BIOCHEMISTRY & CELLULAR AND MOLECULAR BIOLOGY

DISCOVERIES

The Evolution of BCMB

Most of us just assume that the Department of Biochemistry & Cellular and Molecular Biology (BCMB) has been around a long time and has not changed much. But, BMCB is actually fairly young and is the result of three departments, botany, zoology, and biochemistry, merging.

The botany and zoology departments would be more than 100 years old if they were still separate departments. Lexemuel Ray Hesler (for whom Hesler Hall is named) was the first head of the botany department. Both departments were initially housed together in the old Morrill Hall which burned down in 1934. By contrast, the biochemistry department was established much later. Amidst all the political turmoil in 1963, the biochemistry department at the University of Tennessee, Knoxville, came into existence in the fall semester. Prior to 1963, the Department of Chemistry offered a single biochemistry class and the formation of a separate department for biochemistry followed a national trend for this separation. Prior to this, on some campuses there might be found similar departments called agricultural chemistry in agricultural colleges or physiological chemistry in medical schools.

The biochemistry department was founded by Ken Monty (first department head) and three faculty who came to Tennessee from Johns Hopkins University to establish a graduate training program focused on protein structure and enzymology. In the early days, the department only offered a graduate degree. Undergraduates had to be satisfied with a single lecture/lab class. This changed quickly when biochemistry got together with the three other biology departments (botany, microbiology, zoology) in 1973 to establish the Division of Biology and started offering a general biology series of core biology courses. From this, the undergraduate major developed with class instruction in these general courses followed by specialty courses junior and senior year in a student's department of choice. It was also in this time period that the biochemistry department created an electronics shop to support research. This later developed into the Biology Service Facility, which now serves all of the biology departments. Shortly after this, the Biology Business Office was created to handle ordering, receiving, bookkeeping, and financial reports.

The department officially changed its name to biochemistry & cellular and molecular biology in July 1995 when the former zoology department was dissolved. Zoology faculty who focused on cell and developmental biology and genetics joined faculty of the former biochemistry department to form the new BCMB department. It was also at this time the Department of Ecology and Evolutionary Biology was created. Over the next decade, research expertise in other areas was added to BCMB including experimental and computational structural biology and biophysics. This included the hiring of the first Governor's Chair, Jeremy Smith. A key aspect of life is that things change and this is true for BCMB too. In spring 2003, the botany department was dissolved and faculty who focused on plants as model organisms joined BCMB bolstering a strength in this area.

Things have changed dramatically since BCMB was formed. We now have a robust undergraduate curriculum with approximately 250 majors with a declared concentration in BCMB, more than 45 graduate students, and lab and classroom space in Hesler and Mossman Buildings. Class offerings are diverse ranging from structural biology to biochemistry to cell and molecular biology. This diversity is also seen in our research where we have 21 faculty. These research programs focus on answering biological questions across scales from atomic to organismal using diverse approaches including computational and mathematical modeling, biophysics, biochemistry, cell and molecular biology, and various –omics and systems-level biology methods.

*To read more news and updates, visit us online at **bcmb.utk.edu**.*

MESSAGE FROM DEPARTMENT HEAD

It is a great time to be a Vol!

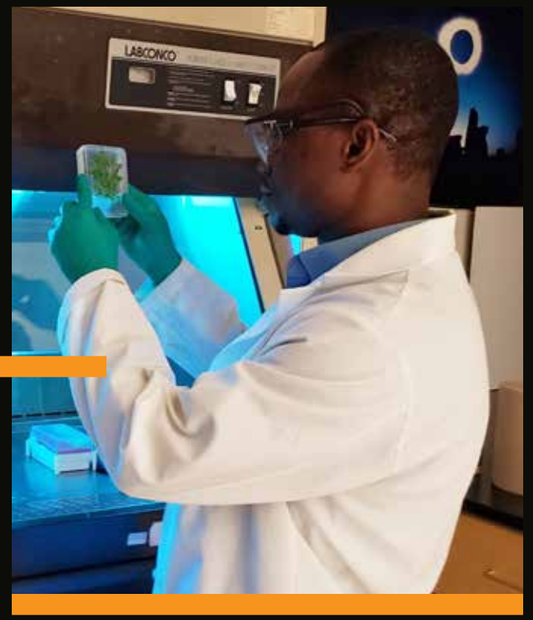
GLADYS ALEXANDRE
Professor and Department Head

