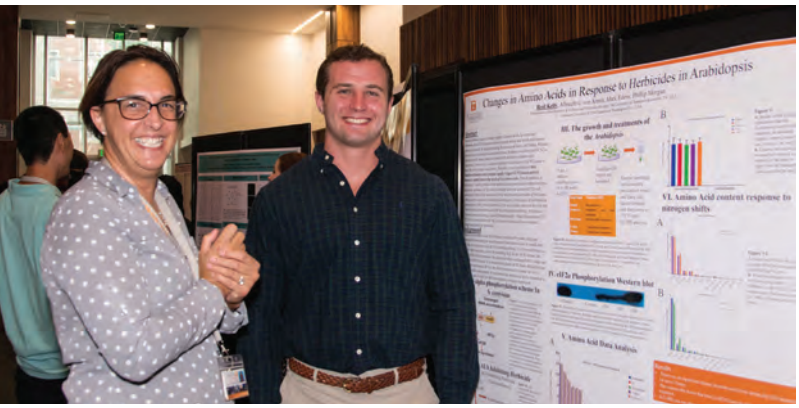
BIOCHEMISTRY & CELLULAR AND MOLECULAR BIOLOGY

DISCOVERIES

How Cells and Organisms Make Decisions

Research experiences for deaf students in systems biology and molecular signaling



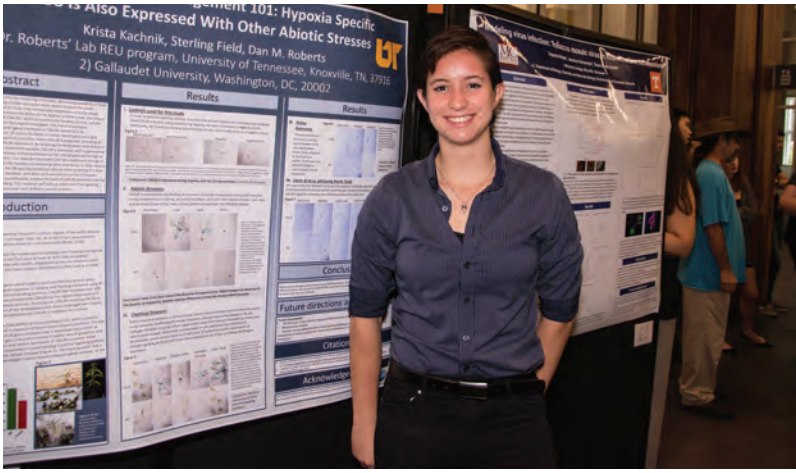
Reid Kelly, REU student from Gallaudet University, with Gladys Alexandre at the campus-wide summer undergraduate STEM poster symposium.

This summer, the department hosted an NSF-funded Research Experience for Undergraduates (REU) event organized around the broad question: "How do cells and organisms perceive their environment and make life or death decisions?" This program was tailored to deaf/hard-of-hearing (D/HH) students, a population drastically underrepresented in STEM careers nationally. For 10 weeks, nine D/HH students, along with two hearing students interested in training in both scientific research as well as American Sign Language (ASL), gained hands-on research experience in modern molecular and cellular biology, with an emphasis on emerging technologies as well as professional training and mentoring. Several of the REU students were from colleges and universities that specialize in deaf education like Galludet University and the National Technical Institute of the Deaf at the Rochester Institute of Technology, as well as from other universities and colleges throughout the nation.

The students worked in eight BCMB labs, one microbiology lab, and one lab at the UT Institute of Agriculture. Alexandre, Binder, Burch-Smith, Das, Krishnan, Lebeis (microbiology), McCord, Olokulu (entomology and plant pathology), Roberts, and von Arnim served as host labs. They performed interdisciplinary research utilizing state-of-the-art molecular, genetic, genomic, and systems biology/bioinformatics techniques to investigate the mechanisms and strategies employed by various model organisms across biological kingdoms to sense and adapt to a changing environment.

