Evolutionary Genomics Research Kindles MD/PhD Plans for Vanderbilt University Undergrad

Vanderbilt University student Charu Balamurugan was raised in a family that not only supported intellectual curiosity, but prioritized it, and it was this culture combined with an awareness of the benefits derived from being supported and given opportunities that motivated her science interests and academic engagement. Balamurugan is the daughter of Indian immigrants. Her parents moved to Southern California to pursue better employment and education, and her father became a researcher at UCLA. Observing this during adolescence imbued Balamurugan with strength and tenacity that she channeled into her learning, participating in science fairs, accelerated math, and research internships – all prior to her time at Vanderbilt University.

Those experiences proved foundational to her undergraduate research career when she began studying with Professor Antonis Rokas and applied to be a Beckman Scholar. The Arnold and Mabel Beckman Foundation's Beckman Scholars Program (BSP) at Vanderbilt University provides funding for 15-month mentored research experiences to exceptional undergraduate students in chemistry, life sciences, and interdisciplinary combinations thereof.

"Doing research at the Rokas Lab since my freshman year at Vanderbilt provided me access to wonderful mentorship experiences, enriching projects, and an array of both support and autonomy in the process of undergraduate research. Consequently, I was

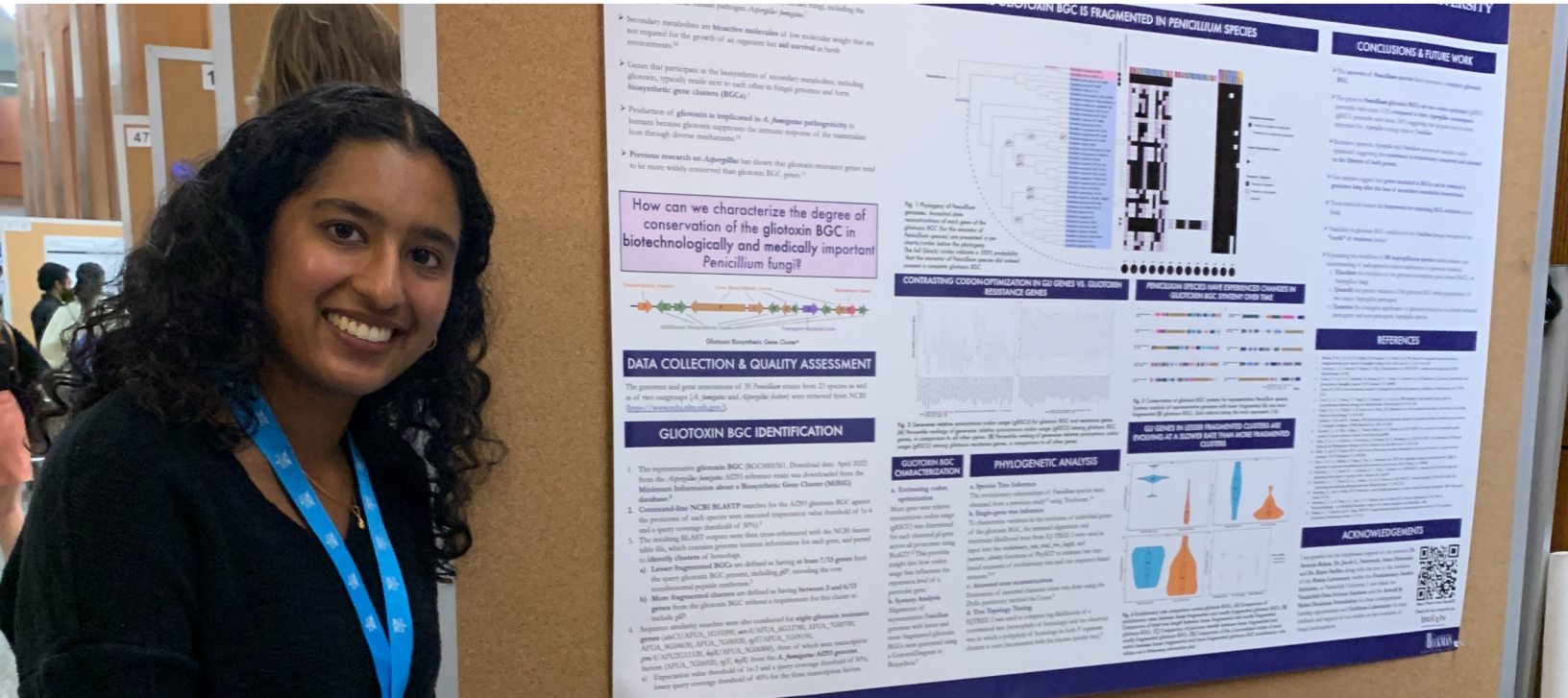
Above: 2023 Beckman Scholar Charu Balamurugan at Vanderbilt University. Photo credit: Anne Rayner

motivated to gain access to a wide array of students equally passionate about science. Moreover, being able to continue pursuing my research in a way that could be interdisciplinary and meaningful, and also through the lens of humility within the Beckman Scholars Program, was extremely appealing to me," shared Balamurugan. "Most importantly, I thought that the community of scholars and programming that facilitated collaboration and career exploration would be extremely enriching. Doing research as an undergraduate student can require a great deal of perseverance and grit at times, so seeing and learning from a multitude of students and faculty with amazing amounts of drive and passion for their respective fields has been a wonderful experience thus far."

