Inquiry: The University of Arkansas Undergraduate Research Journal

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Inquiry Editors

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INQUIRY

The University of Arkansas Undergraduate Research Journal

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University of Arkansas

Volume 22, Issue 1
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table of Contents</td>
<td>1</td>
</tr>
<tr>
<td>Editor’s Note</td>
<td>1</td>
</tr>
<tr>
<td>Faculty Highlights</td>
<td>3</td>
</tr>
<tr>
<td>Research Article</td>
<td>5</td>
</tr>
<tr>
<td>Honors Corner</td>
<td>15</td>
</tr>
<tr>
<td>ONCA Notice</td>
<td>21</td>
</tr>
<tr>
<td>Undergraduate Student - Research Blog</td>
<td>26</td>
</tr>
<tr>
<td>Inquiry Journal Dashboard</td>
<td>28</td>
</tr>
</tbody>
</table>
Editor’s Note

Welcome to the new issue [volume 22 (1)] of the Inquiry Journal. At the outset, we would like to thank Dr. Margaret Sova McCabe, Interim Vice Chancellor of the Division of Research & Innovation (DRI) for her unflinching support to the Office of Undergraduate Research (OUR) in all its endeavors to improve the quality of undergraduate research on this campus. We would also like to express its gratitude to Dr. Cynthia Sides, Assistant Vice Chancellor of DRI and her staff for their relentless “behind-the-scene(s) efforts to support the multitude of activities undertaken by OUR, including the publication of the Inquiry Journal. We hope to receive continued support from all the members of the DRI family!

This issue features a research paper published by an undergraduate student, Gabriel Kupovics. His research paper reports the novel supramolecular assemblies formed by natural aromatic amino acids. Understanding, the mechanistic details of the supramolecular assemblies formed by the natural aromatic amino acids is likely to provide valuable clues for the rational design of new therapeutic design(s) against dilapidating inherited disorders such as, phenylketonuria, tyrosinemia, and hypertryptophanemia. We would like to congratulate Gabriel for his excellent undergraduate research in the Thallapuranam group.

The Office of Scholarly Communications, University Libraries, kindly shared with us the current visibility of the articles published in the Inquiry Journal from Jan-May, 2023. We are pleased to share with the readers the statistics of viewership of articles published in the Inquiry Journal worldwide. In this context, we would like to congratulate both the undergraduate students and their faculty mentors for considering the Inquiry Journal as an avenue to publish their research. Given the impact of the Inquiry Journal, we urge the faculty on this campus to seriously consider publishing their best research in the Inquiry Journal. The Inquiry journal is published in the digital repository (ScholarWorks@UARK) is amenable to citation in research articles published in other research repositories. In this context, we would like to personally thank the faculty who had generously allocated their precious time to peer review research papers published in the Inquiry Journal. We believe that the academic rigor afforded via the peer-review process is one of the main reason(s) for the reliability and current high worldwide visibility of the Inquiry Journal.

OUR has funded the research of about 10 non-honors undergraduate students in the past academic year. We hope to continue funding the research of the bright and motivated non-honors undergraduate students on this campus. In this issue, we are sharing the blog post of David Heinrichs, an undergraduate student who received research funding (from OUR) to work with Dr. Rebekah Samsonraj, an assistant professor in the Biomedical Engineering department. We thank Dr. Samsonraj for enthusiastically working with David to increase his exposure and interest to work on the cutting-edge areas of stem cell research in her laboratory. David’s blog truly epitomizes the quality of undergraduate research on this campus. We intend to publish these types of research blogs, as a motivation to other non-honors undergraduate students to engage in research, in the future issues of the Inquiry Journal.

Credit is due to Sophia Nourani, an undergraduate student worker, who has tirelessly strived hard to interview the faculty who have shown their interest in providing opportunities to
undergraduate students to get involved with their high-quality research. This issue highlights two such outstanding faculty members (Drs. Geebo Song and Robert Coridan) who have a wonderful track record of working with undergraduate students. I salute these faculty members for their commitment to support high quality undergraduate research on this campus.

Our special thanks also go to Dr. Suzanne McCray, Vice Provost, Office of Nationally Competitive Awards (ONCA) and Dr. Chelsea Hodge, Director of Grants and Research Innovation, Honors College, who contributed the material, published as the ONGC notice and Honors Corner, at very short notice. It will be our endeavor to permanently feature both Honors Corner and ONCA Notice in the future issues of the Inquiry Journal. Credit also goes to Mr. Phuc Phan, a graduate student in Dr. Thallapuranam’s research group for meticulously organizing the different features published in this issue of the Inquiry journal. Lastly, we greatly acknowledge the help provided by Dr. Melody Herr and Ms. Cedar Middleton for working closely with us to get this Issue of Inquiry published in Scholarly Works in a timely manner. We hope to continue working with the University Libraries in our pursuit of including additional new features in the Inquiry Journal which will be likely of broad interest to the Undergraduate students on this campus.