The students also participated in numerous professional training workshops that included mentoring in scientific communication, training and practice in poster and stand up presentations, and workshops on postgraduate career opportunities. Professor Adebowale Ogunjirin of the Department of Science, Technology, and Mathematics at Gallaudet University led a special career workshop. At the end of the program, REU students presented their research findings at a campus-wide poster session hosted by the UT Office of Undergraduate Research and at a one-day symposium sponsored by the BCMB department.

NSF support for the BCMB REU site will continue for at least the next two years. Read more about the program online at **bcmb.utk.edu/reu**.



Krista Kachnik, REU student from Gallaudet University, presents her work at the campus-wide summer undergraduate STEM poster symposium.

Fall 2019

what's inside:

GLADYS ALEXANDRE
Professor and Department Head

Rising to the Challenge

As researchers, we are accustomed to facing the challenges of dealing with uncertainty, slow progress, and frustration that research often brings. The pursuit of knowledge is the motivation to overcome these challenges. While these professional hurdles can be small or great, they are made tolerable by many supportive colleagues and students and by our shared passion to learn. This year, BCMB rose to many new challenges, some harder to face than others, with several highlighted in this issue.

The passing of Professor Elizabeth (Liz) Howell on April 9, 2019, after a 31-year career at the University of Tennessee, Knoxville was a difficult time. Liz was an accomplished scientist who had a passion for her research and for training the next generation of scientists. She was an engaged faculty member with an immutable positive attitude and was a role model for many, especially for women in science. A celebration of her life took place May 23, 2019, in Mossman with her students, both current and past, research staff, colleagues from across the campus, and friends and family in attendance. She will be greatly missed.

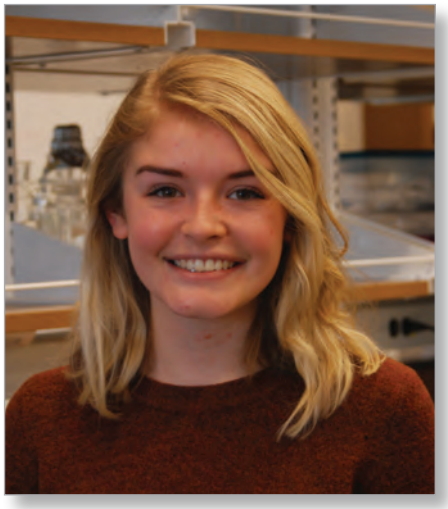
Engaging students from underrepresented groups in the research enterprise is dear to the heart of many in BCMB. After several years in the making, BCMB, under the leadership of Professor Dan Roberts, received a grant to train deaf and hard-of-hearing undergraduate students from around the country in research. We welcomed 11 students who spent 10 weeks working in BCMB laboratories. The experience challenged participating faculty to evaluate how to make our science and teaching inclusive to different learners. We have funding to build on this experience for the next two years.

BCMB faculty have been creative in developing new outreach activities to engage the greater Knoxville community in the research conducted on campus. Under the leadership of Associate Professor Tessa Burch-Smith and Research Associate Elena Ganusova, an *Art of Science* exhibit showcased drawings, photographs, and other media inspired by research and made by scientists from the Departments of Mathematics, Chemistry, Microbiology, and BCMB from September 6 to 27, 2019, in downtown Knoxville. If you missed it, do not worry, the exhibit will be back in two years.

In this fast-changing world, it is a challenge for those wanting to keep up with science and interested in participating in research to learn about us. BCMB is on social media with undergraduate and graduate students managing the accounts as social media ambassadors. They have been quite creative! I hope you check them out (Facebook: UTK Biochemistry & Cellular and Molecular Biology; Twitter: @utk_bcmb).

The Value of Undergraduate Research

Student Perspectives



Parker Stevenson does research in the lab of Keerthi Krishnan where she studies Rett Syndrome, a neurological and developmental genetic disorder that alters brain development. The syndrome causes a progressive loss of motor skills and speech, with seizures and often intellectual disability. Using video coding software, Parker studies the behaviors of mice with Rett Syndrome as they perform a pup-retrieval assay, a learned maternal behavior that can provide insight into their neural plasticity.

