how DNA repair proteins function to recognize and repair different types of DNA damage is of fundamental importance to researchers. Mechanistically elucidating the molecular details of how mutant DNA repair proteins differ from wild-type have significantly expanded our basic knowledge of how DNA repair operates, but several key barriers have resulting in researchers failing to carry out these types of studies in physiologically relevant contexts. Our research program seeks to leverage our expertise in genome editing, nucleic acid chemistry, and chemical biology to study mutant DNA repair proteins in high-throughput in their native environment of the cell, without resorting to overexpression systems.

Educational abstract: Genome editing is a highly impactful, quickly burgeoning field that has applications in a broad range of scientific disciplines. The field has expanded so rapidly that University curricula have not kept pace, despite a pressing need to provide our students with courses that educate them on how to use these technologies responsibly and effectively in their own research projects. Here I propose the implementation and optimization of UCSD's first genome editing course that teaches the subject matter using a combined theoretical and practical approach to build student knowledge from the ground up, with the ultimate goal of equipping students with the requisite knowledge to design their own editing experiments (including generating construct maps) and appropriately analyze the data from these experiments.

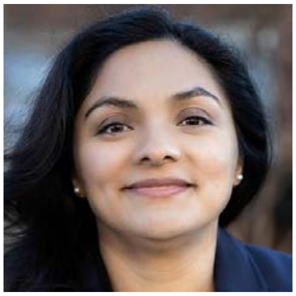
Eli M. Levenson-Falk
Department of Physics and Astronomy, University of Southern California



Creating Custom Quantum Environments with Superconducting Circuits (For Beginners)

Experimental physicists have now developed practical quantum information technologies, harnessing quantum effects for sensing, simulation, and computing. Theorists have developed powerful descriptions of open quantum systems and many-body quantum mechanics. However, to date many of these theories remain untested. Most hardware research has focused on using purely classical control fields, which may be insufficient to realize the quantum environments described by theory. I propose a research program to develop a toolkit for implementing truly quantum environments in superconducting quantum circuits and to use this toolkit to test open quantum systems theories. The experiments I propose include tunable couplings to coherent and incoherent sources of noise, engineering non-Markovian and non-Hermitian Hamiltonians, studying measurement as a quantum resource, and ultimately using these tools to test proposals for enhancing quantum process fidelity. As the QIS field grows, so too does the technical knowledge required to begin research. This barrier to entry drives away many talented students, especially those who are minoritized in physics. It is thus essential both to integrate QIS research into the classroom and to provide effective avenues for self-study. As part of this project, I will develop QuBytes—a "quantum information readers' digest"—to provide readable, undergraduate-level summaries of QIS journal articles. I will use the reading and writing of these summaries as components of my undergraduate quantum mechanics and graduate quantum devices courses. And, in collaboration with education researchers, I will study how QuBytes helps its readers and writers develop QIS knowledge and general journal-reading techniques.

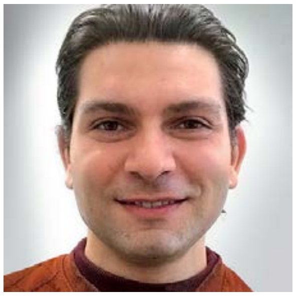
Rosario Porras-Aguilar
Department of Physics and Optics, University of North Carolina at Charlotte



Label-Free Reconfigurable Microscopy with High Specificity

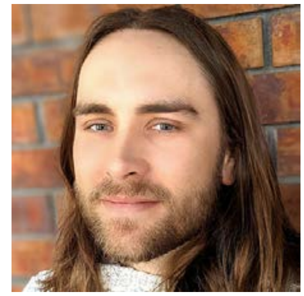
This project addresses the critical need for a smart, reconfigurable imaging system that provides information with quantitative attributes, high-specificity, and selectivity of spatial frequency content. Focused on a non-invasive method to study objects with low visibility (transparent and small area compared to the field of view), this approach leverages smart optical materials and wavefront shaping algorithms to extend the frontier of nonlinear imaging systems. Results are expected to overcome signal-to-noise ratio limitations, provide active and featured selectivity of object's visibility, and provide accurate 3D measurements. The research objectives are to 1) derive a mathematical framework for wavefront shaping techniques and verify that the visibility of mid-spatial frequencies can be enhanced; 2) extend the current phase-contrast theory to feature spatial frequency content ("smart imaging"); and 3) calibrate and verify phase-shifting algorithms using smart optical materials for selective 3D visualization ("smart metrology"). Results can significantly impact areas such as microbiology, quantitative pathology, and ultra-precision manufacturing. The educational plan includes opportunities for students at multilevel of education. For example, hands-on experiences in physics and photonics for high-school students, and teaching strategies to foster talent in undergraduates, especially those from groups traditionally underrepresented in higher education. The outreach plan includes specific components designed to make STEM education more inclusive and diverse, especially focusing on Hispanics and women, including outreach to Hispanic-serving high schools in North Carolina. Specific efforts are included to recruit Hispanic and women students to the graduate program in Physics and Optical Sciences at the University of North Carolina at Charlotte.

Davit Potoyan
Department of Chemistry, Iowa State University



Uncovering Principles of Biomolecular Condensation: from Single Molecules to Cellular Organelles

The phase-separation of partially or wholly disordered biomolecules has recently emerged as a fundamental mechanism underlying the intracellular order and regulation in eukaryotic cells. A significant knowledge gap in the field is understanding how the sequence of disordered proteins and nucleic acids encodes the observed mesoscopic phases. Eliminating this knowledge gap will open the doors for designing novel therapeutic and synthetic applications. A significant bottleneck for overcoming the knowledge gap is the absence of appropriate multi-scale computational tools as well as open-source community databases. To this end, I propose a broad research program with three aims: (1) creating a centralized database containing biophysical characteristics and machine learning tools for modeling phase-separating proteins; (2) Using multi-resolution molecular models for simulating protein-RNA condensation; and (3) using liquid resolution continuum and reaction-diffusion based models to study organelle formation from protein-RNA condensation at mesoscopic scales. In addition to the research program, I propose a major modernizing initiative called JuPChem, which aims to reconstruct undergraduate chemistry curriculum through living lecture notes, an open-source, interactive web-based documents based on project Jupyter and its educational ecosystem. Living lecture notes enhance the chemistry majors' comprehension of quantitative and mathematical concepts and connect students to real-world chemical data, computing, and visualization. The proposal builds upon a number of innovations coming from other disciplines combined with PI's own in-classroom implementations. The expected outcome is that interactive lecture notes will increase student learning by showing them the power, utility, and beauty of seemingly abstract mathematical and quantitative tools in P-Chem textbooks.



Tyler D. Robinson

Department of Astronomy and Planetary Science, Northern Arizona University

Understanding the True Utility of Prior Mass Constraints in Characterizing Exoplanet Atmospheres and Diversifying STEM at NAU

Current, wide-spread thinking states that prior constraints on exoplanet masses are required to interpret spectral features for these worlds—especially for the Earth-like exoplanets that are the primary targets of future reflected light exoplanet direct imaging mission concepts. However, the impact of mass priors on atmospheric characterization of directly imaged exoplanets has seen no detailed study. Furthermore, preliminary results shown in this proposal indicate the opposite of current thinking—at least for Earth-like exoplanets. Specifically, it now appears that mass priors have extremely limited impact on the atmospheric characterization of exo-Earths in reflected light. Given this surprising result, I propose to—for the first time ever—explore the true utility of prior mass constraints in characterizing a diversity of exoplanet atmospheres in reflected light. These investigations will take advantage of in-hand, novel, validated planetary atmospheric characterization and retrieval tools. A key result of these efforts will be a much-needed study that details how increased spectroscopic signal-to-noise ratios could be exchanged for decreased prior mass uncertainty, potentially substantially reducing survey duration and/or required instrument precision for precursor mass observations conducted with radial velocity techniques. Alongside this work, I also propose to: (1) build a new and sustainable bridge to Northern Arizona University's existing Louis Stokes Alliance for Minority Participation program to enable effective research training for underrepresented minority students; (2) study the impact of interdisciplinarity on undergraduate learning and performance; and (3) study and popularize much-needed career training elements of graduate coursework.

