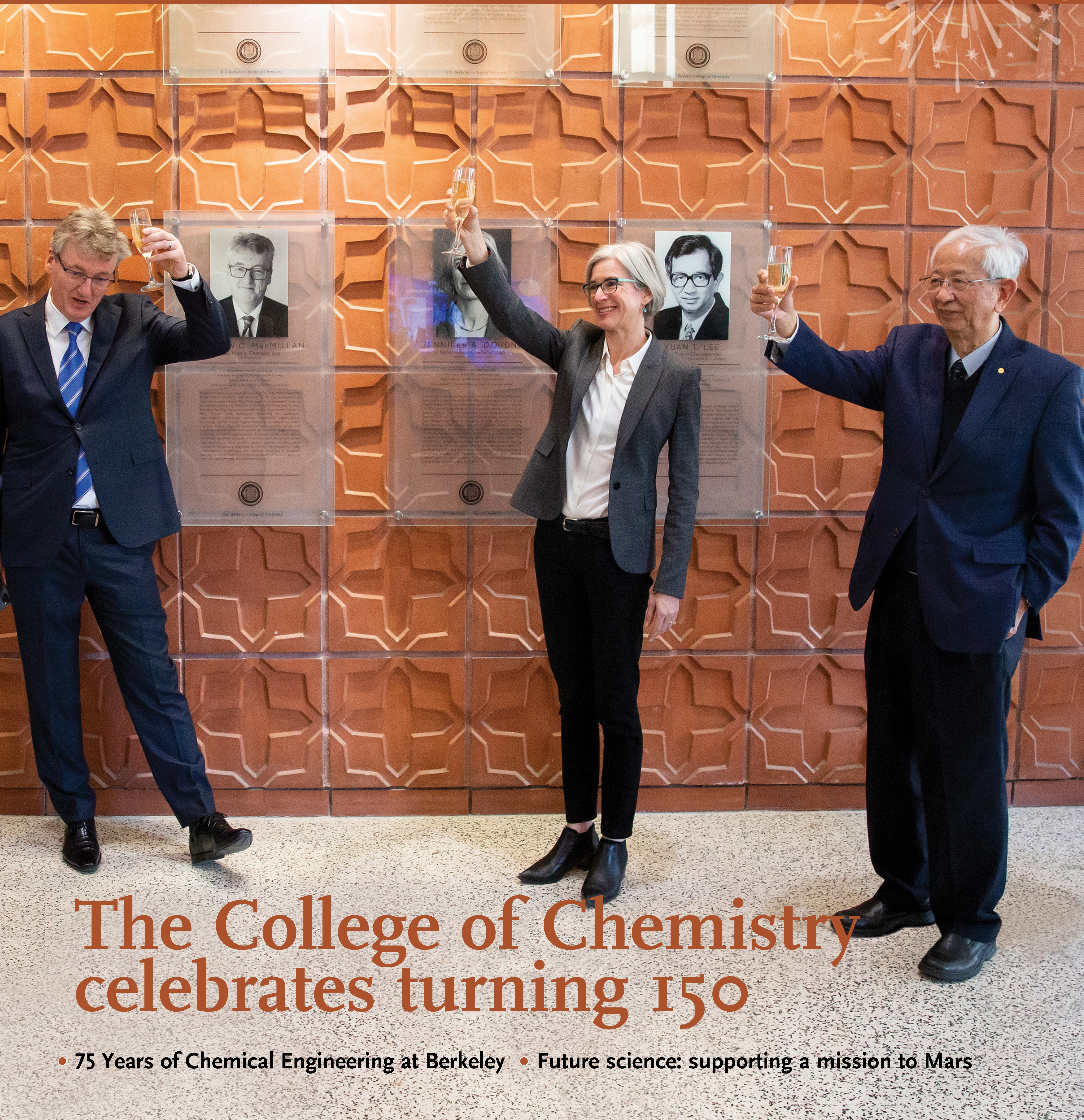
SP21

V 17.1

Catalyst

SPRING/SUMMER 2022 VOLUME 17 • ISSUE 1

COLLEGE OF CHEMISTRY • UNIVERSITY OF CALIFORNIA, BERKELEY



The College of Chemistry celebrates turning 150

• 75 Years of Chemical Engineering at Berkeley • Future science: supporting a mission to Mars

Catalyst

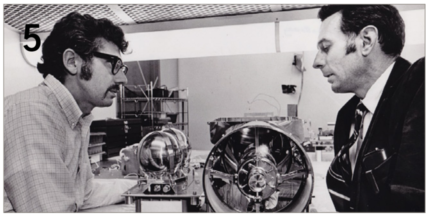
COLLEGE OF CHEMISTRY
UNIVERSITY OF CALIFORNIA, BERKELEY

ON THE COVER

Three powerhouse scientists and Nobel laureates including David MacMillan (2021), Jennifer Doudna (2020), and Yuan T. Lee (1986) raise their glasses to the College's next 150 years at a private event on March 11, 2022.

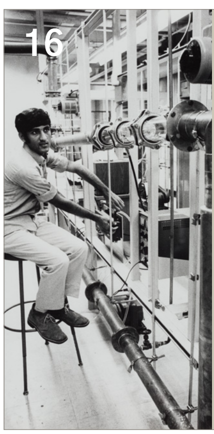
PHOTO BY BRITTANY HOSEA-SMALL

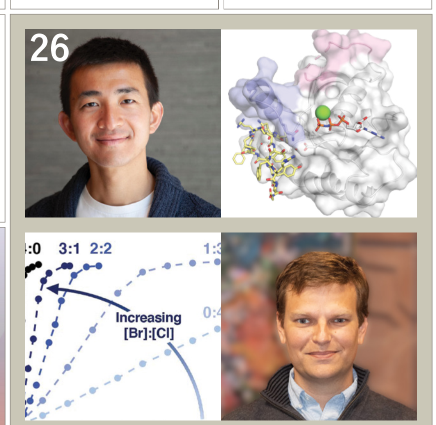
CATALYST ONLINE AT: **catalyst.berkeley.edu**

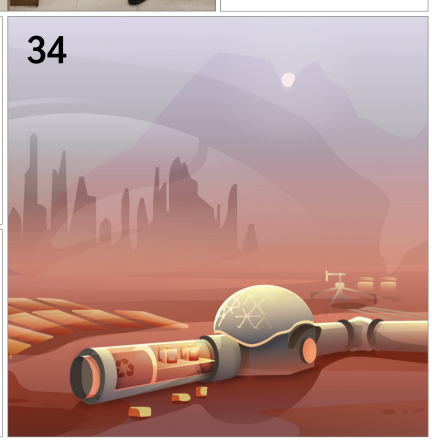


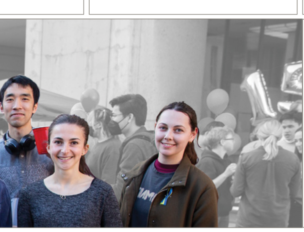
SPRING/SUMMER 2022

VOLUME 17 • ISSUE 1









Looking to the future

THE YEAR WAS 1872

- **Ulysses S. Grant** was president of the United States.
- **Yellowstone National Park** was established as the world's first national park.
- **Julia Morgan,** notable architect, engineer, and Berkeley alum, was born in San Francisco.
- **Susan B. Anthony** became the first woman to vote—albeit illegally—in a presidential election. (She was fined $100, which she never paid.)
- And, acting at the behest of University of California **President Daniel Gilman,** the California State Legislature established the College of Chemistry.

One hundred and fifty years later, over 20,000 undergraduate degrees and over 8,000 graduate degrees have been awarded in the College, and there are over 15,000 College of Chemistry alumni living throughout the world. We have produced 16 Nobel Prizes, helped discover 16 elements, and made countless other contributions in education and research across the spectrum of chemistry, chemical biology, and chemical and biomolecular engineering. Indeed, the College of Chemistry is one of a kind, and it continues to set the standard for academic excellence. I am truly honored to be able to take part in the College of Chemistry's sesquicentennial celebration!

On March 11, the College was thrilled to host a private event in the Latimer Hall lobby with current faculty member and 2020 Nobel laureate in Chemistry Jennifer Doudna and former faculty member and 2021 Nobel laureate in Chemistry David MacMillan to unveil plaques honoring their Nobel Prizes. Also in attendance was Yuan T. Lee, retired faculty member and 1986 Nobel laureate in Chemistry. This historic gathering of three shining stars in the worldwide chemistry community and exemplars of the College's prominence is not one I will soon forget.

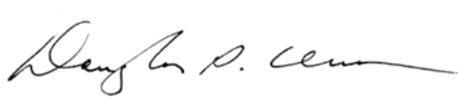
Adding to our group of shining stars, last July assistant professor Brooks Abel joined us in the Department of Chemistry. The Abel Group uses polymer organic chemistry and catalysis to address the issues associated with polymer sustainability. Their major research efforts focus on the development of chemically recyclable and degradable polymers, sustainable living/controlled polymerization methods, and functional materials with tunable properties. These research efforts aim to improve fundamental understanding of organic and polymer chemistry concepts while tackling the larger scale problems of polymer recycling and sustainability.

In addition, this coming July, Ziyang Zhang will join the Department of Chemistry as an assistant professor in the area of chemical biology with a focus on using chemical synthesis to modulate disease-specific targets or processes, particularly those involved in immune signaling. He also plans to identify novel immunomodulatory natural products and characterize their mechanisms of action.

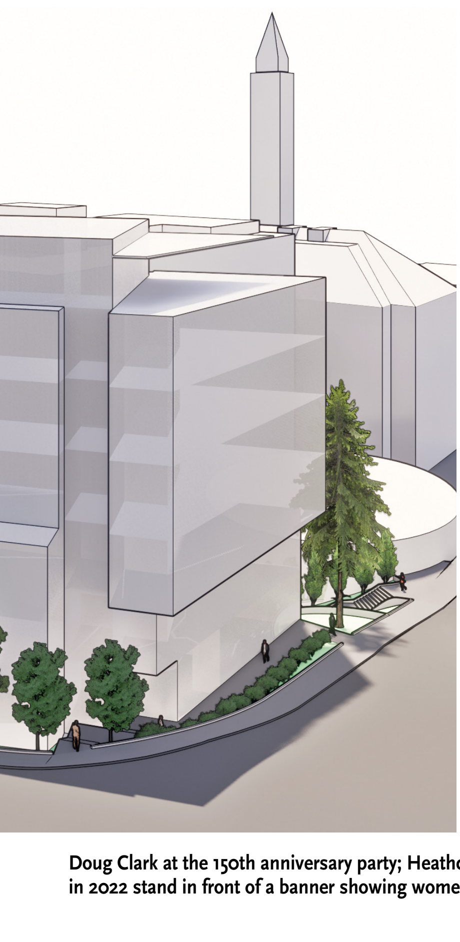
I am overjoyed to announce that we are now more than half way to our fundraising goal for Heathcock Hall, thanks to a wonderfully generous $10M gift from Gordon (B.S. Chemistry, 1950) and Betty Moore. This remarkable donation brings us that much closer to building our new research and teaching facility, which will provide an ideal environment to foster learning and deep discovery for the next 150 years.

In other important College news, associate professor Bryan McCloskey will take the reins as the next chair of the Department of Chemical and Biomolecular Engineering (CBE), effective July 1, 2022. Bryan has been a member of the CBE faculty since 2014, and his work focuses on the synthesis and characterization of electrochemical systems, with special emphasis on energy-storage devices such as metal batteries. As we welcome Bryan into this new role, I would also like to acknowledge the truly remarkable service that current CBE chair, Jeff Reimer, has contributed to the College community over the last nine years (nine out of a total of 14 years Jeff has served as chair!). Jeff's leadership, dedication, and resourcefulness have helped see us through some of the most challenging times in the College's history. His partnership has been invaluable, and I wish him all the best in his well-deserved retirement and transition to emeritus status. You can read more about this leadership change in this issue.

Throughout this year, we will celebrate not only our brilliant past, but also our future. We all contribute to, and we are all part of, the rich history of the College of Chemistry, and if the next 150 years are anything like the last 150 years, we will surely have many more reasons to rejoice together. Happy 150th, College of Chemistry!



DOUGLAS S. CLARK
Dean, College of Chemistry , Gilbert N. Lewis Professor



Doug Clark at the 150th anniversary party; Heathcock Hall rendering; three Nobel laureates in the house with David MacMillan, Jennifer Doudna, and Yuan T. Lee (2022); two College students in 2022 stand in front of a banner showing women students in 1890; process engineering lab (1980s); and Frances Arnold attends her Nobel laureate celebration at the College (2019).

NEW & NOTABLE

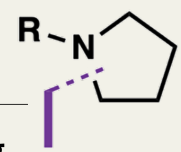
RESEARCH • VIEWS
DISCOVERIES • AWARDS

Markita Landry & Alanna Schepartz receive CZ Biohub Investigator awards

Professors Markita Landry (Chemical and Biomolecular Engineering) and Alanna Schepartz (Chemistry) have been named 2022 Chan Zuckerberg Biohub Investigators. The Investigator Program, open to faculty members at Stanford University, UC San Francisco, and UC Berkeley, awards $1 million in unrestricted funds over five years to each Investigator, with the goal of building engaged, collaborative communities of Bay Area scientists to undertake creative and innovative research that will help solve the biggest challenges in biomedicine.