"My research experience within the Krishnan lab has been and continues to be such a highlight in my undergraduate career. Undergraduate research provides hands-on exposure to the sciences that you cannot get in the classroom, as well as experience with not only conducting research, but also presenting and perhaps even publishing it! I cannot recommend enough that students, especially in STEM, take the time to get involved in undergraduate research. It's as simple as looking up what different professors are researching and if you're interested in joining a lab, email that professor and ask to meet. The worst they can say is no, and UT is a very large university, so if a lab you're interested in is full, there's no shortage of other opportunities."
-Parker Stevenson

For more than a year, **Kyle Freeman** was an undergraduate in the Burch-Smith lab where he investigated the role of plant cell wall-modifying enzymes in intercellular trafficking. Molecules can travel between plant cells through small channels called plasmodesmata. The structure of plasmodesmata depends on the cell wall. Kyle studied the family of enzymes called xyloglucan endotransglucosylases/hydrolase. These enzymes can alter properties of the cell wall by cutting and re-joining structural polymers called xyloglucans. Kyle investigated whether those changes affect plasmodesmata. During last year's EUReCA, Kyle received the Office of Research & Engagement Gold Award and Natural Sciences Award of Excellence for his poster presentation. In February, Kyle presented his research poster to legislators at the annual Tennessee Posters at the Capitol in Nashville.

"Many laboratory techniques that I had read about in class I was able to perform for experiments. My time in the lab solidified concepts using real world examples. I also had the opportunity to present my work at scientific conferences. Participation in these events gave me valuable practice in public speaking and scientific communication. I would recommend that all undergraduates in BCMB seek a position in a lab. Applying knowledge from multiple courses to research questions in the lab helps put what students learn in class into perspective. Speaking with the professors and graduate students can be very beneficial for students who are still looking for what career path or graduate degrees they wish to pursue after undergrad. The earlier that students begin, the more they will be able to accomplish."
-Kyle Freeman

Want to share highlights from your undergraduate experience in a BCMB lab? Send us an email at **eshpak@utk.edu**.

Read more about their experiences and perspectives on undergraduate research opportunities online at **bcmb.utk.edu**.

Investigating New Ways to Produce Renewable Energy

Nathan Brady is a fifth-year graduate student in the lab of Professor Barry Bruce. He is a recipient of an Outstanding Speaker award at the Fourth SMALP Conference in 2019. Nate's talk at the conference focused on his research examining and optimizing the integration of Photosystem I into biohybrid solar devices for the sustainable production of electricity.

Arguably, the most urgent problem facing life on Earth today is global climate change, arising from the destructive way in which we fuel our society. Nate's work focuses on developing a new way to produce electricity from sunlight by integrating photosynthetic proteins into solar energy harvesting devices. This applied photosynthesis approach leverages a truly renewable strategy, refined over billions of years of evolution, to produce energy.

"It's not only our responsibility to mitigate the damage we have dealt to our planet; it's also the only plan that ensures the longevity of our species on it," Nate said.

Nate has been interested in environmental problems for more than 10 years. As an undergraduate chemistry major at the State University of New York (SUNY), Nate chose to focus on environmental chemistry. In his senior year, he was engaged in not one but two research projects. He analyzed the fatty acid profiles of coral reefs off the coast of Florida as a metric for overall ecosystem health, plus he measured the nutrient requirements of anaerobic digesters that can help us to produce methane rich biogas from food waste. After college, he took a job at Life Science Laboratories in Syracuse studying contaminant and nutrient cycling in the environment. This experience gave him first-hand insight into the effort required to manage environmental compliance. Nate became aware of the glacial pace at which toxicity limits are set and communicated and the importance that our understanding of environmental toxicity plays in setting these regulations. Soon he heard about Quicksilver Scientific, a start-up business that assesses the prevalence of trace metals in humans and the environment.

Interested in the job, he emailed or called Chris Shade, Quicksilver's CEO and founder, every three weeks for the following six months, moved to Colorado and delivered sandwiches for another three months, maxing out his credit card. Finally, his persistence paid off and he got the job. Quicksilver was built around a high-performance liquid chromatography system, capable of simultaneously detecting various species of mercury in any environmental matrix to the part-per-trillion level. The five and a half years he spent growing alongside this burgeoning business turned him into a scientist. It also showed him how difficult it is to perform environmental work in our current political climate, work we so desperately need in our world today. Nate thinks this will not change until we address the stranglehold the fossil fuel industry has on our environmental policy and the larger regulatory landscape of our global society.

