Creativity and Innovation in STEM Education

The 28th Annual Cottrell Scholar Conference
July 6-8, 2022

COTTRELL SCHOLAR CONFERENCE

RESEARCH CORPORATION *for* SCIENCE ADVANCEMENT

2022 Conference Planning Committee

Julio de Paula
Chemistry
Lewis & Clark College

Jordan Gerton
Physics
University of Utah

Gina MacDonald
Chemistry and Biochemistry
James Madison University

Maura McLaughlin
Physics and Astronomy
West Virginia University

Nicola Pohl
Chemistry
Indiana University Bloomington

Scott Shaw
Chemistry
University of Iowa

Tom Solomon
Physics
Bucknell University

Silvia Ronco
Senior Program Director
Research Corporation for Science Advancement

Welcome from the President

Back in person again! We are so excited to see all of you in Tucson for the annual Cottrell Scholar Conference.

Throughout the pandemic, we heard from the Cottrell Scholar community about disruptions to research, teaching, and careers. We responded with fellowships to senior postdoctoral fellows who were unable to move into independent positions because of hiring freezes at many universities and colleges, and whose funding in Cottrell Scholar research groups was expiring; we added post-baccalaureate fellowships for students who lost out on research opportunities, and to help Cottrell Scholars who depend on graduating seniors to maintain active scientific programs and to train the next generation of students; we supported shared instrumentation at undergraduate colleges and brought together faculty to share best practices for student online learning and evaluation. We look to you for continued guidance on how to address the highest priorities of the physical sciences community.

The Cottrell Scholar Program Committee, chaired by **Rae Robertson-Anderson**, has been especially effective at bringing forward programmatic recommendations. Most important have been discussions on how to build effectively on the strong commitment of the Cottrell Scholars to enhancing diversity, equity, and inclusion through Cottrell Scholar collaboratives and through new approaches. We look forward to extending those conversations at this conference.

Finally, my thanks to all the staff of the foundation, and in particular to Senior Program Directors **Silvia Ronco**, **Richard Wiener**, and **Andrew Feig**, who so excellently foster a strong sense of community among Cottrell Scholars. We all benefit enormously by working together, sharing concerns and solutions, and caring about each other.

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

Daniel Linzer
President
Research Corporation for Science Advancement

Letter from the Program Director

Welcome to the 2022 Cottrell Scholar Conference!

We are so happy to have you here in Tucson! It's been too long since the last time we met in person. This year's conference will provide the opportunity to bring the community together again, and to make new, meaningful connections, especially with new Scholars who received their awards during the COVID pandemic. And while we celebrate the opportunity to meet in person again, safety remains our first priority. Masks and rapid tests will be available to participants throughout the conference. Our goal is to host an enjoyable meeting where participants feel safe and have productive interactions with a diverse group of colleagues.

Continuing our long-standing tradition, an important goal of the 2022 CS Conference is to welcome the newest class of Cottrell Scholars. If you are a 2022 Cottrell Scholar, please know that you were selected not only for your impressive research and educational programs, but also for your strong potential to become an active member of the Cottrell Scholar family. If you are a returning Scholar, please introduce yourself to new Scholars and welcome them to this fantastic community.

This year's conference, *Creativity and Innovation in STEM Education*, is co-chaired by CS 1994 **Julio de Paula**, Lewis & Clark College, CS 1997 **Gina MacDonald**, James Madison University, and myself. The conference program was planned to offer a platform for thoughtful discussions on how to incorporate creativity and innovation into STEM education. Diversity, equity and inclusion will be embedded throughout the conversations to promote inclusive pedagogical approaches, and ultimately, more equitable academic environments.

We are honored to have an exceptional keynote speaker, **Doug Arion**, Professor Emeritus of Physics and Entrepreneurship at Carthage College, who will challenge the audience to explore multiple ways to adapt STEM courses to better prepare students for 21st century careers. Complementing Doug's workshop, guest speaker **Rich Carter**, Professor of Chemistry at Oregon State, will describe novel ways for inclusive recognition of evolving forms of faculty impact in promotion and tenure processes, including innovation and entrepreneurship, community involvement, and diversity, equity and inclusion. Thought-provoking breakout sessions will generate ideas for implementation on your campuses and beyond.

A great way to explore new educational ideas with potential national impact is to participate in a project with the Cottrell Scholars Collaborative (CSC), a diverse, cross-disciplinary network of Cottrell Scholars working together to improve science education at colleges and universities across the U.S. and Canada. CSC participation is also an excellent way to interact and network with members of the stellar Cottrell Scholar community.

We hope you find this event refreshing, informative and stimulating. We are looking forward to working with you!

Silvia Ronco
Senior Program Director
Research Corporation for Science Advancement

Conference Objectives

To empower scholars to build community and information exchange, participants will:

- → Welcome the members of the 2022 Cottrell Scholar class and facilitate their interactions with other members of the community
- → Engage in authentic dialogue with the goal of identifying pressing issues in STEM education
- → Become familiar with tactics for incorporating creativity and innovation into STEM coursework with the purpose of enhancing career readiness
- → Discuss successful activities and approaches for a more equitable STEM education
- → Identify topics that may lead to successful Cottrell Scholar Collaborative projects
- → Have the opportunity to form teams and become involved in STEM education projects

Diversity, Inclusion and No 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.

Read RCSA's Code of Conduct

2022 Cottrell Scholar Conference Program

Creativity and Innovation in STEM Education
July 6–8, 2022

Wednesday, July 6

2:00 – 6:00 pm	**Registration**	Retail Foyer
3:00 – 4:00 pm	**Opening Reception** Drinks and Light Hors d'Oeuvres	Murphey Patio
4:00 – 5:00 pm	**Welcome and Introductions** Dan Linzer, RCSA President **Conference Overview and Goals** Silvia Ronco and Julio de Paula **Introduction of Scholars**	Sonoran
5:00 – 6:30 pm	**2022 Cottrell Scholar Presentations**	Sonoran
6:30 – 8:30 pm	**Dinner**	Canyon I, III
7:15 – 8:15 pm	**2022 IMPACT Award presentation** Seth Cohen **Cottrell Scholar Trophy Ceremony**	Canyon I, III

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Thursday, July 7

7:00 am	**Registration**	Retail Foyer
7:00 – 8:00 am	**Breakfast**	Murphey Patio
8:00 – 9:30 am	**2022 Cottrell Scholar Presentations**	Sonoran
9:30 – 10:00 am	**Morning Break**	Sonoran Foyer
10:00 – 11:00 am	*The Art of Gathering Scientists* Facilitated discussion led by Nikki Pohl and Andrew Feig	Sonoran
11:00 am – 12:00 pm	*Inclusive Recognition of Innovation and Entrepreneurship: Impact on Promotion and Tenure* Rich Carter	Sonoran
12:00 – 1:15 pm	**Lunch**	Murphey
1:15 – 2:45 pm	**Keynote Presentation and Workshop** Doug Arion Presentation: *It's Not Your Fault: Adapting Education for 21st Century Careers* Workshop: *Creativity and Inventiveness*	Sonoran
2:45 – 3:00 pm	**Afternoon Break**	Sonoran Foyer
3:00 – 4:15 pm	**Breakout Session I** *Incorporating Innovation, Entrepreneurship, Creativity, and Career Preparedness into the Undergraduate Experience*	Finger Rock I, II, III and Primrose
4:15 – 4:30 pm	**Regroup to Discuss**	Sonoran
4:30 – 6:00 pm	**Pool Time** Swimming and Informal Discussions	
6:00 – 7:30 pm	**Drinks and Light Hors D'oeuvres** **Reception Honoring New Cottrell Scholars and Cottrell Scholar Collaborative Fair**	Canyon Foyer Canyon I, III
7:30 – 9:00 pm	**Buffet Dinner** **STAR presentations** Rae Robertson-Anderson and Scott Snyder	Canyon I, III

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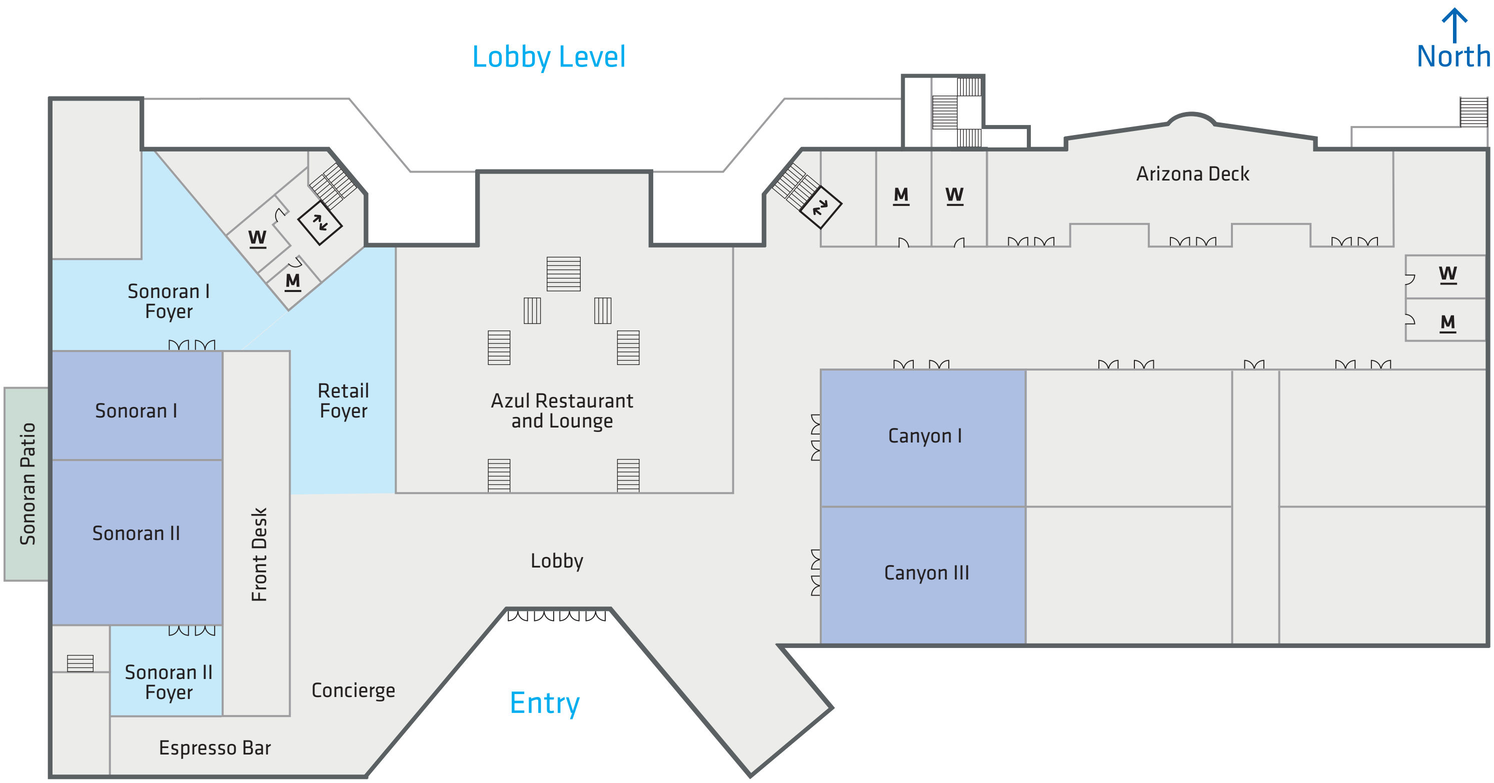
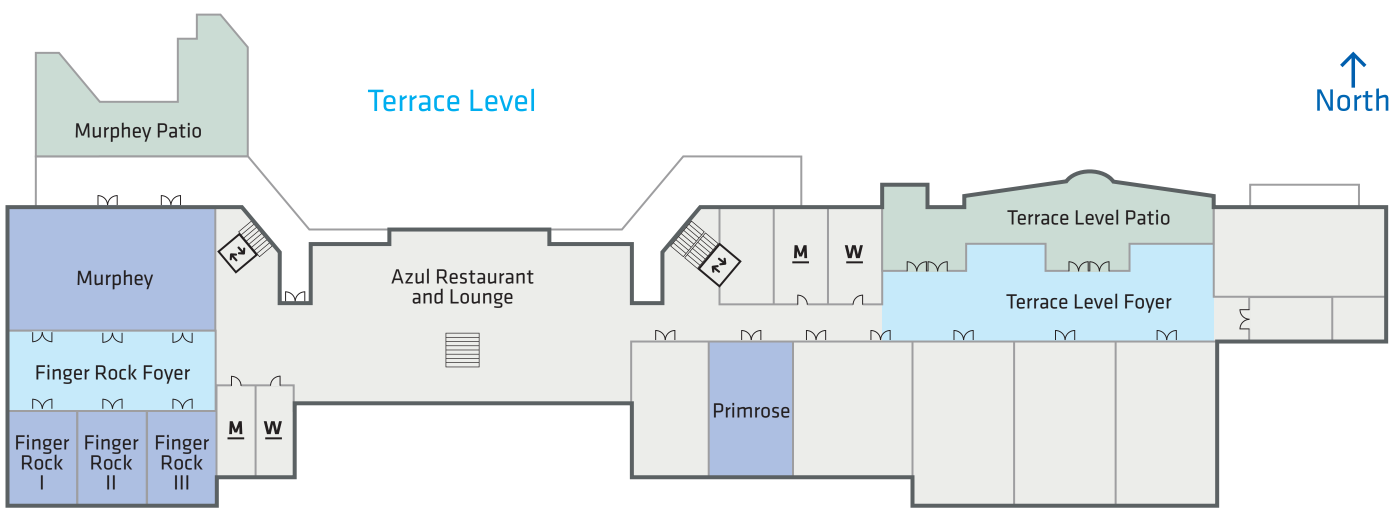
Friday, July 8