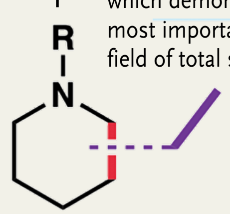
C. Judson King – honored with named endowed professorship

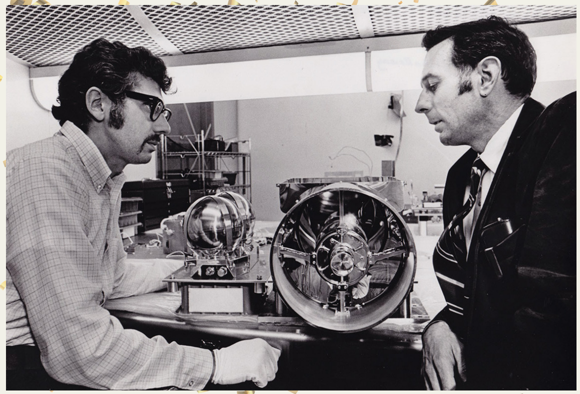
The American University of Armenia has created an Endowed Named Professorship in honor of professor emeritus of chemical and biomolecular engineering, C. Judson King. King served as Chairman of the AUAC Board of Trustees for 14 years as part of his role as UC Berkeley's provost. He served on the board for 27 years in total until 2021. Appointment to an Endowed Named Professorship is the highest academic honor at AUA, which grants appointees the opportunity to make significant contributions to their respective research fields and reach their academic aspirations.



Richmond Sarpong receives 2022 ACS Award for creative work in synthetic organic chemistry

Professor of Chemistry Richmond Sarpong was acknowledged during the ACS annual meeting in March for the development of new strategies for the chemical synthesis of complex molecules based on C-H and C-C bond functionalization. He has made seminal contributions to developing new strategies and methods for the assembly of complex natural products and established a world-recognized research program characterized by the selection of targets which demonstrate a deep appreciation of the most important problems at the forefront of the field of total synthesis.

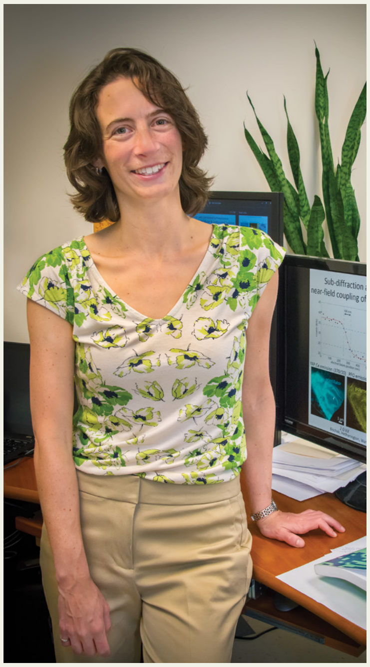




Celebrating George Pimentel on his 100th birthday

Professor of Chemistry George Pimentel *(Ph.D. '49, Chem)* would have been 100 on May 2nd of this year. He passed away in 1989 after a powerful career in research and education in the chemical sciences at Berkeley. Known for his discovery of the chemical laser, Pimentel and members of his lab developed an instrument based on his high-speed infrared spectroscopic technique which was used in the Mars Mariner 6 and 7 programs that discovered water on the surface of the red planet. Read more about his amazing career at chemistry.berkeley.edu/pimentel

Naomi Ginsberg elected fellow of the American Physical Society (APS)



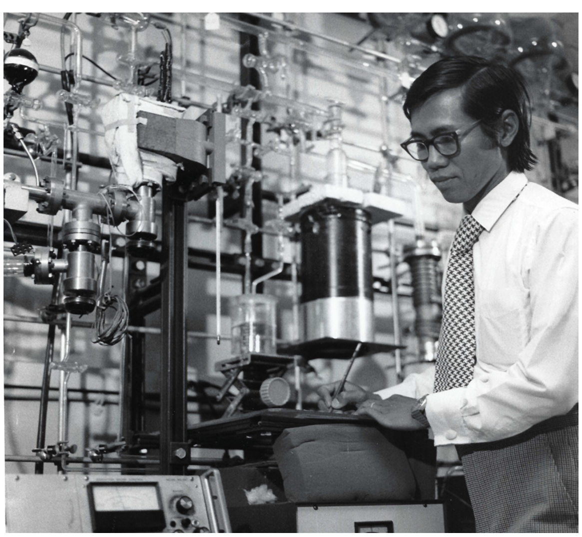
Associate Professor of Chemistry and Physics Naomi Ginsberg has been elected a fellow of the APS for her "innovative development of spatiotemporally resolved imaging and spectroscopy methods, and for their use in elucidating energy transport in hierarchical and heterogeneous materials, as well as in the formation and transformation of said materials." The Fellowship Program was created to recognize members who have made advances in physics through original research and publication or made significant innovative contributions in the application of physics to science and technology.

Jennifer Doudna and co-authors publish new microbe research

Professors Jill Banfield (earth and planetary science) and Jennifer Doudna (Li Ka Shing Chancellor's Professor of Biomedical Science and chemistry) along with a series of co-authors have published new research that takes a major step toward solving the thorny problem of how to study and alter genomes of microbes living in complicated real-world environments. The complexity of microbial communities has been a major obstacle to discovering technologies that can prevent diseases and improve agriculture. It could prove to be a critical step toward curbing methane, a harmful greenhouse gas that is emitted during rice production, the world's second most important cereal crop.

David Schaffer announced as Bakar BioEnginuity Hub Director

David Schaffer, Professor of Chemical and Biomolecular Engineering and recently announced member of the National Academy of Inventors, was named as the new faculty director of the Bakar BioEnginuity Hub (the Hub) and Bakar Fellows Program in March. The Hub, a new UC Berkeley initiative, was launched in May 2021 as a world-class incubator to allow fledging startups the work and lab space they need to develop their ideas and companies. Prof. Schaffer has left his post as Director of QB3-Berkeley to take up this new position.



IN MEMORIAM

Alumnus Shun Chong Fung

(1943 – 2022)

Dr. Shun Chong Fung was born in Guandong province, China. He received his B.S. in ChemE (1965) from Berkeley and Ph.D. (1969) from U. Illinois at Urbana-Champaign. He spent his career at ExxonMobil in corporate research. Shun is best known for his fundamental work in elucidating the mechanistic chemistry involved in the redispersion of noble metal catalysts. He effectively used these insights to develop commercially important methods for regenerating deactivated platinum, palladium, and other supported metal catalysts. His regeneration and metal redispersion techniques have been applied globally to produce high-octane gasoline.

Omar Yaghi - inaugural VinFuture Special Prize

The inaugural VinFuture Special Prize for Innovators with Outstanding Achievements for Emerging Fields was awarded to Omar Yaghi, James and Neeltje Tretter Chair Professor of Chemistry, for the discovery of metal-organic frameworks. The ceremony was held at Hanoi, Vietnam. The VinFuture Prize recognizes fundamental advances in science and engineering that align with the 17 Sustainable Development Goals of the United Nations.

Alumna Carolyn Bertozzi awarded the 2022 Wolf Prize

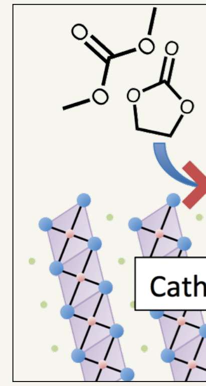
Stanford Professor of Chemistry Carolyn Bertozzi *(Ph.D. '93, Chem)* has been jointly awarded the 2022 Wolf Prize in Chemistry for creating a new biochemical field of study and contributing to the understanding of the glycocalyx, a network of cellular molecules important to health and disease. Her insights into the many roles of sugars on cell surfaces and the development of methods to modify them have transformed our understanding of cell biology. These insights are opening up the field of medicine leading to novel therapeutic opportunities.

Jay Keasling receives distinguished scientist fellow award

Jay Keasling, Professor Chemical & Biomolecular Engineering and Bioengineering has been recognized for his national scientific leadership in synthetic biology that has advanced the Department of Energy's strategy in renewable energy, especially the realization of biofuels and bioproducts that enable biomanufacturing at scale and inspire and grow the U.S. bioeconomy. This award, now in its third year, recognizes scientific leadership and engagement with the academic and research communities, significant mentoring of early-career scientists and engineers, the quality of publications in high-impact journals, and service to the research community.

Alumna Yvette Harris named Quality Engineer of the Year

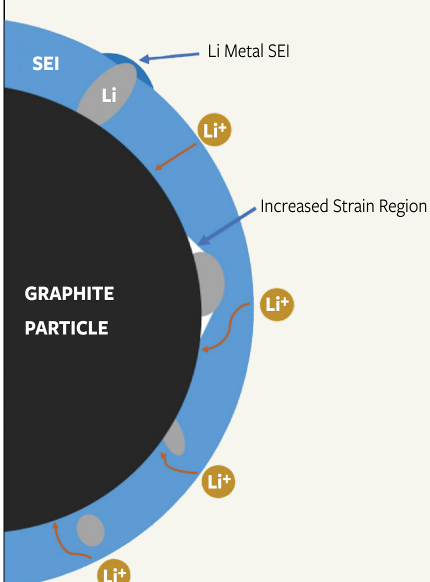
Congratulations to Dr. Yvette Harris *(B.S. '96, ChemE)* who has been named the Quality Engineer of the Year for "outstanding career contributions to quality engineering and continuous improvement and for sustained commitment to STEM education" by the Engineers' Council in collaboration with the ASQ 706 San Fernando Valley Chapter. Harris is currently the Associate Principal Director of the Corporate Quality Management Office at the Aerospace Corporation. Harris was nominated by the leadership team at the Aerospace Corporation. The award was presented during the Engineers' Council's 67th Annual Honors & Awards Banquet.



Bryan McCloskey announced as chair of chemical and biomolecular engineering

BY MARGE D'WYLDE

Bryan McCloskey, Associate Professor of Chemical and Biomolecular Engineering, will serve as the next Chair of the Department of Chemical and Biomolecular Engineering (CBE) in the College of Chemistry, effective July 1, 2022.



Bryan has been a member of the CBE faculty since 2014. His research focuses on the characterization of electrochemical systems, with special emphasis on energy-storage devices such as lithium-ion batteries. He also serves as a Faculty Engineer in the Energy Storage and Distributed Resources Division at Lawrence Berkeley National Laboratory.

Since 2019, Bryan has served as Vice Chair of Graduate Education in CBE. In this position, he has worked with students, staff, and faculty to improve the departmental climate and to foster an inclusive academic environment for all.

Bryan has made pioneering contributions to the structure-function evaluation of electrochemical devices. His research has provided insights into energy storage, electrocatalysis, and related fields such as corrosion science at the molecular and atomic scale. He is considered a leader in the field of batteries, and in particular next generation lithium-ion and metal-air batteries. Additionally, using a combination of electrochemical characterization, spectroscopy, and theory, Bryan's laboratory has systematically explored ion transport in polyelectrolyte solutions, where ion pairing and ion motion coupled to polymer backbone dynamics result in interesting and counterintuitive properties. In total, Bryan has published his work in over 140 journal articles. Bryan's achievements were recently recognized with the Electrochemical Society's 2020 Tobias Award and the International Society of Electrochemistry's 2021 Tajima Prize, two of the highest distinctions for an early career investigator by the premier scholarly societies in his field.

Currently, Bryan teaches several courses in the department's curriculum. They include the introductory required undergraduate course *Introduction to Chemical Process Analysis* and required graduate course *Transport Phenomena*. He also teaches *Electrochemical Processes* which is jointly offered to graduate and undergraduate students. He regularly receives high marks for his courses with students remarking that, "he was always clear, provided useful examples, provided for good continuity between lectures, and was very calm making the course not feel overly stressful."

MARGE D'WILDE

THE COLLEGE OF CHEMISTRY'S GRADUATE STUDENT DIVERSITY PROGRAM

Building a community of belonging

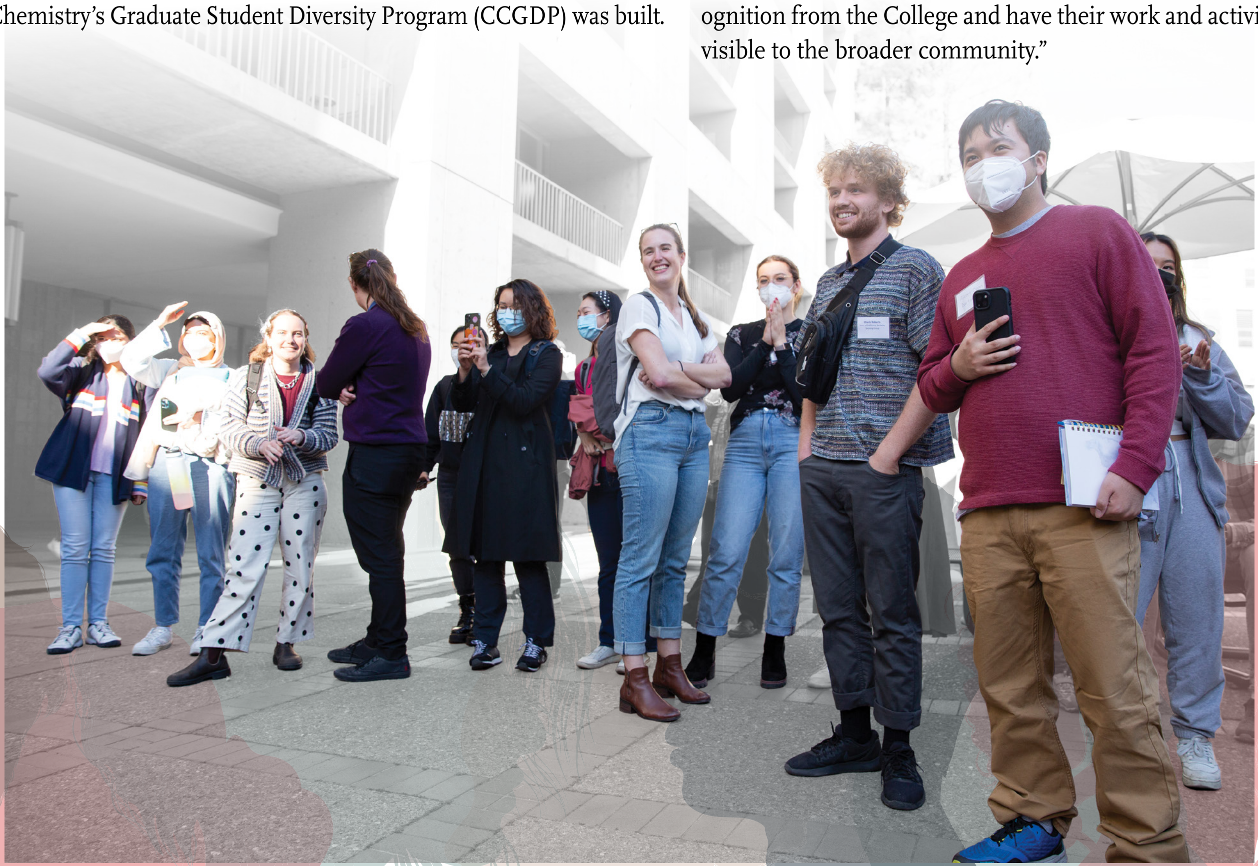
BY DENISE KLARQUIST
PHOTOS BY BRITTANY HOSEA-SMALL

Diversity, equity, and inclusion (DEI) isn't a topic that's always addressed in the physical sciences. When the topic is addressed, it's often given only superficial attention. "DEI in STEM (Science, Technology, Engineering, and Mathematics) isn't just a conversation about adding diversity," emphasizes College of Chemistry Chief Diversity Officer, Dr. Brice Yates. "DEI in STEM is about how we interact with our students in our spaces — are these spaces inclusive and welcoming for students of all backgrounds?"