While considering going to graduate school, Nate stumbled across a TEDx video, filmed on a shaky cell phone, of Professor Barry Bruce and his work in applied photosynthesis. Nate's target was set. He had never heard of the technology before, but it checked all the boxes for him. From there on, he only applied to PhD programs that had researchers focused on this technology, with Barry and UT being his number one choice. Of the dozen researchers he was able to find at the time, the vast majority were focused on wiring the photosynthetic proteins into devices, working in chemical engineering or materials science. What intrigued him most about Bruce was the biological prospective on Applied Photosynthesis technology. The Bruce lab was focusing on understanding how photosynthetic proteins function in vivo, which may allow us to preserve their activity in vitro.

Regarding his late career switch from chemistry to biology, he quotes Andreas Nebenführ: "The biggest questions we have left are in biology; they aren't adding elements to the periodic table anymore." While some

folks at Oak Ridge National Lab may disagree with that last bit, Nate believes that biology is the stage upon which we observe chemistry and physics manifest.

"To this end, our knowledge of the natural world is becoming so comprehensive that the classical divisions between fields are becoming increasingly obscured," Nate said. "I believe that if you want to really solve a problem today, you need to be a student of many disciplines."

BCMB is a multi-faceted department that allows students to learn a variety of experimental approaches

"We have experts in techniques as varied as mutant screens and yeast two-hybrid assays to X-ray crystallography and nuclear magnetic resonance, studying biological processes in diverse model organisms," Nate said. "In my opinion, BCMB is both diverse and cohesive, providing a place ready-made for collaboration, exploration and ultimately success in research."

Being a graduate student is not all about experiments and going to classes. Going to conferences, presenting research and talking to experts is a big part of the learning experience. One of the most memorable moments during Nate's time at UT was his trip to the International Congress on Photosynthesis Research in Maastricht, the Netherlands.

"I went to this conference early in my first year at UT and the overwhelming knowledge there was equal parts humbling and enthralling," Nate said. "This relatively small group of international researchers were housed in a secluded farmhouse in the Southern Dutch countryside for a week. This experience afforded me the opportunity to engage deeply with scientists whose prowess and intellect, I would find in following years both influential and intimidating. Looking back, I'm happy I was so naive at the time, as everyone was so approachable!"

When he is not in the lab, Nate loves to be outside hiking, backpacking, kayaking, rock climbing, mountain biking, or skiing.

"Admittedly, my skis don't get much use here, they mostly sit leaned up against my bedroom wall, taunting me," Nate said. "Over the last year, I've also enjoyed researching and designing an off-grid tiny house that I intend to build. I plan to build this house on a 30-foot long trailer at 8.5 feet wide and 13 feet tall. The primary power for this house will be provided via a photovoltaic array on the roof, the stove will be fueled using an anaerobic digester to produce methane gas and water will be collected and reused on site. This time at UT has given me the ability and inspiration to move on from earlier chapter living fully within my research interests."

To see more faculty news, undergraduate student spotlights, and graduate student spotlights, visit **tiny.utk.edu/BCMB-News**.

In remembrance of Bruce Anderson

It is with sadness we announce that Bruce Anderson, who was a BCMB faculty member from 1963 to 1970, has passed away. Anderson was one of the four founding faculty members of the UT-Knoxville Biochemistry Department when it launched in 1963. After leaving UT, he became head of the Department of Biochemistry and Nutrition at Virginia Polytechnic University. He kept that position for 12 years, and then returned to teaching and research until he retired in 1998. Anderson studied the structure and function of enzymes. He published more than 150 research articles and trained 14 doctorate (six at UT) and five master's students.

Q&A with Tian Hong

Tian Hong joined the BCMB department as an assistant professor two years ago. He is a welcome addition to our growing computational biology group. Tian came to Knoxville from the University of California, Irvine where he was a postdoc with Professor Qing Nie. Although he has been in the department only a short time, he has published four papers, became a Co-PI on a funded grant, and established multiple collaborations with other faculty in BCMB.