As many of you probably already heard or read in the press, this past year has been a year of unprecedented sets of "records" for UT Knoxville: record breaking enrollment (both incoming freshmen students and record retention rates), fundraising, and research growth. This upward trajectory is projected to continue this year. The BCMB department has also seen parallel successes: the percent of funded faculty increased again by 11.5% in the last year. As a result, the direct research expenditure grew by 29.5% and the number of publications per faculty member also increased. This is testament of the quality of our faculty who remain committed and successful in securing federal funding to support their cutting-edge research.

BCMB remains the most sought-after undergraduate concentration in biology. The number of students declaring a major or minor in BCMB grew by an outstanding 37.3% this year. The BCMB faculty keep thinking about curriculum offerings and adjustments to make sure the education we provide is relevant and is delivered using evidence-based best practices. Our undergraduate and graduate students continue to receive accolades, several of which you will read about in this newsletter. This year has also seen Professor Bruce McKee, a former BCMB department head, retire. We saw it fitting to reflect on how far we have gone as a department and our evolution as a faculty by summarizing the history of the BCMB department. I hope you will enjoy learning or for some of you, remembering the evolution of the BCMB department as we know it today. This newsletter highlights the work of a postdoctoral fellow and a graduate student, both originally from Ghana as well as a second graduate student native of Tennessee. We also introduce you to Amit Joshi, our most recently hired faculty colleague. I hope you will appreciate reading their stories and academic interests and see how they each bring unique perspectives to support the ongoing research in the department.

I would like to thank many of you for generously supporting BCMB this year and in the past. We will continue to ensure your investment is impactful and meaningful. I will close to wish all the best. To another great year on Rocky Top, Go Vols!

A new paradigm of ethylene-mediated plant growth: feeding the world



Eric Brenya has had an interest in plants from an early age. He remembers that, "as a child, I visited my grandmom's farm, and I was curious as to how some crops showed more tolerance to diseases, pests, and heat stress while others were more prone to these stressors. Obviously, my grandmom had no scientific knowledge as to why, but she somehow knew that seeds from healthy, robust crops in the previous growing season coupled with good farming practices grew better and were more stress tolerant in the next planting season. Thus, my curiosity as to how plants response to changes in the environment was born at a very young age"

After completing his bachelors in Ghana, Brenya worked at the Cocoa Research Institute of Ghana, which is one of the finest plant research institutes in Ghana. While there, he got a scholarship to pursue a Master of Philosophy in plant science at the University of Queensland in Australia to investigate the role of G-proteins in plant immunity under the supervision of Professor Jimmy Botella.

"It's at the University of Queensland where I learnt the nitty-gritty of scientific investigation and discovered that G- protein signaling is crucial for defense against plant viruses," Brenya said.

After his masters, he won a prestigious Western Sydney University scholarship to investigate the molecular mechanisms mediating a plants response to mechanical stimulation which promotes biotic and abiotic stress tolerance. In 2020, during the COVID-19 pandemic, Brenya completed his PhD and moved from Australia to the United States to start his postdoc in the Binder lab.