This perspective, changing the narrative and weaving DEI into the educational fabric, is the foundation upon which the College of Chemistry's Graduate Student Diversity Program (CCGDP) was built.

Launched in Spring 2021 and led by Anne Baranger and Brice Yates, CCGDP supported nine graduate student-led initiatives targeted at improving the pipeline of underrepresented students into graduate school, recruiting, and supporting DEI in the College's graduate student population, and working with leadership to improve the diversity climate within the College.

"Our initial vision was to create a program that would highlight and foster all of the wonderful DEI efforts our graduate students were already doing, on top of their research and coursework," explains Baranger. "We wanted to have a way for them to receive formal recognition from the College and have their work and activism be more visible to the broader community."



All photos: College undergraduate and graduate students, and graduate recruits, celebrate at the 150th anniversary party.

The College's program also provided for a 1-year fellowship, the Graduate Student DE&I Scholar. The annual award supports a graduate student who wishes to gain significant expertise in DEI program development and assessment. The first recipient was Kay Xia, a Ph.D. candidate in Chemistry.

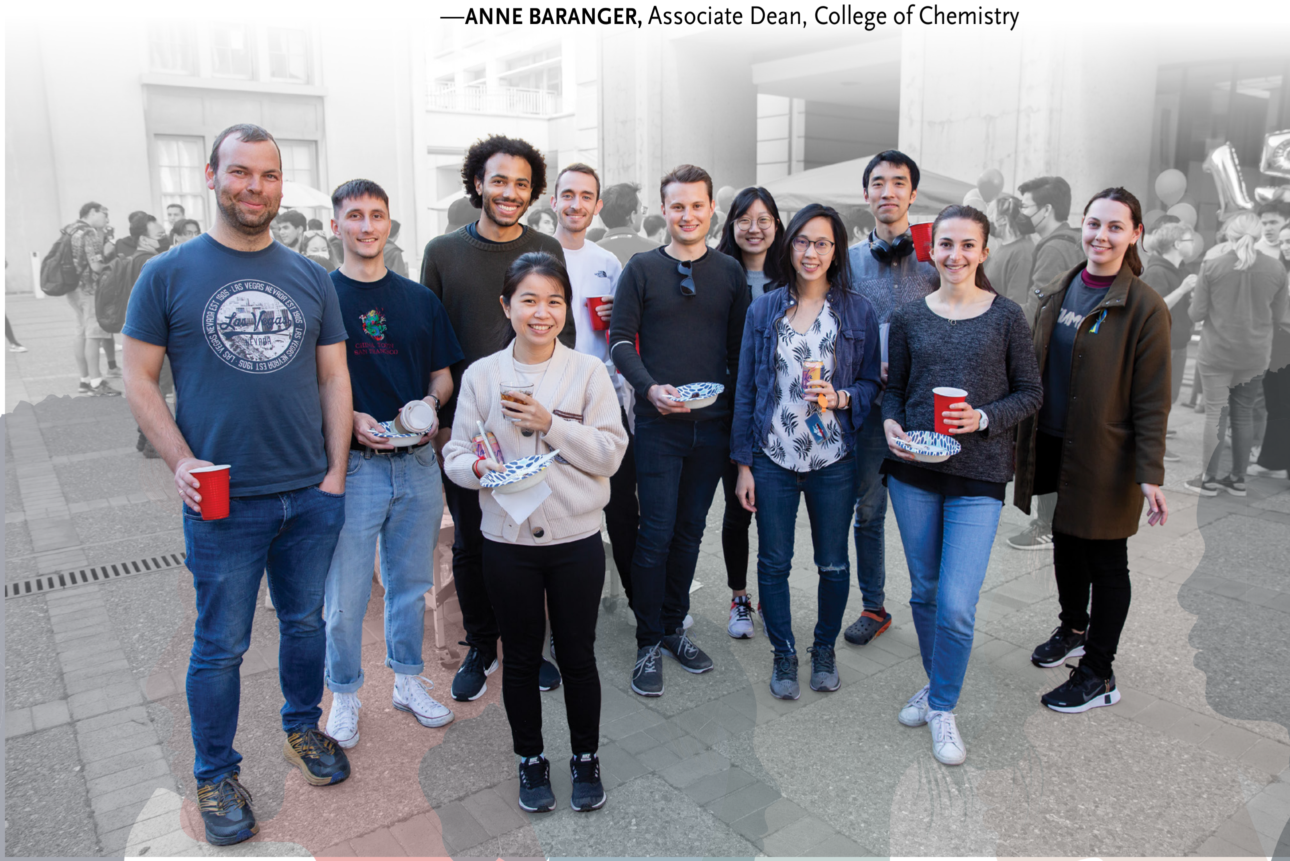
The CCGDP was funded through a Graduate Diversity Pilot Program grant from UC Berkeley's Graduate Division. The program was established in July of 2020, awarding grants totaling $1.5 million over four years to nine departments across campus to support and improve departmental climate for students, staff, and faculty; support faculty graduate student mentorship; and build diversity in graduate outreach and admissions.

In the College of Chemistry, graduate student interest in CCGDP was overwhelming. Initially, eleven proposals were submitted by a total of 29 students. Of those, nine proposals led by 25 graduate students in cohort groups were chosen to be part of the program. In order to acknowledge their efforts, all 29 students who submitted proposals received a stipend of $1000 even though this was not originally budgeted.

The spring 2021 program culminated in December with a poster session where students presented their DEI work. The College has supported an additional six graduate student-led projects during the spring 2022 semester.

"The problems that chemistry and chemical and biomolecular engineering tackle impact all different populations of people. So, it's important to have scientists participating in the development and the discovery be from those communities. It also adds to creativity — it makes more interesting science."

—**ANNE BARANGER,** Associate Dean, College of Chemistry



Student cohorts leading the nine initial projects also received ongoing support from Anne Baranger and Brice Yates, who met regularly with the groups to advise, ensure progress, and help publish their work. An added advantage to program participation is the valuable DEI skill set that will benefit graduate students well into their professional careers. Yates, with his Ph.D. in social sciences, helped the cohorts become grounded in the methodology, rigor and theoretical frameworks surrounding equity and inclusion. The students also learned how to evaluate the effectiveness of their efforts.

"I've really pivoted in my own research — learning more about how to lessen the barriers and improve the experience of groups historically excluded from STEM," explained Audrey Reeves, a fifth-year Chemistry graduate student participant. "It's one thing to want to help and it's another to assess whether you are helping."

DIVERSE APPROACHES TOWARD A COMMON GOAL

Many student initiatives began well before the College formalized its Graduate Diversity Program but found their DEI footing in the program. Originally launched in 2020 and inspired by a similar program in the Department of Molecular Cellular Biology, the Transfer Student Mentorship program (CoC-TSMP) led by Audrey Reeves and Amanda Bischoff paired incoming undergraduate Chemistry transfer students with graduate student mentors to improve their sense of inclusion in the department. Exposing transfer students to research was a primary part of their initiative. "Getting into research labs is a huge step in academia. And so far, our program has made an impact. More of our students have gotten into research labs compared to transfer students who did not attend," says Reeves.

Like all participants, Reeves' passion for making a difference comes from the heart. "You've heard the phrase 'leaky pipeline' where people fall out as they move through academia. But they don't just fall out, they are actively pushed out. I've witnessed this in my own work, as well as in my lab, and nobody deserves that. Everyone deserves to be able to follow their dreams."

Marisol Navarro echoes Audrey's sentiments. "We need to recognize that not everyone starts at the same point, people have different barriers. We should be doing everything we can to support all kinds of students, to include all those perspectives and ideas in science."

Navarro's program, NODE (Normalization of Diversity and Equity) which she co-led with Julia Martin, focused on mentoring first-year graduate students entering the department. Like CoC-TSMP, NODE grew out of an existing effort, though one not originally targeted at URM students. Now in its second year, with the addition of Angel Gonzalez-Valero, the group's activities give first year URM students a space where they can ask questions and talk about their graduate experience outside of science and about what's typical in the lab.

Observing how the disparate math backgrounds of incoming graduate students can negatively impact their first-semester experience, academic trajectory, and well-being, Avishek Das and his team launched the week-long Mathematics Bootcamp. "Not having enough math background can be traumatic for graduate students — we saw this firsthand," reveals Avishek. Their program used innovative remote, and in-person active learning strategies tailored to students' needs to improve graduate students' skills and confidence.

Like other initiatives, the bootcamp had already been in place before becoming part of CCGDP. While the bootcamp was already working to measure DEI impact, being part of the program enhanced their efforts by connecting them with the other groups under and outside of the program's umbrella.

"Most fulfilling is knowing there's a huge team of grad students in the College of Chemistry and beyond who all support each other in these initiatives," Avishek points out. "We've heard speakers from other departments in or even outside of Berkeley who bring different perspectives on how to further DEI initiatives in the STEM context. It's motivating to see everyone working so hard." Along with Das, the Mathematics Bootcamp team included Orion Cohen, Dipti Jasrasaria, Elliot Rossomme, and Rachel Clune. They, as well as two other groups — CoC-TSMP and cDIBS — plan to publish their efforts.

Baranger and Yates' admiration for the groups' passion and efforts keeps them motivated. "DEI isn't an afterthought," says Yates. "It's a component they infuse into their daily work." Added Baranger, "I love working with students because they teach me so much."

While a continuation plan for the College's Graduate Diversity Program is not formalized, the vision is that the student-led programs can be ongoing. As students graduate, a diversity of fresh faces and ideas can join the community to sustain programs that are working well and potentially launch new programs.

"Science and technology are an enormous force — they shape humanity and people's lives in a very real way," concludes Avishek Das. "So, everyone needs to actively and democratically participate to keep it accountable, to ensure it's used for people's benefit, and not to create further oppression then what already exists in society. It's going to determine the future for all of us."

THE SIX ADDITIONAL INITIATIVES IN THE SPRING 2021 PROGRAM

Diversity and Inclusion Focus Group (DIFG) created spaces, and invited guest speakers, for nuanced and in-depth discussions on topics requested by students. The team included Tarini Hardikar, Connie Robinson, and Rebecca Hanscam.

Transformative Pedagogy for Chemists and Chemical Engineers course sought to situate, center, and evaluate the current model for scientific research in the context of race, gender, class, sexual orientation, ability, and religion. The group, including Helen Bergstrom, Adrian Davey, Anthony Abel, and Jeremy Adams, taught a course in fall 2021 open to faculty, staff, graduate, and undergraduate students.

Department of Chemistry Annual Climate Survey and Departmental Information and Brainstorming Session (cDIBS) has been ongoing in the chemistry department since spring of 2018. They aim to assess issues affecting inclusivity in the department, understand the priorities and concerns of various departmental stakeholders, and form actionable policies and programs for improvement. Team partners Daniel Brauer and Jamie Gleason launched a cDIBS survey and held a town hall.

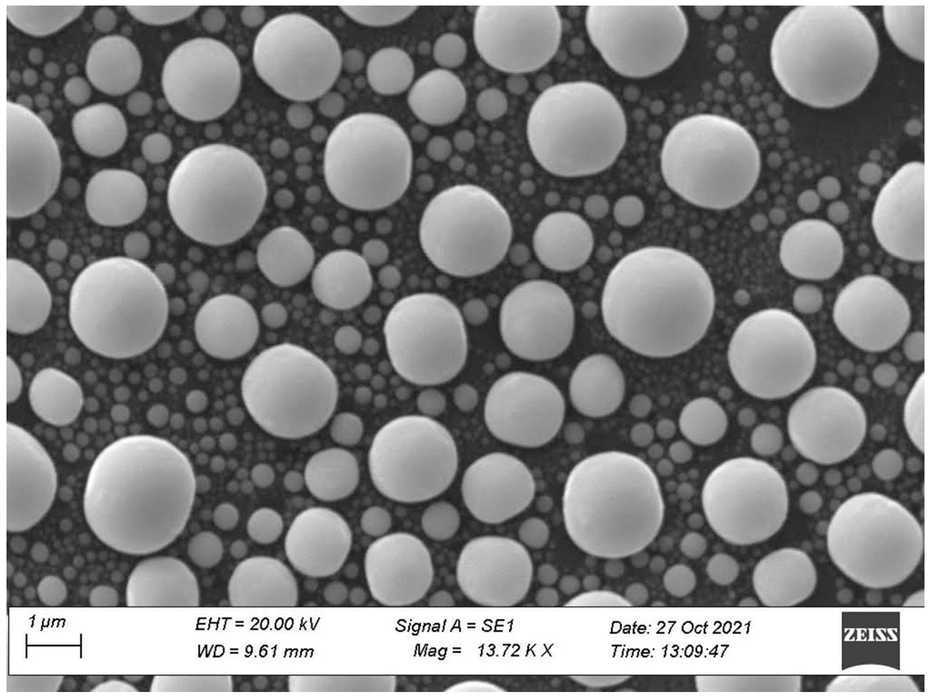
Improving culture and inclusion in Berkeley CBE through mindful redesign and expansion of new student orientation and early Fall semester departmental events. The team leading this project — Francis Cunningham, Lorena Grundy, and David Brown — proposed tying new student orientation with DEI seminars, trainings, and/or workshops on community-building and creating awareness of DEI issues in STEM. The group participated in a joint orientation with iMCB before the start of the fall semester.

