

# University of California, Riverside

## Undergraduate Research Journal

### Table of Contents

A Subset of Brain Neurons Controls a Sexually Dimorphic Proboscis Holding Behavior in Adult <i>Drosophila Melanogaster</i> Sameera Ahmad and Kush Amin . . . . .	7
The Vagrancy of Race Suicide Through the Early Twentieth Century: Reimagining Fear Debbie Arce . . . . .	13
Psychoanalytic Feminism and the Depiction of Women in Surrealist Photography Katherine Bottinelli . . . . .	21
Personality and GPA: The Predictive Roles of Academic Identity and College-Going Culture Alysia Burbidge . . . . .	29
Building a Sense of Self: The Link Between Emotion Regulation and Self-Esteem in Young Adults Tiffany Gomez . . . . .	37
Parent Psychopathology and Parent-Child Conflict Interact to Predict Children's Anxiety but Not Depression Valerie Gomez . . . . .	43
White Matter Integrity and Subclinical Depression: A Diffusion Tensor Imaging Study Nicole Huffman . . . . .	51
Does Parenting Moderate the Relation Between Stress and Children's Emotion Regulation? Karina Lopez-Villegas . . . . .	59
The Neurotoxin Effects of Cycads and Metals: A Review Brendan Mitchell . . . . .	65
Does Napping Boost Benefits of Brain-Training for Working Memory? Rainita Narender and Dakota Salazar . . . . .	75
The Differences in STEM Feeling and Interest Between Boys and Girls Brandon Ngo . . . . .	83
Determination of Immune Signal-Receptors, PD-1 and PD-L1, Interactions in Solution using qFRET Technology Mary Nwangwu . . . . .	89
The Queer Confessional: Foregrounding the Discordant Poetics of Henri Cole Through the Troubling of Genre Jan Leonard Maramot Rodil . . . . .	97
Protocol for Mice Behavioral Analysis in Response to Predator Cues Sunaina Santhiveeran . . . . .	103
Identification of Targetable Surfaces of Cks1 for Development of New Cancer Therapeutics Nolan Winicki . . . . .	111

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## From the Administration



As a research university, one of UC Riverside's most important duties is the creation of knowledge. From exploring the inner workings of the mind to examining the cultural impacts of science fiction literature, UCR is at the forefront of discovery. The *UC Riverside Undergraduate Research Journal*, now in its 12th volume, epitomizes UCR's commitment to ensuring that students at all levels are a part of this effort.

Undergraduate research is a hallmark of UCR's scholarly and educational missions. 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 joy of scholarly research. As you will see in this 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. I congratulate all the students who contributed to this edition of the Journal, and I express my sincere gratitude to the faculty mentors that supported these students in their research journeys.

I hope you enjoy this edition of the *UCR Undergraduate Research Journal*.



Kim W. Wilcox  
Chancellor



Innovation, Creativity, and Scholarship; these ideals, which are the hallmarks of any institution of higher education, are readily expressed in a variety of ways at UCR. Since 2007, this campus has proudly supported the publication of the *UCR Undergraduate Research Journal*, a rigorously reviewed volume, that publishes the highest quality examples original work by our students. Since research is seldom an individual effort, I personally thank those who have mentored the contributors to this volume including faculty members, graduate students, postdoctoral fellows, undergraduate peers, and staff who have passionately supported these students through this journey. I am especially grateful to the contributors themselves who have committed themselves to the high standards that original research demands and have disseminated their work in this journal. It is my hope that these

experiences will not only encourage you to continue as a lifelong explorer but that your work will ignite a spark in future generations of students at UCR.

A critical component to producing any quality research journal is the substantial effort that goes into the peer review process. In this regard, I would like to thank the Student Editorial Board, the Faculty Advisory Board, and especially Gladis Herrera-Berkowitz for their critical and professional efforts in producing this outstanding volume that serves as a testament to the highest standards of excellence.