7:00 – 8:30 am	**Breakfast**	Murphey Patio
8:30 – 9:00 am	**Recap of Previous Days and Setting Goals** Emerging Themes Breakout Session II Themes CS Collaborative Projects	Sonoran
9:00 – 9:30 am	**Program Announcements** *The Holland Award*	Sonoran
9:30 – 10:00 am	**Morning Break**	Sonoran Foyer
10:00 – 11:15 am	**Breakout Session II** *Developing an Impact-Rich "Maker Culture" among Scientists, Artists and Social Scientists; Impact of Science on Society*	Finger Rock I, II, III and Primrose
11:15 – 11:30 am	**Regroup to Discuss**	Sonoran
12:00 – 1:30 pm	**Lunch**	Murphey
1:30 – 3:30 pm	**Breakout Session III** *Unstructured Time to Work on Educational Collaborations*	Sonoran, Finger Rock I, II, III and Primrose
3:30 – 4:00 pm	**Conference Survey and Conference Wrap-up**	Sonoran
4:00 – 6:00 pm	**Pool Time** Swimming and Informal Discussions	
6:00 – 7:00 pm	**Reception** Drinks and Light Hors d'Oeuvres	Terrace Level Foyer
7:00 – 9:30 pm	**Family Dinner** All guests are invited to join	Terrace Level Patio

Westin La Paloma Resort and Spa





Keynote Speaker

It's Not Your Fault: Adapting Education for 21st Century Careers

Douglas N. Arion
Executive Director, Mountains of Stars
Professor Emeritus of Physics and Astronomy,
Donald Hedberg Distinguished Emeritus Professor of Entrepreneurship
Carthage College
Co-Founder, Galileoscope

Abstract: Numerous panels have been convened and detailed reports generated across many disciplines that address the direction of higher education to prepare undergraduate (and graduate) students for 21st century careers. What do these say, and how can we utilize this research to improve student outcomes, improve recruiting and retention, address the growing diversity of the student body, open up new opportunities for education and research, and make the higher education enterprise more sustainable? As a member of several of these panels, and as the founder of the ScienceWorks program at Carthage College – the first program to bring innovation, creativity, entrepreneurship, and career preparation into the undergraduate science curriculum – I can share motivations, techniques, and implementation approaches to help you achieve outcomes for your students in these important areas, along with resources and materials to help you in the process.

Bio: Douglas Arion is the founder and Director of the Mountains of Stars public science education and outreach program, which promotes "environmental awareness from a cosmic perspective," and Professor Emeritus of Physics and Astronomy and Donald D. Hedberg Distinguished Professor Emeritus of Entrepreneurial Studies at Carthage College. He has been actively engaged in business strategy, technology development, and economic development and planning, including the creation of the Center for Advanced Technology and Innovation in Racine, Wisconsin. He has conducted workshops in the U.S., Canada, Brazil and South Africa. He was a member of the J-TUPP commission and co-author of the PHYS21 and PHYS21 Supplement reports, as well as co-PI on the PIPELINE Project and principal author of the EPIC report. He was an early member of VentureWell (formerly the National Collegiate Inventors and Innovators Alliance), served on numerous review panels, and was a frequent speaker at the annual OPEN Conference. He is a member of the U.S. Economic Development Agency Comprehensive Economic Development Strategy group for northern New Hampshire. Doug co-founded Galileoscope LLC, which delivers high quality, low cost telescopes for worldwide promotion of science education and outreach, and co-founder of The Institute to Promote Learning, which developed and published approaches to support student development, retention, and success in higher education. Doug was previously the head of the Applied Physics and Engineering Division and Assistant Vice President at Science Applications International Corporation. He is a Fellow of the American Physical Society, a member of the American Astronomical Society and the International Astronomical Union, has received the Distinguished Service Award from Sigma Pi Sigma, the Volunteer Leadership Award from the Appalachian Mountain Club, and the Dark Sky Defender Award from the International Dark Sky Association. He serves on the national and international commissions on light pollution, radio interference, and space debris. He received his BA in physics from Dartmouth College, and MS and Ph.D. degrees from the University of Maryland.

Guest Speaker

Inclusive Recognition of Innovation and Entrepreneurship Impact in Promotion and Tenure

Rich G. Carter
Co-Founder and CEO, Valliscor
Faculty Lead for Innovation Excellence
and Professor of Chemistry, Oregon State University

Abstract: Composed of over 65 universities from around the country, the Promotion & Tenure - Innovation and Entrepreneurship (PTIE) Coalition has put together detailed consensus recommendations for universities to use as a starting point for conversations about potential changes to fully recognize innovation and entrepreneurship (I&E) impact by university faculty. Included within those recommendations and further articulated in a 2021 *Science* article is a possible superstructure for supporting promotion and tenure (P&T) reforms to recognize other evolving forms of faculty impact - whether that work is in community engagement (CE) or diversity, equity and inclusion (DEI) or innovation and entrepreneurship (I&E). The session will provide an overview of the effort and recommendations followed by interactive discussion with the attendees.

Bio: Rich earned his B.S. degree in Chemistry from Gettysburg College and his Ph.D. degree in Organic Chemistry from the University of Texas at Austin. His expertise is in multi-step organic synthesis and reaction development. Rich's laboratory has had a longstanding interest in the total synthesis of complex, biological active natural products. He has supervised over 50 researchers in his laboratory who have gone onto successful careers in academia and industry. In addition, he works with the OSU Research Office in the role of Faculty Lead for Innovation Excellence. This position focuses on supporting faculty interests in innovation and entrepreneurship (I&E) at OSU. His interest in the intersection of academy and industry originated from his successful co-founding of Valliscor. Rich is the PI of an NSF-funded program to facilitate a national conversation on how to ensure academic incentives such as promotion and tenure (P&T) value I&E and reward broader societal impacts. This led to the creation of the Promotion & Tenure Innovation & Entrepreneurship (PTIE) effort, which involves over 65 institutions from around the country and numerous national stakeholder organizations. This work has resulted in a comprehensive set of recommendations for reform in promotion and tenure. Rich served as Chemistry Department Chair (2012-2017). In addition, he has served on the College-level P&T committee and chaired the Department-level P&T committee for multiple years. Finally, he is currently a mentor for the OSU Advantage Accelerator and sits on their Advisory Board.

2022 STAR Award Winners

Rae Robertson-Anderson

Physics
University of San Diego

Rae received her B.S. in Physics from Georgetown University in 2003, where she was awarded a Clare Boothe Luce Scholarship to conduct research on transport properties in driven granular matter. Rae received her Ph.D. in Physics from the University of California, San Diego in 2007, funded by an NSF Graduate Research Fellowship. Her doctoral work focused on elucidating controversial concepts in polymer physics by pioneering new molecular-level techniques and engineering DNA for use as a model polymer system. She completed an NIH postdoctoral fellowship in molecular biology at The Scripps Research Institute. There, she used single-molecule microscopy techniques to map the binding kinetics and pathways of HIV-1 regulatory proteins. Rae joined the Department of Physics and Biophysics at the University of San Diego in 2009, where she has also served as Chair and USD University Professor.

Rae has received over $4M in grants since 2010 to support her research, including prestigious awards such as a W.M. Keck Foundation Research Grant (2018), an NSF CAREER Award (2013), an Air Force Young Investigator Program Award (2012), and a Cottrell Scholar Award (2010). She has published 53 peer-reviewed papers in top-ranking journals including PRL, Science Advances, Nature Communications, and PNAS. She has given 34 invited talks at institutions and conferences around the world, has organized and hosted four soft matter research symposiums, and currently serves on advisory boards for Research Corporation, the Beckman Foundation, and the Murdock Charitable Trust.

2022 STAR Award Winners

Scott Snyder
Chemistry
University of Chicago

Scott grew up in the suburbs of Buffalo, NY, where his interests in science, particularly chemistry, were forged by a variety of experiences including an opportunity in high school to attend the United States National Study Camp for the International Chemistry Olympiad. Scott pursued his undergraduate studies at Williams College in Williamstown, MA, where he graduated as valedictorian, and in 1999 began his graduate studies with Professor K. C. Nicolaou at The Scripps Research Institute in La Jolla, CA. During the next five years, Scott was fully funded by graduate fellowships from the National Science Foundation, Pfizer, and Bristol-Myers Squibb, and in addition to his benchwork he also co-authored the advanced text *Classics in Total Synthesis II* (Wiley-VCH). He was then an NIH postdoctoral fellow at Harvard University with Prof. E. J. Corey before starting his independent career at Columbia University in 2006. After being promoted to Associate Professor of Chemistry in June of 2011, Scott moved to Jupiter, FL, campus of The Scripps Research Institute in September 2013 as an Associate Professor of Chemistry, and was recruited by the University of Chicago as a Full Professor in September 2015.

His research interests are devoted to the synthesis of complex natural products, particularly those of the terpene, polyphenol, and alkaloid classes, seeking to identify new strategies and tactics of broad significance. Particular emphasis has been placed on dimeric and higher-order natural products of these classes. In addition, Scott and his group have developed a unique group of halogenating reagents that are used in both academia and industry, with one sold by Sigma-Aldrich to create natural and designed compounds.