Suresh K. Thallapuranam
Director, Office of Undergraduate Research
Division of Research & Innovation
Faculty Highlights

Dr. Geoboo Song

Dr. Geoboo Song teaches courses on policy theories, politics of risk, research methods and data analytics in the political science department at the University of Arkansas. In addition to his role as an associate professor, Dr. Song also serves as the PLSC Vice Chair/Director of Graduate Studies and an Associate Editor for the Policy Studies Journal (PSJ).

Dr. Song is originally from Gwanju, South Korea, and received both his undergraduate and master’s degree in Seoul, South Korea. Dr. Song continued his education in the United States, receiving his PhD at the University of Oklahoma before pursuing scholarly research at UARK.

Dr. Song’s current research primarily focuses on working with biomedical engineering students to better understand current efforts to improve the COVID-19 vaccine and works to create a systemic explanation of an individuals’ perceptions of the pandemic and their policy preferences when it comes to taking the vaccine.

“I'm one of very few social scientists who have tried to track the process [of the vaccine], and then focus on researching the sort of social and policy implications of that research endeavor,” Dr. Song stated.

Dr. Song and his collaborators use data-driven analyses on various pressing policy issues beyond the pandemic—such as climate change, hydraulic fracturing, sustainable energy and more. He emphasizes the importance of undergraduate students in his research and hopes to encourage more diversity in the research program as a whole.

In his free time, Dr. Song tries to take the time to connect with his students. He emphasized the value of the relationships he has developed through his research with both his pupils and peers.
Dr. Robert Coridan

Dr. Robert Coridan teaches both entry-level chemistry and courses specializing in physical chemistry and biochemistry at the University of Arkansas. In addition to these, Dr. Coridan teaches a class on inorganic chemistry for undergraduate students.

Dr. Coridan received his BS in physics and computer science from the Ohio State University and a PhD in physics from the University of Illinois, Urbana-Champaign. Dr. Coridan’s current research primarily focuses on observing and optimizing different chemical interactions that can be used as a source of power or electricity.

To develop strategies for the optimization of light absorption and catalysis, Dr. Coridan and his students use “self-assembled colloidal solids to create precisely controlled hierarchical structures”. These structures can be used to support the chemical synthesis of these materials.

“A lot of people are familiar with solar cells…they see these panels out in the field, and what those are doing is generating electricity while the sun is up. But they aren't doing anything when the sun is down,” Dr. Coridan said. “What we're trying to build is essentially the same thing, but instead of it being wired to the grid and producing electricity, it's wired to metals that turn water into hydrogen oxygen, for example.”

Dr. Coridan supports the philosophy that undergraduate research is beneficial to both the student and the primary researchers.

“The university has very bright undergraduate students. Many of them are really excited to just do something new,” Dr. Coridan said, “They are looking beyond the textbook to see the actual day-to-day and how this stuff really works.”

In Dr. Coridan's free time, he enjoys spending time outside with his wife and children.
Research Article

High Order Structures Formed by the Natural Aromatic Amino Acids

Gabriel Alexander Kupovics and Zeina Alraawi
Faculty Advisor – Dr. Thallapuranam Krishnaswamy Suresh Kumar

J. William Fulbright College of Arts and Sciences, University of Arkansas, Chemistry and Biochemistry Department, Fayetteville, AR 72701

Abstract

Excessive concentrations of the natural aromatic amino acids phenylalanine and tyrosine are characteristic of the severe genetic abnormalities known as phenylketonuria (PKU) and tyrosinemia, respectively. Within this context, this feature article authenticates claims that tryptophan can form amyloid-like supramolecular structures in vitro and is the first to propose potential mechanisms of tryptophan self-assembly, including hydrophobic and electrostatic interactions. Thioflavin T (ThT) fluorescence kinetics and transmission electron microscopy (TEM) data suggest the formation of amyloid-like fibrillar structures by natural aromatic amino acids in vitro. Additionally, the propensity of amino acid aggregation increases in the presence of sodium dodecyl sulfate (SDS). The structures formed by these amino acids are likely nucleated via hydrophobic interactions and elongated by π-π interactions. Fluorescence kinetics reveal a higher propensity of phenylalanine to self-assemble at pH 2, while tyrosine and tryptophan assemble best at pH 7, suggesting the necessity of zwitterionic charges in self-assembly.
Profiles of the Authors

**Gabriel Kupovics** graduated from the University of Arkansas in 2020, where he obtained a degree in Biochemistry from the Fulbright College of Arts & Sciences. While at the University of Arkansas, he studied the mechanisms that underlie metabolic diseases, such as phenylketonuria and tyrosinemia. Gabriel is currently pursuing a degree in Osteopathic Medicine from the UNTHSC Texas College of Osteopathic Medicine, where he is exploring his interest in surgery.