Brian J. Shuve

Department of Physics, Harvey Mudd College

Matter-Antimatter Asymmetry from Dark Matter Freeze-In

The origin of the matter-antimatter asymmetry and the nature of dark matter are among the most important unanswered questions in particle physics. For my research proposal, I will undertake a comprehensive study of freeze-in baryogenesis through dark matter oscillations, a recently proposed framework for baryogenesis and dark matter production at the electroweak scale that gives concrete, testable phenomenological predictions. The initial study was of a single model with a particular coupling to quarks; I propose to significantly broaden our understanding of these scenarios by developing models where the asymmetry is instead produced in leptons, Higgs fields, and via ultraviolet freeze-in. This will allow a fuller determination of the viability and phenomenology of freeze-in baryogenesis. For my educational project, I will develop a set of interactive simulation applets and associated curricular materials for the Harvey Mudd College Junior-level Theoretical Mechanics course. The concepts in this class are more abstract and removed from the physical reasoning of introductory coursework. The applets will focus on the most conceptually challenging aspects of the course material, including building intuition for the Principle of Least Action and the machinery of Lagrangian Mechanics, central-force motion, coupled oscillators, rigidbody dynamics, and Hamiltonian mechanics. The applets are designed to allow students to visualize and explore the connections between abstract concepts and the more familiar Cartesian forces and momenta. This project will incorporate current physics education research of engaged exploration simulations and active learning into Theoretical Mechanics, aiming to improve learning outcomes and student satisfaction, especially for under-represented students.

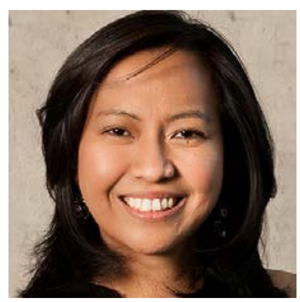
Marcelle Soares-Santos
Department of Physics, University of Michigan

Cosmology with Merging Black Holes and Neutron Stars

Research: We propose to establish a cosmology program to perform precise and accurate measurements of the rate of expansion of the Universe using mergers of binary neutron stars and black holes. We will use data from the DESI and LSST sky surveys and from the gravitational wave detectors LIGO, Virgo, and KAGRA. Previously, the PI led the DESGW project, a precursor program that ran three successful observing campaigns using the DES camera. DESGW's most prominent results include the groundbreaking discovery of GW170817, the first neutron star merger ever observed, and the first cosmology measurement using a black hole merger. This new proposed program will greatly expand the sample of mergers. Our results will shed light upon the issue of discrepant measurements from traditional methods such as supernovae and the cosmic microwave background, a key problem in modern cosmology.

Education: The experience shared widely by the academic community since the COVID-19 pandemic is that, compared to traditional settings, virtual teaching takes more work, is less engaging, undermines assessment, and exacerbates inequities. Improving upon this negative experience is a priority goal of our department at the University of Michigan. We propose to implement a virtual reality educational application aiming at achieving that goal. As online teaching and learning will likely continue to be part of our reality for the foreseeable future, a solution to the specific challenges of online learning will be of great value to our community.

Ruby May A. Sullan
Department Physical and Environmental Sciences,
University of Toronto Scarborough



Multifunctional and Stimuli-Responsive Nanotherapeutic Platform for Targeted Disruption of Bacterial Biofilms

The rise of pathogens increasingly resistant to all known antibiotics is an alarming and pressing global problem. Strong evidence points to the critical role of biofilms in the development of antimicrobial resistance. Behind this growing concern is the ineffectiveness of conventional antibiotic-only-based therapies to eradicate or control recalcitrant biofilms. My Cottrell research proposal seeks to engineer a novel antimicrobial platform with (1) multiple and highly synergistic modes of bactericidal mechanisms; (2) precision targeting of pathogens; and (3) stimuliresponsive bactericidal activity all combined into one polydopamine nanoparticle-based nanotherapeutic (PdNP-NT). By combining these multifunctional and coordinated biocidal mechanisms, along with the biocompatibility of polydopamine nanoparticles, the resulting PdNP-NT is a promising new technology to control biofilm related infections. Results of our mechanistic study on biofilm-nanotherapeutic interactions, at the single cell and single-nanoparticle levels, is also poised to provide design principles that could launch novel and critical technologies towards precision therapeutics. My Cottrell educational proposal draws upon my teaching/mentoring/research experience and aims to develop two platforms, research-based learning and community-based learning, which collectively tackles aspects of our departmental and campus educational priorities. A common thread in my proposed set of initiatives is to provide students with a transformative and experiential learning opportunities while at the same time contributing to timely issues on underrepresentation, gender disparity, and achievement gaps in STEM, with a focus on Chemistry.

Alexandra Velian

Department of Chemistry, University of Washington

Synthesis of Functional Metal Chalcogenide Lattices Using Symmetry-Encoded, Atomically Precise Clusters

Empirically developed, traditional heterogeneous catalysts are ill-defined and energy inefficient. Single atom catalysts are poised to overcome existential limitations of traditional catalysts and promise solutions to environmentally relevant catalytic sequences of global importance. Our research addresses one of the main limitations of single atom catalysts, their synthesis. Specifically, our group seeks to develop methods broadly applicable to the synthesis of conductive, high-surface area and scalable atomically defined materials with pre-encoded, low-coordinate single atom active sites. Our strategy relies on the use of symmetry-encoded, designer building blocks prepared via the surface functionalization of metal chalcogenide clusters with transition metals. This project is focused on elucidating the origin of an unusual redox-switchable, allosteric site-differentiation of edge sites in designer transition metal chalcogenide nanoclusters introduced by our group, and harnessing it to guide reactivity of edge sites, and dimensionality of self-assembled lattices. This work will enable our long-term research goal of creating deterministic and modular syntheses for single atom catalysts. Active learning and involvement in research are two strategies demonstrated to narrow the achievement gap and increase retention of underserved students in STEM. Our educational plan integrates mentorship components, engagement in research, immersion into the scientific community at UW, as well as implementation of active learning principles in science teaching designed to reduce achievement gaps, promote equity.

Rongsheng (Ross) Wang

Department of Chemistry, Temple University

A Fluorine Displacement Based Bioorthogonal Labeling Approach to Interrogate Non-Histone Substrates of “Histone” Deacetylases

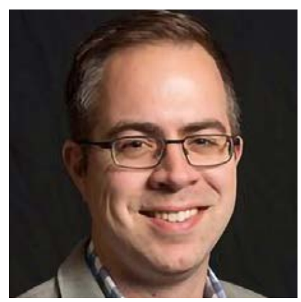
“Histone” deacetylases (HDACs) have been long observed to mediate cellular homeostasis and regulate diverse cellular processes such as activation, proliferation, and migration, through the modulation of acetylation, a typical post-translational modification. Increasing evidence has recently emerged pinpointing the pivotal roles of nonhistone HDAC substrates in these events, yet remarkably little is known about their identity and the involved signaling networks, due to the lack of an efficient and broadly applicable research tool. My group seeks to understand these non-histone substrates by inventing fluorine-displacement based bioorthogonal chemical labeling reactions that are less sterically hindered than the traditionally-used azide-alkyne cycloaddition, and can occur efficiently in physiological solutions for a more sensitive target detection than antibody-based immunointeraction. We are using these reactions to tag cellular substrates of specific HDAC isoforms through the hijacking of the acetylation pathway, and are exploring cutting-edge techniques in cell biology to characterize these protein substrates and interrogate their roles in cell motility and immune responses. This novel approach will further our understanding of the impact of deacetylation on fundamental cellular events and the related human diseases in the long run. Concurrently, we are incorporating the deacetylation research based on the aforementioned bioorthogonal labeling into a second-year undergraduate laboratory course. This research-based active learning experience will expose early year students to the design and utilization of chemistry probes to answer biologically important questions, which, coupled with the near-peer mentoring system established in parallel, will have profound impact on the retention and recruitment of students interested in interdisciplinary STEM fields.

Leah Witus
Department of Chemistry, Macalester College

Investigation of β-Hairpin Hydrolytic Peptides and Development of an Advanced Undergraduate Scientific Communication Course

Peptide catalysts have many practical applications in addition to providing important model systems for understanding enzymatic catalysis. β-hairpin peptides can be used to spatially orient reactive groups; however, there remains a need to more fully explore their sequence-catalytic activity relationship to design β-hairpin catalysts for important reactions and applications. We propose to address this gap by investigating the effects of turn residues, cross-strand interactions, and reactive dyad positioning on β-hairpin ester hydrolysis catalysts. These studies will increase fundamental knowledge about catalytic peptide design and will help us and others apply the design principles learned from this work to interesting and important substrates. This proposal also includes an educational plan that addresses the pressing need to train scientists as ethical and effective communicators within the profession, and as leaders for the broader public, through the development of a Macalester College course entitled 'Scientific Communication for Chemists.' This course will give students the opportunity to gain training in professional and public scientific communication by dedicating course time to the particular conventions, challenges, and opportunities of communicating as a scientist.