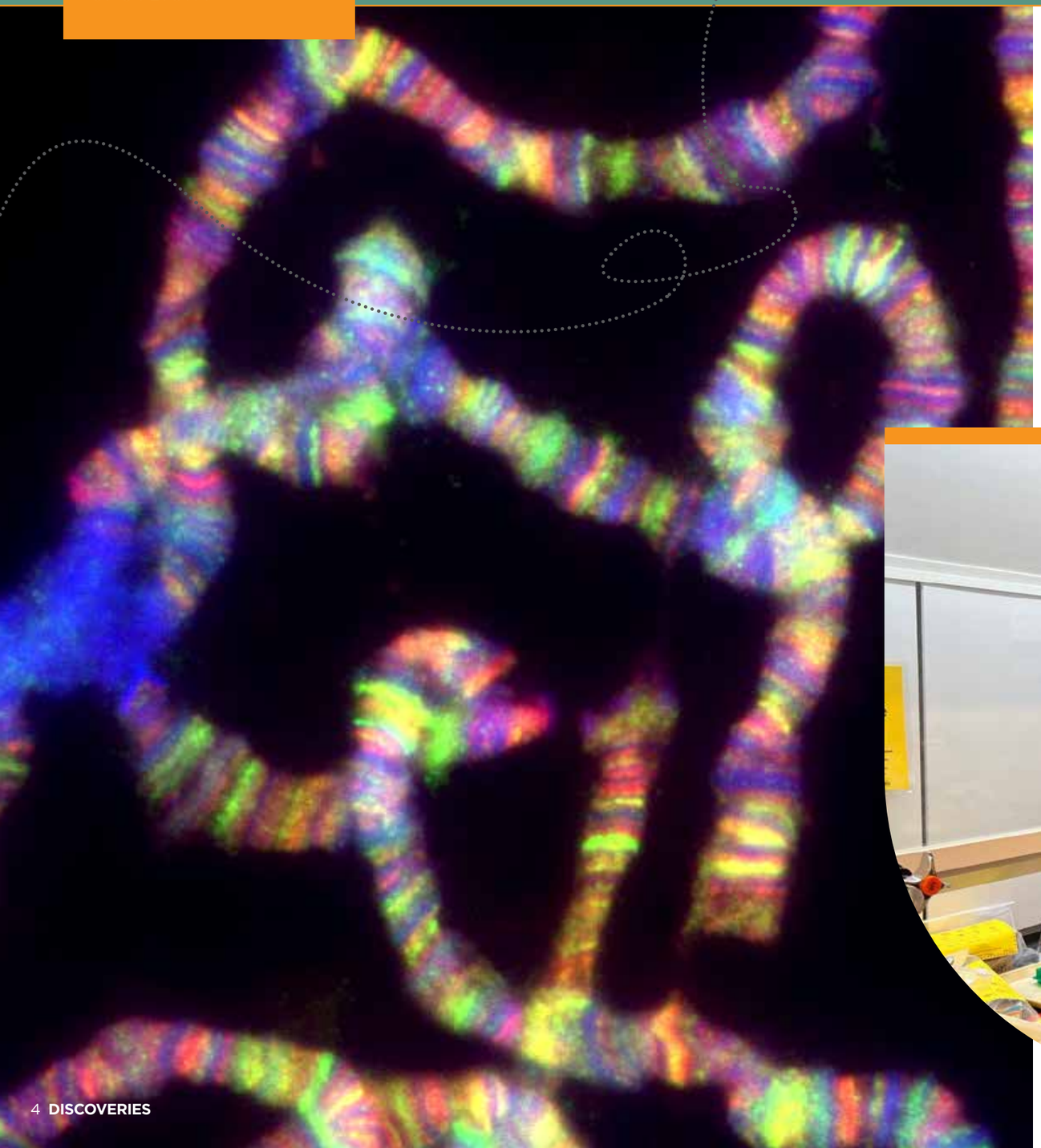
His research here is to elucidate how the plant hormone ethylene and the soil-borne bacteria *Azospirillum brasilense* mediate plant growth. He recently discovered pre-treatment of plants with ethylene primes metabolic processes resulting in enhanced plant growth and stress tolerance.