**Zeina Alraawi** is a Ph.D. student in Cell and Molecular Biology at Fulbright College of Arts & Sciences, University of Arkansas. She is interested in researching biomolecule structures and how they function in the human body.
Dr. Thallapuranam is a professor of Chemistry & Biochemistry with significant interest in design of novel fibroblast growth factor (FGF)-based rational design of therapeutic principles for chronic wound care, anti-diabetes, anti-obesity, and osteoporosis. His research is supported by several Federal grants (NIH/DOE/NSF/USDA). He currently serves as the NIH sponsored AIMRC Bioenergetics core. He also currently serves as the Director of the Office of Undergraduate Research (in DRI). He has published about 10 US patents and 175 peer-reviewed research papers in high-impact Journals. He is the recipient of several teaching, research, and service awards including the Honors College Distinguished Faculty award, Honors College Faculty Gold medal, Collis Geren Outstanding Interdisciplinary Graduate Faculty award, elected as the member of the National Academy of Inventors, ARSC Master Teacher award. Golden Tusk Award, and the prestigious Nadine Baum Award for outstanding teaching. He is also the member of the University of Arkansas Teaching Academy. Dr. Thallapuranam also regularly serves on the grant proposal review panel of Federal agencies such as NIH, NSF, and DOE. He currently serves as the Associate Editor of the Frontiers of Molecular Biophysics journal and on the Editorial Board of several peer-reviewed journals including the prestigious Journal of Biological Chemistry.
Introduction

Amino acids are organic compounds that create the foundation of the essential biological macromolecules known as proteins. Proteins are synthesized by the sequential formation of peptide bonds between the amine (-NH$_3$) and carboxyl (-COOH) groups of a series of amino acids specific for that protein. Along with the amine and carboxyl functional groups, amino acids contain a unique side chain (-R), which determines their physical and chemical properties. In this project, the properties of the three canonical aromatic amino acids, phenylalanine, tyrosine, and tryptophan, were explored. Phenylketonuria (PKU) is an autosomal recessive inborn error resulting from the decreased activity of phenylalanine hydroxylase (PAH), the enzyme that is required to convert L-Phenylalanine to L-Tyrosine. Decreased activity of PAH interrupts phenylalanine metabolism allowing for accumulation of phenylalanine and its toxic catabolic by-products$^1$ in the plasma, cerebrospinal fluid and brain tissue$^2$. This accumulation has been found to inhibit the transport of large neutral amino acids (LNAAs) into the brain$^3,4$. Additionally, increased free phenylalanine in the brain is believed to result in the amyloid-like deposits which characterize PKU$^2$.

Tyrosinemia is another neurodegenerative autosomal recessive inherited metabolic disease characterized by an accumulation of tyrosine in body fluids and tissues. Tyrosinemia Types I, II and III are characterized by deficiencies of the critical tyrosine metabolism enzymes fumarylacetoacetate hydrolase (FAH), tyrosine aminotransferase (TAT) and 4-hydroxyphenylpyruvicdioxygenase, respectively$^5$. The etiology of hypertryptophanemia was recently established to be a deficiency of tryptophan 2,3-dioxygenase, the metabolic enzyme responsible for the rate-limiting oxidation of L-Tryptophan to N-formyl-L-kynurenine in the kynurenine pathway. The disease is commonly associated with elevated levels of fasting plasma tryptophan$^6$. Exploration of aromatic amino acid (AA) self-assembly processes has experienced increasing attention specifically within the context of human disease. Simulation of these processes has revealed the tendency of phenylalanine, tyrosine and tryptophan to form fibril-like structures$^7$.

Previous studies have suggested that the intermolecular interactions between single phenylalanine molecules are mediated through hydrophobic interactions, β-sheet generation, and π-π interactions$^8,9$. Similarly, the formation of tyrosine and tryptophan aggregates has been proposed to be due to π-π stacking and hydrogen bonding interactions, producing cross-β-like structures$^{10,11}$. The primary objective of this study is to determine the tendency aromatic (AAs) to form high order structures in vitro. In addition, to investigate the mechanism(s) of (AAS) self-assembly. In this context, the aggregation propensity of phenylalanine, tyrosine and tryptophan at millimolar concentrations were investigated utilizing ThT fluorescence experiments.