As an undergrad, Balamurugan approached research with openness and a willingness to learn, but felt she needed to hone her abilities for an environment that was still relatively new to her. The mentored aspect of the BSP experience offered guidance toward that goal, teaching about methods, modifications, design, investigation, computational functions, research careers, and even perseverance. Balamurugan expressed gratitude for her time with Dr. Antonis Rokas and members of the Rokas lab (Dr. Jacob Steenwyk, Dr. Karin Steffen), crediting it with helping to build her skillset and expand her knowledge while working on her Beckman-funded research project.

"The Rokas Lab studies the DNA record to gain insight into the patterns and processes of evolution. My project within the Rokas Lab specifically focuses on the study of gliotoxin, a secondary metabolite produced by certain species of fungi. Something that is especially conducive to my research is the fact that the genes that are used to produce these secondary metabolites often reside next to each other on fungal genomes to produce biosynthetic gene clusters (BGCs)," explained Balamurugan. "Although a great deal is known about the function of gliotoxin in its ability to suppress the host immune response during infection, being produced by highly pathogenic species of fungi such as *Aspergillus fumigatus*, gliotoxin is also produced by closely-related non-pathogenic species, as well. This aligns with the cards of virulence theory in that a specific combination of secondary metabolites, or cards, contributes to pathogenicity. Although we know a substantial amount about the identity of the cards, we do not know much about how the cards are dealt. In other words, we do not know how certain species of fungi have evolved to obtain a special combination of secondary metabolites that aids in fungal pathogenicity. More specifically, I use genomic methods to explore evolutionary relationships

Below: 2023 Beckman Scholar Charu Balamurugan stands next to a poster presentation of her Beckman-funded research. Photo credit: Southeastern Medical Scientist Symposium



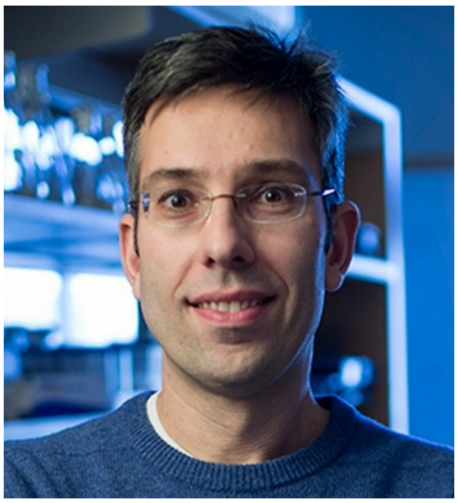
between genes of the gliotoxin biosynthetic gene cluster in *Aspergillus* and *Penicillium* fungi within the larger family *Aspergillaceae*, which contains a mix of pathogenic and non-pathogenic fungi."

Upon considering the impact of her research, Balamurugan noted that it contributes to a framework for exploring biosynthetic gene cluster evolution in fungi and said that overall, it promotes the understanding that genes that are part of BGCs can be retained in genomes long after the loss of secondary metabolite biosynthesis. To further clarify those points, she drew attention to the specifics: Whereas earlier parts of Balamurugan's project focused on *Penicillium* species generally not considered pathogenic and mostly not producers of gliotoxin, her research found fragmented gliotoxin BGCs among a dataset of biotechnologically and medically important *Penicillium* species. That, she explained, furthers understanding of how the tools of virulence are evolutionarily related among many important fungal species.

"By contributing to our understanding of secondary metabolites like gliotoxin," expounded Balamurugan, "we can enhance our ability to potentially even predict pathogenicity among various species of fungi using genomic information. This has clinical implications, enabling us to even more effectively treat fungal infections in humans in the future!"

Well on her way toward that promising future, she plans to continue her work and delve deeper still into evolutionary genomics research at the Rokas lab and ultimately fulfill an honors thesis in Biological Sciences during her final year at Vanderbilt University.

"I plan on enhancing my skill set within this research towards pursuing an MD-PhD in the future with the goal of becoming a physician scientist," said Balamurugan. "I am extremely grateful for the Beckman Scholars Program in providing me with the opportunity to nurture my scientific experiences and grow my confidence to pursue a research-oriented career in the future!" ■



Above: BSP Mentor Dr. Antonis Rokas, Professor of Biological Sciences and Biomedical Informatics, Cornelius Vanderbilt Chair in Biological Sciences at Vanderbilt University. Photo credit: The Rokas Lab website, https://as.vanderbilt.edu/rokaslab/people/

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"My experience as a Beckman Scholar has been life-changing. By supporting me in my research with my wonderful mentor(s) at the Rokas Lab, Dr. Antonis Rokas, Dr. Jacob Steenwyk, and Dr. Karin Steffen, the program has allowed me to solidify my interest in pursuing a research career in the future. And for that, I am so grateful!"

Charu Balamurugan