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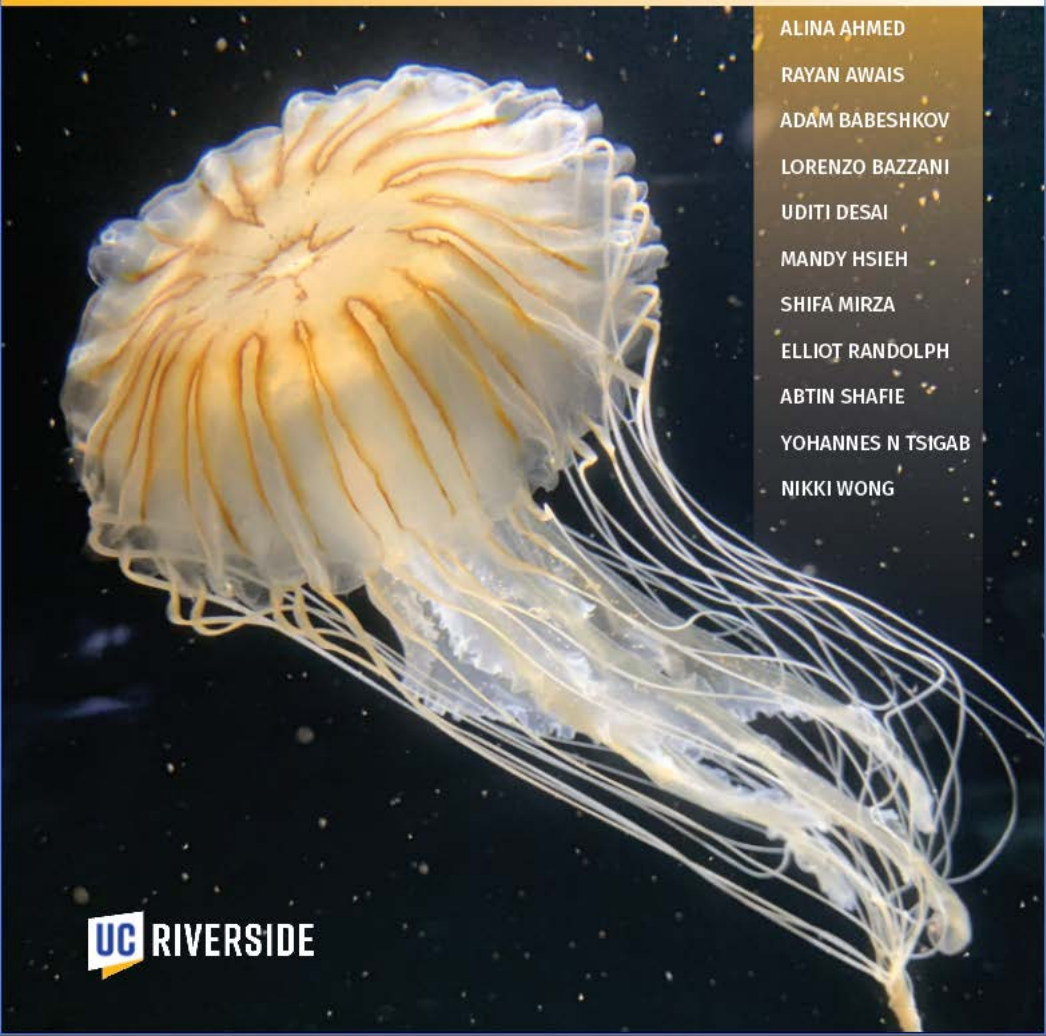
UNIVERSITY OF CALIFORNIA, RIVERSIDE