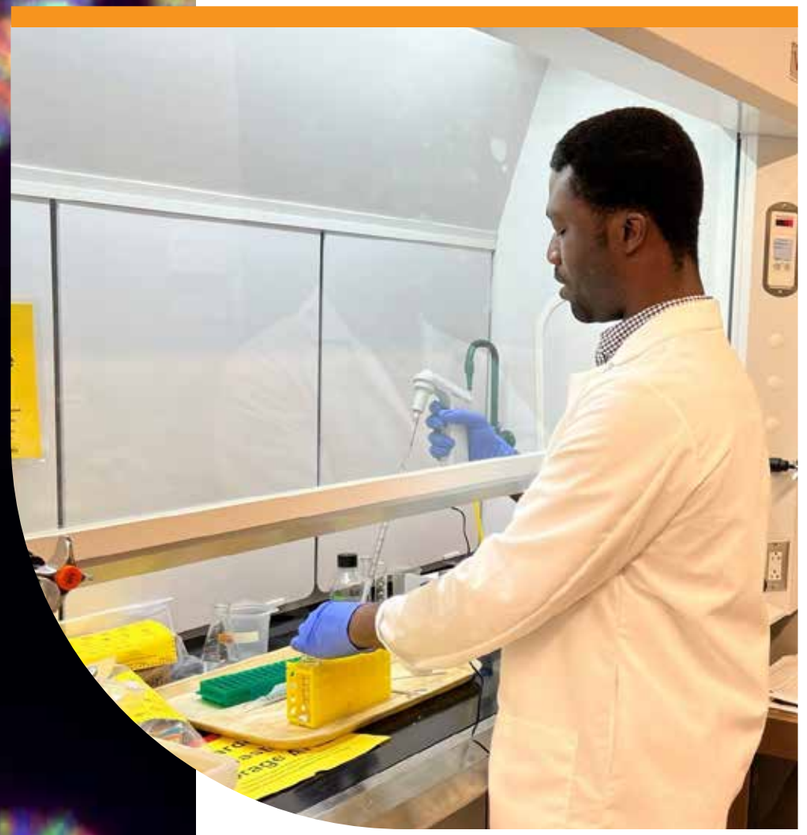
"My findings provide a simple way to increase crop yield which is under serious threat due to climate change which causes unfavorable environmental conditions that impact the quality and quantity of the global food supply. My research is very important because it has the potential of reducing food insecurity as the human population reaches 9.7 billion by 2050."

"My research experience here has been exciting since I have had the opportunity to be more independent, a critical thinker, and ask the appropriate questions that need to be addressed. These are important to being a successful scientist. The department has diverse researchers studying plants which creates a good working environment to collaborate and explore avenues which I might not have enough experience with, and it's been exciting working here."

GRADUATE STUDENT
SPOTLIGHT

Cutting Edge Fruit Fly Research





Bright Amankwaa credits his brother for inspiring his interest in science and education.

"I grew up in the eastern part of Ghana and I remember seeing my brother, Lawrence, regularly engrossed in books while he was pursuing a PhD in biochemistry. I always drew inspiration from him, and it is through his guidance I gained entry into the graduate school at the University of Tennessee."

Before joining the BCMB department, Amankwaa worked as a medical laboratory scientist.

"I have a strong interest in understanding the molecular basis of genetic diseases after getting to know I carried the hemoglobin C trait. Hemoglobin C is one of the structural hemoglobin variants that lead to benign hemoglobinopathy. Against this backdrop, I studied medical laboratory science and chemical pathology for my first and second degrees respectively during which I investigated the genetics and biochemical basis of cardiometabolic diseases. From there, I worked with Synlab Ghana Limited in the hematology, microbiology, and clinical chemistry departments before joining the BCMB program."

The BCMB program aligned with Amankwaa's interest in gaining a basic understanding of molecular biology.

"I sought advice from mentors and friends and their insights about the BCMB department dovetailed with everything I wanted in a PhD program: diverse faculty who are carrying out cutting-edge genetics and molecular biology research and close ties with the internationally recognized Oak Ridge National Laboratory which provides prospects for collaborations."

Amankwaa enrolled in the BCMB program in fall 2018 and after three rotations, he joined the Labrador lab, which studies how chromosome structure impacts cellular functions including gene expression and DNA damage.