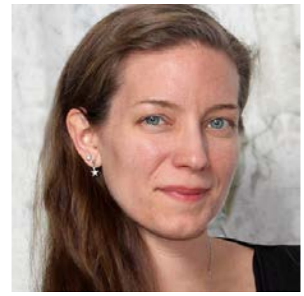
Joseph M. Zadrozny
Department of Chemistry, Colorado State University



Harnessing Ligand-Shell Nuclear Spins to Control Molecular Spin Coherence

Electron spin coherence is a fundamentally quantum property of open-shell molecules that is vital to applications like quantum computing, information storage, and designing novel magnetic resonance bioimaging agents. Spin coherence arises when spins exist as in a fragile quantum superposition of two orientations. Designing long-lived superpositions is a critical challenge for future applications, as environmental magnetic noise, which is nearly ubiquitous, rapidly destroys spin. Hence, sources of environmental magnetism, e.g. magnetic nuclei, are avoided in molecular design. The scientific segment of this work hypothesizes that specific classes or arrangements of these environmental nuclei, which have not yet been explored in detail, will protect the superpositions of open-shell molecules. We propose two sets of experiments to test this hypothesis. The educational focus of this proposal is to integrate the undergraduate inorganic laboratory course with the graduate inorganic physical methods track. The effort will enable lessons at the cutting edge of modern inorganic chemistry, which would otherwise be too advanced for a standard undergraduate inorganic curriculum. Second, it will provide effective physical-methods characterization and analysis training for incoming graduate students, which will prove invaluable for future progress in their Ph.D thesis studies. The effort will further foster "soft" (yet vital) skills like mentoring and educating undergraduates in advanced concepts, building proficiency in scientific communication. In doing so, the semester-long teaching structure produced by the proposed work will enable these outcomes and produce valuable and impactful outcomes to chemistry students at CSU at both the graduate and undergraduate levels.

Gail Zasowski
Department of Physics and Astronomy, University of Utah



Understanding the Chemical Enrichment of Our Universe: Unifying Evidence from the Milky Way and Other Galaxies

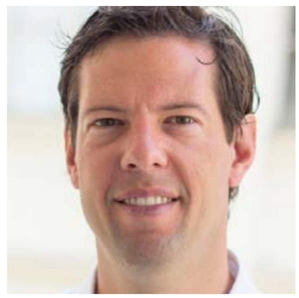
Every hydrogen atom on Earth has its origins in the primordial soup of plasma and radiation that followed the Big Bang. The other 99.5% of Earth's mass comprises atoms forged in generations of stars over billions of years. This same "stardust" governs most of the Universe's observable phenomena, from galactic superclusters to cells here on Earth. The key to understanding the Universe's evolution, then, is how it has been enriched in these heavy elements by stars and gas in galaxies. Most of the Universe's 1020 stars live in galaxies like our own Milky Way, but the Milky Way is the only one of these systems we can study in high definition. In the proposed research program, we will study both the Milky Way and Milky Way-like galaxies, targeting how and when the Milky Way's stars enriched our own Galaxy, how we can use these data to better understand other galaxies, and what other galaxies tell us about the Milky Way. By connecting the Milky Way's stars, dust, and gas to those in similar systems, we will constrain galaxy enrichment on scales that are simply unresolvable throughout most of the Universe. For this proposal's educational component, we will develop a peer-mentoring and peer-teaching network for our department's undergraduate community. This network will provide students with both academic and psychosocial support from faculty, staff, and especially their peers. These activities will enhance positive science identities, success in and out of the classroom, and a strong sense of belonging for all students.

Juliane Simmchen

Department of Physical Chemistry, Technical University of Dresden

Unraveling the Influence of Activity in the Formation of Matter

Active matter has developed into an active and exciting field of research, and it is posing challenges to the interdisciplinary community working on it. One of these challenges is image analysis and data handlin, which are frequently taught in depth in physics but somewhat neglected in chemistry. This proposal joins cutting-edge active matter research and builds the opportunity for students to improve on their computational skills.



Simon Stellmer

Department of Physics and Astronomy, University of Bonn

A Passive Ring Laser Gyroscope to Measure the Rotation of Earth

The rotation of Earth is not at all constant: on the contrary, its temporal variations treasure a wealth of information for fields as diverse as astronomy and geodesy, and is affected by the anthropogenic climate change. The Earth's rotation parameters are commonly determined through astronomical observations (VLBI). This technique, however, lacks short-term temporal resolution and is insensitive to perturbations induced by the Earth's tides. We have set up an international collaboration to explore passive ring laser gyroscopes to drastically increase measurement sensitivity. We will fuse technologies from active ring lasers and optical clocks, thereby putting experience with high-precision quantum technology to use in the field of geodesy. This interdisciplinary endeavor already involves a dozen research groups and has the potential to impact various fields of science.

In this project, we will set up a miniature version of the envisioned gyroscope, to serve for training purposes and technology development of the collaboration. It will become part of the Advanced Lab Courses at both the Physics and Geodesy departments at the University of Bonn, thereby fostering interdisciplinary research already at the bachelor and master level. Following Humboldt's ideal, top-notch research and teaching will be interweaved in a single experiment. Experimental control and data acquisition will be made fully accessible online, such that students and researchers world-wide, and even high-school students, can operate the experiment remotely. This timely approach responds to the COVID-19 pandemic, and allows us to establish international partnerships with universities in the Global South for integrated lab courses.

Conference Participants

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Glass research, property and structural characterization. Love doing research with undergraduate students.

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School of Chemistry and Biochemistry, Georgia Institute of Technology
Natural products are the language of life. Vinny is unlocking the genetic potential in marine invertebrates to synthesize natural products. Curriculum innovation at Georgia Tech is providing undergraduates with hands on interdisciplinary training in multi-omic technologies.

Jeanine Amacher CS 2021
amachej@wwu.edu
Department of Chemistry, Western Washington University
Deciphering the selectivity determinants of target recognition in peptide-binding domains using biochemistry and structural biology. Facilitating near-peer mentoring opportunities and equal access to research for students at our primarily undergraduate institution.

Robbyn Anand CS 2019
rkanand@iastate.edu
Department of Chemistry, Iowa State University
We broaden access to diagnostics by developing electrochemical and electrokinetic methods that can be implemented with limited resources. We teach core chemistry concepts through the lens of electrochemistry to increase fluency in and familiarity with electrochemical concepts.

John Antos CS 2016
antosj@wwu.edu
Department Chemistry, Western Washington University
Protein engineering and sortase-mediated protein modification. We teach core chemistry concepts through the lens of electrochemistry to increase fluency in and familiarity with electrochemical concepts.

Shane Ardo CS 2017
ardo@uci.edu
Department of Chemistry, University of California Irvine
Controlling rates of proton transfer for protonic solar cells, diodes, ion-exchange membranes, and oceanic carbon capture. New STEM pipeline model to grow undergrad research at minority-serving institutions via collaboration, personnel exchange and online training.

Jeff Bandar CS 2021
jeff.bandar@colostate.edu
Department of Chemistry, Colorado State University
My research group develops base-promoted synthetic methodology, including new ways to engage strong C–F bonds in coupling reactions. I am creating new content and activities for undergraduate organic chemistry courses to help motivate students with diverse interests.

Sarbajit Banerjee CS 2010
banerjee@chem.tamu.edu
Department of Chemistry, Texas A&M University
Solid-state chemistry, electronic structure, metastable solids, energy storage. Diversity, equity, and inclusion; first-year chemistry; mentoring networks.

Conference Participants Continued

Robert Berger CS 2017
bergerr@wwu.edu
Department of Chemistry,
Western Washington University
I study relationships between crystal and electronic structure in solids. This often involves DFT calculations of perovskite materials. I aim to blend conceptual and equation-based learning in a flipped undergraduate physical chemistry classroom.