Methods

ThT fluorescence was observed at a wavelength of 485 nm for phenylalanine, tyrosine, and tryptophan over 30 days. Phenylalanine and tryptophan concentrations (mM): 1, 4, 6, 8, 10. Tyrosine concentrations (mM): 0.8, 1, 1.4, 1.6, 2. All extrinsic fluorescence spectroscopy kinetics were performed on a Hitachi F-2500 spectrophotometer at 25 ºC using a slit width of 2.5 nm and a quartz cuvette with a path length of 10 mm.

In addition, aromatic AA self-assembly morphology was investigated via transmission
electron microscopy (TEM). Formation of aromatic amino acids fibrils was achieved via 15-day incubation under physiological conditions (37 °C, pH 7.4). The samples were centrifuged for approximately 40 minutes to isolate the self-assembled fibrils and washed three times with 150-μL aliquots of water distilled. The fibrils were ultimately suspended in 150 μL of distilled water. A 2-μL volume of each type of amino acid was added to a separate Formvar- and carbon-coated copper grid. Electron micrographs of aromatic amino acid aggregates were observed on a Hitachi H-7500 transmission electron microscope. Micrographs were obtained at a voltage range of 80-100 kV and magnifications ranging from 20000x to 100000x.

ThT fluorescence was also observed for phenylalanine, tyrosine and tryptophan presence and absence sodium dodecyl sulfate (SDS). Additionally, ThT fluorescence of different concentrations of phenylalanine, tyrosine and tryptophan was observed at pH 2, 7, and 9 after 15 days of incubation.

Results

ThT is a small molecule that gives rise to fluorescence upon binding to the side chain channels along the long axis of amyloidogenic structures. A significant rise in the relative fluorescence intensity of ThT at 485 nm (Fig. 1) suggests the amyloid-like aggregation of all three natural aromatic AAs at low millimolar concentrations. A lag time of approximately 10 days was experienced for all three AAs. Additionally, ThT signal saturation was achieved for phenylalanine and tyrosine after 30 days of incubation (Fig. 1a-b) whereas saturation for tryptophan samples was reached after 35 days (Fig. 1c).

![Figure 1](image-url)

**Figure 1**
ThT fluorescence at various concentrations of phenylalanine (*Panel a*), tyrosine (*Panel b*) and tryptophan (*Panel c*) over 30 days. Phenylalanine and tryptophan concentrations (mM): 1 (open diamonds), 4 (open squares), 6 (open triangles), 8 (crosses), and 10 (asterisks). Tyrosine concentrations (mM): 0.8 (open diamonds), 1.0 (open squares), 1.4 (open triangles), 1.6 (crosses), and 2.0 (asterisks).

Aromatic AA self-assembly was further investigated with transmission electron...
microscopy. Formation of aromatic AA fibrils was achieved via 15-day incubation under physiological conditions. The sample concentrations were based on those used in previous studies and their representative behavior of other millimolar concentrations studied. The pre-formed fibrils were isolated and washed with buffer before transferring to a 400-mesh copper grid. Transmission electron microscopy (Fig. 2) reveals that the aromatic AA self-assemblies formed are fibrillar, exhibiting varying degrees of branching. Phenylalanine and tyrosine aggregates display minimal to no branching (Fig. 2a-d) whereas tryptophan supramolecular structures appear to be highly branched (Fig. 2e-f).

Additionally, the structures are discrete and well-organized, typical of aggregates formed by amyloidogenic proteins. Previous studies suggest the possibility that π-π interactions play a role in amyloid fibril self-assembly processes due to the presence of aromatic residues. We believe that the π-stacking hypothesis may be employed here as a potential mechanism of self-assembly and may contribute to the order and directionality of the process, specifically for phenylalanine.

Figure 2
Transmission electron microscopy after 15 days of fibril formation. Phenylalanine (6 mM) is depicted at magnifications of 50000x (Panel a) and 100000x (Panel b). Tyrosine (1 mM) is shown at magnifications of 50000x (Panel c) and 100000x (Panel d). Tryptophan (6 mM) is depicted at magnifications of 50000x (Panel e) and 100000x (Panel f).