Overall, Scott has trained more than 70 scientists in his laboratory from the high school through postdoctoral levels, and has delivered more than 175 lectures to date worldwide. He is dedicated to chemical education in its broadest sense as recognized by a 2009 Cottrell Scholar Award. Scott is also helping to shape the face of undergraduate education worldwide as co-author (with T. W. G. Solomons and C. B. Fryhle) of the 11th and 12th editions of *Organic Chemistry* (Wiley). Scott has also edited a set of volumes on domino chemistry that was just published by Thieme, and finally, Scott has also co-authored, with P. J. Beuning, D. Z. Besson and Nicola L.B. Pohl, the just-published second edition of the RCSA-supported book on teaching and mentoring in science entitled *Teach Better, Save Time, and Have More Fun*.

2022 IMPACT Award Winner

Seth M. Cohen
Chemistry and Biochemistry
University of California, San Diego

Seth grew up in the San Fernando Valley of Southern California and moved to the San Francisco bay area to attend Stanford University, where he earned a B.S. in Chemistry and a B.A. in Political Science. He then earned his Ph.D. from the University of California, Berkeley, under the mentorship of Prof. Kenneth N. Raymond, followed by an NIH postdoctoral fellowship in the laboratory of Prof. Stephen J. Lippard at MIT. He has spent his independent research career at the University of California, San Diego, including service as Chair of the Department of Chemistry and Biochemistry. His research program is focused on the interface of bioinorganic and medicinal chemistry, as well as advanced materials, specifically the chemistry of metal-organic frameworks (MOFs). Seth previously served as the AAAS Roger Revelle Fellow in Global Stewardship in the Office of Science and Technology Policy (OSTP) and he is an alumnus of the Defense Science Study Group (DSSG). He presently serves as a Program Manager in the Biological Technologies Office (BTO) of the Defense Advanced Research Projects Agency (DARPA), where he overseas programs on antiviral and antibiotic medical countermeasures, as well as water-from-air capture technologies. Seth is an elected fellow of the American Chemical Society (ACS), the Royal Society of Chemistry (RSC), and the American Association for the Advancement of Science (AAAS). He has been recognized with several awards for his research and teaching, including an NSF CAREER award, 2004 Cottrell Scholar and 2017 TREE awards from RCSA, and the ACS Cope Scholar Award.

Presentations by 2022 Cottrell Scholars

Wednesday, June 6, 5:00 – 6:30 pm

Darcy Barron	Physics, University of New Mexico
Ilse Cleeves	Astronomy, University of Virginia
Scott Cushing	Chemistry, California Institute of Technology
Ryan Davis	Chemistry, Trinity University and Sandia National Labs
Ben Feldman	Physics, Stanford University
Christine Hagan	Chemistry, College of the Holy Cross
Michael Larsen	Chemistry, Western Washington University
Lisa Olshansky	Chemistry, University of Illinois at Urbana-Champaign
Ryan Trainor	Astronomy, Franklin & Marshall College

Thursday, June 7, 8:00 – 9:30 am

Carl Brozek	Chemistry, University of Oregon
Serena Eley	Physics, Colorado School of Mines
Stephen Fried	Chemistry, Johns Hopkins University
Ryan Hadt	Chemistry, California Institute of Technology
Daniel Keedy	Chemistry, CUNY Advanced Science Research Center
Lauren Marbella	Chemistry, Columbia University
Krystle McLaughlin	Chemistry, Vassar College
Jorge Muñoz	Physics, University of Texas at El Paso
Amanda Patrick	Chemistry, Mississippi State University
Orit Peleg	Physics, University of Colorado Boulder
Aurora Pribram-Jones	Chemistry, University of California, Merced

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.
- Team members are Cottrell Scholars who received their awards from 1994-2022.
- The proposal could involve a new project that will expand the impact of existing funded collaborative projects. New collaborative projects are also welcome.
- Proposal should briefly describe an innovative approach for projects with potentially broad impact and explain how funds will be spent.
- Two-page proposal must be submitted through the RCSA online submission system by **11:59 p.m. PST** on **July 22, 2022**.
- To submit go to: https://www.GrantRequest.com/SID_596?SA=SNA&FID=35081
- Awards will be announced within a month of submission.

Conference Evaluation Survey

An online conference survey will be available on **Friday, July 8, 2022**. To access and complete the survey, please go to: https://www.surveymonkey.com/r/RB7PFMT

2022 Cottrell Scholars

Darcy Barron
Physics and Astronomy, University of New Mexico

Enabling Discoveries in Fundamental Physics by Maximizing the Sensitivity of Cosmic Microwave Background Polarization Surveys from Chile

Upcoming measurements of the polarization of the cosmic microwave background will answer outstanding questions in cosmology and particle physics, seeking evidence of inflation and signatures of new particles and new physics. This requires characterizing microwave polarization over the majority of the sky, with high resolution along with excellent sensitivity at large angular scales, and precise understanding and control over systematic effects. These exciting, challenging measurements are building on the significant progress made in technology development and demonstrations from three generations of ground-based CMB instruments. This proposed work is part of a larger effort, but targets specific areas where our group can provide valuable feedback and insight. This includes our work on the currently observing POLARBEAR-2/Simons Array survey of CMB polarization, which expanded the sky area and sensitivity beyond what was achieved with POLARBEAR-1 by expanding the superconducting detector count by over an order of magnitude. Our group will combine experience with POLARBEAR-1, incoming data from POLARBEAR-2/Simons Array, and instrument and survey requirements under development for upcoming surveys including CMB-S4, to better understand and maximize the achievable sky area and sensitivity from Chile. This is especially critical for achieving the theoretically motivated sensitivity thresholds for discovering signatures of new light relic particles in the CMB.

A seminar course will be taught each spring, designed to better support physics students at UNM in their first four semesters. This course and supporting workshops will tie together existing efforts to improve retention rates at this minority institution, and create a multi-tiered mentorship network.

Carl Brozek
Chemistry and Biochemistry, University of Oregon

Clean Water from Porous Nanocrystals: an Undergraduate Training Program in Soft Skills and Sustainable Materials

The research goal is to design solution-processable nanomaterials capable of detoxifying water through selective filtration and photoredox chemistry, with emphasis on learning the fundamental molecular chemistry that governs transport, interfacial redox chemistry, and nanocrystal assembly. We will accomplish this goal by synthesizing new porous nanocrystals of metal-organic frameworks that feature photoredox-active metal sites with tunable reactivity. Particles of different sizes will be prepared as colloids and assembled into membranes with variable inter-particle pore dimensions to understand the impact of transport on reactivity and toxin capture. We will use optical spectroscopy to probe mechanisms of interfacial photoredox chemistry and for operando monitoring of toxin degradation. This fundamental research will offer a well-defined platform for understanding water detoxification with molecularly precise reactivity and selective guest capture, while providing a new class of materials with size-dependent behavior amenable to thin film applications.

The education goal is to develop, implement, and evaluate a workshop program that trains undergraduates in “soft” skills to jumpstart their research. The program will be organized around modules focused on specific skills such as software proficiency (graphic design, Microsoft Office, and data analysis), communication (written, oral, and visual), and career preparation. Modules will range from general-use to field-specific, e.g., electrochemistry data analysis, and will be made publicly available online. Students from group underrepresented in STEM will be addressed in particular, guided by our hypothesis that early preparation in soft skills will greatly improve retention.

2022 Cottrell Scholars Continued

Ilse Cleeves

Astronomy, University of Virginia

Identifying Molecular Patterns that Reveal the Chemistry of Planet Formation

Planet formation begins within gas, ice, and dust rich disks encircling young stars, i.e., protoplanetary disks. The chemical composition of these disks provides the initial composition(s) for both rocky and gas-rich planets formed from them. We are in an exciting time where both the compositions of distant exoplanets and of planet forming disks are being independently characterized. However, most of the information we have about the pre-planetary building blocks comes from biased, massive disks that are easily detected. We propose to combine our well-tested, detailed physical and chemical simulations of disks with novel data science techniques to construct a molecular "tool box" that will allow us to utilize readily observable combinations of molecules to uncover fundamental truths about the planet forming environment, specifically what bulk compositions planets can inherit. These efforts will enable us to better understand the full range of possible chemical outcomes of planet formation and to better put our own Solar System into context. As part of my educational proposal, I will leverage my existing strong group culture and expertise to create a pilot program for a first-year undergraduate mentoring experience for URMs. With the support of the Cottrell Scholars Award, we will be able to support two students per semester part time for all three years of the program. The emphasis of this program will be on "demystifying" STEM through a combination of guidance on courses, career paths, and research projects that are primarily designed to provide skill-based training, such as coding and scientific writing.

Scott Cushing

Chemistry and Chemical Engineering, California Institute of Technology

The Role of Picosecond Correlations in Solid-State Electrolytes for Batteries

Lithium ion batteries using solid-state electrolytes promise higher energy densities and non-flammable operation. Forcing a Li ion to hop through the small atomic gaps in a crystal structure usually leads to a lower conductivity compared to liquids and polymers. However, a class of solid-state electrolytes termed superionic conductors have been found that actually transport Li ions faster than their liquid counterparts. The increased ion conduction is theorized to originate in ultrafast, picosecond timescale cooperative interactions between the Li ions and electrons, phonons, and other ions. My lab specializes in building new ultrafast tools using photons and electrons. In this proposal, we will build a new type of ultrafast impedance instrument that can measure picosecond ion hopping in solid-state electrolytes. The measurement can quantify the relative contribution of ion-electron, ion-phonon, and ion-ion correlations to the DC conductivity. Once built, the technique will be used to quantify the interplay between ion pathway geometry and picosecond ion correlations in two top-of-class superionic conductors (LLZO and LGPS). The developed technique can equally measure ion hopping in fuel cells, solar to fuels conversion, and biology in future studies. I will also initiate a year-round mentorship program between Caltech and local minority serving institutes (MSI). Based on a one-year trial project, the program aims to give undergraduates at MSI's flexible and consistent mentorship on the path to being a young scientist, especially when the MSI does not have the laboratory, specialties, or mentors needed for a high-level career in STEM.

2022 Cottrell Scholars Continued

Ryan Davis
Chemistry, Trinity University and Sandia National Labs

Chemistry Beyond the Beaker: Exploring Supramolecular Assembly in Aqueous Microdroplets and Addressing Inequities in Chemical Education

This proposal addresses emerging issues in fundamental aerosol chemistry and the chemistry curriculum at Trinity University, and it describes an approach to integrate aspects of research and teaching to enhance equity, improve student learning outcomes, and facilitate research collaborations. The research plan proposes the use of levitation-based techniques to study supramolecular assembly in aerosolized microdroplets relevant to understanding the airborne transmission of disease (Aim 1) and to develop a conceptual framework for predicting the effects of supramolecular assembly on the phase state of aqueous microdroplets, in general (Aim 2). The study of novel chemical interactions is enabled through a combination of levitation to achieve non-bulk conditions, microscopy to infer phase state, and spectroscopy to probe ion-molecule interactions. Specifically, the proposal focuses on the humidity-dependent phase behavior of aqueous microdroplets composed of inorganic ions and biomolecules. In particular, chemical systems that undergo gel transitions will be identified. The molecular functionality and size of the organic components will be systematically varied to develop a conceptual understanding that can be parameterized and modeled, with a goal of understanding, e.g., the fundamental processes that influence pathogen survival in respiratory aerosols. The education plan describes an asset- and design-based general chemistry laboratory that seeks to enhance equity and student self-efficacy (Aim 1), and a multi-institution, collaborative, course-based research experience (Co-CURE) that provides advanced undergraduates with networking and team science opportunities through virtual collaborations (Aim 2).