Sincerely,



Richard A. Cardullo, Ph.D.  
Interim Vice Provost, Undergraduate Education  
Howard H Hays Jr. Chair, University Honors  
Professor of Biology

# UCR Undergraduate Research Journal

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*It is with great pleasure to present UC Riverside's Twelfth Edition of the Undergraduate Research Journal. It has been a truly rewarding experience to work with dedicated individuals, all of whom have contributed to the success and advancement of undergraduate research and legacy of the Journal itself. Congratulations to all the authors for your excellence – your achievements are a hallmark to UCR's academic and creative culture, built upon the pursuit of knowledge. Congratulations also to the Student Editorial Board and Faculty Advisory Board – your dedication and diligence to the publication process have assured the quality and success of the Journal. I am extremely grateful to have been a part of this team of talented individuals and to have contributed to the journey that is the Undergraduate Research Journal.*

**Kollan Doan — Editor-In-Chief**



**Back** (left to right) – Daniel Choi, Nolan Winicki, Jordan Cohen, Amrik Kang, Nicole Huffman, Debora Handoyo

**Front** (left to right) – Amy Ayotte, Emily Harris, Sarah Ruckman, Debbie Arce, Kollan Doan

**Not Pictured** – Hayden Jackson, Sarah Miller, Tevin Bui, Syris Norelli, Siddharth Sai, Jayapriya Vengadesan, Mirella Rodriguez

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Physics

## From the Faculty Advisory Board



Since UCR's *Undergraduate Research Journal* started, it has published almost 130 scholarly articles across many fields. These papers represent the commitment of our undergraduates to performing independent research as part of their experience at UCR. The Journal thus fills a critical need for our students. More often than not, undergraduate research forms part of a larger work with many contributors, which can mean a dilution of the student's contributions as well as a longer wait time between completion of the work and its publication. With the *Undergraduate Research Journal*, our students can write about their specific research findings and get first-author credit. They can publish before the end of their degree, and gain the experience of seeing their manuscript go through a peer-review and publication process just like articles in a standard research journal. When a paper becomes a part of a student's professional experience, it contributes to their record of scholarly achievement in a unique way. The submission and review process is run primarily 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 you see here. We are also grateful for the participation of the members of the Faculty Advisory Board in guiding the student reviewers. If you are interested in publishing your undergraduate research at UCR, consider submitting to our next issue!

A handwritten signature in blue ink that reads "Morris F. Maduro".

Dr. Morris F. Maduro  
Chair of the Undergraduate Research Journal Faculty Advisory Board  
Professor of Biology

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## About the Cover...



### **Caylin Yorba-Ruiz**

*Department of Art  
& Department of Media  
and Cultural Studies*

Caylin Yorba-Ruiz is a third-year double major in Art and Media & Cultural Studies. Her work utilizes art to advocate for issues regarding mental health, feminism, environmentalism, and sexual violence awareness. Through funding from the Healthy Campus Initiative, Caylin is working on self-care coloring books and free survivor-directed zines for the UCR community. Currently, she interns at CARE, is the Marketing Assistant for Undergraduate Admissions, and is a Unit Assistant for the ARC. Caylin plans on pursuing a PhD in media studies.



### **“Untitled” by Caylin Yorba-Ruiz**

This photo was taken at the UCR Botanic Gardens of green moss on a branch. It was inspired by a photography assignment given through a course offered by the Department of Art. The course prompted students to create intriguing work in which perspective was utilized. As an artist, I am most inspired by simplicities and small workings within the world, such as the intricate structure of flowers and the process of pollination. I believe these workings and simplicities are reflections of faith, hope, resilience, and love. The beauty of the world motivates and inspires me to continue my work in social justice, ecology, and mental health. I created this image in hopes that it will act as a means to impel individuals to be more cognizant of nature, even the small self-sustaining systems pictured in this image. Moreover, I chose this image as it illustrates my desire to create work that embodies and articulates issues that are cross disciplinary — something I believe that all good work does. I hope that this image inspires individuals across disciplines to view art as a medium which can string various disciplines together and thereby cultivate solidarity amongst those disciplines.