Penny Beuning CS 2009
beuning@neu.edu
Department of Chemistry,
Northeastern University
DNA damage responses, DNA metabolism, and protein engineering, with applications in cancer, antibiotic resistance, and forensic science. Interested in CUREs, undergraduate early research, active learning, professional development, and mentoring.

Rachel Bezanson CS 2021
rachel.bezanson@pitt.edu
Department of Physics and Astronomy,
University of Pittsburgh
Observational studies of massive galaxies throughout cosmic time. Strengthening undergraduate and graduate student mentoring and bolstering the APS Bridge Program at the University of Pittsburgh.

Connor Bischak Cottrell Fellow
connorb@uw.edu
Department of Chemistry,
University of Washington
Uncovering new design principles in energy and healthcare materials through nanoscale observations of materials dynamics. Interested in integrating hands-on data science approaches into the science curriculum.

Karen Bjorkman CS 1999
karen.bjorkman@utoledo.edu
Office of the Provost and
Department of Physics and Astronomy,
University of Toledo
Focus on circumstellar disks, variable stars, and spectropolarimetry. STEM education, student engagement and student success, women in STEM, science and public engagement.

Laura Blecha CS 2021
lblecha@ufl.edu
Department of Physics, University of Florida
I study how the evolution of supermassive black holes impacts their host galaxies and leads to the formation of gravitational-wave sources. I am interested in expanding computational education for high school and undergrad students, especially underrepresented minority students.

Mark Bussell CS 1994
mark.bussell@wwu.edu
Department of Chemistry,
Western Washington University
Photocatalysis and thermal catalysis of energy transformation processes. Broadening participation of undergraduate students in research experiences.

Jeff Byers CS 2015
jeffery.byers@bc.edu
Department of Chemistry, Boston College
I am an organometallic chemist interested in catalysis related to the synthesis of sustainable polymers, renewable energy, and organic methods development. I am interested incorporating innovative teaching styles to better engage a broader population in STEM disciplines.

Luis Campos CS 2015
lcampos@columbia.edu
Department of Chemistry, Columbia University
I am interested in physical organic chemistry, with a focus on polymers/macromolecules. Current topics include: multiexciton systems, carbon capture and photochemistry. I am interested in active learning, diversity, equity, and inclusion in the sciences.

Conference Participants Continued

Dennis Cao CS 2019
dcao@macalester.edu
Department of Chemistry, Macalester College
Building stabilized aromatic radical ions and electron-accepting heteroacenes. Building introductory-appropriate literature-backed resources for organic chemistry.

Justin Caram CS 2021
jcaram@chem.ucla.edu
Department of Chemistry and Biochemistry, University of California, Los Angeles
I am interested in designing and studying materials which absorb and emit in the shortwave infrared, the spectral window beyond where they I can see, for applications in imaging, quantum science and detection. I am passionate about developing first year coursework which is scalable while natively incorporating peer learning and guided inquiry.

Lou Charkoudian CS 2018
lcharkou@haverford.edu
Department of Chemistry, Haverford College
Our undergraduate research team studies the protein assembly lines that microorganisms use to manufacture structurally complex and medicinally relevant molecules. Integrating original research into biochemistry courses and understanding how interpersonal factors influence diversity and inclusion in STEM.

Shaowei Chen CS 2001
shaowei@ucsc.edu
Department of Chemistry and Biochemistry, University of California, Santa Cruz
Organically functionalized nanoparticle, functional nanocomposites for electrochemical energy technologies and antimicrobial applications. Physical and materials chemistry; outreach to high school students (SIP and COSMOS).

Laura Chomiuk CS 2017
chomiukl@msu.edu
Department of Physics and Astronomy, Michigan State University
Understanding stellar deaths and after-lives through multi-wavelength observations and working closely with theorists. Working with diverse undergrads to help them meet their personal, research, and education goals.

Tim Clark CS 2007
clarkt@sandiego.edu
Department of Chemistry and Biochemistry, University of San Diego
Metal-catalyzed borylation of organic compounds: C-H borylation of amines and phosphines and carbonyl borylation and carbon-boron bond homologation reaction development.Engagement and mentoring of undergraduate and high school students and high school teachers in chemical research.

Seth Cohen CS 2004
scohen@ucsd.edu
Department of Chemistry and Biochemistry, University of California, San Diego
Metal-organic framework materials and bioinorganic chemistry. Science policy, science communication.

Eva-Maria Collins CS 2016
ecollin3@swarthmore.edu
Department of Biology, Swarthmore College
From hydra gymnastics to pattern formation and high-throughput toxicology: we love to use physics principles to solve biological problems. I am passionate about learning via hands-on research and interdisciplinary problem-solving skills.

Luca Comisso Cottrell Fellow
luca.comisso@columbia.edu
Department of Astronomy, Columbia University
I investigate the plasma processes underpinning the generation of high energy particles from various astrophysical sources such as the Sun, neutron stars, and black holes.

Conference Participants Continued

Lindsay Currie
lcurrie@cur.org
Council on Undergraduate Research

Rachel Davidson **Cottrell Fellow**
racheldavidson@tamu.edu
Chemistry and Materials Science and Engineering, Texas A&M University

I'm interested in accelerating the discovery of new materials by combining design of experiment techniques and robotic synthesis with machine learning.

Julio de Paula **CS 1994**
jdepaula@lclark.edu
Department of Chemistry, Lewis and Clark College

Porphyrin-based photonic nanomaterials, photocatalytic water remediation, spectroscopic analysis of Renaissance-era paintings and manuscripts. General chemistry, physical chemistry, biochemistry, environmental chemistry, analytical chemistry, textbook writing.

Sean Decatur **CS 1996**
decatur@kenyon.edu
President, Kenyon College

Biophysical chemistry, with particular focus on protein structure/function/dynamics, probed by vibrational spectroscopy. Creating access to students from all background/socioeconomic groups to high-quality undergraduate liberal arts education.

Michael Dennin **CS 2000**
mdennin@uci.edu
Department of Physics and Astronomy, University of California, Irvine

Interested in equity and inclusion issues in undergraduate teaching. Institutional change management of teaching reform.

Joel Destino **CS 2021**
joeldestino@creighton.edu
Department of Chemistry and Biochemistry, Creighton University

Developing materials and measuring properties. 3D-printing glass from colloids. Luminescent materials, chemical sensors, and spectroscopy. UG research mentorship. 1st gen and URS engagement. Active learning that informs social consciousness & connects the classroom to the world.

Kelling Donald **CS 2008**
kdonald@richmond.edu
Department of Chemistry, University of Richmond

Research in the Donald Theory Group spans chemical bonding phenomena from across the periodic table, halogen bonding and other weak interactions, and structure prediction. Donald is interested in equity in the classroom, persistence for underrepresented students, and models for flipped classrooms.

Charlie Doret **CS 2017**
scd2@williams.edu
Department of Physics, Williams College

Quantum simulation and precision measurements with trapped ions. Inclusive practices in STEM; realistic classroom laboratory experiences.

Peter Dorhout **CS 1994**
dorhout@iastate.edu
Department of Chemistry/VP for Research, Iowa State University

While no longer active in the laboratory, I study trends in hiring, funding, and mentoring faculty and corporate engagement.Undergraduate research as an enterprise, RCR training, and professional development for researchers.

Conference Participants Continued

Kateri DuBay **CS 2020**
dubay@virginia.edu
Department of Chemistry, University of Virginia
Simulating self-assembly within complex nanoscale systems, such as nanoparticle monolayers, viral capsids assemblies, and copolymerizations. Teaching thermodynamics to undergrads and grad student chemists and teaching entropy to all.

Henriette Elvang **CS 2013**
h.elvang@gmail.com
Department of Physics, University of Michigan
Theoretical physics on the intersection of quantum field theory, general relativity, and string theory. Long-term outcomes of new teaching methods. Scientific communication as a didactic tool for improved learning.

Daniela Fera **CS 2021**
dfera1@swarthmore.edu
Department of Chemistry and Biochemistry,
Swarthmore College
Understanding how antibodies bind to viruses to prevent infections and how molecular switches in immune cells control antibody production. Providing real-world biochemistry training to students through research-based lab courses, practical case studies, and seminars on viruses.