Q: Tian, how did you become interested in your current research?
I love biology and mathematics. I started my research career as a mathematical biologist because I was amazed by the deep insights that we can obtain by describing and analyzing biological systems with mathematical tools.

There are many types of mathematical models. In my research area, scientists use equations to describe systems and analyze them to get useful information. In biology, both intuitive models and mathematical models are important, but the rigorous and quantitative nature of mathematical models is essential for understanding many complex biological systems.

One of the most influential mathematical models built for biological systems is the reaction-diffusion system that Alan Turing proposed in 1952. The models that Turing built predicted robust pattern formations arising from simple chemical reactions, and he explained the mathematical basis of such phenomena. The concept of Turing pattern became a major theory in biology, because this mechanism may hold the key to understanding a wide range of developmental processes, such as the formation of the digits in the limb.

Q: What are you working on now?
We are working on models for a variety of biological systems. The overarching theme of our research is to understand how gene regulatory networks control the dynamics of cells. We ask why certain types of network structures were selected, and what kind of performance advantages these networks can bring to specific biological systems. For example, we are interested in how epithelial cells gain motility during development and metastasis and how gene regulatory networks influence this process. We build mathematical models to analyze these systems, and these models provide critical information on how the behaviors of cells may change when we perturb gene networks in a quantitative manner. With these models, we will gain better understanding of our cells at the fundamental level, and ultimately, we will be able to use them to develop better therapeutic strategies to cure diseases.

I hope that we will uncover the functions of several network structures that occur frequently in biology but are not well understood. I hope that we will have some unifying theories that may help to understand a wide range of biological systems containing complex gene networks.

Q: If a student wants to learn mathematical modeling, what skills are necessary? What classes that student should take?
The student should have basic understanding of differential equations and nonlinear dynamical systems, which in turn require some understanding of calculus and linear algebra. They will also need some basic computer skills. This list of topics may look intimidating, but my observation is that many motivated students can learn most of these important materials in a couple of semesters.

Q: What classes do you teach?
I teach programming for biological data analysis in the fall, and molecular and cellular biology in the spring. I really enjoy teaching courses that benefit many students with very diverse career goals. Students in my programming classes include those who have decided to go to medical industry and those who are starting their academic research career. It is satisfying to see that the skills that they learn in the class will help all of them to achieve their goals.

Q: What do you like to do in your spare time?
I play flute and I like traveling. At the moment, our two-year-old son keeps us busy most of the time.

Liz Howell

It is with deep sadness we report the passing of our friend and colleague, Professor Liz Howell. Liz joined the Department of Biochemistry as an assistant professor in January 1988. Liz was internationally renowned for her work on the biophysics and mechanisms of various enzymes in the dihydrofolate reductase (DHFR) family. This enzyme plays an important role in nucleotide biosynthesis and is a notable target for several anti-cancer therapies, and Liz made several seminal contributions to our understanding of the mechanism of this fundamental enzyme. In addition to a groundbreaking, highly cited publication in Science on the structure and mechanism of chromosomal DHFR, Liz's work over the past 30 years provided fundamental information on primitive enzymes using the R67 DHFR as a model. Her more recent work moved into the use of this protein as a model to understand how molecular crowding, characteristic of the environment inside biological cellular compartments, affects enzyme behavior. As an indication of her leadership and national standing in her field, Liz earned almost continuous support for her research from extramural grants since she won her first award as a young junior faculty member at UT in 1988. These included awards from the National Science Foundation, the Petroleum Research Foundation, and the National Institutes of Health. She published more than 90 peer-reviewed papers on her work and received numerous awards for her outstanding scholarship. Her fundamental and transformative contributions to enzyme structure and function were recognized with her election as a Fellow of the American Association for the Advancement of Science in 2014.

While most faculty members eventually lose touch with day-to-day laboratory science as they move forward in their careers, Liz never compromised her passion and love for hands-on bench science and scientific discovery. She was happiest when working at the bench! Liz was an exceptional and creative teacher and mentor, devising graduate and undergraduate courses that ranged from first year graduate offerings in fundamental protein chemistry to grant writing courses stressing critical thinking and scientific writing. She also spearheaded outside the box offerings in science ethics that addressed key questions of the ethics and impact of science and innovation on society. More recently, she instituted a course in cancer biology (Oncology from the Bench to the Bedside and Beyond) at the senior undergraduate level that provided a novel format offering a comprehensive view of cancer from basic biochemistry and cell biology, to animal models for studying cancer, to clinical rounds with oncologists.