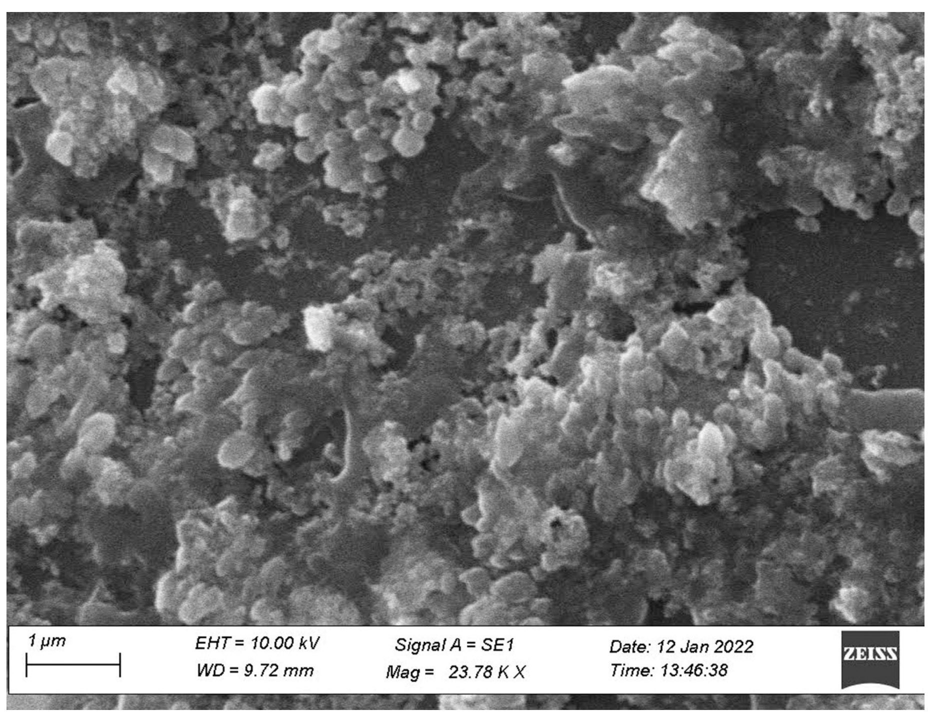
Monthly Mentorship Meeting for Faculty. This project's team aspired to engage faculty members with material on different mentorship styles and techniques and encourage co-sharing of their mentoring experiences, with surveys to examine how the material and discussion impacted faculty members' perspectives and awareness. Rebecca Hanscam and Tarini Hardikar partnered on this initiative.

Women in Chemistry Initiative (WICI) explored opportunities for expanding the impact of WICI, increasing visibility and further serving the College of Chemistry. The team of Matthew Rollings, Kiera Wilhelm, Kaydren Orcutt, Maria Paley, and Rachel Clune hosted a spring social and trivia night to increase visibility and participation.

New microscope technology energizes undergraduate research

BY MICHAEL ZUERCH
Assistant Professor of Chemistry





COURTESY NADIA BERNDT

ZEISS has provided the instructional physical chemistry labs at the College of Chemistry with a state-of-the-art scanning electron microscope (SEM), EVO LS 15, that allows our students to take images of nanoscale matter down to 3 nm spatial resolution. In doing so, ZEISS is supporting our educational and research mission to train undergraduates with modern technology relevant to chemistry and nanoscience such that they are optimally prepared for the job market after their studies at UC Berkeley.

This support of our research-near instruction approach allows us to enable lab experiments for students who are interested in conducting research at the vibrant interface of chemistry, materials science, and nanoscience. It is important for the College to use modern technology to train our students and provide them with the opportunity to experience top-of-the-line instrumentation they would find, for example, if they later start their professional careers in the semiconductor industry.

There are two ways the instrument is implemented in our instructional and research activities. First, the instrument is integrated into our upper division physical chemistry lab courses where students learn about the technology and applications, with the opportunity to perform hands-on quantitative material analysis. Second, both undergraduate and graduate students can perform their independent and group experiments using the instrument to inspect samples that, for example, they synthesize as part of their research. This ability to capture real-space images at the nanoscale of samples that students prepare by chemical synthesis, enables bringing together different areas of their training in a unique way, namely the relationship between materials processing and characterization.

Key aspects of this modern instrument are the high spatial resolution and ease of operation, meaning students who have never seen a SEM before can effectively walk into the lab and take pictures of their samples with nanoscale resolution after only a brief training session. This is unlike SEM lab experiments from 15 years ago. At that time, students spent a whole afternoon doing alignments and then taking a few poorly resolved images on a much older system. That our students can now so easily take sharp images in a short period of time and focus on their chemical and materials system under study rather than instrument optimization, shows how much this technology has advanced.

The computer-controlled instrument interface also allows students to participate remotely in lab experiments through screen sharing, which is an option often utilized during the COVID-19 pandemic. Throughout this partnership, our experiences with hands-on instruction of students will in turn benefit development of the next generation of these instruments through direct feedback to the product and applications teams at ZEISS.


MICHAEL BARNES

SENIOR NADIA BERNDT DISCUSSES HER EXPERIENCE WITH THE NEW SCANNING ELECTRON MICROSCOPE (SEM)

In her research project this semester, Nadia Berndt is investigating charge dynamics in clay-encapsulated 2D materials to understand why the addition of the clay increases the photocatalytic abilities of these materials. Previous studies have shown that they form nanoflake structures, and by using the SEM we can directly visualize the surface of the samples. Opposite is an example of the surface of one sample. They are quite disorganized, which makes analysis of the dynamics difficult, but not impossible.

The SEM is a great tool for the physical chemistry teaching laboratory as it lets students work with state-of-the-art technology that is used in many related disciplines. Many interesting materials that can be studied, such as the tin balls in the photo opposite, will give valuable insights into how structure affects a material's properties. This understanding in turn helps us leverage these relationships so we can develop new materials to solve challenges in our world.

The new SEM is located in our undergraduate physical chemistry laboratory along with many other cutting-edge instruments. It is being integrated into our upper-division lab courses in CHEM 125 where we expect about 60 to 80 students annually to conduct experiments with the new instrument. In these experiments, students will prepare samples and use the SEM to conduct the experiments that allow them to quantify size distributions of crystals that are synthetically grown under varying conditions.

ABOUT ZEISS

ZEISS Research Microscopy Solutions is the world's only one-stop manufacturer of light, electron, X-ray and ion microscope systems and offers solutions for correlative microscopy. The portfolio is comprised of products and services for life sciences, materials and industrial research, as well as education and clinical practice. The unit is headquartered in Jena. Additional production and development sites are located in Oberkochen, Göttingen and Munich, as well as in Cambridge in the UK, and in Peabody, MA and Pleasanton, CA in the USA.

The College of Chemistry turns 150

The College celebrates *150 years* of inspiring scientific exploration and education

BY MARGE D'WYLDE

In a star-studded private event Friday, March 11th, the College of Chemistry ushered in its 150th anniversary. On hand for the celebration were three Nobel laureates in Chemistry: Jennifer Doudna (2020), David MacMillan (2021), and a special guest appearance by Yuan T. Lee (1986). Jennifer and David unveiled their newly installed plaques honoring their Nobel prize in the College's Latimer lobby.

Douglas Clark, dean of the College said in his remarks opening the festivities, "You must forgive me, I'm a little star struck. This is an amazing occasion. In fact, it's a once in a lifetime event. Not only do we have three Nobel laureates here, but we are also on the eve of our 150th anniversary."

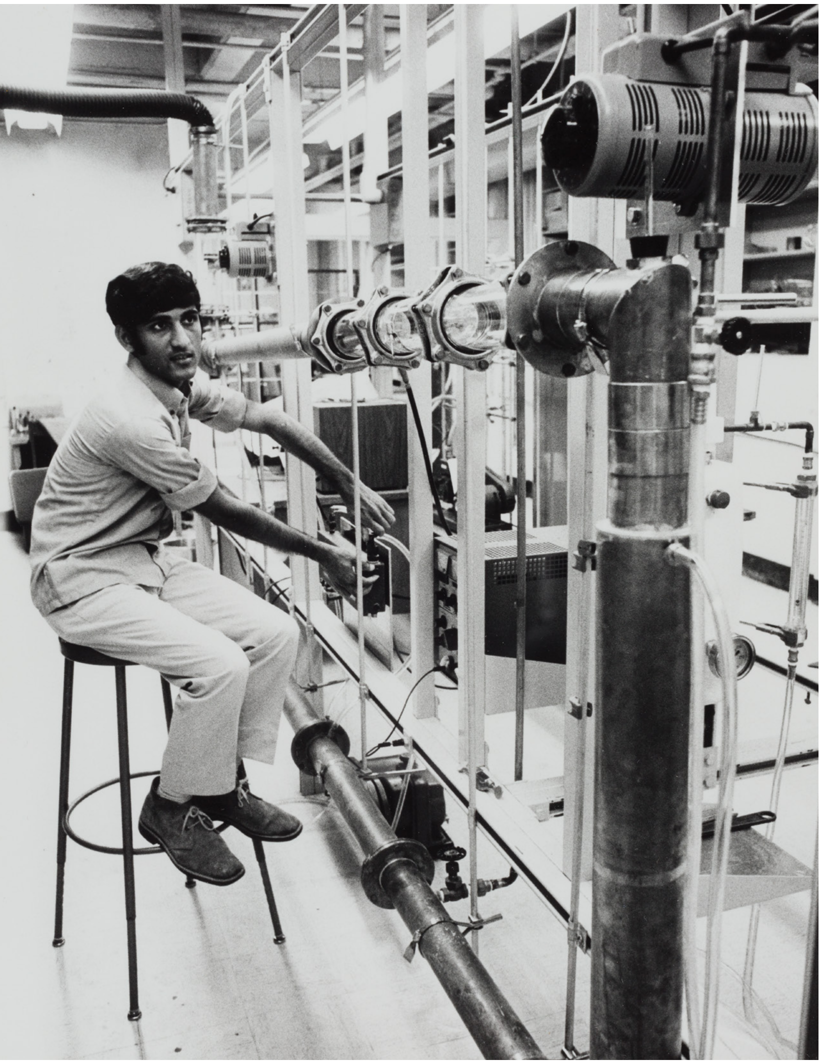
Jennifer and David received their prizes in the time of COVID and were unable to attend the regular award ceremonies in Stockholm. Their medals were flown to the U.S. by diplomatic courier for presentation to them. Jennifer is the first woman faculty member to receive the Nobel Prize in Chemistry at UC Berkeley. David is the first faculty member in the department of chemistry at Princeton to receive the Nobel Prize in Chemistry (he was at Berkeley when he made his Nobel recognized discovery). Yuan was the first chemist born in Taiwan to receive the Nobel Prize in Chemistry.

After the plaque unveiling, all attendees headed outside for cake on the plaza and a rousing chorus of happy birthday to the College. It was a beautiful afternoon and the cake quickly disappeared while music echoed across the courtyard. Historic banners placed around the plaza added a festive note. A student at the event commented, "It's really nice to see the College doing this and us being able to all get together. I have missed these kinds of events."

The College will celebrate the anniversary throughout the year with a series of engaging online and in person events. This spring the College hosted online discussions with faculty and alumni in conversation about climate sustainability and fighting climate change from the grocery store aisle. These are available on the College's website at chemistry.berkeley.edu/150celebration along with a recording of the ceremony honoring College Nobel laureates Jennifer Doudna and David MacMillan. Keep an eye out for email announcements about future events.

Established on March 12, 1872, by the California State legislature, the College has been host to numerous renowned chemists who have made world changing discoveries. Our current faculty members hail from 21 countries and research and teach in one of the three disciplines of chemistry, chemical biology, and chemical and biomolecular engineering. The College prides itself on a balanced approach to science, with research areas ranging from experimental to theoretical. The faculty collaborate with scientists across campus, the nation, and internationally.

75 years of chemical engineering at Berkeley



BY C. JUDSON KING

2022 is not only the 150th anniversary of the College of Chemistry, but also the 75th anniversary of the start of the chemical engineering program at Berkeley. Although the 75-year-old program is half the age of the College, it is still relatively young as chemical engineering programs go. Programs at most other universities were formed earlier in the twentieth century or even at the end of the nineteenth. The American Institute of Chemical Engineers traces back to 1908.

The chemical engineering program that has thrived at Berkeley is a product of its times. The Allies in World War II had derived considerable advantage from several highly technical war-related projects, most notably the development of radar and the Manhattan Project for the atomic bomb in the United States and the development of the proximity fuse in the United Kingdom. These engineering projects had been carried out largely by scientists because there was a growing belief that the education of the engineers in that era did not contain sufficient science and math for them to contribute well to such rapid and innovative advances. This view set off a national wave to remedy the situation.

When the establishment of a full program in chemical engineering was explored seriously in 1945, both the College of Chemistry and the College of Engineering were interested and made competing proposals. Chemistry faculty member Joel Hildebrand was a longtime member of the Academic Senate's Committee on Budget and Interdepartmental Relations. He argued that the need for more science and mathematics was a cogent reason for placing chemical engineering within the College of Chemistry, and that rationale carried the

day with both the Academic Senate and Provost Monroe Deutsch. Instruction in chemical engineering began in the College of Chemistry in the Fall of 1946.