The buffer salt coating of phenylalanine fibrils observed in the micrographs support this hypothesis (Fig. 2a-b), as positively charged salts may stabilize the electron repulsion experienced between aromatic rings in the form of cation-π interactions. The lack of buffer salt coating of tyrosine and tryptophan fibrils prompts further exploration prior to addressing such an elongation mechanism. It is worth noting that the micrographs (Fig. 2b, 2d-e) depict small clusters of phenylalanine, tyrosine and tryptophan existing independent of their respective fibrils. These micelle-resembling clusters may serve as nucleation sites for self-assembly and suggest that...
hydrophobic interactions play a significant role in nucleation of the fibrils. The results of this electron microscopy experiment confirm that the natural aromatic AA self-assemblies exhibit amyloid-like characteristics. Additionally, the results reveal that phenylalanine supramolecular structures may possess a π-stacking mechanism of assembly and that hydrophobic interactions could play a role in the nucleation of aromatic AA aggregation.

Sodium dodecyl sulfate (SDS) is an anionic surfactant which mimics the amphipathic character of the plasma membrane\textsuperscript{17}. SDS-induced aromatic AA fibrils were incubated for 15 days at physiological temperature (37 °C) and pH 7.4. The results in Fig. 3 display a higher fluorescence intensity of ThT for samples incubated with SDS (compared to those without SDS) revealing a higher aggregation propensity in the presence of the detergent. The difference in fluorescence intensity was apparent at all monitored concentrations for tyrosine (Fig. 3b) while only at concentrations above 1 mM for phenylalanine (Fig. 3a) and tryptophan (Fig. 3c). The results of this experiment suggest that 0.2 mM SDS facilitates the formation of aromatic AA self-assembled fibrils. The SDS-induced fibrils were further investigated with transmission electron microscopy.

Figure 3
ThT fluorescence at varying concentrations of phenylalanine (Panel a), tyrosine (Panel b), and tryptophan (Panel c) in the presence (open diamonds) and absence (open squares) of 0.2 mM SDS after 15 days of incubation.

Samples of 6 mM phenylalanine, 1 mM tyrosine and 6 mM tryptophan were incubated with SDS under physiological conditions for 15 days. The aggregates formed were isolated and washed prior to microscopic examination. The micrographs (Fig. 4) depict well-ordered, fibrillar
structures, similar to the self-assemblies observed in the absence of SDS. Interestingly, SDS-induced phenylalanine self-assemblies (Fig. 4a-b) exhibit greater branching compared to those seen in the absence of SDS (Fig 2). The micrographs depict SDS micelles as dark structures (Fig. 4b, 4d, 4f) from which the fibrils project and elongate. All visible aromatic AA fibrils are depicted extending from micelles, which supports the hypothesis that SDS may play a facilitative role in the formation of these self-assemblies.

**Figure 4**
Transmission electron micrographs of SDS-induced aromatic AA fibrils. Phenylalanine (6 mM) is depicted at a magnification of 50000x (Panel a and Panel b). Tyrosine (1 mM) is shown at magnifications of 20000x (Panel c) and 100000x (Panel d). Tryptophan (6 mM) is depicted at magnifications of 25000x (Panel e) and 50000x (Panel f).

Additionally, the micelles appear to play a similar role to the AA clusters seen in Fig. 2b, 2d and 2e, further suggesting that hydrophobic interactions initiate aromatic AA aggregation processes. These results confirm that SDS can induce aromatic AA aggregation and proposes hydrophobic interactions as a potential self-assembly mechanism. The hypothesis that π-π interactions play a role in phenylalanine and tyrosine fibril formation suggests the importance of charge for aggregation of these AAs.

In this context, the effects of pH on aromatic AA aggregation were studied with ThT binding experiments. At low (acidic) pH, all groups of these amino acids are protonated and the net charge for each is +1. At neutral pH, the carboxyl group is ionized, giving the group a charge of -1. Therefore, the overall charge of each amino acid at neutral pH is 0. At high (basic) pH, the carboxyl and amine groups are deprotonated, and the net charge of each amino acid is -1. Aggregation propensities at pH 2, 7, and 9 were studied after 15 days of incubation at physiological temperature.

A higher fluorescence of ThT was observed at pH 2 for phenylalanine concentrations in the 1 to 10 mM range (Fig. 5a). This suggests that a +1 charge on phenylalanine is more favorable for its self-assembly. The plausible requirement of a positive charge on the AA supports the
hypothesis that π-stacking is the mechanism of fibril elongation. The π-electron repulsions may be stabilized by the positive charge on the amine group at low pH. Tyrosine and tryptophan exhibited a higher relative fluorescence intensity of ThT at a neutral pH (Fig. 5b, 5c), indicating that the zwitterionic form of the AAs is favorable for aggregation.

Figures 5
ThT fluorescence of varying concentrations of phenylalanine (Panel a), tyrosine (Panel b), and tryptophan (Panel c) at pH 2 (open diamond), 7 (open square), and 9 (open triangle) after 15 days of incubation.

