

UC Riverside

UC Riverside Undergraduate Research Journal

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UNIVERSITY OF CALIFORNIA, RIVERSIDE

UNDERGRADUATE RESEARCH JOURNAL

TABLE OF CONTENTS

Dissecting Human and Influenza Virus Interaction with qFRET Technology Chuchu Liu	9
Has Anybody Asked How People Change Their Minds? Pre-crastination and Its Underlying Basis in Decision-Making Disha Patel & Thuresa Veliz	19
Evaluating Poly(anhydride-ester) Encapsulation Characteristics for Delivery of Hydrophobic Small Molecules Kaitlyn Ngo	31
Transborder Realities: Its Effect on Bordertown Students Pursuing a Higher Education Karla Hernandez	39
Effects of Parenthood on Neural Responses to Pup-Related Cues Kelsey Rosales-Torres	53
Sexualizing Señoritas: Portrayals of Mexican Women during World War I Rossandra Martinez.....	65
Evaluating Imatinib's Affinities and Specificities for Tyrosine Kinases Using Molecular Dynamics Simulations William Troxel.....	75

FROM THE ADMINISTRATION



As a research university, one of UC Riverside's most important duties is the creation of knowledge. Undergraduate research is a hallmark of UCR's scholarly and educational missions and a factor in our university's impressive trajectory. With faculty-mentored research projects across a breadth of disciplines, UCR provides a wealth of opportunities for students to investigate complex questions and discover the joys of scholarly research.

As you will see in this 16th volume of the UC Riverside Undergraduate Research Journal, our students are making the most of these opportunities and accomplishing truly inspiring work. The scholarship that appears each year in this publication represents research excellence and creative endeavors of the highest order. UCR is at the forefront of discovery, with a world-class faculty, including two Nobel laureates, and state-of-the-art instructional and

testing laboratories. UCR is creating a home for students, faculty, and community members to collaborate, test, and learn.

At UCR we are stewards of transformation; it is in our DNA to ensure that we create an environment and structure that fosters innovation to solve our community and the world's greatest challenges. I am impressed by the dedication and innovation displayed by the students and their mentors in pushing forward in research despite the challenges faced by the pandemic.

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,

A handwritten signature in blue ink, appearing to read "Kim A. Wilcox".

Kim A. Wilcox
Chancellor



Research is a crucial component of all disciplines—from the arts to the sciences, business to engineering, philosophy to biology. Each field undertakes research in its own way, but they are united by their curiosity and desire to advance knowledge. This year's scholars conducted their research during a time of significant transition as the university returned to primarily in-person learning and research activities. The articles in these pages reflect the wide range of research and creative activities undertaken by our students—from a study of students' experiences in the US-Mexico transborder community to the biomedical applications of biodegradable salicylic acid-based compounds.

A common image of a researcher is of a figure in isolation; however, the actual practice of research is a collaborative effort. Faculty mentors encourage students to follow their curiosity, guide them in crafting important questions, and help them to develop the courage to seek answers. As a team, they advance knowledge in their

disciplines and open the door to further inquiry. The Undergraduate Research Journal provides students a platform to share their research and an opportunity to continue their development as researchers.

During my time at UCR, I have watched the Undergraduate Research Journal grow from its first issue in 2006. Throughout, it has featured some of our university's best faculty-mentored undergraduate research and scholarship. The Sixteenth Edition continues to add to the university's 68-year legacy and reflects the breadth of undergraduate research at UCR. I want to thank the faculty mentors for supporting and encouraging our undergraduates, the Student Editorial Board for leading the peer-review process, the Faculty Advisory Board for its consultation and advice, and the staff of Student Engagement for their roles in producing this edition.

Sincerely,

A handwritten signature in blue ink, appearing to read "Ken Baerenklau".

Ken Baerenklau, Ph.D.
Associate Provost and Chief of Staff
Interim Vice Provost and Dean of Undergraduate Education

UNDERGRADUATE RESEARCH JOURNAL EDITORIAL BOARD



Shayan Saeed
Editor-in-Chief
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It is with great pleasure that we present UC Riverside's 16th edition of the Undergraduate Research Journal. We have had the honor of collaborating with brilliant minds across campus in bringing this publication to fruition during such an unpredictable year. It is the collective efforts of everyone involved that ensures the integrity and standards of the Journal reflect the excellence that UCR represents. Congratulations to the authors for your commitment — your ability to adapt to a constantly evolving environment, one that is not conducive to traditional undergraduate research, is commendable and serves as a testament to UCR's academic and creative culture built upon the pursuit of knowledge. Your achievements found in this 16th edition will forever be a part of the Journal's legacy. Congratulations to the Student Editorial Board and Faculty Advisory Board — your diligence and dedication to the publication process have ensured the quality and success of the Journal. We are remarkably grateful to have been part of the outstanding team that made this edition possible. Sincerely,

Shayan Saeed & Preeti Sivakumar, Co-Editors-In-Chief



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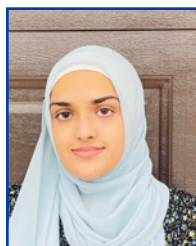
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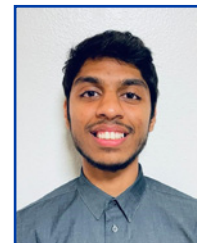
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Since UCR's *Undergraduate Research Journal* started 16 years ago, it has published over 160 scholarly articles across many fields. These papers represent the commitment of our undergraduate students to performing independent research as part of their undergraduate experience. Because undergraduate research can often form part of a larger work with many contributors, the importance of the student's contribution can sometimes be lost. With

a part of a student's 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 the students for their professionalism and dedication for 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 Gladis Herrera-Berkowitz for her work in supporting and guiding the process every year, Lisa Des Jardins for providing Graphic Design assistance, 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
Chair of the Undergraduate Research Journal
Faculty Advisory Board
Professor of Biology

the *Undergraduate Research Journal*, students can publish their work as first authors before the end of the academic year through a peer-review and publication process. The paper becomes

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ABOUT THE COVER



Joshua Wang

Joshua Wang is a 4th year Neuroscience major and University Honors student. For the past three years, he has been involved in prostate cancer research under the guidance of Dr. Manuela Martins-Green. In 2021/2022 he served as a Chancellor's Research Fellow and the President of the Medical Emergency Education Project at UCR. In his free time, Joshua enjoys photography and rock climbing.

TIDES

Taken in La Jolla, San Diego. The tides can represent a lot to different people. To some, it represents persistence - with time even indestructible rocks crumble. To others, it represents change - high some days and low some nights. I find that the tides are similar to our experience in research, with every changing day giving us something new --- until finally, a new discovery washes ashore.