For the better part of a decade, the College of Engineering maintained a competing program under the name Process Engineering. The matter was finally resolved when Clark Kerr, in 1952, became Berkeley's first chancellor. Kerr set up a systematic review process and ultimately decided in favor of the College of Chemistry. Thus, Chemical Engineering became a separate Department in 1957. In his 2001 memoirs, Kerr stated "I decided to leave chemical engineering in the College of Chemistry where it had an outstanding record and where its faculty members were very satisfied. Chemistry was a 'college', not a department, as it remains to this day. It has been, and still is, in my judgment, the outstanding unit within the University of California – superb in research, superb in the teaching of both undergraduate and graduate students, and superb in the contributions of its faculty to university governance." No small praise!

The department's founding faculty members were highly capable and achieved much distinction, raising the department to high national standing by the time of the 1966 reputational survey of the American Council on Education. Three of the early faculty members (Charles Wilke, LeRoy Bromley, and John Prausnitz) received the Allan P. Colburn Award of the American Institute of Chemical Engineers (AIChE) during the period 1951-1962. The AIChE William H. Walker Award went to Charles Wilke, John Prausnitz, Theodore Vermeulen, and Judson King during the period 1965-1976. Nineteen faculty members of the department have so far become members of the National Academy of Engineering, including two of the department's founding five.

Chemical Engineering as a field had originally been created to provide for the engineering needs of the petroleum and heavy chemical industries. At Berkeley, the approach has to a much greater degree been to seek the places where fundamental engineering principles are useful for applications of chemistry, without any limitations regarding what specific industries, products, or processes are involved. This more general approach was continually and strongly advocated for by Charles Tobias from the beginning of the department onward. The Berkeley program has therefore been a leader in instituting and fostering newer applications of chemical engineering, something that is now reflected in most academic chemical engineering programs nationwide and worldwide. The focus on instituting and fostering newer applications has been a healthy trend for the profession of chemical engineering as well, expanding the job market and leveling out the ups and downs in a market that was historically attached to the economic circumstances of the petroleum, petrochemical, and chemical industries. Two prime examples – electrochemical engineering and biomolecular engineering – illustrate the ways in which Berkeley chemical engineering helped to make this transition.

Charles Tobias, one of the original five faculty members, came to Berkeley in 1947 as an émigré from Hungary to join his brother Cornelius, who worked with Ernest Lawrence's brother John in medical physics at Berkeley Lab. Upon his arrival, he sought out Wendell Latimer who was then dean of the College. Seizing upon the fact that Tobias had worked as a chemical engineer in the United Incandescent Lamp and Electrochemical Company in Hungary, Latimer urged him to start a program in electrochemical engineering at Berkeley. That is precisely what Tobias did, building what was to become the preeminent electrochemical engineering program in the United States, with

graduates founding similar programs across the nation and world. In 2019, the Nobel Prize for Chemistry was given for the development of lithium-ion batteries. The report from the Nobel committee on scientific background for that prize cited the 1958 Ph.D. dissertation of William S. Harris, supervised by Tobias, on the use of propylene carbonate and related solvents as being crucial for the development of those now-workhorse batteries. That report also cites the theoretical contributions of Berkeley faculty member John Newman.

Berkeley chemical engineering has continued to be a world leader in the field as batteries have become more and more important for electric cars, leveling energy loads, and powering mobile devices of all sorts and sizes. Berkeley chemical engineering faculty member Elton Cairns devoted his entire academic career to research on batteries and fuel cells. Nitash Balsara has developed novel and improved electrolytes for lithium-ion batteries, and, most recently, Bryan McCloskey has characterized fundamental electrochemistry occurring at multi-phase interfaces to provide design insight for energy storage, electrocatalysis, and corrosion-resistant materials.

About 1967, Charles Wilke, another of the original five faculty members, who at the time stood at the top of his field of mass transfer, made the striking decision to switch his research efforts completely to the nascent field of biochemical engineering. This was a remarkably foresighted move, as the biotech industry evolved rapidly in the late 1970s and early 1980s based on scientific advances in recombinant DNA and other molecular-based scientific advances, with the San Francisco Bay area becoming an industrial powerhouse. Subsequent faculty additions in the area through 2010 included Harvey Blanch, Douglas Clark, Jay Keasling, David Schaffer, and Wenjun Zhang, covering a variety of areas in bioprocessing, synthesis of new and natural molecules, bio-separations, enzyme engineering, and biomedical applications. Research in these areas has been one of the principal ways in which the capabilities of science and engineering departments on the campus have been brought together synergistically. Keasling has achieved major recognition for the synthetic production of artemisinin, the major drug for the treatment of malaria.

Remarkably, the first four (counting Wilke) faculty members involved with biochemical and biomolecular engineering are all now members of the National Academy of Engineering, and the number will surely increase. Between them, Keasling and Schaffer have been involved in launching eight new companies so far. In 2022, Schaffer has taken on the role of Director of the Bakar BioEnginuity Hub, a joint activity of the Berkeley and San Francisco campuses located at Berkeley and devoted to entrepreneurial development of products of biological and biomedical research. Because of the growth in this area, the name of the Chemical Engineering department was changed in 2010 to Chemical and Biomolecular Engineering. Also, more women chemical engineering faculty continue to join the department with the most recent additions of Markita Landry (nanomaterials and molecular engineering), Michelle Chang (biochemistry, chemical biology, and synthetic biology), and Joelle Frechette (soft materials, interfacial science, and adhesion).

In 2018 Frances Arnold *(Ph.D.'85, ChemE)* who studied with Harvey Blanch, was awarded the Nobel Prize in Chemistry for her original work in directed evolution of organisms. She was the fourth woman, and only the second chemical engineer to receive that award.

This article is based on Professor King's 2020 book, *A History of Berkeley Chemical Engineering: Pairing Engineering and Science*, which is available both in print from Amazon and as an open-access download at https://escholarship.org/uc/item/000395px.

Historical List of Tenure Track
Chemical Engineering Faculty

1946	**Philip Schutz**
	LeRoy Bromley
	Theodore Vermeulen
	Charles Wilke chair 1957–1963
1947	**Donald Hanson** chair 1963–1967
	Charles Tobias chair 1967–1972
1948	**Campbell Williams**
1952	**Kenneth Gordon**
1953	**Eugene Petersen**
1954	**Andreas Acrivos**
1955	**John Prausnitz**
1958	**Don Olander**
1961	**Michel Boudart**
	Alan Foss
	Richard Wallace
1962	**Simon Goren** chair 1994–1997
1963	**Edward Grens**
	John Newman
	Judson King chair 1972–1981
	Richard Ayen
1964	**Robert Merrill**
1965	**David Lyon**
	Michael Williams
1966	**Robert Pigford**
1967	**Scott Lynn**
	Alexis Bell chair 1981–91; interim chair 2005–06
1969	**Mitchell Shen**
1970	**Thomas Sherwood**
	Lee Donaghey
1975	**Clayton Radke**
1977	**Dennis Hess**
1978	**Elton Cairns**
	Harvey Blanch chair, 1997–2001
1979	**David Soane**
	Edward Reiff
1981	**Morton Denn** chair 1991–94
1982	**Jeffrey Reimer** chair 2006–2011; 2013 –2015; 2016–2022
1983	**Jim Michaels**
1986	**Douglas Clark** chair 2011–2013
	David Graves
	Doros Theodorou
1988	**Arup Chakraborty** chair 2001–2005
1991	**Susan Muller**
1992	**Jay Keasling**
1993	**Enrique Iglesia**
	Roya Maboudian
1999	**David Schaffer**
2000	**Alexander Katz**
	Nitash Balsara
2004	**Rachel Segalman**
2006	**Jhih-Wei Chu**
2007	**Berend Smit**
2008	**Keith Alexander**
2009	**Danielle Tullman-Ercek**
2011	**Wenjung Zhang**
2013	**Bryan McCloskey** chair 2022–
2014	**Ali Mesbah**
2016	**Markita Landry**
	Kranthi Mandadapu
2019	**Rui Wang**
2020	**Karthik Shekhar**
2021	**Joelle Frechette**

Pages 18-19
Student in process engineering lab.
PHOTO DENNIS GALLOWAY CIRCA 1980S

Chemical Engineer students Bryan Rogers ('71) and Peter Cukor ('71) protest against the Vietnam war.
PHOTOGRAPHER UNKNOWN CIRCA 1970

Student with slide-rule.
PHOTO DENNIS GALLOWAY CIRCA 1980S

Wanda Clearwaters, first woman member of the Chemical Engineering club.
PHOTOGRAPHER UNKNOWN CIRCA 1963

Pages 20-21
Chemists, chemical engineers and their wives at a party. Charles Tobias is about to shoot off a cap gun.
(Left group) seated Mary Ellen Powell and Jean Pitzer; standing Dick Powell (Center group) Charles Tobias (l) and Bill Gwinn (r) (seated) Laura Lee McClure; (Right group) standing Ken Pitzer; seated Don McClure.
PHOTOGRAPHER UNKNOWN CIRCA 1949-1955

(l to r) Charles Tobias, F. Campbell Williams, and Donald Hanson.
UNKNOWN PHOTOGRAPHER AND DATE

Charles Wilke, one of the first faculty in the department of Chemical Engineering (1946), department chair 1957-1963.
PHOTO DENNIS GALLOWAY, DATE UNKNOWN

Celebrating *25 years* of discovery in Tan Kah Kee Hall

BY MARGE D'WYLDE

Tan Kah Kee Hall (Tan Hall) is the most recent addition to the suite of research buildings in the College of Chemistry. Dedicated in April of 1997, it was designed primarily to support research and graduate education in fields of major importance to the Bay Area and California, including biotechnology and pharmaceuticals, electronic and advanced materials, fuels and chemicals, and the environment.

"The investment in this building," said Alexis T. Bell, who was dean of the College at the time, "will be repaid many times over in the contributions of our faculty and students to our health, economy, and the environment."

Tan Hall was the result of a partnership between the state, which provided approximately one-third of the $40M cost ($70M today) following the passage of the Higher Education Bond Act (Proposition 153) in 1992, and the private sector. Hundreds of individuals, corporations, and foundations contributed to the broad-based funding effort.

The nine-floor building contains seven floors of laboratory space, an undergraduate computer facility and lecture hall on the first floor, and the Ross and Irma McCollum Conference Room on the seventh floor with a spectacular view of the campus, Berkeley, and the Bay. The building also houses a storeroom and chemical storage.

The building is named in honor of the late Tan Kah Kee (1874-1961), a pioneering industrialist and philanthropist based in China and Singapore who devoted his wealth to promoting education. Members of the overseas Chinese community in Southeast Asia, led by prominent business and philanthropic interests, donated millions of dollars to the building in Tan's honor.

"This building is a testimony to the international recognition of Berkeley's contributions in chemical science and engineering," Chancellor Tien commented. Set in the northwest corner of the College Plaza, Tan Hall joined Gilman Hall (1917), Lewis Hall (1948), Giauque Hall (1954), Latimer Hall (1962), and Hildebrand Hall (1966).

To date, eight chemistry faculty and fifteen chemical and biomolecular engineering faculty have established research labs over time in Tan Hall. Current scientists working in the building include chemistry researchers Christopher Chang, Michelle Chang*, Felix Fischer, and Don Tilley. Chemical engineering researchers include Alex Bell, Nitash Balsara, Douglas Clark*, Enrique Iglesia, Roya Maboudian, Ali Mesbah, Clayton Radke, and Jeffrey Reimer,

Our newest faculty members in the building include chemists Ashok Ajoy and Alanna Schepartz, and chemical engineer Joelle Frechette representing a wide range of research interests. Ajoy's research looks at nanoscale NMR spectroscopy, targetable spin hyperpolarization agents, methods for quantum sensing and quantum computing with spins, and the chemical physics of spin transport and dynamics at the nanoscale. Frechette's research is focused on materials at interfaces to address issues in the fields of adhesion, surface chemistry, wetting, and material science. Schepartz's research spans the chemistry-biology continuum seeking to establish new knowledge about the chemistry of complex cellular processes and apply this knowledge to design or discover molecules–both small and large–with unique or useful properties.

Emeritus faculty who did their research in Tan Hall include Robert Bergman, Angelica Stacy, Harvey Blanch, Morton Denn, David Graves, Susan Muller, and Rachel Segalman.

*Douglas Clark and Michelle Chang are both now located in Lewis Hall.

A scientist's journey to the *Nobel Prize*

BY MARGE D'WYLDE

The Nobel Prize is one of the most prestigious awards for the sciences in the world. Other notable international awards include the National Medal of Science (United States), the Wolf Prize (Israel), The Royal (Queen's) Medal (England), and the Leibniz Prize (Germany) acknowledging many long research hours spent by scientists and their teams in labs around the world.

But the Nobel Prize remains the most renowned. College of Chemistry faculty have been awarded the Prize five times, most recently in 2020 when Professor Jennifer Doudna shared the prize with colleague Emmanuelle Charpentier for their groundbreaking work on CRISPR technology.

Members of the College of Chemistry were delighted when Professors David MacMillan of Princeton University and Benjamin List of the Max-Planck-Institut were awarded the 2021 Nobel Prize in Chemistry for their independent discovery in 2000 of asymmetric organocatalysis. Researchers had long believed that there were, in principle, just two types of catalysts available: metals and enzymes. Their research showed that small organic molecules could also be used to create catalyzing reactions. We were also very pleased because UC Berkeley and the College were part of Prof. MacMillan's research journey to the Nobel Prize. In fact, his first appointment as an assistant professor in chemistry was at Berkeley in 1998 where he did his initial Nobel Prize winning research.

Prof. MacMillian was working with two co-researchers Kateri Ahrendt *(Ph.D. '03, Chem)* and Christopher Borths *(M.S. '00, Chem)* at the time. Kateri was working on her Ph.D. in Chemistry in the lab of Jonathan. A. Ellman. Currently she is Associate Professor of Chemistry at Regis College, Weston, Massachusetts. Christopher received his M.S. in Chemistry at Berkeley and then went on to CalTech for his Ph.D. He has more than 17 years' experience in the pharmaceutical industry as a synthetic organic chemist with Amgen.