Serena Eley
Physics, Colorado School of Mines

Identifying the Microscopic Origins of Energy Loss Mechanisms in Superconducting Quantum Circuits through Defect Landscape Engineering

The performance of superconducting quantum circuits is limited by energy losses from parasitic two-level systems (TLSs), quasiparticle poisoning, and dissipative vortex motion. Despite numerous studies that have tuned the effects of these decoherence mechanisms, the microscopic origin of TLSs and source of quasiparticles is usually unknown and no methods exist to fully eliminate these mechanisms. We propose a novel approach to precisely identify the microstructural defects responsible for energy losses in superconducting quantum circuits – defect landscape engineering. We will fabricate epitaxial superconducting resonators then use ion implantation/irradiation to add known types and densities of disorder in precise locations. Using accelerators at a no-fee user facility at Sandia National Laboratories, we can place these defects with high precision matched by few facilities worldwide. Subsequent comparisons of the low-temperature microwave properties in the clean versus the irradiated resonators, in conjunction with modeling, will enable identification of the microscopic origin of TLSs that interfere with device performance. We will then study engineered TLS-TLS interactions. The goal is to devise a universal strategy to mitigate energy loss and identify novel materials for high coherence next-generation quantum circuits. My educational plan includes helping to develop a quantum-ready workforce, incorporating more research-based instructional strategies into my lab courses, matching students with industry mentors and modifying senior design to produce industry-recognized final products.

2022 Cottrell Scholars Continued

Ben Feldman

Physics, Stanford University

Thermodynamic Characterization of Metal-Insulator Transitions in Dual Gated Moiré Superlattices

The research component of this project will focus on strongly correlated behavior in moiré superlattices composed from twisted transition metal dichalcogenide layers. We will conduct electronic compressibility and transport measurements in dual gated samples as a function of electric field and carrier density to probe metal-insulator transitions and extract a variety of thermodynamic quantities in their vicinity. Key objectives include full characterization of the single-particle band structure and many-body gaps as a function of electric field, as well as probing the nature of the excitations and metallic states adjacent to a Mott insulator. We will also extract the entropy and the charge diffusivity as a function of filling factor to shed further light on these emergent quantum ground states. Finally, we will undertake a similar investigation of states at fractional filling factors. Together, these combined studies represent a new approach to investigate longstanding puzzles in strongly correlated electron systems. The educational component of the project includes two primary goals. First, we will facilitate early undergraduate research experiences among a diverse cohort of students by reducing barriers to access. We will do this by adding structural backstops to encourage student participation and help them match with faculty mentors. The second major goal of the educational work will be to build a robust network of mentors to support students and foster their professional development. Together, these efforts will increase the diversity of physics majors and research participants, and will help to attract and retain students in the major and beyond.

Katherine Follette

Physics and Astronomy, Amherst College

Moving Forward – Towards Accurate Recovery and Interpretation of Accreting Protoplanets and a Socially Just Undergraduate Astronomy Curriculum

We are entering an exciting era where it is possible to directly observe the assembly of giant planets through detection and characterization of forming protoplanets. These detections enable estimates of mass accretion (growth) rates, informing formation mechanisms, evolutionary processes, and the physics of accretion; However, estimates of accretion rates for protoplanets suffer from two key problems. First, accreting protoplanets are embedded in complex circumstellar disks, and disentangling planetary and disk emission is a difficult and controversial process. Robust, well-validated techniques are a pressing need in the community. Second, translation of protoplanet observations to accretion rate estimates currently assumes an equivalence between stellar and planetary accretion physics, and this assumption is almost certainly incorrect. In other words, we need to learn to interpret planetary accretion signatures accurately. Together with my team of primarily undergraduate researchers, I aim to: (a) test the broad applicability of our newly-developed planetary signal extraction technique by applying it to new datasets, instruments, and wavelengths, and (b) assemble multiwavelength observations of young accreting brown dwarfs to test the validity of the stellar accretion paradigm at substellar masses. These efforts will help move us toward reliably detecting and accurately interpreting the observational signatures of accreting protoplanets. At the same time, I will integrate activities designed to increase sense of belonging, acknowledge the benefits of equity, normalize struggle, instill growth mindset, and foster collaboration into the Astronomy major sequence at Amherst College. This will improve the climate and inclusivity of our currently majority white, majority male department.

2022 Cottrell Scholars Continued

Wen-fai Fong
Physics and Astronomy, Northwestern University

Toward the Next Breakthroughs in Time-Domain Astronomy: The Origins of Fast Radio Bursts

Astronomical surveys which repeatedly image the sky have revealed that our universe is full of cosmic transients, or sources that change in brightness over time. As a Cottrell Scholar, I will lead my research group to make significant contributions to one of the central unanswered questions in time-domain astronomy: what are the origins of Fast Radio Bursts (FRBs)? Our approach to this question will be multi-wavelength and holistic, driven by investigations that have yet to be conducted in a systematic way. We will use the full power of electromagnetic spectrum to perform systematic and detailed broad-band studies of their host galaxies, identify counterparts to FRBs through rapid observations, and use archival information to unearth connections between FRBs and complementary (historical) transients. Motivated by the dearth of female and under-represented minority (f-URM) in physics, and the transformative social justice movement in our community, I will develop educational programming to cultivate that crucial "sense of belonging" in higher education, that research has shown to be so paramount to the persistence of f-URM students in physics (and STEM at large). In partnership with researchers in education and diversity, I will develop and teach an innovative and sustainable undergraduate course that is centered on the contributions of women and astronomers of color to major astronomical discoveries in history. I will also make Northwestern a permanent site of the American Physical Society's Conference for Undergraduate Women in Physics, providing a further avenue for talented, but underserved, f-URM students to matriculate to graduate school.

Stephen Fried
Chemistry and Biophysics, Johns Hopkins University

Bringing New Life to Prebiotic Peptide Chemistry and to the Physical Chemistry Curriculum

Research Abstract: Peptides that self-assemble into amyloids may have played key prebiotic roles as early catalysts, compartments, and interaction hubs for other biomolecules. However, it has yet to be demonstrated whether an amyloid can act as a template to direct the condensation of amino acids to create additional copies of the same amyloidogenic peptide. This project proposes to use modern mass spectrometry proteomics to analyze peptides generated by wet/dry cycling of early amino acid mixtures to search for evidence of selective amplification of peptide sequences with structure-forming sequences. The results would constitute compelling evidence that peptides could have served as informational molecules in a prebiotic context independent of nucleic acids, and acted as a bridge from the 'Miller-Urey amino acid world' to a subsequent 'RNA-peptide world.'

Educational Abstract: The standard physical chemistry syllabus needs reform, as it retains a historic emphasis of gas phase spectroscopy of small molecules, and macroscopic formulations of heat and entropy originating from the industrial revolution. I propose a systematically modernized curriculum, with a strong emphasis on training computational skills (virtually absent in many chemistry departments' undergraduate programs), developing a microscopic intuition for heat and entropy, and applying these principles to problems in biomolecular and medical sciences to better serve our medically-inclined student population. In my capacity as a member of the Undergraduate Curriculum Committee, I also propose broader reforms to the undergraduate program to modernize it and better prepare our graduates for diverse opportunities following their bachelor's degrees.

Ryan Hadt

Chemistry and Chemical Engineering, California Institute of Technology

Research: Learning How to Engineer Spin-Phonon Coupling in Molecules and Materials; Educational: Tackling Theoretical Topics in Inorganic Chemistry: A Worked Example Approach

We have recently developed a molecular paradigm based on symmetry and vibrational principles to describe spin-phonon coupling in electron spin quantum bits (qubits). This allowed for the elucidation of the specific vibrational modes giving rise to decoherence and provided a chemical rationalization of room temperature coherence in transition metal complexes. This proposal seeks to control and understand structural and spin-phonon coupling contributions to information loss in single ion magnetism, molecular electronics, and qubit platforms based on transition metal complexes. Developing scalable qubit architectures is an additional challenge in quantum information science. We aim to incorporate well-studied molecular qubits into 2D layered materials, with the goal of understanding how electron spin relaxation is influenced by spin-phonon coupling in one versus two dimensions. We further aim to create an open educational resource (OER) that will be initially developed and evaluated though my inorganic chemistry courses at Caltech and then disseminated more broadly. The OER will integrate active learning components and provide students with critical worked examples and guided self-explanations to lower the barrier to mastering theoretical topics in inorganic chemistry. This approach increases student learning by reducing cognitive load and increasing the availability of working memory to productively create schema. The positive effects of OERs have been demonstrated more generally, but are disproportionately found to be especially important for populations of historically underserved students, where access to resources is often a deciding factor in their success. Finally, the development of OER materials provides a new mechanism to mentor students in my group.

Christine Hagan

Chemistry, College of the Holy Cross

Mechanistic Studies of Protein Toxin Delivery by Bacterial Contact-Dependent Inhibition Systems

New therapeutics are urgently needed to treat infections caused by Gram-negative bacteria, but it is difficult to develop new antibiotics capable of killing these pathogens because their cells are surrounded by an outer membrane (OM) that is impermeable to many small, hydrophobic, drug-like molecules. Many Gram-negative bacteria, however, deliver large protein toxins across the OMs of competing bacteria in their environments. I aim to understand how these protein toxins are transported across a membrane that normally excludes much smaller molecules in order to identify principles that could guide the development of novel therapeutics. I will focus on the mechanism of a contact-dependent inhibition (CDI) system from E. coli and will develop a biochemical assay to monitor its transport of a protein toxin across a model membrane. This assay will be used to identify the specific molecular requirements for toxin translocation and to characterize intermediate steps in the translocation mechanism. Undergraduate students from underrepresented groups will participate in this research on CDI systems in a course I will offer in the summer before their first-year of college. Students will learn basic chemistry and biology concepts, make connections between those concepts, and apply them to a research question. Specifically, the students will attempt to change the specificity of a particular CDI system to allow it to target different species of Gram-negative bacteria. The summer course will be tied to a system of peer support and faculty mentoring during the academic year, which aims to improve student retention in STEM courses.

2022 Cottrell Scholars Continued

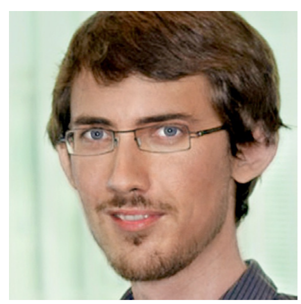
Sarah Keane
Chemistry / Biophysics, University of Michigan

RNA Matchmaker: The Role of Loops and Mismatches in RNA Processing

Research Plan: Non-coding RNAs are key regulators of diverse biological processes in both prokaryotes and eukaryotes. MicroRNAs are a family of small non-coding RNAs that are important post-transcriptional regulators of gene expression. Dysregulation of specific microRNA levels, either reduced or enhanced expression, has been linked to myriad diseases. To maintain proper microRNA expression levels, eukaryotic cells must tightly control the enzymatic processing of primary and precursor microRNA elements. However, the molecular determinants underlying this strict regulation of microRNA biogenesis are not fully understood. The work proposed here will interrogate the role of unpaired nucleotides in the helical stem and apical loop of precursor microRNA-31 in regulating its processing. We will examine the dynamics of these nucleotides and monitor changes in RNA structure that occur during processing. Furthermore, we will explore the ligandability of these RNA elements for targeting with small molecules.

Education Plan: My educational initiatives are aimed at providing authentic learning experiences for upper-level undergraduate students studying Biochemistry and Biophysics. Rather than didactic, lecture-based instruction in biochemistry, I will give students the opportunity to learn “like a scientist,” by reading and discussing the primary literature. I will also develop a CURE module for the Techniques in Biophysics Laboratory course, which will give students the opportunity to conduct a research project, analyze their data, and report their findings. Furthermore, a Graduate Student Instructor will assist in the CURE development, providing them with valuable insight into curricular development and instruction that is typically invisible to them as students.