Jay Foley **CS 2019**
foleyj10@wpunj.edu
Department of Chemistry,
William Peterson University
Wave enthusiast focused on pushing theory and computation for designing materials to control light and heat. Physical chemistry, nano, and food all under the umbrella of sustainability.

Alex Frañó **CS 2021**
afrano@ucsd.edu
Department of Physics,
University of California, San Diego
Strongly correlated electronic materials studied by synchrotron x-ray methods, superconductivity, magnetism, neuromorphic computing. Enhance creativity in the physics undergraduate education by allowing students to approach problems from a "divergent thinking" angle.

Carla Frohlich **CS 2014**
cfrohli@ncsu.edu
Department of Physics,
North Carolina State University
Computational astrophysics. Supernovae. Multi-messenger predictions: NS/BH masses, light curves, nuclei and neutrinos. Machine learning. Fulbright-Cottrell New Faculty Workshop. Computational tools for undergrads. Effective oral and written communication.

Amelia Fuller **CS 2010**
aafuller@scu.edu
Department of Chemistry and Biochemistry,
Santa Clara University
The Fuller lab prepares novel peptidomimetic compounds to explore both their structures and their functions as biomimetic materials. I am driven to engage as many students as possible in authentic research experiences, within and outside of the curriculum.

Jordan Gerton **CS 2007**
jgerton@physics.utah.edu
Department of Physics and Astronomy,
University of Utah
Nanoscale light-matter interactions; hyperspectral imaging of nanostructures; spectrally-resolved superresolution microscopy; science education research. Course and curriculum reform. I also direct the University of Utah's Center for Science and Mathematics Education.

Conference Participants Continued

Thomas Gianetti CS 2021
tgianetti@arizona.edu
Department of Chemistry and Biochemistry,
University of Arizona
My research targets the development of a new organic-based redox flow battery for long-duration storage of renewable energy. My educational interest is to enhance communication between scientists and Policymakers by developing an interdisciplinary curriculum.

John Gilbertson CS 2009
gilberj4@wwu.edu
Department of Chemistry,
Western Washington University
Small molecule activation utilizing inorganic chemistry. Inorganic and general chemistry.

Daren Ginete
dginete@sciphil.org
Science Philanthropy Alliance

Natalie Gosnell CS 2021
ngosnell@coloradocollege.edu
Department of Physics, Colorado College
I am an observational astrophysicist studying stars in binary systems, and how being in a binary system can change the way a star evolves. I am building creativity exercises into the intro physics curriculum to support belongingness + allow full exploration of physics identity.

Martin Gruebele CS 1995
mgruebel@illinois.edu
Department of Physics and Biophysics,
University of Illinois
Dynamics of Complex Systems. Sonification, or the use of data driven sound to enhance visualization.

Kathryn Haas CS 2016
khaas@saintmarys.edu
Department of Chemistry and Biochemistry,
Saint Mary's College
Probing metal binding sites using spectroscopic tools to learn how proteins control metal redox chemistry. Integrating research and teaching through CUREs and CoRes to engage students in the practices of science.

Amanda Hargrove CS 2017
amanda.hargrove@duke.edu
Department of Chemistry, Duke University
The Hargrove Lab explores RNA-biased small molecules and privileged RNA topologies for selective molecule: RNA recognition. Hargrove runs a CURE where students ID patterns in RNA recognition via VR, binding assays and principal component analysis.

Ute Hellmich CFS 2017
ute.hellmich@uni-jena.de
Organic and Macromolecular Chemistry,
Friedrich-Schiller-University Jena
Protein structure and dynamics by an integrated structural biology approach… and a newly found interest in intrinsic disorder. Fostering passion and enthusiasm for research and science, one day and one course at a time.

Chris Hendon CS 2021
chendon@uoregon.edu
Department of Chemistry and Biochemistry,
University of Oregon
Electronic structure modeling of molecules and materials, and the chemistry and physics of coffee. The development of a remote general chemistry laboratory using home-built devices, to make measurements on coffee.

Rigoberto Hernandez CS 1999
r.hernandez@jhu.edu
Department of Chemistry, John Hopkins University
Theoretical and Comp Chemistry @JHUChemistry, nonequilibrium dynamics: reactions, TST, nanoparticles, proteins @EveryWhereChem, Diversity and Inclusion @OxideChem, Academic Leadership Training Workshops, ACS Leadership Experience, APS DCP Vice Chair.

Mike Hildreth CS 2003
hildreth.2@nd.edu
Department of Physics, University of Notre Dame
I pair looking for new physics at the Large Hadron Collider with interests in computing and digital knowledge preservation. I'm looking for new methods of making active learning welcoming and inclusive to all students.

Conference Participants Continued

Geoff Hutchison CS 2012
geoffh@pitt.edu
Department of Chemistry, University of Pittsburgh
Interested in computationally-driven design of organic materials, from solar cells and energy storage to piezoelectrics and thermoelectrics, including accurate properties and environmental degradation. I'm interested in visualization, molecular modeling, and expanding coding and computational proficiency across the curriculum.

Ahamed Irshad Cottrell Fellow
irshad@usc.edu
Department of Chemistry,
University of California, Los Angeles
Electrochemical energy conversion and storage devices such as batteries, electrolyzers, fuel cells, etc. Teaching general chemistry, electrochemistry, analytical chemistry, laboratory courses, research supervisory, student support service.

Jeffery Johnson CS 2008
jjohnson@hope.edu
Department of Chemistry, Hope College
Developing new organic methods featuring carbon-carbon single bond activation and studying the mechanisms of these reactions. Engaging undergraduate students in authentic research experiences; organic teaching focusing on inclusivity and real-world connections.

Chenfeng Ke CS 2019
chenfeng.ke@dartmouth.edu
Department of Chemistry, Dartmouth College
The Ke group focuses on the development of supramolecular 3D printing materials and porous organic crystals. Active learning class for organic chemistry, women in science project.

Catherine Kealhofer CS 2020
ck12@williams.edu
Department of Physics, Williams College
I develop techniques to study phonon dynamics in ultra-thin materials using ultrafast electron diffraction. My education project is to introduce first-year students to reading original research papers in a modern physics course.

Sarah Keller CS 2003
slkeller@chem.washington.edu
Department of Chemistry, University of Washington
I investigate how cell membranes demix to form domains enriched in particular lipid and protein types. To a physicist, I study 2-D phase separation. To a cell biologist, I study membrane "rafts". Graduate students "mentoring up".

Alexis Komor CS 2021
akomor@ucsd.edu
Department of Chemistry and Biochemistry,
University of California, San Diego
We develop and apply new genome editing tools to better understand how mutations in DNA repair genes impact human health. I teach students at UCSD about genome editing using combined theoretical and practical approaches to enable their research endeavors.

Dimitri Kosenkov CS 2016
dkosenkov@monmouth.edu
Department of Chemistry and Physics,
Monmouth University
Quantum dynamics of energy transfer in proteins; Machine learning. Research-based labs.

Kristin Koutmou CS 2020
kkoutmou@umich.edu
Department of Chemistry, University of Michigan
Molecular level investigations into the impact of RNA modifications on protein synthesis. Improving biochemical education through writing and instructional coaching.

Michelle Kovarik CS 2017
michelle.kovarik@trincoll.edu
Department of Chemistry, Trinity College
Cellular responses to stress, especially heterogeneous responses; microelectrophoretic separations—chips and capillaries; using peptides and fluorogenic dyes to report on enzyme activity. Teaching from the primary literature, project-based laboratories, evidence-based strategies in the classroom, DEI and STEM education.

Conference Participants Continued

Kah Chun Lau CS 2020
kahchun.lau@csun.edu
Department of Physics and Astronomy,
California State University, Northridge

Atomistic simulation on energy related materials, data mining and machine-learning. Computational physics, modern physics, physics in general.

Moses Lee CS 1994
mosesl@murdocktrust.org
Department of Science, M.J. Murdock Charitable Trust

Biomedicinal chemistry, gene control, STAT3 inhibitors, anticancer drugs, vaccines for parasites and viruses. Discovery and course-based pedagogies.

Frank Leibfarth CS 2020
FrankL@email.unc.edu
Department of Chemistry,
University of North Carolina at Chapel Hill

Using modern methods in organic chemistry to make plastics more functional and sustainable. Getting students excited about polymer chemistry (and STEM broadly) by teaching them how and why to read the literature.