"Dave started as an assistant professor the year after me at the College. It was amazing to see firsthand the fire and creativity he brought to his research. From day one, he thought beyond accepted dogma with a passion for impactful science that was inspirational to his students and colleagues," stated Jeffrey Long, UC Berkeley Professor of Chemistry and Chemical Engineering.

Born in Bellshill, Scotland and armed with a B.Sc. in Chemistry from the University of Glasgow, he came to the United States to earn his Ph.D. at UC Irvine in 1996. He went on to postdoctoral research at UC Irvine and Harvard through 1998. In 1998 he joined UC Berkeley as an assistant professor in the College of Chemistry. He moved to Caltech in 2000 and ultimately settled in as a professor of chemistry at Princeton University in 2006.

Prof. MacMillan had been pursuing early research into organocatalysis during his postdoc at Harvard when he came to Berkeley. At Berkeley, he developed a more durable catalyst from organic molecules that, like metals, could temporarily accommodate or provide electrons. He tested the organic molecule's ability to drive a Diels-Alder reaction, which can build rings of carbon atoms.

His reaction worked perfectly. He states, "I remember jumping up and down and telling myself, I think I'm going to get tenure."

The most important thing about their discovery was that now scientists could make medicines faster with less dire consequences. Chemists and pharmaceutical researchers often only want one version of a molecule, and typically in a catalytic reaction they will produce two (a left and right mirror version of the same molecule). Having both can lead to disastrous results. A tragic example was in the 1950s and 1960s, when a mirror image of the molecule thalidomide caused severe birth defects in thousands of babies in a treatment for morning sickness in women.

But asymmetric catalysis has the ability to produce just one asymmetric molecule, the left or the right, a boon for safety and for reducing chemical waste moving toward more green chemical processing in pharmaceuticals.

BRITTANY HOSEA-SMALL

Ziyang Zhang's drug discovery journey

ASSISTANT PROFESSOR OF CHEMISTRY AND CHEMICAL BIOLOGY

BY MARGE D'WYLDE

The College is pleased to welcome Dr. Ziyang Zhang who will be an assistant professor in the Chemistry department in the areas of chemistry and chemical biology. Ziyang is coming from a postdoctoral appointment with Professor Kevan Shokat at the University of California San Francisco (UCSF) where he has been focused on research devising ways to drug mutant forms of KRAS, a protein commonly implicated in cancer. He also created a new strategy for recruiting the immune system to attack cancers with the G12C mutation and devised a new method for selectively delivering kinase inhibitors into the brain while minimizing side effects in the rest of the body.

Ziyang grew up in Taizhou, China. He describes it as a lovely small city on the east coast. "I would say it is a very cozy city," Zhang comments. "I had a lot of fun there as a child. My parents still live there. When I was in sixth grade, I discovered I really liked computers and was good at coding. We didn't call it coding back then. Instead, we used the phrase 'computer interest club'. It was a little bit about learning to write code, but it was also a little bit about playing video games without other people knowing about it."

Mentors were very important to Ziyang. "Ligang Ni was my wonderful mentor in high school. He really got me interested in chemistry. He would do some crazy experiments that were just cool...high school kids cool", Ziyang states. "He was unique. It is very painful for a lot of high school students to study science in China because the way our curriculum is constructed it involves a lot of memorizations without understanding the underlying science. But his approach was totally different somehow. He just made it fun. But there was science behind it too."

Ziyang went on to double major in chemistry and computer science as an undergraduate at Peking University. "It's interesting that there is a creative practice in common between coding for computers and chemistry discoveries. You are developing something completely new that hasn't existed before," he comments.

During Ziyang's second year he was introduced to autoimmune diseases because of a family member. "I was fascinated that the body's immune system does not know what to do and decides to destroy itself. Why would it do that? And then I started to learn about organic synthesis and these natural products that are immune suppressants. And that became very interesting."

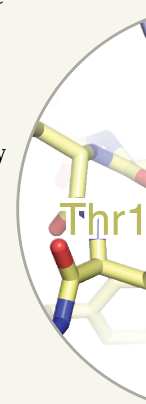
Ziyang went on to graduate studies at Harvard in the lab of Andrew Myers. As a first-year student he was introduced to a project to devise a general strategy for the total synthesis of macrolides, a class of well-known and widely used antibiotics with complex structures. Traditionally these antibiotics are made by modifying naturally derived macrolides—an approach that limits the potential diversity of new molecules. "They are not trivial to make from scratch," Zhang says. But he found a way to do it.

Ziyang co-led a team that divided macrolides into eight generic parts. By making several varieties of each of those eight parts and then stitching them together in different combinations, the team created hundreds of new macrolides. Many of them showed promise at killing bacteria resistant to commercial macrolides, and the work, published in 2016, formed the basis of a company called Macrolide Pharmaceuticals, now Eloxx Pharmaceuticals.

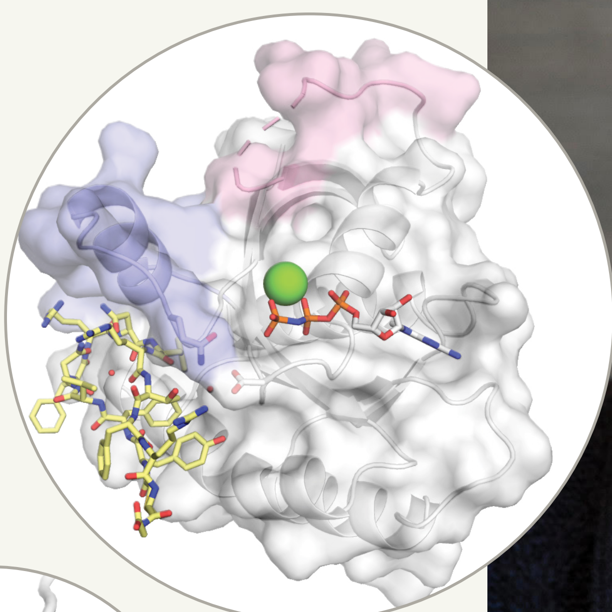
After Harvard, Ziyang joined Professor of Chemistry and Cellular and Molecular Pharmacology Kevan Shokat's lab at UCSF for his postdoctoral work. During his five-year appointment, Ziyang has done research in multiple areas focusing on ways to drug mutant forms of KRAS, a protein commonly implicated in cancer.

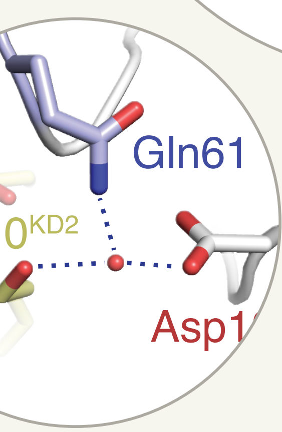
Shokat's lab had developed a small-molecule inhibitor of KRAS G12C, a mutant in which a glycine has been replaced by a cysteine. But a form of the protein in which the same glycine is replaced by an aspartate—a G12D mutation—had proved particularly difficult to drug. The mutation is frequently found in pancreatic cancers. Ziyang discovered a new G12D inhibitor. The discovery is timely because doctors have recently seen tumors develop resistance to G12C inhibitors. Shokat says the approach "could lead to cures" for some cancers. Zhang hopes to generalize the strategy and apply it to other proteins beyond KRAS.

"I am looking forward to starting at UC Berkeley," Ziyang states. "I am very interested in continuing to explore autoimmune diseases. I feel I now have the tools to research ways we can



use small molecule chemicals to change how our T cells work. Our T cells are amazing. They are constantly checking on nearly every cell in the body. But they can make mistakes which can lead to certain autoimmune diseases. One of the areas of exploration that we will be researching in my lab is ways to help with antigen presentation of cancer finding ways to block the presentation of disease associated antigens. That hasn't been done with chemical approaches before."






COURTESY ZIYANG ZHANG

MARGE D'WYLDE

The College welcomes polymer scientist Brooks Abel

ASSISTANT PROFESSOR OF CHEMISTRY

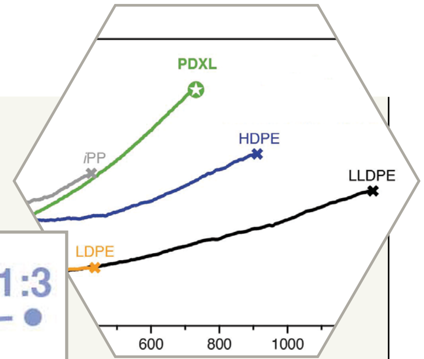
BY MARGE D'WYLDE

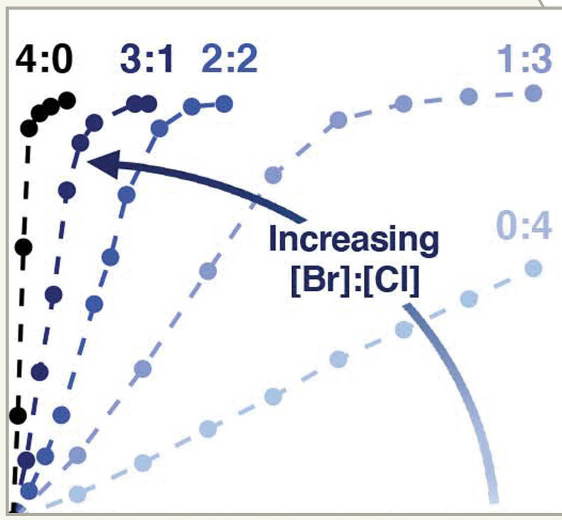
We are delighted to introduce Dr. Brooks Abel who joined the College of Chemistry as an assistant professor in the summer of 2021 with a focus in polymer chemistry.

Brooks arrived from a postdoctoral appointment in the lab of Tisch University Professor Geoffrey Coates at Cornell University where he researched the development of catalysts for controlled anionic and cationic ring-opening polymerizations creating new materials capable of repeated chemical recycling to monomers.

Brooks grew up in McComb, Mississippi which is also the hometown of musical artists Britney Spears and Brandy. During high school he developed an interest in cycling and raced bikes with teams such as the New Orleans Bicycle Club for more than ten years. He attended school through junior college in McComb before heading to the University of Southern Mississippi (USM) where he received his undergraduate degree in chemistry. USM houses one of the three top polymer chemistry programs in the country.

His discovery and love of chemistry happened around the age of 11 when he developed a huge interest in aquariums. Brooks comments, "I didn't know it at the time, but that's when I fell in love with chemistry and research. When I got my first fish I thought, 'Oh yeah, I'm an expert'. I'm 11. I know how to dechlori-





nate the water. I know everything there is to know about fish." And then of course, a week later it was dead. And I am thinking to myself, "What the heck happened?"

He continues, "Our library had five books on maintaining aquariums. You could check out books for two weeks. Every two weeks I checked out those five books and read them over and over. I learned about the nitrogen cycle, pH, buffers, and the all-important information you needed to run an aquarium. I loved doing the research. I just wanted my aquarium to be successful. That was my start."

He started studying at the local junior college and then transferred to USM because initially he didn't know what he wanted to major in. He thought about architecture, but since there was no architecture track, he began taking math and science classes. Brooks says, "Halfway through junior college I started hearing my friends complain about their chemistry courses, which re-triggered my interest in the subject." So, he switched to chemistry.

"And then I learned about these things called polymers and that there was a world-renowned polymer program that I had never heard of an hour away from where I grew up. I went on to finish my undergraduate degree and do my graduate studies in polymer chemistry at USM," Brooks states. While an undergraduate at USM, he and a fellow classmate founded the University of Southern Mississippi's first and only Collegiate Cycling Team. "We funded the team by working the concession stands at football games and obtaining sponsorships from local businesses. We even ended up on the podium at a few races."

Brooks received his Ph.D. in 2016 in Polymer Science and Engineering. His doctoral research focused on the development of synthetic approaches toward novel polymer architectures that specifically address the issues of in vivo drug delivery.

During Brooks' postdoc at Cornell, he started looking more closely at the science of recycling. He states, "The traditional way of recycling where you collect plastic waste, melt it down, and make something else out of it is what we all know as 'recycling'. But from a chemical perspective the plastics are being 'down-cycled' to lower value materials due to polymer degradation and the presence of contaminates like pigments, dyes, stabilizers, etc."

"During my postdoc at Cornell, we were working on developing a method to control the polymerization of cyclic acetals to make polymer electrolytes for batteries," Brooks states. "We developed a new synthetic method that allows us to control the polymerization and obtain very high molecular weight materials. What surprised us was that some of the polyacetal derivatives had incredible thermomechanical properties so long as the polymers were of suitably high molecular weight. We had not anticipated these properties when we originally synthesized these materials."

It turned out that these polymers have properties comparable to polyolefins like polyethylene and polypropylene which cannot be readily depolymerized to monomer. We had synthesized an inexpensive material that could be easily turned back into monomer and then repolymerized to polymer. The polymerization-depolymerization process can effectively be repeated an infinite number of times.

"We started experimenting with the contents of our recycling bins and garbage cans at home. We used every type of plastic that we could find," Brooks comments. "We mixed in our polyacetals and found that we were able to isolate pure monomer out of that mixture in near quantitative yield. We were then able to repolymerize the recovered cyclic acetal monomer back into polymer."

Now that he is at Berkeley, Brooks is focused on developing new polymer chemistries to address issues surrounding polymer sustainability. A key objective of his research is to realize new polymerization methods to create polymer materials capable of repeated chemical recycling to monomers. He is interested in both designing and optimizing catalysts for both living and stereoselective polymerizations and developing new techniques for studying catalyst selectivity, activity, and reaction mechanisms. The end goal is to improve the fundamental understanding of organic and polymer chemistry concepts.

JASON RYDER

Better living through bioprocess engineering

New master's program opens new doors for students

BY DENISE KLARQUIST
PHOTOS BY THOR SWIFT/BERKELEY LAB

SASHA HAAGENSEN

The phrase 'Better Living Through Chemistry' has been around since the 1930s. Associated with everything from plastics to prescription medications, it has not always had the most positive connotations. A more accurate slogan for our current times might be 'Better Living Through Bioprocess Engineering'. There is no doubt Adjunct Professor Jason Ryder *(Ph.D. '03, ChemE)* would agree.