Daniel Keedy
Structural Biology Initiative,
CUNY Advanced Science Research Center



Illuminating Structural Motions that Underlie Allostery in Dynamic Phosphatase Enzymes

The research proposed here aims to elucidate in unprecedented detail how atomic motions control enzyme catalysis. In particular, I will explore how such motions differ in evolutionarily divergent members of the same human enzyme family, Protein Tyrosine Phosphatases (PTPs), which play distinct cellular roles and are linked to distinct diseases, to enable design of selective allosteric inhibitors for specific PTPs. To do so, I will exploit emerging techniques in structural biology to measure atomic motions at high resolution, including new methods in X-ray crystallography to directly reveal correlated motions in enzymes when at rest vs. during catalysis, as well as high-resolution mass spectrometry experiments to map changes in dynamics for both ordered and disordered enzyme regions in solution. This work will provide novel insights into how individual PTPs have evolved unique dynamic signatures despite sharing a structural architecture and catalytic mechanism. Such lessons will guide efforts to specifically inhibit individual PTPs with allosteric small molecules by exploiting their unique dynamic signatures, enabling the design of new drugs to combat diseases associated with specific PTPs including diabetes, cancer, and Alzheimer’s. To integrate my research and educational plans, I propose to implement evidence-based teaching methodology, in particular active learning, into my undergraduate Biochemistry course, centered on a unique group-based, crowd-sourced project in which students prospectively interrogate how amino acid mutations affect enzyme structure and function.

2022 Cottrell Scholars Continued

Michael Larsen

Chemistry, Western Washington University

Diverse N-Functionalized Polyureas by Cationic Ring-Opening Polymerization of Iminooxazolidines

Research Proposal: Polyureas are a broadly useful class of materials that are traditionally made by step-growth polymerization, which inherently lacks easy control of polymer molar mass, endgroups, and dispersity. We propose a new, modular synthetic pathway to iminooxazolidine monomers and the corresponding polyureas made by chain-growth cationic ring-opening polymerization. The monomers derive from widely available amines or isothiocyanates and aldehydes, and the versatility of the synthetic approach is such that a variety of functionalities can be incorporated into the resulting polyurea. Furthermore, the mechanism of polymerization lends itself to termination by nucleophiles, with the result that block polymers are easily obtained when a suitably functionalized polymer or chain transfer agent is reacted with the growing polyurea chain end.

Educational Proposal: The goals of Western Washington University (WWU) and the WWU Department of Chemistry include advancing success for students of all identities and backgrounds as well as facilitating opportunities for graduates with regional employers. These goals may be hindered by reliance on often-unwritten professional skills, as students from marginalized communities may lack experience with these implicit norms. My educational proposal centers on the creation of a one-credit elective class to teach valuable, transferrable professional skills that will contribute to equitable outcomes for our department's graduates. Additionally, the proposal seeks to leverage our department's strong existing ties to regional employers to create a formal recruiting program for our students. This will provide career opportunities that are not reliant on informal networks, a documented source of inequity and bias in the professional world.

Lauren Marbella

Chemical Engineering, Columbia University

Tracking (Electro)Chemical Reduction at Electrode/ Electrolyte Interfaces with Operando NMR

Li metal anodes react with both liquid and solid electrolytes, generating a solid electrolyte interphase (SEI) that impacts the stability of Li stripping and plating during battery operation. Although the SEI plays a key role in Li metal battery performance, current approaches to SEI characterization (e.g., electron microscopy, X-ray photoelectron spectroscopy) are performed post-mortem and cannot capture SEI formation in situ. We propose to leverage our distinct abilities in operando NMR to elucidate the chemical and electrochemical reduction mechanisms underpinning SEI formation in liquid and solid electrolytes. Completion of the proposed research will create some of the first molecular-level descriptions of interfacial reactivity in Li metal batteries, with NMR providing the chemical and temporal insight required to discover electrolyte formulations for smooth Li deposition. This research plan is strongly coupled to educational activities that will establish an inclusive learning environment for NMR education and research training. Specifically, I will create and implement mathematical modules required to interpret data in the NMR of Materials course at Columbia, moving beyond current approaches in organic chemistry curricula. These efforts are complemented with a "NMR of Our World" module that fuels a personal connection with science as well as an interactive Escape Room exam to complete learning objectives for practical NMR application. In addition, I describe efforts to integrate advanced solid-state NMR experimentation into undergraduate research projects. This inclusive learning approach is expected to improve outcomes for students from a variety of backgrounds in Columbia's 3+2 and 4+1 science-to-engineering combined plan programs.

2022 Cottrell Scholars Continued

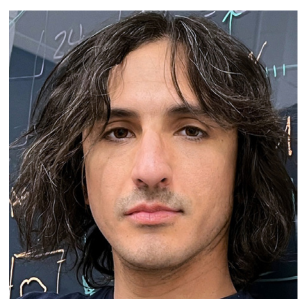
Krystle McLaughlin
Chemistry, Vassar College

Structural Basis for the Conjugative Spread of Antibiotic Resistance

Multidrug resistant bacterial strains are on the rise, posing a major threat to human health. Conjugative plasmid transfer is a major driver in the emergence of these pathogens, but many of the underlying processes are not well studied. During conjugation a DNA plasmid moves unidirectionally from a donor cell to recipient cell through a pore. Mediating the transfer are several plasmid-encoded protein complexes including the relaxosome, a secretion system, and coupling protein. The secretion system forms a pore connecting the bacteria, and the coupling protein links the pore to the relaxosome, which coordinates all plasmid processing before translocation can occur. Yet, the basic molecular details of the relaxosome remain poorly characterized. Through the study of plasmids from Salmonella Typhimurium and Staphylococcus aureus, we will characterize the structure and function of the relaxosome. Unraveling the molecular mechanism of the relaxosome may reveal new avenues for understanding and preventing the spread of antibiotic resistance.

Macromolecular x-ray crystallography is the leading technique for solving protein structures, though it is rarely introduced at the undergraduate level. Course-based Undergraduate Research Experiences (CUREs) have been shown to be an effective way to integrate authentic research projects into the curriculum, however there are currently no CUREs available for adoption that include protein crystallography. My educational proposal discusses the creation of a protein crystallography focused CURE and aims to develop comprehensive macromolecular crystallography materials to enable widespread integration into the undergraduate curriculum.

Jorge Muñoz
Physics, University of Texas at El Paso



Fast and Accurate Computation of Anharmonic Phonons in Polymorphic Materials

Knowledge of the lattice dynamics is critical to understand, predict, and manipulate the properties of solids. Density functional theory can be used to calculate the lattice dynamics accurately from first principles, but these methods are computationally expensive. The computation of the interatomic force constants (IFC), tensorial quantities that represent derivatives of the potential energy surface (PES) with respect to atomic displacements from equilibrium, is the main bottleneck. We propose to use a Gaussian Process Regression machine learning model with a marginalized graph kernel to learn PESs via active learning and the technique of automatic differentiation to acquire IFCs directly, and we propose to use this to investigate the role of phonon anharmonicity on the mechanical stability of intermetallics with the B2 austenite structure at high pressure and the phonon anharmonicity of carbon allotropes at elevated temperature.

Many students potentially interested in pursuing a physics career never get the opportunity because their math preparation when they get to college precludes them from taking calculus-based introductory physics classes in their first semester. When they eventually take these classes, they already have enough credits in other majors to discourage them from switching to physics. We propose to create an algebra-based computational materials physics class with Team-Based Learning (TBL) and elements of Course Undergraduate Research Experience (CURE) that students at The University of Texas at El Paso (UTEP) and elsewhere so they can take it in their first semester to expose them early to mentoring and physics research and encourage them to think scientifically.

Lisa Olshansky

Chemistry, University of Illinois at Urbana-Champaign

Exploring and Exploiting Conformational Dynamics for Proton-Coupled Electron Transfer

Proton-coupled electron transfer (PCET) processes mediated by metalloenzymes underlie biosynthesis, energy transduction, and transport processes that govern global bio- and geochemical cycles. Precise control over the synchronicity of PCET steps in these enzymes is gated by rate-limiting conformational changes. However, most synthetic and artificial PCET systems ignore the powerful role that structural changes can play therein. By creating faithful metallocofactor mimics in which carboxylate-mediated hydrogen bond (H-bond) interactions are manipulated to control PCET reactivity, we will define the factors governing proton and electron transfer energetics and kinetics as influenced by carboxylate shift dynamics. These complexes represent structural models for nonheme diiron enzyme active sites and insights gained will inform the development of novel catalysts for the oxidation of strong chemical bonds (e.g. the C–H bond of methane, which has a BDE of ~104 kcal/mol). In synergistic educational work, a community building initiative for underrepresented undergraduate Illinois chemistry majors will be created. The program combines one-on-one peer mentorship, networking and professional development workshops, research fellowships, presentations, and travel awards. Together, these activities will create a community of scholars in which assumed knowledge is explicitly transmitted, role models are celebrated, and excellence and diversity are able to thrive at Illinois.

Zachariah Page

Chemistry, University of Texas at Austin

Color-Coded Orthogonal Photochemistry from a Single Dye & Guiding Student Mindsets in Organic Chemistry

Research. The health and well-being of society is reliant on advancements in polymers, yet the sophistication of contemporary synthetic materials pales in comparison to those in nature. Proposed herein is the development of a new route that utilizes different colors of light as stimuli to fabricate next generation materials with unprecedented spatial precision of composition and, in-turn, functionality. This objective will be accomplished through the synthesis, characterization, and implementation of novel visible to near infrared (NIR) light activated dyes that absorb two distinct colors of light to facilitate wavelength-selective (i.e., color-coded) activation of distinct (orthogonal) chemical reactions. As a result, fundamental scientific insights stemming from the proposed efforts will inform the design of energy-efficient, light-driven reactions and enable the preparation of multifunctional 3D objects.

Education. A diverse workforce fosters innovation required to solve evermore-complex questions, yet STEM attrition at the university/college level disproportionately affects underprivileged students and counteracts efforts to produce the next generation of competent, well-trained STEM professionals. Proposed herein are a combination of innovative mindset intervention strategies to break the negative perceptions surrounding Organic Chemistry, a course that historically acts as a "gatekeeper" to persistence in STEM. Three primary intervention methods will be implemented into two out of four large lecture (>300 pupils) Organic Chemistry I classes at The University of Texas (UT) at Austin and evaluated for their combined efficacy on learning and retention of underprivileged students in STEM: 1) a role model video of UT-Austin alumni, 2) value affirmation questions, and 3) growth mindset education.

2022 Cottrell Scholars Continued

Amanda Patrick
Chemistry, Mississippi State University

Winnowing the Possible Identities of Metabolomics "Features" by Hydrogen-Deuterium Exchange Mass Spectrometry

Advances in separations science and improvements in mass spectrometry resolution have yielded unprecedented abilities to identify "features" in metabolomics data. However, standard retention times and dissociation pathways aren't known, easily predicted, nor necessarily unique, for all metabolites, and monoisotopic mass only narrows possible structures down to isomers at best. Here, it is proposed that using predicted number of exchangeable protons, along with hydrogen-deuterium exchange mass spectrometry experiments, can provide an additional dimension of analysis that will greatly narrow down possible candidates, through a direct structural interrogation, without significant barriers. We propose to annotate Human Metabolome Database entries with predicted number of exchangeable protons, analyze those frequencies as a function of mass to determine the power of this dimension of analysis, and perform preliminary experiments to validate the assignments and to move the analysis toward routine implementation.