Adam Leibovich CS 2006
akl2@pitt.edu
Department of Physics and Astronomy,
University of Pittsburgh

Theoretical Particle Physics and Gravitational Wave Physics. Improving both undergraduate and graduate education working out of the Dean's office.

Eli Levenson-Falk CS 2021
elevenso@usc.edu
Department of Physics and Astronomy,
University of Southern California

My work focuses on using superconducting circuits for quantum information applications and to study the foundations of quantum mechanics. My educational work focuses using popular science and "lay-scientist" writing as an educational tool for both its readers and its authors.

Emily Levesque CS 2019
emsque@uw.edu
Department of Astronomy, University of Washington

I study the physical properties and evolution of massive stars, focusing on their late-time evolution and how these stars age and die. I'm interested in the intersection of STEM and the arts and how multidisciplinary efforts can improve the impact of scientific teaching.

Huey-Wen Lin CS 2020
hwlin@pa.msu.edu
Department of Physics and Astronomy,
Michigan State University

I use QCD on supercomputers to solve physics at the quark level, helping experiments big as LHC or small as a desktop probe new physics. Learning physics should be fun and inclusive. Adding research in undergrad lets them see how physics research would work for all students.

Song Lin CS 2020
songlin@cornell.edu
Department of Chemistry and Chemical Biology,
Cornell University

We are interested in exploring fundamental concepts of electrochemistry and radical chemistry to discover new organic transformations. We are interested in incorporating synthetic electrochemistry into college and graduate curricula.

Casey Londergan CS 2008
clonderg@haverford.edu
Department of Chemistry, Haverford College

Biophysical chemistry, vibrational spectroscopy, and protein dynamics. Inquiry- and research-based labs and courses, access for all students at all levels.

Britt Lundgren CS 2020
blundgre@unca.edu
Department of Physics and Astronomy,
University of North Carolina, Ashville

My research applies observations of gas flows around distant galaxies to understand the processes that regulate galaxy evolution. I am interested in improving DEI in STEM fields and modernizing astronomy education through the incorporation of computational methods.

Conference Participants Continued

Gina MacDonald CS 1997
macdongx@jmu.edu
Department of Chemistry and Biochemistry, James Madison University

Our group studies how salts, solution conditions and metals alter proteins and peptides structure, function, stability, solvation and aggregation. I am interested integrating teaching and research and increasing diversity in the sciences.

Dustin Madison Cottrell Fellow
dustin.madison@mail.wvu.edu
Department of Physics and Astronomy, University of West Virginia

I'm interested in gravitational waves and what they can tell us about supermassive black holes, the early Universe, and gravity itself. Physics is a creative endeavor and should be taught as such. Different students show mastery in different ways and on different timelines.

Ellen Matson CS 2019
matson@chem.rochester.edu
Department of Chemistry, University of Rochester

The Matson Group studies the synthesis of metal oxide clusters and their application in energy storage and conversion schematics. Our educational efforts are focused on enhancing diversity in the chemical sciences through community engagement learning experiences!

Sabetta Matsumoto CS 2020
sabetta@gatech.edu
School of Physics, Georgia Institute of Technology

We are interested in the mathematical and mechanical properties of textiles. We also use virtual reality and real-time graphics to study physics in curved spaces. I have developed virtual reality tools to help students learn vector calculus. I am also interested in inquiry-based learning through making and other student-centered mastery-based learning tools.

Charles McCrory CS 2019
cmccrory@umich.edu
Department of Chemistry, University of Michigan

We design electrocatalysts for energy and environmental chemistry, with specific focus on chemical microenvironment and extended structure. My focus is promoting conceptual knowledge development by rethinking and improving interactions between students and teaching assistants.

Ryan McGorty CS 2019
rmcgorty@sandiego.edu
Department of Physics, University of San Diego

Our lab studies soft matter and biological materials with optical microscopy and rheology. Interested in developing our biophysics curriculum and in engaging undergraduate students in research.

Maura McLaughlin CS 2009
maura.mclaughlin@mail.wvu.edu
Department of Physics and Astronomy, West Virginia University

Neutron stars, pulsars, gravitational waves, and radio transients. Broadening participation through research networks spanning high schools, community colleges, four-year colleges, and universities.

Ognjen Miljanic CS 2013
miljanic@uh.edu
Department of Chemistry, University of Houston

Supramolecular chemistry and porous materials, CO2 capture. Organic chemistry, 3D printing, science and education policy, energy and sustainability.

Jill Millstone CS 2015
jem210@pitt.edu
Department of Chemistry, University of Pittsburgh

We want to develop the chemical principles that define and predict the evolution of metal and metal-like materials from first metal-metal bond to extended solid forms. I am interested in both learning and developing ways to help all scientists and students become effective public communicators.

Conference Participants Continued

Katherine Mirica **CS 2019**
katherine.a.mirica@dartmouth.edu
Department of Chemistry, Dartmouth College
The Mirica group focuses on the design, synthesis, and structure-function relationships of stimuli-responsive multifunctional materials for healthcare and environment. My educational interests center on scientific creativity, written and oral communication, and mentorship.

Jamie Moore
moore@fulbright.de
Special Programs, Fulbright Germany
Recovering French literature scholar, wine enthusiast and social justice advocate, now deeply engaged in international education and exchange. The benefits of international academic exchange and learning another language, communicating science, "turning scientists into people."

Katie Mouzakis **CS 2017**
kathryn.mouzakis@lmu.edu
Department of Chemistry and Biochemistry,
Loyola Marymount University
I am interested in understanding and targeting viral RNA structures critical to translation. I am interested in using course-based undergraduate research experiences to enhance undergraduate biochemistry education.

Diego Munoz **Cottrell Fellow**
diego.munoz@northwestern.edu
Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA), Northwestern University
I work on different applications of orbital dynamics and fluid mechanics to extreme astrophysical systems.

Dominik Munz **FCS 2019**
dominik.munz@uni-saarland.de
Department of Chemistry, Saarland University
Inorganic and organic chemistry with a focus on reactive intermediates, photochemistry, and catalysis. Fostering motivation and self-esteem to promote the underprivileged and build future's leaders.

Cathy Murphy **CS 1996**
murphycj@illinois.edu
Department of Chemistry,
University of Illinois at Urbana-Champaign
Inorganic-bio-eco-nanomaterials. Materials and sustainability.

Sharon Neufeldt **CS 2020**
sharon.neufeldt@montana.edu
Department of Chemistry and Biochemistry,
Montana State University
My research focuses on controlling and understanding the selectivity of transition metal catalysts for organic reactions. I teach organic and organometallic chemistry and I work with students to make computer animations of multi-step organic reaction mechanisms.

Teri Odom **CS 2005**
todom@northwestern.edu
Department of Chemistry, Northwestern University
Nanoscale alchemy; multi-scale fabrication of hard and soft materials; manipulation of light and water at the nanoscale. Creating nanoscale experts; mentoring up and mentoring down.

Glen O'Neil **CS 2020**
oneilg@montclair.edu
Department of Chemistry, Montclair State University
My group develops new measurement strategies for understanding complex chemical systems in their native states using photoelectrochemistry and 3D printing. I am interested in increasing participation in upper-level chemistry courses for community college transfer students

Peter Orth **CS 2020**
porth@iastate.edu
Department of Physics, Iowa State University
Theoretical condensed matter physicist researching the properties of quantum materials at low temperatures and how to probe them. Interested team-based learning (TBL) approaches, use of peer mentoring and quantitative assessment of active learning methods.

Conference Participants Continued

David Patrick CS 1997
david.patrick@wwu.edu
Department of Chemistry,
Western Washington University
Molecular crystallization and growth; crystal engineering; optical materials and light management for solar energy harvesting. Graduate education, undergraduate research.

Dennis Perepelitsa CS 2020
dvp@colorado.edu
Department of Physics,
University of Colorado, Boulder
My research is in experimental nuclear physics. Using large particle colliders, my group creates and studies the primordial quantum matter that existed a few microseconds after the Big Bang, before it expanded and cooled to form the universe we live in today. My educational interests are in integrating computational elements and thinking into upper-division physics instruction.

Nicola Pohl CS 2003
npohl@indiana.edu
Department of Chemistry, Indiana University
Development of synthetic methods for automated synthesis of oligosaccharides and glycopeptides and tools to study the roles of carbohydrates in plant, microbial and human biology. Development of low-cost experiments to introduce cutting-edge science into undergrad labs using all the senses and diversity of scientists.