A natural entrepreneur, Ryder's resume is peppered with numerous achievements from a career in industrial biotechnology and food tech including the design of large-scale facilities for bio-based chemicals and fuels, the manufacture of recombinant spider silk to replace nylon fibers, the processing of plant-based proteins to make egg-free scrambled eggs, and the production of sweet plant proteins to reduce our global dependency on sugar.

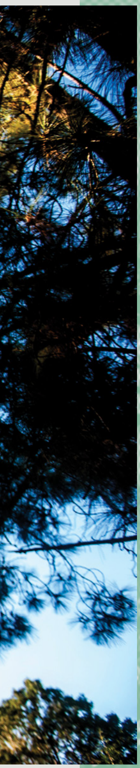
His passion for his work is effervescent, a lot like the soon-to-be-released drinks from his company, Joywell Foods, where he and his team are establishing a new category of delicious foods and beverages based on naturally sweet plant proteins. "I love bioprocessing in all forms," Ryder enthuses. "They're like my kids, they're all my favorites. I am passionate about closing mass and energy balances around the world, using biotechnology to solve problems spanning climate, food, and health. And I love developing and growing microbes, plants, people, scientists, engineers, and companies along the way."

What may be his most impactful endeavor, however, is the creation of the new Master of Bioprocess Engineering Program (MBPE) in the College of Chemistry which he leads as executive director.

The intensive nine-month curriculum is designed to prepare students for meaningful careers as bioprocess scientists and engineers in the biopharmaceutical, industrial biotech, and food tech industries. Key to the program is a balanced curriculum of fundamentals and hands-on training with common bioprocess equipment at both benchscale and pilot-scale.

The program evolved from a very real need in the burgeoning bioprocess engineering field, one which Ryder experienced acutely in his professional life as well as from his own academic journey.

While earning his undergraduate degree in chemical engineering at the University of Alabama in the 1990s, Ryder experienced an existential crisis while participating in internships and research projects with Dow, DuPont, and Exxon. "In each of these roles, I questioned where all the materials and waste products I was making were going post-consumer. If we continued on



Shreyash Savant makes a sterile addition to the ABEC 300L stainless steel bioreactor.

the path of making more single-use materials, what would the mass and energy balances around the world look like?" he relates. A prescient professor pointed him to UC Berkeley where Ryder was able to focus on research projects aligned with his passion for sustainability, working with Alexis Bell and Arup Chakraborty and obtaining a Ph.D. in 2003. From there he built his career in bioprocess engineering, developing renewable alternatives to petrochemical-based products, and more sustainable foodstuffs through the application of biotechnology.

After nearly 20 years in the industry, he and others in the field came up against a hard reality. "The field of biotechnology is exploding, growing far faster than the supply of trained bioprocess scientists and engineers needed to develop, scale, and commercialize it," notes Ryder.

Vicky Olivares (front) with ABPDU Principal Process Engineer Jan-Philip Prahl (back) take a fermentation sample from ABEC 300L stainless steel bioreactor.

Tiffany Chen at the high throughput bioreactor platform, Berkeley Lab.

The potential for people entering the field is enormous. According to the 2020 California Life Sciences Sector Report, there are currently over 3700 companies in the life sciences sector, including biopharma industrial biotech, food tech, advanced biologics and more. Combined, they directly employ over 300,000 Californians at an average salary of $123,000 annually.

"The challenge," Ryder says, "is that the bioprocess industry has benchmarks on the training required to perform roles such as associate scientist or process engineer. In the past, many of our graduating students did not meet or even know about these benchmarks and were instead hired into operations roles with no clear growth path. Companies, in turn, were continuously poaching from each other, relying on contract positions, and not investing in the scientists and engineers they will need in 10 years. This was a recipe for failure."

When UC Berkeley invited Ryder to return and share his industry experience to help better prepare students to take advantage of the wealth of opportunity in the field, he enthusiastically accepted. Pulling together colleagues in the bioprocess industry from Amyris, Bayer, Boehringer Ingelheim, Sutro Biopharma, and Vir Biotechnology, Ryder created an Industrial Advisory Board to help develop the curriculum and ensure graduates met or exceeded the hiring benchmarks set by the industry. As an early sign of the MBPE program's success, all graduates of the inaugural 2020-21 MBPE class received job offers and accepted full-time roles in bioprocess development and engineering.

The foundation of the new Master of Bioprocess Engineering program is the CHMENG 170 Biochemical Engineering series. Co-taught by Profs. Wenjun Zhang and Brian Maiorella, these lecture and laboratory courses are designed to introduce the essential concepts of bioprocessing to chemical and biomolecular engineers for applications in the biopharmaceutical, industrial biotech, and food tech industries.

Vicky Olivares, Alaina Anand, Jose Vidal, and Mikk Otsmaa during the CHMENG 275L course.

Ryder's particular favorite in the course series is the "Pet Biomolecule" term project. Leveraging their creativity and biochemical engineering fundamentals, students design a process over the course of the semester to make their own biomolecules. At the end of the term, they present their projects to a panel of colleagues from the bioprocess industry. "It's loads of fun and a way for our students to demonstrate what they've learned through an industry-relevant application," Ryder emphasizes.

Ryder aims to keep term projects highly relevant to current challenges facing our students and world. This goal is reflected in the fact that for their 2020-21 capstone projects, MBPE students designed both upstream and downstream processes to make novel SARS-CoV-2 monoclonal antibodies (mAbs) to treat COVID-19. Unique to UC Berkeley's Master of Bioprocess Engineering program, during the second semester students learn quality frameworks like Quality by Design (QbD), statistical experimental design tools like Design of Experiments (DOE), and other advanced concepts recommended and co-taught by the Industrial Advisory Board.

The students, in turn, apply these frameworks and tools to their capstone bioprocesses, biopharmaceutical ingredients, and final drug products to build additional industry-relevant skills and experience. Recognizing that our current arsenal of antibiotics may no longer be effective against pathogenic bacteria within the next 50 years, the 2021-22 capstone projects also included novel antibiotics.

Another key differentiator to the MBPE program is the *Advanced Bioprocess Engineering Laboratory* course. Taught at the Advanced Biofuels and Bioproducts Process Development Unit (ABPDU), part of Lawrence Berkeley National Laboratory and established by the United States Department of Energy to help ramp up the bioeconomy, students get hands-on pilot-scale training on five different unit operations identified by the Industrial Advisory Board as critical in the industry. Ryder points to, for example, the Sartorius Ambr250 High Throughput Bioreactor Platform, which is ubiquitous across biopharma, industrial biotech and food tech.

Lastly, recognizing that there are many career paths for students to follow from biopharma to industrial biotech to food tech and more, a bioprocess engineering seminar series is integral to the program. Each week industry speakers are invited to give presentations on bio-based technology processes and products, providing an engaging platform where students can ask questions and interact with industry professionals. Speakers have included leaders and alumni from Impossible Foods, Genentech, Pfizer, Moderna, Artemys Foods, and Tenaya Therapeutics to name a few.

Referring to a recent seminar featuring Bob Kiss of Upside Foods, Ryder shared his efforts toward building momentum in the program. "I invited all next year's newly accepted MBPE cohort to join remotely via Zoom while Bob was on campus speaking to our current MBPE students as well as a number of BS and Ph.D. students from across chemistry, bioengineering, and molecular cell biology. This is another example of how I'm trying to bring our students and industry closer together."

Naturally, Ryder's focus is on his current students and helping them take the next steps beyond Berkeley in their professional careers. However, in the future he envisions being able to invite more of the bioprocess community to that seminar and to offer more training, not just to MBPE students, but potentially to continuing students and to professionals who may want to return to UC Berkeley for a workshop or executive course.

These possibilities illuminate Ryder's bigger goal. "What I'm trying to do here is build a bioprocess community," he explains. "I look at the MBPE program as a center of a much larger bioprocess community that surrounds us in the Bay Area, California, the US, and the world. We're right here in the middle of it in Silicon Valley. We have the knowledge, the tools, and the people from which to teach and grow these aspiring bioprocess scientists and engineers. They in turn will help us translate the biotechnology that we're developing into solutions spanning climate, food, and health."

Supporting a mission to Mars

As the concept of sending a long-term team of astronauts, scientists, and other specialists to Mars to setup a habitat becomes more realistic, NASA is asking scientists and engineers to look at solutions to some of the many problems that will confront the mission's day to day operations.

DISCOVERING THE BEST POWER OPTIONS

One question being asked is: what is the most practical way to power future Mars missions? The seemingly simple question took UC Berkeley engineering students Anthony Abel and Aaron Berliner four years of hard work to figure out.

Most scientists and engineers who have thought about the logistics of living on the surface of the Red Planet have assumed that nuclear power is the best alternative, in large part because of its reliability and 24/7 operation. Solar power, on the other hand, must be stored for use at night, which on Mars lasts about the same length of time as on Earth. And on Mars, solar panels' power production can be reduced by the omnipresent red dust that covers everything.

A new study, recently published in the journal *Frontiers in Astronomy* and *Space Sciences,* used a systems approach to compare the two technologies for a six-person extended mission to Mars involving a 480-day stay on the planet's surface before returning to Earth.

"If humanity collectively decides that we want to go to Mars, this kind of systems-level approach is necessary to accomplish it safely and minimize costs in a way that is ethical. We want to have a clear-eyed comparison between options, whether we're deciding

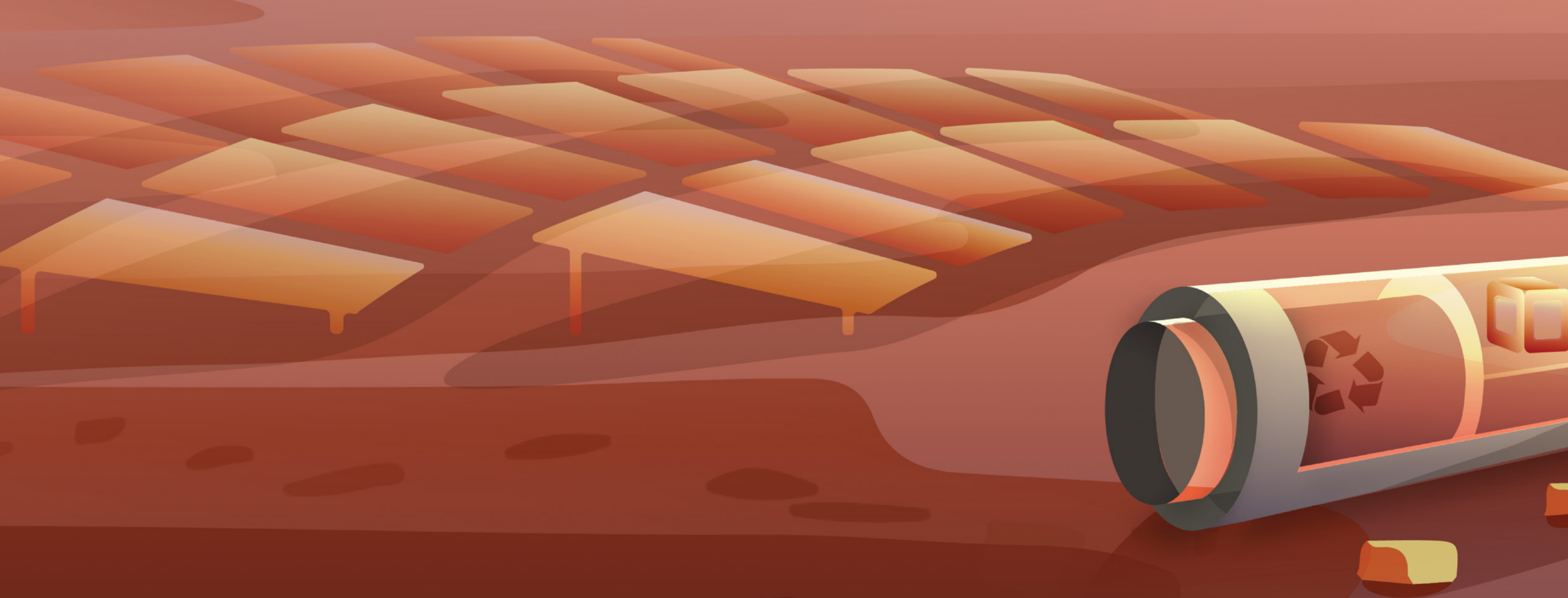


ILLUSTRATION OF MARTIAN BIOMANUFACTORY POWERED WITH PHOTOVOLTAICS BY DAVIAN HO.

which technologies to use, which locations to go to on Mars, how to go, and whom to bring," said co-first author Anthony Abel, a graduate student in the Chemical and Biomolecular Engineering lab of Douglas Clark.

"Photovoltaic energy generation coupled to certain energy storage configurations in molecular hydrogen outperformed nuclear fusion reactors over 50% of the planet's surface in our research," said co-author Aaron Berliner, a bioengineering doctoral student in the Arkin lab.

Their published findings showed that solar power was more economical toward the equator and nuclear power would be more efficient toward the poles. Read more about this research at chemistry.berkeley.edu/marspower.

USING MATERIALS AT HAND TO PRODUCE FOOD AND SUPPLIES FOR A MARTIAN MISSION

Stefano Cestellos-Blanco will receive his Ph.D. this May from the College of Chemistry. He entered the College as a graduate student in the lab of Peidong Yang in 2016. He didn't plan to figure out how to manufacture sugar on Mars as part of his research but what turned out to be an after-hours research project, stimulated by a NASA competition to spin sugar directly from carbon dioxide, is exactly what he and fellow scientists YiFan Li and Michael Ross accomplished.

CO_2 is an abundant material on Mars. NASA was interested in a conversion process that would turn CO_2 into sugar with the aim of feeding it to microbes that will make more complex materials, like food or drugs, for use by astronauts or settlers on Mars.