This proposal also includes an educational plan to better integrate writing into our chemistry education at Mississippi State University through increased inclusion in coursework and through the development, implementation, and evaluation of a Summer Science Communication Workshop for undergraduate and graduate students. The coursework integration will focus on improving student engagement and content mastery. The workshop will cover job-related writing (resume, CV, cover letter, statements), outreach via blogging and social media, and highlights for effective formal scientific writing.

Orit Peleg
Computer Science and BioFrontiers Institute, University of Colorado Boulder

The Physics of Firefly Communications: Principles and Predictions

Our world is full of living creatures that must communicate information to survive and reproduce. A better understanding of how these communication signals are generated and interpreted – an important challenge in ecology—could benefit from physics and mathematics, via application of concepts like energetic cost, compression, and detectability. I propose to work with firefly swarms, which offer a rare avenue into this interdisciplinary endeavor, as their signals are purely visual, approximately digital, and traceable, even in vast congested groups of individuals. Recent advances in field and virtual-reality technologies allow us to probe further than ever before and investigate deep questions about signal-design strategies and their broadcasting and processing. My extensive background in quantitative studies of insect swarms and fluency in both theoretical and experimental approaches places me in a unique position to develop a deeper understanding of animal communication through testable phenomenological theories.

As a Cottrell Scholar, I will develop a class titled "Physics, Artificial-Intelligence, and Generative-Art of Agent-Based Models", that will encourage a Feynman-like joy in learning. Building on the materials from the multi-agent systems class I piloted at CU Boulder, I will increase the class's accessibility via interdisciplinary visual experiences. The visual component will be aligned with my current research on firefly behavior, with content inspired by and connected to the Research Proposal. As multi-agent systems have long been used to seed generative artwork, the course will build on these aesthetic expressions while teaching the students about the physics and artificial intelligence of multi-agent systems.

2022 Cottrell Scholars Continued

Aurora Pribram-Jones
Chemistry, University of California, Merced

Reframing Interaction in Quantum Mechanical Ensembles and Across Chemistry Learning Communities

Density functional theory is known to struggle with accurate simulation of diradicals, transition metal oxides, and other strongly correlated systems, where non-interacting references present formal structures difficult to overcome in approximations. Thermal density functional theory raises questions about the importance of temperature dependence, especially as systems become strongly correlated or otherwise complex. A new formalism, finite-temperature strictly correlated electron density functional theory, provides a novel path to overcoming these challenges. Though approaching the strong interaction limit is complicated in thermal ensembles by tied density-temperature-interaction strength scaling, tools valuable in cold limits can help untangle these influences. Preliminary results using adiabatic connection approaches and new approximations to interaction free energies support the proposed aims.

In this proposal, quantum mechanical classroom-based research on local water contaminants is used to build mathematical skills, examine study and learning practices, and span the undergraduate-graduate student divide. The educational proposal has three main objectives: 1) provide a culturally relevant and student-driven skill building program centered on mathematical and computational models, 2) improve metacognitive skills in UCM students, and 3) construct a broad-based chemistry learning community through course-bridging research experiences that incorporate peer and near-peer mentoring.

Ryan Trainor
Physics and Astronomy, Franklin & Marshall College

Feedback in the Circumgalactic Medium Probed with Lyman-alpha Emission

Galaxy evolution depends on "feedback"– the interactions of stars, black holes, and gas. Feedback affects star formation within galaxies as well as the large-scale ionization of the Universe, but this research program targets the relatively unconstrained region at the interface between them: the circumgalactic medium (CGM) that surrounds galaxies. Lyman-alpha (Ly?) emission is a sensitive tracer of CGM gas, particularly with the advent of new models to extract density and kinematic information encoded through Ly? scattering. This proposal will characterize the effects of external and internal ionizing fields on the CGM by correlating extended Ly? emission with proxies for (a) the rate of ionizing photon leakage through the interstellar medium, and (b) large variations in the local UV background. In addition, the project will analyze an exemplar system where both ionization and large-scale gaseous outflows are associated with an accreting supermassive black hole. This work will thus provide several new constraints on the role of different feedback mechanisms in the CGM of galaxies.

The education program aims to build a stronger sense of "belonging" and "science identity" among minoritized students in my department. The proposal includes classroom assignments that expand the concept of science identity to include skills such as ethical reasoning and critical thinking. Other assignments will explicitly explore the sociological factors that maintain inequity in science, thereby disrupting harmful stereotypes. Finally, a new paid fellowship will provide opportunities for students to take on scientific research and teaching responsibilities while contributing to social good in our local community.

Conference Participants

Victor M. Acosta CS 2019
vmacosta@unm.edu
Physics and Astronomy, University of New Mexico
My research is in quantum sensing, basically using qubits to detect stuff. Our model qubit is the NV center, an atom-like defect in diamond. I am interested in attracting undergraduates from New Mexico to the Quantum Technologies field through our summer program, QU-REACH.

Mario Affatigato CS 1996
maffatig@coe.edu
Physics, Coe College
Interested in oxide glasses and amorphous materials: properties, structure, applications. Deeply involved and interested in undergraduate research.

Vinny Agarwal CS 2021
vagarwal@gatech.edu
Chemistry and Biochemistry,
Georgia Institute of Technology
Building organic molecules using genes and enzymes from marine animals. Bringing hands-on training in microbiology and mass spectrometry to undergraduates at Georgia Tech.

Douglas Arion
darion@carthage.edu
Executive Director and Emeritus Professor,
Mountains of Stars and Carthage College
Public Science Education and Outreach; Astronomy and instrumentation. Innovation, Creativity, and Professional Development for Students.

Tim Atherton CS 2015
Timothy.Atherton@tufts.edu
Physics and Astronomy, Tufts University
Soft matter theory, including computational studies of shapeshifting. Teach computation through the lens of disciplinary practices and inclusion.

Ashleigh E. Baber CS 2018
baberae@jmu.edu
Chemistry and Biochemistry,
James Madison University
Understanding the role of surface modifications on chemical selectivity and reactivity. Enhancing student success and retention in general chemistry.

Carlos R. Baiz CS 2020
cbaiz@cm.utexas.edu
Chemistry, University of Texas at Austin
Membrane physical chemistry; crowded environments; protein biophysics. Ultrafast vibrational spectroscopy and simulations. Student mental health; teaching high-achieving undergraduate students; graduate student diversity and education.

Amy Barrios
amy.barrios@utah.edu
Medicinal Chemistry, University of Utah
The Barrios lab develops chemical tools for studying protein phosphorylation in cellular signaling. Helping clinicians understand the basic science behind therapeutics, science literacy for nonscientists, supporting research trainees.

Darcy Barron CS 2022
dbarron2@unm.edu
Physics and Astronomy, University of New Mexico
I study our universe with measurements of the cosmic microwave background, from building instruments to understanding the data they produce. I'm interested in bringing elements of research and discovery into physics courses, to give a broader audience access to these experiences.

Penny Beuning CS 2009
penny@neu.edu
Chemistry and Chemical Biology,
Northeastern University
DNA damage responses, DNA replication, and protein engineering, with applications in cancer, antibiotic resistance, and forensic science. Education interest in CUREs, undergraduate early research, classroom active learning, graduate student and faculty professional development.

Rachel Bezanson CS 2021
rachel.bezanson@pitt.edu
Physics and Astronomy, University of Pittsburgh
I am an observational astronomer and use telescopes (including JWST!) to study how distant galaxies form and grow over billions of years. At Pitt I am working to improve undergraduate and graduate student mentoring and bolster the nascent APS Bridge Ph.D. Program.

Laura Blecha CS 2021
lblecha@ufl.edu
Physics, University of Florida
I use multi-scale simulations to study the evolution of supermassive black holes and galaxies, including gravitational-wave sources. I am expanding scientific computing opportunities for undergraduate and high school, with a focus on historically excluded groups in STEM.

Carl K. Brozek CS 2022
cbrozek@uoregon.edu
Chemistry and Biochemistry, University of Oregon
We design water purification membranes that simultaneously accomplish the goals normally meant for many separate water filtration steps. We train undergraduates in soft skills, from graphic design to resumé building, to prepare them as leaders in their careers.

Mark Bussell CS 1994
mark.bussell@wwu.edu
Chemistry, Western Washington University
Surface and materials chemistry of heterogeneous catalysis. Renewable energy-focused CUREs for 2- and 4-year institutions.

Jeff A. Byers CS 2015
jeffery.byers@bc.edu
Chemistry, Boston College
Organometallic chemist interested in catalysis related to renewable energy, sustainable plastics, and biologically-active small molecules. Applying active learning principles and course-based undergraduate research experiences.

Justin Caram CS 2021
jcaram@chem.ucla.edu
Chemistry and Biochemistry,
University of California, Los Angeles
Quantum materials, infrared imaging, the extremes of excitonic photophysics. Supportive general chemistry for non-majors. Replacing remedial coursework with responsive and peer based learning.

Rich G. Carter
rich.carter@oregonstate.edu
Research Office / Chemistry, Oregon State University
Research interests range from total synthesis of biologically active natural products to organofluorine chemistry for industry. Education interests in reform of promotion and *tenure to be more inclusive of innovation* and *entrepreneurship faculty impact.*

Bert Chandler CS 2001
bert.chandler@psu.edu
Chemical Engineering, Pennsylvania State University
We eat, drink, think, and breathe catalysis. Developing systems and programs to extend the benefits of undergraduate research to as many students as possible.

Lou Charkoudian CS 2018
lcharkou@haverford.edu
Chemistry, Haverford College
Our undergraduate research team studies natural product biosynthesis. Integrating original research into courses and understanding how interpersonal factors influence diversity and inclusion in STEM.

Laura Chomiuk CS 2017
chomiuk@pa.msu.edu
Physics and Astronomy, Michigan State University
I carry out multi-wavelength, holistic studies of novae, supernovae, and accreting black holes. I involve a large number of diverse undergrads in research at the MSU Observatory and beyond.

Ilse Cleeves CS 2022
lic3f@virginia.edu
Astronomy, University of Virginia
We work on understanding the astrochemical origins of forming planets using models and radio/infrared telescopes. I want to reach students from unconventional backgrounds to get them excited about problems in astro(physics, chemistry, biology, etc.).

Seth M. Cohen CS 2004
scohen@ucsd.edu
Chemistry and Biochemistry,
University of California, San Diego
Inorganic, bioinorganic, medicinal, and materials chemistry. Innovative pedagogy, science policy.

Conference Participants Continued

Linda Columbus CS 2010
columbus@virginia.edu
Chemistry, University of Virginia
Membrane and membrane protein interactions and conformational changes. Parity in grade distribution and student experiences.

Lindsay Currie
lcurrie@cur.org
Executive Officer, Council on Undergraduate Research
All things undergraduate research.

Scott K. Cushing CS 2022
scushing@caltech.edu
Chemistry and Chemical Engineering,
California Institute of Technology
The Cushing lab develops ultrafast instrumentation based on X-rays, entangled photons, and ultrafast electrons and ion techniques. Scott runs multiple programs regarding mental health and DEI outreach.

Ryan D. Davis CS 2022
rdavis5@trinity.edu / rddavis@sandia.gov
Chemistry,
Trinity University and Sandia National Labs
Studying how the chemistry and physics of micro-environments can differ from in a beaker, with application to climate and disease transmission. An education philosophy centered on asset-focused pedagogy, discovery-driven learning, and interdisciplinary topics.

Julio C. de Paula CS 1994
jdepaula@lclark.edu
Chemistry, Lewis & Clark College
Nanomaterials, archaeometry, photochemistry. Physical, analytical, general, and environmental chemistry, biochemistry.

Michael Dennin CS 2000
mdennin@uci.edu
Physics and Astronomy,
University of California, Irvine
Identifying structural barriers to student success. Eliminating structure barriers to student success.