Further, this finding suggests that electrostatic interactions may play a role in the formation of tyrosine and tryptophan high order structures. However, in contrast to tyrosine, basic pH appears to have an inhibiting effect on tryptophan aggregation, suggesting a deprotonated amine is unfavorable for its self-assembly. The results of this experiment support the π-stacking hypothesis of phenylalanine aggregation and reveal electrostatic interactions may play a significant role in the tyrosine and tryptophan self-assembly.

Conclusion
In summary, this study explores the etiologies of phenylketonuria, tyrosinemia and hypertryptophanemia and explores a possible mechanism of assembly for natural aromatic AA high order structures. Our findings authenticate reports of previous studies that phenylalanine and tyrosine form fibrillar structures in vitro at millimolar concentrations. The aromatic AA fibrils are discrete and well-organized, exhibiting amyloid-like characteristics. Positively charged salts from the phosphate buffer saline are depicted coating fibrils in phenylalanine electron micrographs. This suggests that π-electron repulsions are stabilized by the salts in cation-π interactions, supporting the π-stacking hypothesis of phenylalanine self-assembly. Micrographs of tyrosine and tryptophan depict small independent clusters of the AAs indicating the significant role of hydrophobic interactions in the initiation of these self-assembly processes. SDS-induced aggregation suggests that SDS serves as a nucleation site, further suggesting that hydrophobic
interactions may be responsible for the initiation of aromatic AA fibril formation. It is possible that the highly branched aggregates formed by phenylalanine in these membrane-like environments may contribute to the negative effects experienced by phenylketonuria patients.

Tyrosine and tryptophan exhibit higher propensities to aggregate at neutral pH suggesting the necessity of the zwitterionic AA form in the self-assembly process. In these contexts, it appears that hydrophobic interactions are responsible for nucleation of self-assembly processes in aromatic AAs, and \( \pi-\pi \) interactions may serve as the mechanism of phenylalanine fibril elongation whereas electrostatic interactions could be responsible for tyrosine and tryptophan aggregate extension.

Acknowledgment

This work is supported by the National Institute of Health (NIH) (R015569) and Department of Energy (DOE) (DE-02-01ER15161).

References

Honors Corner

National Undergraduate Research Week Celebrations

The University celebrated National Undergraduate Research Week April 17th through 21st. A combined effort of the Honors College, University Libraries, and the Office of Undergraduate Research. DRI, this week recognized the work of undergraduate students and provided extensive programming to help students develop their research initiatives. The feature event of the week was the Research Poster Competition. Sixty-seven students submitted abstracts to the first round, and fifty students moved on to the poster and presentation round which were judged by faculty panels. Students presented their posters at an in-person session on April 20th in the Union Ballroom. The students competed in seven different discipline categories, four of which were divided into two competition groups due to the high number of submissions. The first-place winners in each category provided a quote about the value of research to their academic experience.

Competition Winners

Category: Art and Design
Name: Lilli Martin
Honors Affiliation: Honors Student
Major(s): Apparel Merchandising and Product Development
Title: Creating Adaptive Clothing for Dialysis Patients

Quote: My undergraduate research has given me the experience to create a solution to a real-world problem. I've been able to gain a deeper understanding and knowledge of the apparel industry and the needs of those in our community. Conducting my research has been an opportunity to help find solutions for those who are often looked over in the apparel industry and has helped me find a gap in the industry and has inspired me to fill that gap.
**Category:** Business & Social Sciences  
**Name:** Gabrielle Gies  
**Honors Affiliation:** Honors College Fellow  
**Major(s):** Political Science (and Psychology)  
**Title:** Analysis of The Relationship Between Pharmaceutical Political Action Committee Contributions And Congressional Voting Actions

**Quote:** I have had a great experience working with Dr. Song on this research project for the past several semesters. I've learned so much about how to gather and report data, run statistical analyses, and present my research to others. I'm very thankful I had this opportunity and can't imagine a more useful way to apply my learning in my undergraduate career.

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**Category:** Engineering 1  
**Name:** Julliana Renales  
**Honors Affiliation:** Honors Student  
**Major(s):** Biomedical Engineering  
**Title:** Mapping Macrophage Fate in Muscle Injuries Using Spatial Transcriptomics

**Quote:** This research experience has allowed me pursue passions and skills that I did not think I would have the opportunity to do. It has been the best learning experience to apply my skills and watching my project develop has given me new motivation for future endeavors. I would like to sincerely thank my research advisor and mentor, Dr. Chris Nelson for this opportunity and continuous support.
**Category:** Engineering 2  
**Name:** David Heinrichs  
**Major(s):** Biomedical Engineering  
**Title:** Assessing the Effects of Dasatinib on Mesenchymal Stem Cell Potency

**Quote:** The past few months researching in a lab have been more productive than the last year of school. Getting to experience what it's like to work in a lab has provided invaluable experience in the biomedical field, as well as the academic field overall. I have learned to divide my focus to work on multiple complex things such as running experiments, processing data, and interpreting results all at once which I can use in the future to provide a valuable insight and work ethic in the medical field.