UNDERGRADUATE RESEARCH JOURNAL



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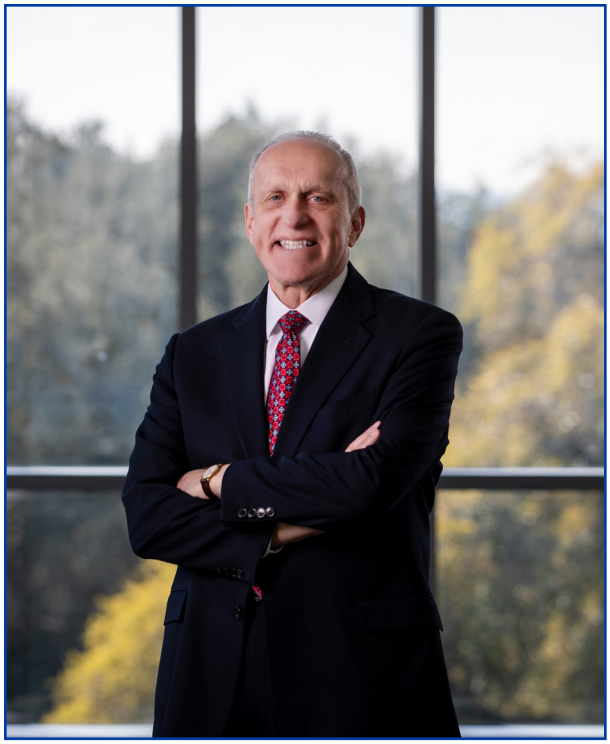
FROM THE CHANCELLOR



As a research university, one of UC Riverside's most important duties is the creation of knowledge. Creating an environment and structure that fosters innovation to solve our community and world's greatest challenges is in our university DNA.

With faculty-mentored research projects across a breadth of disciplines, UCR provides a wealth of opportunities for students to investigate complex questions while building research skills. Each year, I am excited to see how students have embraced this part of their education while further developing their own scholarly interests.

In this 18h volume of the UC Riverside Undergraduate Research Journal, our students are making the most of these opportunities and accomplishing truly inspiring work. From knee health to procrastination, haptic search to food insecurity, this edition of the Journal covers significant scientific ground while showing research excellence and creative endeavors of the highest order. Yet, the Journal has something more to offer than discovery. It seems that hope for a future led by these bold and brilliant minds is the true gift within these pages.

I congratulate all the students who contributed to this edition of the Journal, and I express my sincere gratitude to the faculty mentors and staff members that supported these students in their scholarly endeavors.

Sincerely,

Kim A. Wilcox
Chancellor

FROM THE VICE PROVOST AND DEAN

Whether a student is interested in the humanities, arts, social sciences, policy issues, education, business, agricultural, or the natural sciences, students bring a commitment to rigor, relevance, and knowledge-creation to the creative and research endeavor—commitments that are captured by the articles within this journal. Such work is only possible when students are surrounded by a community of peers and faculty mentors who are dedicated to the pursuit of knowledge—institutional characteristics that are no doubt present and thriving at UC Riverside.

Undergraduate student research is the beginning of a journey driven by student curiosity about a topic and their commitment to exploring it further. When embarking on a new topic, researchers, and emerging researchers, are often inspired to ask and develop well-formulated questions; explore the work that has already been done in the topic area; identify a set of methods that coincides with the research question(s); and work diligently to create, generate, or collect data to help answer the question(s). In the university context, students are often driven toward a topic that sparks their interests, passions, and commitments to a discipline, community, or problem they are trying to address in the world.

The student-authors in this issue of the Journal demonstrate the benefits of living, learning, and engaging in research at a research-intensive university. In fact, to be surrounded by scholars who engage in cutting-edge research and scholarship is one of the greatest benefits of being at a university like UC Riverside. The student-authors in this journal have taken full advantage of the opportunities in front of them and should be applauded for sharing their work with the world of research, which extends far beyond UC Riverside.

I congratulate all of the student-authors and faculty mentors who made this research possible, and I look forward to seeing their future contributions.