> "The BCMB department provides an opportunity for rotations in at least three different laboratories. I relished the experience of learning different levels of gene regulation in each of these labs with molecular biology toolkits. I was particularly fascinated by the Labrador lab's focus on how chromatin organization modulates the eukaryotic genome function."

"In the Labrador lab, we use the fruit fly, *Drosophila melanogaster*, and human cell culture as model systems to investigate how specific genetic elements, called insulators, are recognized by their cognate proteins (architecture proteins) to change the eukaryote chromosome structure. Chromatin insulators are significant in gene functions and defects are implicated in several diseases including Beckwith-Wiedemann syndrome, Wilms' Tumor, and T cell acute lymphoblastic leukemias."

Outside of science, Amankwaa likes to listen to poetry and watch movies on Greek and African mythologies. He loves to write stories on the same topics and try to relate the flaws of characters like the gods to modern-day happenings in religion and politics.

"I see mythologies as imaginative fantasies from which civilizations are not especially far removed. I hope to someday get some of my stories adapted into movies."

Plant Development is Complex and Interesting

Alex Overholt became interested in biology, especially plant biology from an early age.

"My parents and grandparents exposed me to science throughout my entire childhood. I got to go on a national geographic dinosaur dig in Utah and travel across Costa Rica thanks to my grandparents, and I always had a love for the complexity and diversity of the nature around me. When I was in high school, my grandfather (who is a gastroenterologist) gave me the opportunity to help at his office and conduct research on photodynamic therapy for the treatment of Barrett's Esophagus. Even though I originally joined BCMB with the intent of following in my grandfather's footsteps, the medical field was not for me. I also spent a bunch of time in the woods (I hiked 500 miles of Appalachian Trail alone) and worked as a landscaper for two years, and I always loved plants and flowers. This is why I decided to pursue plant biology instead of medicine."

Overholt is from Knoxville and was an undergraduate at UT Knoxville who carried out his undergraduate research in the Shpak lab. He started off simply washing dishes and plating seeds, but eventually he began to carry out more complex tasks like GUS staining of EPFL reporters in the meristem followed by sectioning, RT-PCR, and confocal microscopy experiments.

> "My experience with BCMB at UT Knoxville as an undergraduate was great, and this convinced me that this would be a good place to continue my education."

Overholt joined the BCMB graduate program in fall 2018 and joined the Shpak lab after several rotations.

"When I chose to join the Shpak lab as an undergraduate, I had a year left before I was set to graduate, and my advisor said I needed to get involved with research if I wanted to go to graduate school. I looked through the topics of the plant research professors and chose Shpak's lab because of her heavy focus on plant development. At the time I didn't really understand the research topic, but I was interested in the stomata development pathway on her information page. I quickly became very interested in the EPFL genes while working with former grad student, Pawel Kosentka. I was so interested that I was determined to go to graduate school studying these genes with the hope of identifying a novel downstream target of the less studied EPFL genes. Even though my research of ovule initiation in Arabidopsis is narrowly focused, the possibility of learning more about the function of ERf signaling could affect our understanding of these processes in a large proportion of plants."

Regarding joining BCMB, he says "I think the BCMB program has a great set of knowledgeable and motivated professors that lead the program. The educational experience is extremely valuable and fully prepares one to enter the fields of BCMB. The research professors also study a diverse set of research topics, and this gives incoming students many options when deciding what area to pursue for their career."

When not working in the lab, Overholt takes advantage of the many outdoor recreational activities near Knoxville such as hiking, identifying mushrooms, and fly fishing as well as continuing a lifelong interest in writing music and playing guitar.

Award Winning Undergraduate

Hannah Lee is a senior who carried out research in the lab of Keerthi Krishnan. This past year she was awarded a prestigious Goldwater Scholarship.

"I will be using the scholarship money to help pay for a postgraduate education. Right now, I am still considering two different career paths: a PhD in neurobiology or a MD/PhD in neurodevelopmental disorders. With a PhD, I would research disorders that involve neuroplasticity using animal models, data visualization, and principles of graphic design. If I decide to pursue a MD/PhD, I would study the individualization of medicine and therapy with neurodevelopmental and learning disorders. Either way, I want to delve deeper into the world of neurobiology, and it is thanks to the Goldwater Foundation that I can pursue my dream career."