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**Category:** Health  
**Name:** Kyra Resende  
**Honors Affiliation:** Honors Student  
**Major(s):** Communication Sciences and Disorders  
**Title:** Measuring awareness of SPD and interprofessional collaboration & practices among professionals in an elementary public school setting

**Quote:** Over the past two years, my Honors undergraduate research project has provided me with meaningful experiences, context, and information on a topic that is so important to me. I am very grateful to have been able to participate in the Undergraduate Research Poster Competition and share the findings of my project, and I am honored to have been recognized. This event has given me a great exposure on presenting research and it was fun to see the amazing research that other students have conducted. I am also deeply grateful for my mentor, Dr. Angela Elsass, for her help, support, and guidance during this process.
Category: Humanities  
Name: Joshua Jacobs  
Honors Affiliation: Bodenhamer Fellow  
Major(s): Classical Studies  
Title: PQD in the Prophets

**Quote:** I will be attending graduate school next fall, and the opportunity to conduct and present my own research during my undergraduate career has been a crucial step towards my academic and professional goals. As a humanist, I rarely have the opportunity to present my research through the poster medium, and this experience allowed me to learn what a good research poster and presentation looks like.

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Category: Natural Sciences  
Name: Ashlyn DesCarpentrie  
Honors Affiliation: Sturgis Fellow  
Major(s): Chemistry  
Title: Developing Methods for Pattern Transfer in Photoelectrochemical Lithography

**Quote:** Research has taught me far more about chemistry and about what it takes to be an independent and creative scientist than a classroom setting alone ever could. I’m very grateful for the encouragement and support of the UARK Honors College for undergraduate students interested in academic research. These experiences have helped prepare me to continue my academic career to doctoral studies in chemistry.
**Category:** Natural Sciences 2  
**Name:** Ethan Peters  
**Honors Affiliation:** Honors College Fellow  
**Major(s):** Biochemistry and Spanish  
**Title:** Design of a Stable Variant of FGF1-FGF2 Dimer with Potent Cell Proliferation Activity

**Quote:** Undergraduate research has been a pathway for me to apply my theoretical knowledge about biochemistry to a tangible project which I hope will effect change. I now have the skillset to continue research during medical school as well as synthesize complex information into a digestible format, which is an essential skill for physicians. I am honored to be recognized in this way, and enthusiastically encourage any undergraduates considering research to go for it!

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**Category:** Social Science 1  
**Name:** Sophia Chier  
**Honors Affiliation:** Honors Student  
**Major(s):** Psychology  
**Title:** Longevity Bias, Ingroup Bias, and Culture: A Comparative Study in the U.S. and Japan

**Quote:** I was extremely fortunate to be able to do my research while studying abroad in Japan thanks to funding from the Honors College. I never imagined that I would be able to even travel to a foreign country, much less do psychology research while I was there! I learned so many valuable lessons about how to conduct research while simultaneously experiencing a new culture and practicing a new language. I am planning my future around returning to Japan and working there because of this experience, and I am so grateful.
Category: Social Science 2
Name: Cindy Mao
Honors Affiliation: Honors student
Major(s): Public Health & Psychology
Title: Creativity and Humor: The Role of Alcohol Expectation Effects and Familiarity in Creative Cognition

Quote: In my undergraduate research experience, I've learned everything involved in creating, designing, and executing an in-person psychology study. I've grown confident in my abilities as a presenter, and I'm excited to continue research in public health and medicine. Research is powerful and valuable, and that knowledge can be used to further discussion and development in all fields.
ONCA Notice

Office of Nationally Competitive Awards
2022-2023 Student Profiles

The University of Arkansas had a bumper year this year! Several of the bright undergraduate students, listed below, have won prestigious Nationally Competitive awards! The Office of Undergraduate Research (OUR) would like to thank Dr. Suzanne McCray, vice-provost, Office of Nationally Competitive Awards for her leadership and guidance to the students to prepare competitive applications for these prestigious scholarships.