Sincerely,

Louie F. Rodriguez
Vice Provost and Dean, Division of Undergraduate Education
Professor of Education
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It is with great pleasure that we present UC Riverside's 18th edition of the *Undergraduate Research Journal*. The *Journal* encapsulates the 4 pillars of UCR's Tartan Soul: Excellence, Respect, Integrity, and Accountability. We are excited to publish the cumulative efforts of our students' brilliance, persistence, and patience. This issue of the *Journal* represents the continuous hard work and dedication of the Student Editorial Board and the Faculty Advisory Board. We thank the authors for their commitment to ensuring the endless possibilities of the future in research. Your achievements, found in this edition, will forever be a part of the *Journal*'s legacy. We also thank our Student Editorial Board and Faculty Advisory Board—your diligence and dedication to the publication process have ensured the quality and success of the 18th edition of the *Journal*. We are grateful to have been part of the outstanding team that made this edition possible.

Sincerely,
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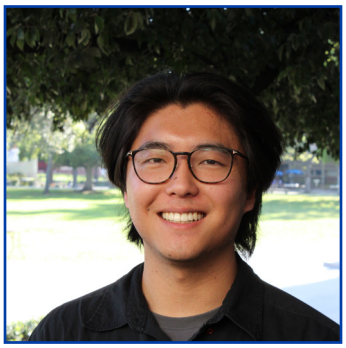

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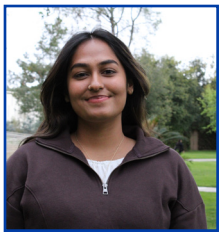

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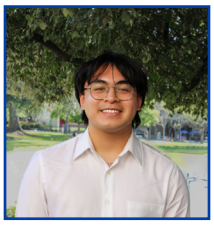

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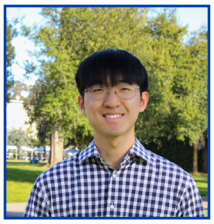

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Since UCR's Undergraduate Research Journal started 18 years ago, it has published over 175 scholarly articles across many fields. These papers represent the commitment of our undergraduate students to performing independent research as part of their undergraduate experience. Because undergraduate research can often form part of a larger work with many contributors, the importance of undergraduate students' contribution can sometimes be lost. With the Undergraduate Research Journal, students can publish their work as first authors before the end of the academic year through a peer-review publication process. The paper becomes a part of students' professional experience, contributing to their record of scholarly achievement. The Journal's submission and review process is run by undergraduates who form the Student Editorial Board, working with members of the Faculty Advisory Board. We owe a debt of gratitude to these students for their professionalism and dedication to the review and preparation of the articles in this issue. We are also grateful for the participation of the members of the Faculty Advisory Board in guiding the reviewers. I would like to thank Jennifer Kavetsky for her work in supporting and guiding the process, Gladis Herrera-Berkowitz and the CUREL team, as well as Undergraduate Education for their funding support. If you are interested in publishing your undergraduate research at UCR, consider submitting to our next issue!

Prof. Morris F. Maduro
Professor of Biology
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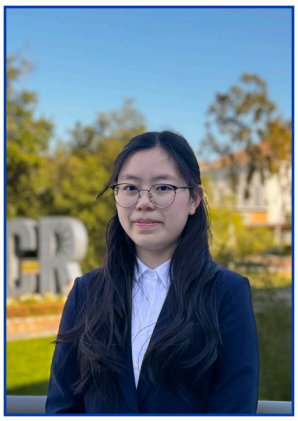

MANDY HSIEH

Mandy Hsieh is a third-year Bioengineering major with a minor in Data Science. She is involved in research as a member of the Biotransport and Bioreaction Kinetics (B2K) Group under Dr. Victor G. J. Rodgers. Additionally, she contributes to the chemical synthesis and bioprinting team led by Dr. Iman Noshadi in the Innovative Biomaterials Laboratory, where she received a mini-grant award. Mandy also leads the Power Team in AIChE's ChemE Car Competition and is passionate about pharmaceuticals, regenerative medicine, tissue engineering, and biophysics. In her free time, she enjoys sightseeing, drawing, and photography.

This is a Japanese Sea Nettle, taken at the Aquarium of the Pacific. Despite their delicate appearance, jellyfish symbolize fluidity, adaptability, grace, and resilience through their capability of navigation in uncertain situations. Their tranquil movements serve as a reminder to embrace change, to have faith in our abilities, and to be resilient in the ever-changing tides of life.