Will Pomerantz CS 2016
wcp@umn.edu
Department of Chemistry, University of Michigan
I apply my love of molecular recognition to problems in the field of chemical epigenetics. I continue to enjoy exploring new ideas for CUREs in Chem Bio and organic chemistry.

Ann-Christin Pöppler FCS 2020
ann-christin.poeppler@uni-wuerzburg.de
Department of Chemistry, University of Würzburg
I'm interested in developing improved future materials in the context of drug delivery through better and detailed structural understanding. I'm passionate about interactive and research-based teaching.

Rosario Porras-Aguilar CS 2021
rporrasa@uncc.edu
Department of Physics and Optical Sciences,
University of North Carolina at Charlotte
Reconfigurable, quantitative label-free microscopy using polarization-sensitive nonlinear optical materials and wavefront shaping techniques. Committed to excellence and diversity, my goal is to promote autonomous learning and challenge students to their highest level of achievement.

Davit Potoyan CS 2021
potoyan@iastate.edu
Department of Chemistry, Iowa State University
Computational chemistry and biophysics of protein phase separation. Developing web-based interactive course content based on python/Jupyter ecosystem of tools.

Jenn Prescher CS 2014
jpresche@uci.edu
Department of Chemistry,
University of California, Irvine
Developing chemical probes and imaging technologies to spy on cellular communication. Cross-disciplinary research experiments for large undergraduate labs

Paul Raston CS 2019
rastonpl@jmu.edu
Department of Chemistry and Biochemistry,
James Madison University
I am interested in using lasers to probe unusual chemical intermediates that are relevant to the atmosphere and/or interstellar space. I enjoy teaching quantum chemistry to undergrads, and am interested in developing tools that help with discovery-based experimentation.

Cindy Regal CS 2014
regal@colorado.edu
Department of Physics, University of Colorado
Experimental quantum science and sensing. Teaching physics to engineers, interactive lab courses.

Shahir Rizk **CS 2019**
srizk@iu.edu
Department of Chemistry,
Indiana University South Bend
The Rizk lab loves protein engineering, we try to make these amazing molecules do even more amazing things, we also use various forms of art to communicate science to the public. Science communication, biochemistry, protein structure and function. Enhancing science education through art. #SciArt.

Rae Robertson-Anderson **CS 2010**
randerson@sandiego.edu
Department of Physics and Biophysics,
University of San Diego
Soft and active matter, biopolymers, microrheology, optical trapping, fluorescence microscopy. Research-based curriculum, interdisciplinary biophysics, intro seminars, science writing.

Tyler Robinson **CS 2021**
tyler.robinson@nau.edu
Department of Astronomy and Planetary Science,
Northern Arizona University
Tyler works on problems related to planetary atmospheres, exoplanets, the search for habitable and inhabited worlds, and the design of future space-based telescopes. Tyler is interested in interdisciplinary approaches to undergraduate education and career-focused approaches to graduate student training.

Leslie Rogers **CS 2020**
larogers@uchicago.edu
Department of Astronomy and Astrophysics,
University of Chicago
I study the formation, interior structure, and evolution of exoplanets. I am working to constrain the underlying composition distribution of planets. I have developed an Astrophysics Escape Room activity to help my students develop problem solving, communication, and collaboration skills.

Jenny Ross **CS 2010**
jlross@syr.edu
Department of Physics, Syracuse University
The Ross Lab is interested in uncovering how cells organize their insides without a manager through physics and chemis=try. Engaging students in physics through experiential learning, hands-on group work, and interventions that reduce stereotype threat.

Vince Rotello **CS 1996**
rotello@chem.umass.edu
Department of Chemistry, University of Massachusetts
Creating new nanomaterials for biomedical applications—antimicrobials, nanozymes, gene editing… you name it! Developing graduate courses covering in all the things I wish they had taught me.

Brenda Rubenstein **CS 2020**
brenda_rubenstein@brown.edu
Department of Chemistry, Brown University
Leveraging computational science to address challenges in chemistry, physics, and beyond. Decolonizing STEM to make it more inviting for all.

Daniel Ruterbories **Cottrell Fellow**
druterbo@pas.rochester.edu
Department of Physics and Astronomy,
University of Rochester
Understanding the nature of neutrino-nucleus interactions and their impact on the international neutrino interferometry program. Cultivating a learning environment to meet the individual needs of vulnerable and non-traditional students learning introductory physics.

Sohini Sarkar **Cottrell Fellow**
sohinisa@usc.edu
Department of Chemistry,
University of Southern California
My research interests lie in using operando spectroelectrochemistry to study tailored electric fields at interfaces that influence catalysis. I am interested in connecting chemistry beyond classroom with greater emphasis on environmental applications of chemistry.

Zac Schultz CS 2013
schultz.133@osu.edu
Department of Chemistry and Biochemistry, The Ohio State University

Understanding the interactions of light and nanomaterials for ultrasensitive detection and imaging. Promoting engagement and inclusion at all levels of education.

Mats Selen CS 1996
mats@illinois.edu
Department of Physics, University of Illinois at Urbana-Champaign

PER, Particle Physics. Sustainable implementation of our new skills-based intro physics labs for about five thousand undergraduates and one hundred TAs per year.

Scott Shaw CS 2016
scott-k-shaw@uiowa.edu
Department of Chemistry, University of Iowa

Chemistry to create new understanding of molecular-level behaviors at surfaces and interfaces. Energy and Environmental focus. SciComm and Chemistry education research proselytizer who thinks we should actually teach graduate students how to write.

George Shields CS 1994
george.shields@furman.edu
Department of Chemistry, Furman University

Computational chemistry applied to questions of interest in the fields of Atmospheric Chemistry and Physical Chemistry. Broadening access to chemistry through better teaching of general chemistry and undergraduate research projects.

Natalia Shustova CS 2017
shustova@sc.edu
Department of Chemistry, University of South Carolina

Graphitic hybrid materials (metal- and covalent-organic frameworks) for sustainable energy conversion, sensors, and artificial biomimetic systems. The Women-in-Science (Wi-Sci) Program through collaboration with nearby historically black colleges and universities.

Brian Shuve CS 2021
bshuve@g.hmc.edu
Department of Physics, Harvey Mudd College

I study connections between elementary particles and cosmology, and use terrestrial experiments to test the physics of the early universe. I am interested in applying active learning methods in upper division major classes, and expanding equity and anti-racist work in physics.

Juliane Simmchen FCS 2021
juliane.simmchen@tu-dresden.de
Department of Physical Chemistry, Technische Universität Dresden

My lab focusses on active colloidal materials, the physical principles governing their interactions and their biological analoga. Educate students to become independently thinking scientists.

Lorenzo Sironi CS 2020
lsironi@astro.columbia.edu
Department of Astronomy, Columbia University

High-energy plasma astrophysics, i.e., how light is emitted by cosmic explosions. Educate Columbia undergraduate students to the art of looking at reality with quantitative eyes, and drawing order of magnitude conclusions.

Sara Skrabalak CS 2012
sskrabal@indiana.edu
Department of Chemistry, Indiana University

I love developing chemical pathways to structurally precise nanomaterials and discovering their beautiful properties! Currently I am passionate about demystifying graduate school and providing strong mental health resources for graduate students.

Hanadi Sleiman CS 2002
hanadi.sleiman@mcgill.ca
Department of Chemistry, McGill University

My research focuses on using the molecule DNA as a building block to assemble nanostructures, for biological and materials applications. Teach Supramolecular Chemistry, mentor ~20 researchers, lead a Canadian Training Program to teach graduate students soft skills for the workplace.

Brad Smith **CS 1994**
smith.115@nd.edu
Department of Chemistry and Biochemistry, University of Notre Dame
Supramolecular chemistry applied to biological systems; fluorescent probes for biomedical imaging; membrane biophysics. On-line learning materials for organic chemistry and molecular structure elucidation using spectroscopic data.

Joshua Smith **CS 2010**
josmith@fullerton.edu
Department of Physics, California State University, Fullerton
I am an experimental gravitational-wave physicist and a member of the LIGO Collaboration and Cosmic Explorer Consortium. At CSUF, I direct the Nicholas and Lee Begovich Center for Gravitational-Wave Physics and Astronomy.