For the competition, the team demonstrated that the Formose reaction using formaldehyde, potentially from thermochemical CO_2 fixation, and glycolaldehyde from CO_2 electrosynthesis, generates sugars — from three-carbon sugars up to eight-carbon sugars — in about four hours, within the time frame specified in the competition.

"Converting CO_2 directly to sugar is a pretty tall task that had never been demonstrated before, and NASA not only wanted you to demonstrate that you could do it, but also within a few hours, which is a relatively short amount of time," Cestellos-Blanco said. "The individual parts of our process had been reported before, but no one knew that you could put them all together and essentially come up with a pathway to produce useful sugars from CO_2."

"We made a soup of sugars and have been able to identify which sugars those are. We also went ahead and fed the sugars to E. coli and grew them in cultures," he continued. Read more about this project at chemistry.berkeley.edu/marssugar.

Also, be sure to read the online version of this article for more Mars research innovations from the lab of Ali Mesbah. Professor Mesbah is participating in the NASA Center for Utilization of Biological Engineering in Space (CUBES) focused on learning-based predictive control systems research with a view to optimization-based systems analysis, fault diagnosis, and predictive control of uncertain and stochastic systems.

Read about this at catalyst.berkeley.edu/mars.

Jane L. Scheiber

BY CAMILLE OLUFSON

Jane Scheiber, beloved colleague, and former Assistant Dean of College Relations & Development in the College of Chemistry at UC Berkeley, passed away on March 6, 2022, after a difficult battle with cancer. Her husband, Harry Scheiber and her family whom she so dearly loved, were with her when she passed.

As assistant dean, Jane was responsible for the development of a cohesive set of fundraising, alumni relations, and public affairs programs for the College. During her tenure (1986-2009), she championed development activities that brought in more than $165 million. Jane played a key fundraising role in the College's most important capital projects, including Tan Kah Kee Hall, Pitzer Center, and the renovation of research laboratories in the upper Latimer and Lewis Halls. Jane created and oversaw the establishment of 19 endowed chairs, 39 fellowship funds, 12 scholarship funds, and 16 discretionary funds in the College. She also established the Industrial Friends Program, as well as a 25-member College Advisory Board, which has since been extremely beneficial for the College.

Jane had the opportunity to work with seven deans during her tenure: Judson King, Robert Connick, Bradley Moore, Alexis Bell, Clayton Heathcock, Charles Harris, and Richard Mathies. Jane was a truly talented and dedicated campus leader who provided 26 years of exceptional service to Berkeley's College of Chemistry, as well as 11 years at UC San Diego.

MICHAEL BARNES

Jane had the special ability to cultivate relationships and was beloved by many alumni and friends. She forged genuine personal connections with our alumni, and she was a very caring and dedicated ambassador for the College and the University.

Jane's commitment to Berkeley never diminished. Following her retirement, she took on a volunteer position as Special Assistant to the Dean and continued with a number of ongoing development projects. As one of our beloved alumni, T.Z. Chu, noted, "Jane is a scholar in her own right, having published a number of articles in academic journals and presented papers at professional conferences...and with her husband co-authored *Bayonets in Paradise: Martial Law in Hawaii During World War II*...In every way, she gained honor and respect for Berkeley."

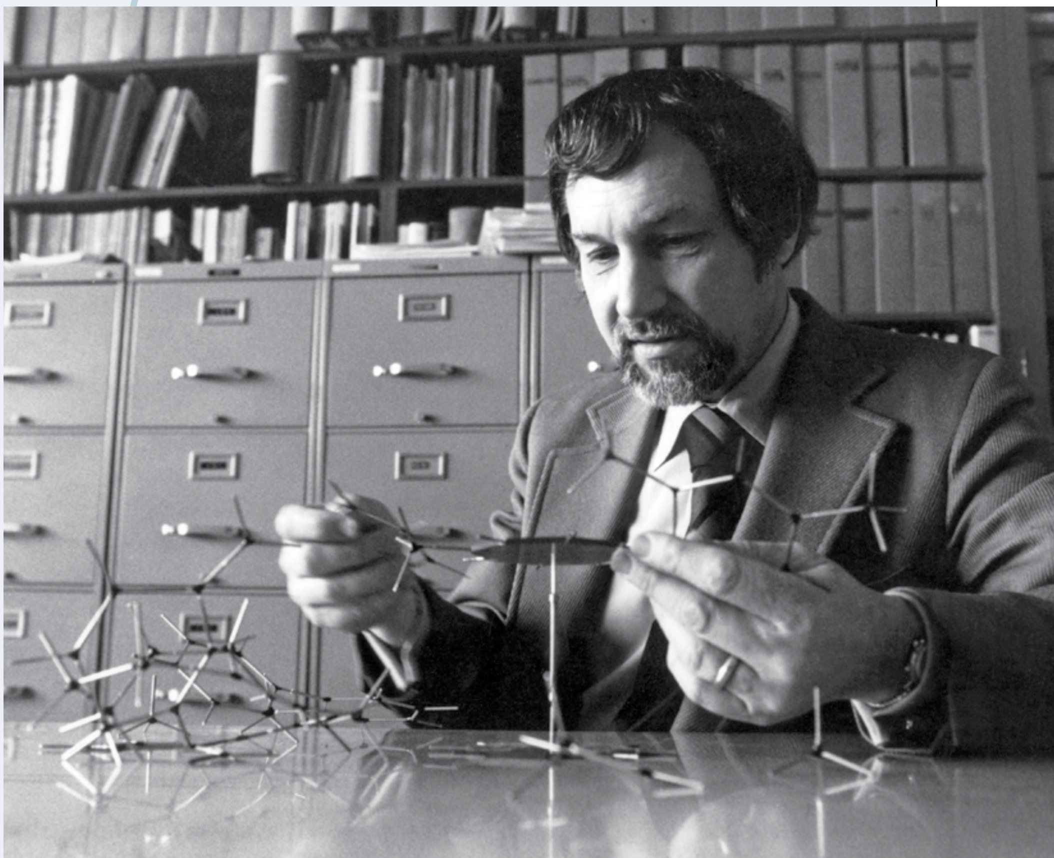
Upon Jane's retirement, she received the Berkeley Citation, which is awarded to select individuals whose contributions to campus go beyond the call of duty and whose achievements exceed the standard of excellence in their fields. The Berkeley Citation was fitting recognition for Jane's exemplary career at Berkeley.

Please join with us in honoring our distinguished colleague, Jane Scheiber, who will be greatly missed.

Andrew Streitwieser

BY DOUGLAS CLARK AND ROBERT BERGMAN

Andy was born in Buffalo, New York in 1927. He attended Columbia College and then Columbia University, where he earned his Ph.D. in 1952 under the direction of William von Eggers Doering. He was a postdoctoral fellow in the laboratory of John D. Roberts at MIT. In 1952 he joined Berkeley as an instructor and then rose through the ranks to become a professor of chemistry. Andy retired in 1993 but remained active in the department as a professor of the graduate school.



DENNIS GALLOWAY

Andy was a major figure in the field of physical organic chemistry and was one of the earliest contributors to apply the concepts of physical and theoretical chemistry to organic chemistry. A notable area of study of his involved the inspection of organic compound intermediates called carbocations, or "short-lived" compounds that would form as a result of organic reactions. His textbook on *Solvolytic Displacement Reactions* was purchased and read by most organic chemists with an interest in mechanisms, and his book on *Molecular Orbital Theory for Organic Chemists* brought understanding and utility to a wide range of workers in the field. Another major contribution was his understanding and application of kinetic isotope effects to the study of reaction mechanisms, which made him a leader in that area of physical organic chemistry as well.

A major achievement of Andy's was the theoretical prediction, followed by the synthesis, of uranocene, a compound formed by combining two organic molecules (cyclic ring compounds called cyclooctatetraene) and uranium. "He was working at a time when most organic chemists were focused almost exclusively on organic compounds," comments Robert Bergman, Gerald E. K. Branch distinguished Professor Emeritus of Chemistry. "There was little attention given by organic chemists to compounds with metals in them. Andy bridged that gap in a very interesting way."

For his numerous original contributions to the field, he was honored with the ACS Award in Petroleum Chemistry (1967), the Alexander von Humboldt Medal (1979), the ACS James Flack Norris Award in Physical Organic Chemistry (1982), the ACS Cope Scholar Award (1989), the Berkeley Citation (1993), and the ACS Roger Adams Award in Organic Chemistry in 2009, among many other awards. In addition, he was a member of the National Academy of Sciences (1969) and the American Academy of Arts and Sciences (1977), and a fellow of the American Association for the Advancement of Science (1978).

He had many interests outside of chemistry. He loved music, regularly attending the San Francisco Opera, and traveled around the globe for Wagner's Ring Cycle. As an avid nature photographer with a particular interest in solar eclipses, Andy was a longtime member of the Berkeley Camera Club.

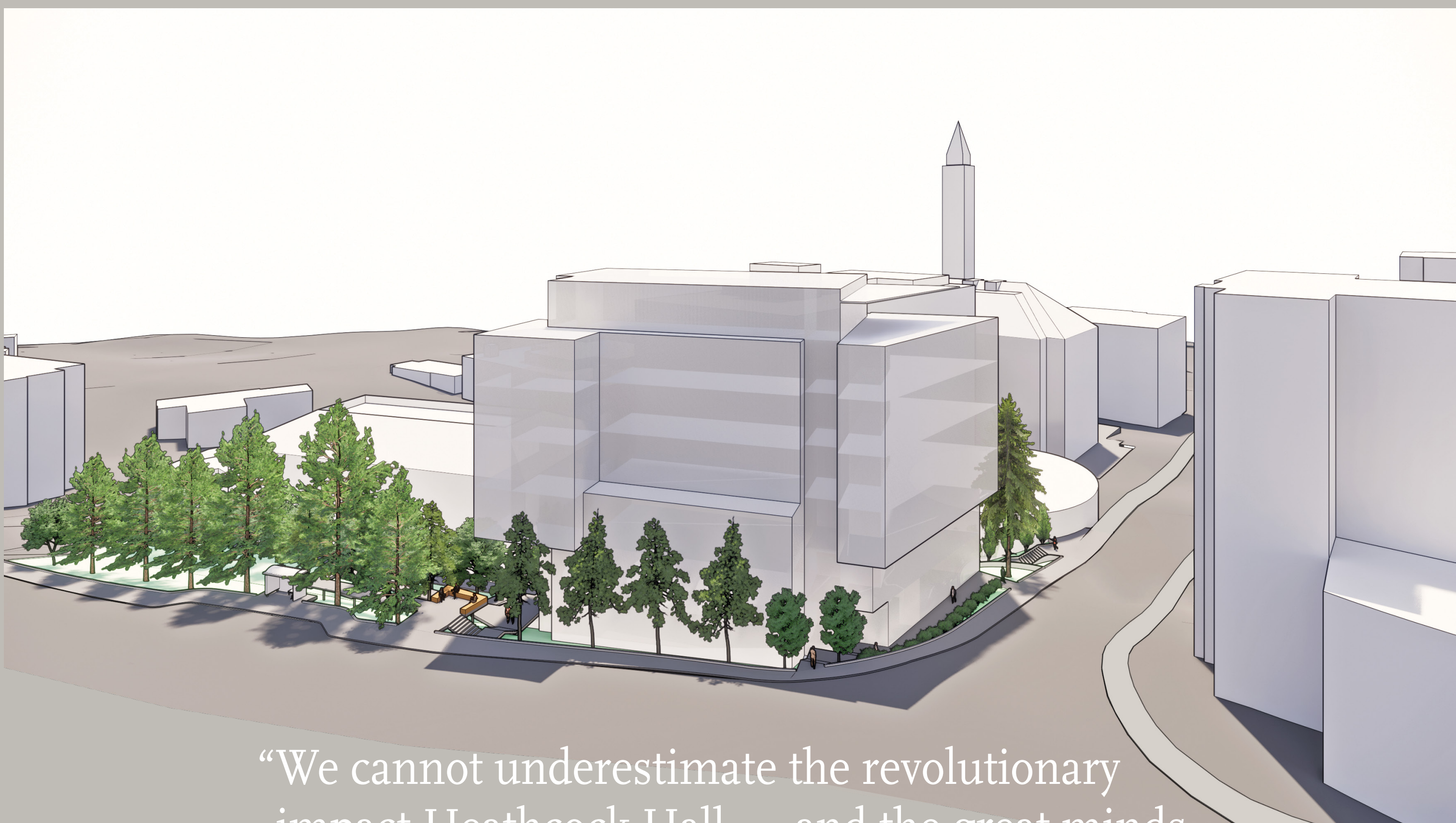
He was a fly-fishing enthusiast, unstoppable punster, and a favorite tablemate at the Berkeley Breakfast Club. He loved art, football (especially the 49ers), books, a great meal, laughter, and spirited discussion. He especially enjoyed wine and was a longtime member of several East Bay wine tasting groups.

Andy is survived by his two children David and Susan (Anders) and their families.

Catalyst

UNIVERSITY OF CALIFORNIA BERKELEY
College of Chemistry
420 LATIMER HALL #1460
BERKELEY, CA 94720-1460

NONPROFIT ORG.
U.S. POSTAGE
PAID
UNIVERSITY OF CALIFORNIA,
BERKELEY



"We cannot underestimate the revolutionary impact Heathcock Hall — and the great minds and equipment that will inhabit it — can have on making life-changing discoveries."

—**JENNIFER DOUDNA,** 2020 Nobel laureate in Chemistry

Heathcock Hall will be a place of groundbreaking research possibilities and an important educational portal for generations of chemistry and chemical engineering students. Help the College reach our goal of commencing construction in 2023. Consider a naming opportunity to sponsor a floor or a lab.

Contact Mindy Rex by email at **rex@berkeley.edu** or call **(510) 642-9506** to discuss opportunities for naming donations.

Stay connected with the College @ **chemistry.berkeley.edu** and online at Linkedin, Twitter, Facebook, and Instagram. Berkeley College of Chemistry

Please recycle this magazine