Amit Joshi began his interest in the formation and function of organelles during his doctorate at Wayne State University that continued through his postdocs. Joshi's doctoral research focused on understanding the role of cardiolipin, a mitochondria specific phospholipid, on the function of mitochondria.

"I got interested in this research because I was fascinated by this special phospholipid that could affect the function of the mitochondria, commonly known as the 'powerhouse of the cell'. I was immediately attracted by these dynamic and fascinating organelles."

Following this, he did his post-doctoral training in the Prinz lab at National Institutes of Health in Bethesda and the Cohen lab at University of North Carolina in Chapel Hill. During this time he discovered a novel family of proteins that generate localized membrane curvature responsible for formation of new organelles such as peroxisomes and lipid droplets. His lab in BCMB continues this research.

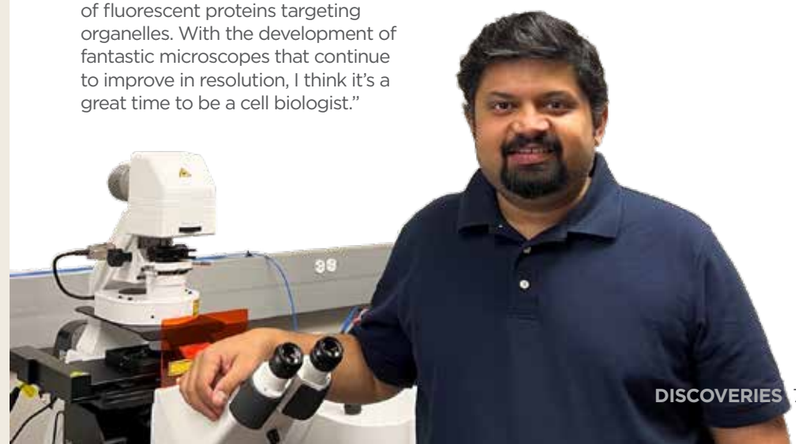
"My lab is interested in investigating molecular mechanisms of peroxisome and lipid droplet biogenesis at specialized sites in the endoplasmic reticulum membrane. Both of these organelles play crucial roles in cellular function because they are required for lipid homeostasis," Joshi said. "As a cell biologist, my approach towards science is, 'see it to believe it'. To do that, we use a high-resolution confocal microscope that allows us to see finer details at higher magnification inside of a living cell, which are stained with a variety of fluorescent proteins targeting organelles. With the development of fantastic microscopes that continue to improve in resolution, I think it's a great time to be a cell biologist."

Students in his lab utilize a combination of genetic, biochemical, and cell biological techniques to answer fundamental biology questions.

> "It is always great when students admire the dynamic cell structures live in action using high-resolution microscopy for the first time."

Joshi's research has medical implications since defects in the formation and function of these organelles leads to neurodegenerative diseases such as Zellweger syndrome, and metabolic disorders such as lipodystrophy, obesity and diabetes. A major goal of his research is to uncover the protein complexes and membrane lipids that might be required specifically for formation of peroxisomes and lipid droplets from the ER membrane and financial support for this was recently received as a NIH MIRA award.

Joshi joined BCMB in January 2021 and teaches BCMB 311: Advanced Cell Biology and BCMB 607: Journal Club in Cell and Molecular Biology. He also co-taught a BCMB 615 seminar series focused on cell architecture as a theme where students had a terrific opportunity to discuss the research with the leading experts in the field of cell biology. In his spare time he loves watching movies, traveling, and photography.



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COVER STORY:

Learn about the the history and evolution of the Department of Biochemistry & Cellular and Molecular Biology.

DISCOVERIES

The DISCOVERIES newsletter is published annually by the UT Department of Biochemistry & Cellular and Molecular Biology.
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