Tristan Smith **CS 2019**
tsmith2@swarthmore.edu
Department of Physics, Swarthmore College
I am a theoretical cosmologist with a focus on understanding the physics of the early universe cosmology, gravity, and gravitational waves. I am interested in science communication, especially efforts which use techniques from improvisation and theater.

Marcelle Soares-Santos **CS 2021**
mssantos@umich.edu
Department of Physics, University of Michigan
Marcelle Soares-Santos pursues a multimessenger cosmology program to perform precise and accurate measurements of the rate of expansion of the Universe using mergers of binary neutron stars and black holes. Results of the research will shed light upon the issue of discrepant measurements from traditional methods such as supernovae and the cosmic microwave background, a key problem in modern cosmology. Soares-Santos is interested in ways to improve the experience of students and instructors in online teaching environments.

Tom Solomon **CS 1995**
tsolomon@bucknell.edu
Department of Physics and Astronomy, Bucknell University
Nonlinear dynamics, fluid mixing, chaotic mixing; effects of fluid flows on front propagation and swimming microbes. I love all aspects of teaching except grading. I am particularly interested in the value of exploration and a broad, liberal arts education.

Eileen Spain **CS 1995**
emspain@oxy.edu
Department of Chemistry, Occidental College
My interests focus on the chemistry and physics of interfaces. Currently, I investigate the chemical sensing mechanisms of a bacterial predator in model biofilms. My primary education interest is to build welcoming educational experiences and spaces for BIPOC and first-generation students in STEM.

Snezana Stanimirovic **CS 2009**
sstanimi@astro.wisc.edu
Department of Astronomy, University of Wisconsin
Interstellar medium, galaxy evolution, astrochemistry. STEM retention, effective teaching practices, emotional well-being of students.

Simon Stellmer **FCS 2021**
stellmer@uni-bonn.de
Institute of Physics, University of Bonn
Approaching fundamental physics through high-precision measurements. Interdisciplinary lab courses.

Stefan Stoll **CS 2015**
stst@uw.edu
Department of Chemistry, University of Washington
Interests are protein structure, enzymes, catalysis, spectroscopy; expertise in electron paramagnetic resonance. Make physical chemistry, particularly quantum, accessible to all.

David Strubbe **CS 2020**
dstrubbe@ucmerced.edu
Department of Physics, University of California, Merced
Condensed-matter theory: electronic structure methods, Raman spectroscopy, excited state dynamics, 2D materials, amorphous materials, photovoltaics. Condensed matter physics and computational physics, Course-based Undergraduate Research Experiences, interactive simulations.

Ruby Sullan **CS 2021**
ruby.sullan@utoronto.ca
Department of Chemistry, University of Toronto Scarborough
Tackle bacterial biofilms, one molecule and one cell at a time and develop nanomaterial-based antimicrobial for targeted biofilm disruption. Undergraduate research experience at the nanoscale, with beyond-the-classroom program to help students (re)think of themselves as scientists.

Kana Takematsu CS 2019
ktakemat@bowdoin.edu
Department of Chemistry, Bowdoin College
Moving protons and electrons in the excited state using chemical structures and solvents; photochemistry and spectroscopy. Building inclusion and belonging for students, staff, and faculty; quantitative and scientific confidence for majors and nonmajors.

Aaron Teator Cottrell Fellow
teator@ku.edu
Department of Chemistry, University of Kansas
Expanding the limits of synthetic materials through a combination of physical organic chemistry, polymer chemistry, and catalysis. Continue to develop and enhance teaching skills related to inclusive teaching, active learning pedagogies, and activating student interest.

Günther Thiele FCS 2020
guenther.thiele@fu-berlin.de
Department of Inorganic Chemistry,
Freie Universität Berlin
Solid state and Material Chemistry Research using Metalates and Electrides. Augmented and Virtual Reality Approaches in Teaching.

Claire Till CS 2020
claire.till@humboldt.edu
Department of Chemistry, Humboldt State University
Chemical similarities and differences between iron and scandium; biogeochemical cycling of trace metals in the ocean. Group work leading to spontaneous collaboration; raising student's confidence in their ability to learn.

Eric Toberer CS 2015
etoberer@mines.edu
Department of Physics, Colorado School of Mines
New crystalline matter for addressing energy challenges. Textbooks in a flipped world—what's different? Simulation—creating model worlds!

Weichao Tu CS 2019
wetu@mail.wvu.edu
Department of Physics and Astronomy,
West Virginia University
Do you know the near-Earth space environment is radioactive? My research focuses on studying this near-Earth environment called Van Allen radiation belts. My educational interest is to develop a new space science learning module for introductory undergraduate courses.

Olalla Vázquez FCS 2016
olalla.vazquez@staff.uni-marburg.de
Department of Chemistry,
Philipps-Universität Marburg
Chemical Biology. Light-driven chemical tools to understand and manipulate biological processes at molecular level. Epigenetic chemical probes. My educational interest is to develop a new space science learning module for introductory undergraduate courses.

Alexandra Velian CS 2021
avelian@uw.edu
Department of Chemistry,
University of Washington
Surface functionalization of atomically precise inorganic clusters and 2D crystals for catalytic, electronic and quantum information applications. Active learning and involvement in research to narrow the achievement gap and increase retention of underserved students in STEM.

Christina Vizcarra CS 2019
cvizcarr@barnard.edu
Department of Chemistry, Barnard University
I study cytoskeletal regulatory proteins and small molecules that inhibit those proteins. I am interested in research collaborations with upper-level lab courses, and I am also interested in student success in General Chemistry.

Rongsheng (Ross) Wang CS 2021
rosswang@temple.edu
Department of Chemistry, Temple University
Novel chemical biology approaches to probe the substrates and enzymes of post-translational modifications. Research-based active learning experience to answer biologically important questions using chemistry probes.

Rory Waterman CS 2009
rory.waterman@uvm.edu
Department of Chemistry, University of Vermont
New catalysis molecules, materials with fun elements. All kinds of fun stuff: Research opportunities, equity and inclusion, curricular development, student success.

Laurie Waters CS 2016
watersl@uwosh.edu
Department of Chemistry,
University of Wisconsin Oshkosh
Stress responses in bacteria, particularly metal homeostasis, membrane transporters, and unique roles of small proteins (<50 aa). Engaging students in biochemistry research and real-world applications, in-class activities, supporting first-gen and non-trad students.

Elizabeth Weiss
eweiss@sciphil.org
Advisor, Science Philanthropy Alliance

Tim Wencewicz CS 2017
wencewicz@wustl.edu
Department of Chemistry,
Washington University in St. Louis
Chemistry-based strategies to combat antibiotic resistance. Teaching at the interface of chemistry and biology.

Jessica Werk CS 2020
jwerk@uw.edu
Astronomy Department, University of Washington
I study the vast reservoirs of gas surrounding and between galaxies, called the intergalactic medium, using spectra from the Hubble Space Telescope and by analyzing hydrodynamical simulations. I am interested in building supportive academic communities in which all students are empowered to succeed and thrive.

Luisa Whittaker-Brooks CS 2018
luisa.whittaker@utah.edu
Department of Chemistry, University of Utah
Deep understanding of spin and charge transport and ion-migration in energy storage and quantum materials and devices using diffraction and spectroscopy. Transforming the chemistry experience by replacing weed-out courses with more deep-root courses early on in student's college careers.

Leah Witus CS 2021
lwitus@macalester.edu
Department of Chemistry, Macalester College
We are interested in the links between sequence, conformation, and catalytic activity in peptide catalysts. I am interested in how we educate students in professional and public scientific communication.

Amanda Wolfe CS 2017
awolfe@unca.edu
Department of Chemistry,
University of North Carolina at Asheville
The Wolfe lab is interested in developing antibiotics and adjuvants to help treat Gram-negative pathogens. I am interested in integrating high impact research projects into all levels of the undergraduate curriculum.

Joe Zadrozny CS 2021
joe.zadrozny@colostate.edu
Department of Chemistry,
Colorado State University
The many intersections between synthetic inorganic chemistry and quantum properties of molecules. Hands-on training and infusing cutting edge research with instructional material.

Hongbin Zhang FCS 2019
hongbin.zhang@tu-darmstadt.de
Institute of Materials Science,
Technical University of Darmstadt
I am fascinated by in-silico materials design based on high-throughput calculations and machine learning modelling. Python, the bridge between theoretical courses and frontier research!

Research Corporation Participants

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