Outside the classroom and the research lab, Liz was a pioneer and role model for women in science. When she joined us in 1988, she represented the first woman faculty recruit in the 25-year history of the department. She served as a stellar role model for other women biologists and biochemists and was a strong proponent and advocate that led to the recruitment of additional women faculty, postdocs, and graduate students to the department. As our colleague Cynthia Peterson noted: "Liz was one of the main attractions in my recruitment to the University in 1992…even so, I could not have anticipated at the time of my hiring what a great influence and great colleague I would have in Liz Howell. She was a mentor and a friend who always had the right guidance at the right time."

Liz directed the research of 14 female postdoctoral, PhD, or MS students and helped to launch their careers as independent scientists. She was selfless and gave her time to those she supported generously. She was a core member of the faculty mentoring team for UT's Program for Excellence & Equity in Research (PEER) program, an NIH funded program that actively pursues the recruitment and training of women as well as students from underrepresented groups, with the goal of increasing the number of students graduating with doctoral degrees in STEM disciplines.

Liz was also a talented artist. She was renowned in the community for her work with ceramics and clay and was a member of the Terra Madre-Women in Clay group in Knoxville. Her artistic bent also permeated her science. She was particularly talented with effective use of visual imagery in science. Her research on R67 DHFR and structural symmetry was selected for display at the National Science Foundation as an example of art reflecting the beauty of science. Liz delighted in finding novel and creative approaches in the use of art to provide new ways of viewing science. Such approaches help bridge the gap between scientists and the general public, emphasizing the beauty of nature while conveying knowledge and information.

-Dan Roberts, Professor

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Department of Biochemistry & Cellular and Molecular Biology
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1311 Cumberland Avenue
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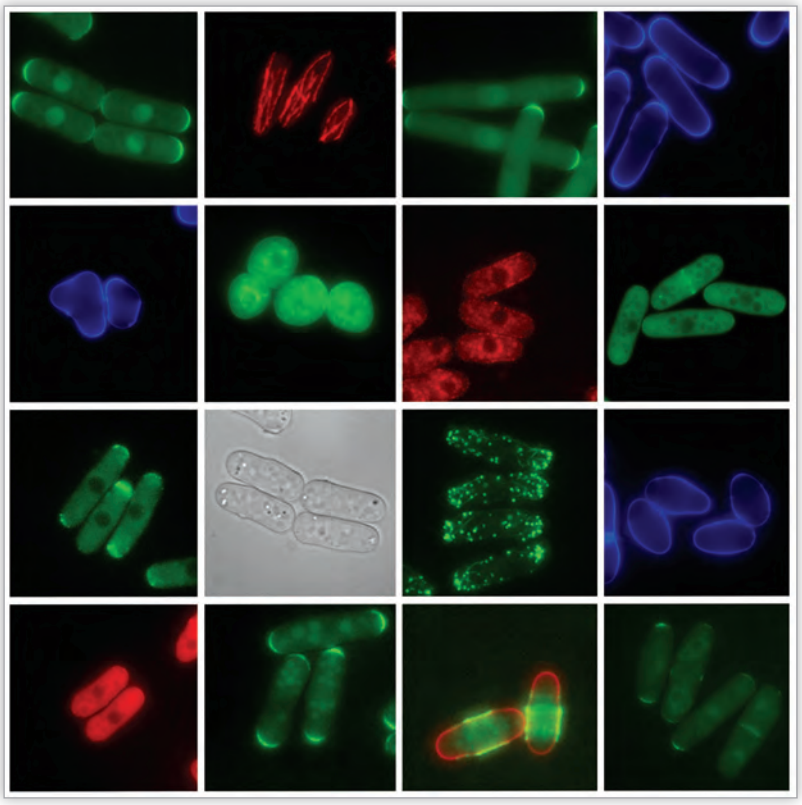

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