Joel F. Destino CS 2021
joeldestino@creighton.edu
Chemistry and Biochemistry, Creighton University
Developing materials and chemical measurement with interests in colloids, glass, 3D-printing, luminescent chemical sensors, and spectroscopy. UG research mentorship. 1st gen and URS engagement. Active learning that informs social consciousness and *connects the classroom to the world.*

Kelling Donald CS 2008
kdonald@richmond.edu
Chemistry, University of Richmond
The Donald computational chemistry group works on problems in chemical bonding and reactivity across (in) organic and materials chemistry. Donald is interested in the role model effect, inclusive teaching, and flipped classrooms in general and physical chemistry courses.

Charlie Doret CS 2017
scd2@williams.edu
Physics, Williams College
Precision Measurements and Quantum Simulation with Trapped Ions. Making undergraduate courses and laboratories more engaging and inclusive.

Serena Eley CS 2022
serenaeley@mines.edu
Physics, Colorado School of Mines
Superconductivity, magnetism, energy loss mechanisms in superconducting quantum circuits. Broadening participation in quantum science and engineering.

Ben Feldman CS 2022
bef@stanford.edu
Physics, Stanford University
Research interests: developing new techniques to engineer and study emergent quantum electronic phases in reduced dimensional systems. Educational interests: enhancing undergraduate research opportunities as well as developing active learning and inquiry-based coursework.

Conference Participants Continued

Jay Foley CS 2019
foleyj10@wpunj.edu
Chemistry, William Paterson University
Computational design of materials for harnessing light and heat. Integrating programming into the chemistry curriculum.

Alex Frañó CS 2021
afrano@ucsd.edu
Physics, University of California, San Diego
I do research on quantum materials, condensed matter, neuromorphic computing, x-ray light/matter interactions, self-assembly, etc. I aim to teach in an inclusive, holistic way, enabling students to use creative thinking skills combined with analytical skills.

Stephen Fried CS 2022
sdfried@jhu.edu
Chemistry, Johns Hopkins University
We leverage mass spec proteomics to interrogate protein folding globally, sensitively, and across the Tree of Life. Trying to revitalize the ossified physical chemistry curriculum and introduce computation to chem majors.

Carla Fröhlich CS 2014
cfrohli@ncsu.edu
Physics, North Carolina State University
Light, nuclei, neutrinos, neutron stars, and black holes from stellar explosions. Astrophysics simulations. Machine learning. Inclusive teaching. Non-traditional forms of assessment.

Jordan Gerton CS 2007
jgerton@physics.utah.edu
Physics and Astronomy, University of Utah
My legacy research is in nanophotonics. I am now building a research profile in Physics education.Equitable teaching and assessment practices; integrating scientific practices into the curriculum.

Thomas Gianetti CS 2021
tgianetti@arizona.edu
Chemistry and Biochemistry, University of Arizona
My research interest revolves around the synthesis of organic molecules that can act as novel electrolytes for redox flow batteries. My educational interest lies at the frontier between Science and Law. I developed a curriculum that engage both STEM and non-STEM students.

John Gilbertson CS 2009
gilberj4@wwu.edu
Chemistry, Western Washington University
Small molecule activation, redox-actoive ligands, deoxygenation reactions. Student-centered, inclusive learning.

Jason G. Gillmore CS 2006
gillmore@hope.edu
Chemistry, Hope College
Organic dyes and photochromes, photochemistry and electrochemistry, heteroaromatic synthesis, computation, photoresponsive materials. Organic and general chemistry, undergrad research, peer-led team learning, CUREs, mentoring new and future PUI faculty.

Eilat Glikman CS 2017
eglikman@middlebury.edu
Physics, Middlebury College
Astrophysicist studying how black holes and galaxies grow. I focus on dust reddened quasars involving galaxy mergers. I teach astronomy and physics to liberal arts students across disciplines, focusing on numeracy and a connection to the arts and humanities.

Ryan Hadt CS 2022
rghadt@caltech.edu
Chemistry and Chemical Engineering,
California Institute for Technology
Hadt's research seeks to understand transition metal electronic structure in catalysis, photophysics, and quantum information science. Hadt's educational goal is to develop an open educational resource for group theory, electronic structure, and spectroscopic methods.

Christine Hagan CS 2022
chagan@holycross.edu
Chemistry, College of the Holy Cross
Mechanisms of protein toxin transport across the membranes of Gram-negative bacteria. Developing course-based research experiences that integrate chemical and biological concepts at the introductory level.

Conference Participants Continued

Philip (Bo) Hammer
bo@imsi.institute
Executive Director, Institute for Mathematical and Statistical Innovation, University of Chicago

Amanda Hargrove CS 2017
amanda.hargrove@duke.edu
Chemistry, Duke University
The Hargrove Lab explores RNA-biased small molecules and privileged RNA topologies for selective modulation of RNA conformation and function. Hargrove has developed a CURE lab as part of a freshman seminar course where students ID patterns in RNA recognition.

Michael Hayden CS 1994
hayden@umbc.edu
Physics, University of Maryland, Baltimore County
Current work uses an optical pump – THz probe technique to study 2D materials like transition metal di-chalcogenides (MoS2, WS2, WSe2). Most interested in small group or one-on-one student interactions via graduate and undergraduate mentoring.

Christopher H. Hendon CS 2021
chendon@uoregon.edu
Chemistry and Biochemistry, University of Oregon
Electronic structure modeling of functional inorganic materials. Development of a curriculum and application of electrochemistry for real time measurement of coffee quality.

Rigoberto Hernandez CS 1999
r.hernandez@jhu.edu
Chemistry, Johns 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, ACS President-Elect Candidate.

Mike Hildreth CS 2003
mhildret@nd.edu
Physics, University of Notre Dame
We study properties of the Higgs boson and top quark to look for signs of new physics. We are trying to change the pedagogical culture at Notre Dame to an active, inclusive, creative one.

Malkanthi Karunananda
mkarun@scripps.edu
Chemistry, Scripps Research Institute
My research utilizes synthetic inorganic, organometallic, and computational chemistry techniques to solve pressing challenges in catalysis. Develop coursework to interrogate organometallic reaction mechanisms through computational techniques for the next generation of scientists.

Chenfeng Ke CS 2019
chenfeng.ke@dartmouth.edu
Chemistry, Dartmouth College
We focus on developing smart 3D printing materials, elastic crystalline porous organic materials, and carbohydrate receptors. We are committed to improve undergraudate learning experience by developing active learning classes.

Daniel Keedy CS 2022
dkeedy@gc.cuny.edu
Structural Biology Initiative,
CUNY Advanced Science Research Center
The Keedy lab uses computational and experimental techniques in structural biology to study protein dynamics and function. I propose to develop a classroom-based, crowd-sourced biochemistry research project centered on protein mutagenesis and functional assays.

Luke Kelley
LZKelley@northwestern.edu
CIERA / Physics and Astronomy,
Northwestern University
Theoretical astrophysics, using gravitational waves and transients to probe the Universe's most massive objects and most energetic events. Generate enthusiasm in science and stimulate curiosity about how the Universe works, while being equitable to students from all background.

Conference Participants Continued

Alexis C. Komor CS 2021
akomor@ucsd.edu
Chemistry and Biochemistry,
University of California, San Diego
Understanding human genetic variation using precision genome editing tools. Preparing students for research-intensive careers through practical instruction on the ethical use of genome editing technologies.

Dmitri Kosenkov CS 2016
dkosenkov@monmouth.edu
Chemistry and Physics, Monmouth University
Quantum dynamics of excitation energy transfer in fluorescent labels and light-harvesting proteins. Course-based Undergraduate Research Experiences (CURE), Physical-Chemistry Labs.

Mike Larsen CS 2022
larsen32@wwu.edu
Chemistry, Western Washington University
Our research group is broadly interested in the link between molecular structure and the properties of polymeric materials. Dr. Larsen believes in structure as a tool to enhance inclusivity in teaching and educational outcomes.

Frank A. Leibfarth CS 2020
FrankL@unc.edu
Chemistry, University of North Carolina at Chapel Hill
Using synthetic chemistry to create materials for the circular plastics economy. Incorporating a research-as-teaching strategy in polymer chemistry lecture and lab courses.

Adam Leibovich CS 2006
Akl2@pitt.edu
Physics and Astronomy, University of Pittsburgh
Theoretical physics focusing on particle physics and gravitational waves. Improving both undergraduate and graduate education using best practices.

Dinah Loerke CS 2014
dinah.loerke@du.edu
Physics and Astronomy, University of Denver
Computational image and data analysis of dynamic cellular processes, ranging from subcellular to tissue length scales. Effective practices for student engagement in large undergraduate classrooms; graduate student mental health.

Casey Londergan CS 2008
clonderg@haverford.edu
Chemistry, Haverford College
Developing and applying physical methods to protein dynamics, especially infrared and Raman spectroscopy. Inquiry- and research-based lab courses; flipped classroom and active learning pedagogy; programming in general and physical chemistry.

Tyler Luchko CS 2017
tluchko@csun.edu
Physics and Astronomy,
California State University, Northridge
Modeling solvation at biomolecular interfaces: solvation thermodynamics, protein-ligand and protein-protein binding, and liquid state theory. Improving graduation rates (undergraduate and graduate), active learning, student learning skills, coding to learn and learning to code.

Britt Lundgren CS 2020
blundgre@unca.edu
Physics and Astronomy,
University of North Carolina Asheville
Using multi-wavelength observations to study how the flows of gas around galaxies affect their evolution throughout cosmic history. Developing educational activities that build computational literacy, and supporting the inclusion of diverse ways of knowing in STEM.

Lauren Marbella CS 2022
lem2221@columbia.edu
Chemical Engineering, Columbia University
Identifying the relationship between electrochemistry and interfacial properties in energy devices. Creating inclusive learning environments and improving NMR education and research training.

Conference Participants Continued

Sabetta Matsumoto CS 2020
sabetta@gatech.edu
Physics, Georgia Institute of Technology
How geometry and topology give mechanical properties to fabrics. Creativity/making/art, student agency, equality in the classroom.

Kevin McFarland CS 2001
kevin@rochester.edu
Physics and Astronomy, University of Rochester
Neutrinos are weakly-interacting footprints of critical nuclear reactions in the universe. I study their properties and interactions. I work to provide opportunities for authentic research to undergraduate and secondary school students and their teachers.

Krystle J. McLaughlin CS 2022
kmclaughlin@vassar.edu
Chemistry, Vassar College
Structural investigation of the relaxosome, a key complex involved in the transfer of antibiotic resistance. Teaching protein crystallography through a biochemistry Course-based Undergraduate Research Experience (CURE).

Emily Miller
emily.miller@aau.edu
Deputy VP for Institutional Policy,
Association of American Universities
@ERMillerPhD research focuses on organizational change and faculty work in academia to improve education.

Katrina Miranda
kmiranda@email.arizona.edu
Chemistry and Biochemistry, University of Arizona
Study of redox signaling and development of nitrogen oxide donors for treatment of cancer, heart failure and pain. Teaching inorganic chemistry, modernizing the curriculum, providing professional development opportunities and supporting student success.

Katie Mouzakis CS 2017
kathryn.mouzakis@lmu.edu
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.

Karl T. Mueller CS 1996
drktmueller@gmail.com
Physical and Computational Sciences, Pacific Northwest National Laboratory
Discovering new materials and electrolytes for advanced batteries. Preparing students for career outside of the academy.

Jorge Muñoz CS 2022
jamunoz@utep.edu
Physics, University of Texas at El Paso
Phonons thermodynamics via novel machine learning: computational physics and data science with a focus on fundamental excitations in solids. Improved access to an education of excellence through early engagement in research and mentoring that leverages the pursuit of science.

Sharon Neufeldt CS 2020
sharon.neufeldt@montana.edu
Chemistry and Biochemistry,
Montana State University
Understanding and controlling selectivity of transition metal catalysts for organic reactions. Organic and organometallic chemistry. Making animated videos of organic reaction mechanisms.

Lisa Olshansky CS 2022
lolshans@illinois.edu
Chemistry, University of Illinois at Urbana-Champaign
We use switchable metal complexes and artificial metalloproteins to demonstrate and apply conformational gating in metal ion activation. C^2 is a community-building program aimed at creating a vibrant network of scholars from underrepresented groups in chemistry.

Conference Participants Continued

Glen O'Neil CS 2020
oneilg@montclair.edu
Chemistry and Biochemistry,
Montclair State University

My research group uses the tools of electrochemistry and photoelectrochemistry to solve challenging problems in chemical sensing. I am interested in increasing opportunities and improving outcomes for community college transfer students.

Cedric Owens CS 2020
cpowens@chapman.edu
Chemistry and Biochemistry, Chapman University

Warning to all diazotrophs: Carbon monoxide kills (nitrogen fixation activity). Take preventative measures! Don't follow instructions. Make your own instruction.

Amanda Patrick CS 2022
apatrick@chemistry.msstate.edu
Chemistry, Mississippi State University

We aim to understand how (isomeric) molecules behave in mass spectrometers and how we can exploit this to improve characterization. I am implementing creative writing activities in undergrad classes and developing a chemistry communication workshop for research students.

Orit Peleg CS 2022
orit.peleg@colorado.edu
Physics and Computer Science,
University of Colorado Boulder

Using insect swarms as a model system, I aim to identify how biological communication signals are generated and interpreted. "Develop a class" Physics.

Dennis V. Perepelitsa CS 2020
dvp@colorado.edu
Physics, University of Colorado Boulder

My research group uses large particle colliders to re-create the conditions of the early universe one microsecond after the Big Bang. I am interested in developing computational physics materials for upper-division classes and integrating them into our curriculum.

Nikki Pohl CS 2003
npohl@indiana.edu
Chemistry, Indiana University Bloomington

Methods for automated synthesis of oligosaccharides/glycopeptides; tools to study roles of carbohydrates in plant, microbial, human biology. Development of low-cost experiments to introduce cutting-edge science into undergraduate labs for all senses and the diversity of scientists.

Rosario Porras-Aguilar CS 2021
rporrasa@uncc.edu
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
Chemistry, Iowa State University

Computational modeling of protein and RNA condensation. Building interactive jupyter notebook based web resources to supplement traditional lectures.

Aurora Pribram-Jones CS 2022
apj@ucmerced.edu
Chemistry and Biochemistry,
University of California, Merced

I study how interaction strength, temperature, and density impact our understanding of electronic structure in molecules and materials. I focus on subverting unjust barriers and boundaries, analyzing structures of scholarly identity, and exploring reflective practice in STEM.

Paul Raston CS 2019
rastonpl@jmu.edu
Chemistry and Biochemistry,
James Madison University

Microwave and laser spectroscopy of unstable molecules that are relevant to combustion, the atmosphere, or interstellar space. Teaching physical chemistry to undergrads in lecture and lab, and developing virtual spectrometers.

Conference Participants Continued

Chad M. Risko CS 2018
chad.risko@uky.edu
Chemistry, University of Kentucky
Our research is inspired by synthetic materials and the desire to seek fundamental insights that determine performance. #compchem #ML Develop a love of fndamental principles to drive insights into larger chemical problems.

Shahir Rizk CS 2019
srizk@iusb.edu
Chemistry and Biochemistry,
Indiana University South Bend
Protein engineering, biosensor design, and science communication through the arts. Engaging first generation college students with STEM education and increasing the sense of belonging in science.

Rae Robertson-Anderson CS 2010
randerson@sandiego.edu
Physics and Biophysics, University of San Diego
Soft and active matter, biopolymer networks, microrheology, microscopy. Research-based curriculum, interdisciplinary courses, undergraduate courses.

Leslie Rogers CS 2020
larogers@uchicago.edu
Astronomy and Astrophysics, University of Chicago
I aim to discover composition trends in the growing census of known exoplanets, and to connect these trends to planet formation pathways. I am developing astronomy escape room activities and applying course blogs as formative assessments in quantitative STEM classes.

Jenny Ross CS 2010
jlross@syr.edu
Physics, Syracuse University
How does the cell organize its insides without a manager? Supporting students to try, fail, and recover to learn.

Brenda Rubenstein CS 2020
brenda_rubenstein@brown.edu
Chemistry, Brown University
Advancing the physical and biological sciences through computational science. Ensuring equity in STEM courses and integrating data science into the chemistry curriculum.

Zac Schultz CS 2013
schultz.133@osu.edu
Chemistry and Biochemistry,
The Ohio State University
Trace detection and imaging of molecules in complex environments. Making science accessible, inclusive, and interesting to everyone.

Mats Selen CS 1996
mats@illinois.edu
Physics, University of Illinois at Urbana-Champaign
I retired last summer. Before that I worked on Particle Physics and Physics Education Research. Reforming Intro Physics Labs to focus on Collaboration, Experimental Design, Data Interpretation, and Communication.

Brian Shuve CS 2021
bshuve@g.hmc.edu
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
Physical Chemistry, Dresden University of Technology
Colloids and catalysis, a great combination to result in active matter. 'Nothing will work unless you do' —Maya Angelou

Scott Snyder CS 2009
sasnyder@uchicago.edu
Chemistry, University of Chicago
We seek to develop new reagents, strategies, and tactics to effect the most efficient syntheses of complex organic molecules possible. I seek to inspire the next generation to tackle the problems facing the field and to educate voting members of democratic societies.

Conference Participants Continued

Marcelle Soares-Santos CS 2021
mssantos@umich.edu
Physics, University of Michigan
My research is on dark energy, the dominant, albeit poorly understood, component of our universe which accelerates cosmic expansion. I am interested in bringing Virtual Reality technology into the classroom to improve students' learning experience.

Tom Solomon CS 1995
tsolomon@bucknell.edu
Physics and Astronomy, Bucknell University
Chaotic fluid mixing and the effects of fluid flows on front propagation and on the motion of self-propelled tracers ("active mixing"). Emphasis on how awesomely cool the universe is; mindset interventions and reflection activities; undergraduate research opportunities.

Alexander Spokoyny CS 2018
spokoyny@chem.ucla.edu
Chemistry and Biochemistry,
University of California, Los Angeles
Our research focuses on chemistry of inorganic clusters. My educational interests lie in advancing and improving scientific literacy among general population.

Keivan Stassun CS 2006
keivan.stassun@vanderbilt.edu
Physics and Astronomy, Vanderbilt University
Formation and evolution of stars and planets. Diversity and inclusion, including neurodiversity.

Grace Stokes CS 2018
gstokes@scu.edu
Chemistry and Biochemistry, Santa Clara University
I use nonlinear optical spectrocopies to study peptoids and small molecule drugs interacting with lipids and transmembrane proteins. I integrate Python-based activities into physical and general chemistry to increase retention of 1st generation college students in STEM.

David Strubbe CS 2020
dstrubbe@ucmerced.edu
Physics, University of California, Merced
Condensed matter theory, 2D materials, defects, photovoltaics, new excited-state methods, amorphous materials, high energy density science. Condensed matter physics and computational physics with Course-based Undergraduate Research Experiences (CUREs).

Ruby Sullan CS 2021
ruby.sullan@utoronto.ca
Physical and Environmental Sciences, and
Chemistry, University of Toronto Scarborough
Combines smart nanomaterial design and nanoscale characterization towards antimicrobial therapeutic platform development. Seeing beyond the obvious: expose undergraduates to hands-on surface/interface research to develop a sense of the nanoscale.

Kana Takematsu CS 2019
ktakemat@bowdoin.edu
Chemistry and Biochemistry, Bowdoin College
Controlling reactions and charge transfer processes using light; ionic liquids and unique solvent environments. Building community through scientific identity and belonging; undergraduate research.

Günther Thiele FCS 2020
guenther.thiele@fu-berlin.de
Chemistry, Biology, and Pharmacy,
Freie Universität Berlin
Materials and Solid State Chemistry: Iron-Sulfur Salts for Battery and Spintronic Applications. Augmented and Virtual Reality in Higher Education to enhance Traditional Teaching Methods.

Claire Till CS 2020
claire.till@humboldt.edu
Chemistry,
California State Polytechnic University, Humboldt
When does scandium act like iron? Unraveling the mysteries of iron biogeochemistry using scandium as a new tool. Helping students learn how to learn: effective feedback, self-grading, confidence and belonging, teaching effective learning strategies.

Conference Participants Continued

Ryan Trainor CS 2022
ryan.trainor@fandm.edu
Physics and Astronomy, Franklin & Marshall College
I use optical/IR telescopes on Earth and in space to study the interactions of stars, gas, and black holes in galaxies over cosmic time. I am using sociology-driven course content and research+teaching internships to support minoritized students in their growth as scientists.

Jesús Velázquez CS 2020
jevelazquez@ucdavis.edu
Chemistry, University of California, Davis
Solid-state energy materials design and characterization that involve combined electrochemistry and synchrotron-based methods. Promoting inclusive and culturally responsive undergraduate and graduate education.

Christina Vizcarra CS 2019
cvizcarr@barnard.edu
Chemistry, Barnard College
We study proteins that regulate the eukaryotic cytoskeleton and how those proteins interact with small molecule inhibitors. I am interested in collaborations between teaching and research labs, particularly in the upper-level curriculum.

Rory Waterman CS 2009
rory.waterman@uvm.edu
Chemistry, University of Vermont
Rory loves making molecules and materials, focusing on reactions and products that better utilize limited resources. Access, access, access. Rory works for more students and students marginalized from science to be involved in STEM and research.

Jessica Werk CS 2020
jwerk@uw.edu
Astronomy, University of Washington, Seattle
I count atoms in intergalactic space. Cohort/community building among undergraduate science majors.

Luisa Whittaker-Brooks CS 2018
luisa.whittaker@utah.edu
Chemistry, University of Utah
Understanding spin and charge transport and ion-migration in energy 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.

Justin J. Wilson CS 2019
jjw275@cornell.edu
Chemistry and Chemical Biology, Cornell University
Metals in medicine with specific applications in the development of radiopharmaceutical agents and ion channel inhibitors. Developing new, accessible learning objects and activities for the topic of nuclear chemistry at all education levels.

Leah S. Witus CS 2021
lwitus@macalester.edu
Chemistry, Macalester College
We are interested in role of secondary structure in beta-hairpin peptide catalysts. Biochemistry, general chemistry, scientific communication, inclusive excellence.

Amanda L. Wolfe CS 2017
awolfe@unca.edu
Chemistry and Biochemistry,
University of North Carolina Asheville
Synthesis and evaluation of antibiotics and adjuvants that can overcome resistance in Pseudomonas aeruginosa. Improving student assessment strategies and Developing strategies to turn CUREs into fundable and publishable research.

Gail Zasowski CS 2021
gail.zasowski@gmail.com
Physics and Astronomy, University of Utah
Studying our Milky Way Galaxy, and galaxies like it, to learn how and when the universe enriched itself in today's abundance of elements. Supporting classroom success by building strong student communities through mentorship, networking, and other activities.

Notes

Notes

Research Corporation Participants

Jennifer Dukes
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jdukes@rescorp.org

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lesham@rescorp.org

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