The Goldwater Scholarship (established by Congress in 1986) works to provide a continuing source of highly qualified scientists, mathematicians, and engineers by awarding scholarships to college sophomores and juniors who intend to pursue careers in these fields. Scholars receive up to $7,500, and the award can be renewed for an additional year. To be competitive students should have some experience with research at the time of application.

STEPHEN PIERSON – An honors mechanical engineering student who focuses on microchannel heat sinks research, Pierson uses advanced manufacturing techniques to improve thermal performance in liquid-cooled heat sinks. With three first-author publications and presentations at significant conferences, Pierson is making strides in his field. He's also an active tutor and volunteer, an Honors College Fellow, Arkansas Governor’s Distinguished Scholar, and National Merit Scholar. Praised for his academic achievements and leadership, he plans to pursue a Ph.D. in mechanical engineering.

The Fulbright U.S. Student Program awards fellowships for U.S. graduating college seniors, graduate students, young professionals and artists to study, conduct research, and/or teach English abroad. Stipends and the length of stay in the selected country vary depending on the individual program. Recipients of the Fulbright U.S. Student fellowships are referred to as Finalists.

JACOB CONDRAN – A 2021 honors graduate majoring in history, international and global studies, and political science, Condran was named a 2023 Finalist for the Fulbright U.S. Student Program and will serve as an English teaching assistant in Azerbaijan. He is pursuing a graduate degree from Charles University in Prague. At the University of Arkansas, Condran worked as an intern for Canopy NWA and as the fundraising coordinator for Students with Refugees. He interned with the U.S. Department of State in Cyprus. While studying in the Czech Republic, Condran volunteered with Dignity, a Czech refugee resettlement organization, taught English, and served as a graduate research assistant. He plans a career in academia.
SPENCER HAZESLIP – A 2023 honors graduate majoring in chemistry and Spanish, Hazeslip was an Honors College Fellow and an Arkansas Governor’s Distinguished Scholar. He also received a U.S. State Department Critical Language Scholarship to study Russian. Hazeslip is a Finalist for an English teaching assistantship to Kazakhstan. On campus, Hazeslip was involved in the Russian-Eurasian Student Organization, volunteered for the Jane B. Gearhart Full Circle Food Pantry, and tutored students studying Russian. After his time as an English teaching assistant, he plans to attend medical school.

The Marshall Scholarship is a prestigious postgraduate award funded by the British government that allows American students to pursue graduate study in any field at a university in the United Kingdom. The scholarship seeks to strengthen the enduring relationship between the British and American peoples. It recognizes high-achieving American students who demonstrate distinguished academic prowess, leadership potential, and ambassadorial potential.

JULIANNA KANTNER – A 2023 Marshall Scholarship Finalist, Kantner is involved in refugee resettlement efforts in Northwest Arkansas. Kantner served as president and vice president of Students with Refugees and volunteered with nonprofits working towards food security and youth mentorship. She was also vice president of Rotaract where she trained students on strategies for social change. For her honors thesis, she researched volunteer program development in refugee resettlement and launched an advocacy training program for college students to assist the local resettlement agency. Kantner, an international and global studies, and political science major, will pursue a law degree to gain the legal knowledge necessary to represent clients and provide legal aid to marginalized communities.

National Science Foundation – Graduate Research Fellowship, is a prestigious grant program that supports exceptional graduate students in NSF-supported science, technology, engineering, and mathematics disciplines who are pursuing research-based master’s and doctoral degrees at accredited United States institutions. The fellowship provides three years of financial support within a five-year fellowship period, including a stipend and education allowance. The program prioritizes promoting diversity in STEM fields, fostering international collaborations, and developing the next generation of scientific leaders.

ALEXIS APPLIQUEST – A graduate in biomedical engineering in 2021, Applequist conducted research with Morten Jensen and Kartik Balachandran, both associate professors of biomedical engineering. She also conducted industry research at a medical technology startup company in Bangalore, India. Currently a Ph.D. student in biomedical engineering at the U of A, she is developing a heart-on-chip platform, Coco Chip, to be used as a novel drug screening device in the pharmaceutical industry. She plans a career in industry research and development with the goal of minimizing the socioeconomic gap in healthcare worldwide.
MARY JIA – A graduate with an honors B.S.Bm.E. degree in biomedical engineering in the spring of 2023, she is a Bodenhamer Fellow conducting research with Christopher Nelson, an assistant professor in biomedical engineering and is investigating CRISPR editing tools using orthogonal sequencing methods for curative rare genetic disease therapeutics. In her graduate studies, she will continue research in molecular therapeutics.

CARSON MOLDER – A summa cum laude graduate with a B.S.C.E. in computer engineering in 2021, Molder was an Honors College Fellow, performing undergraduate research with data science professor Justin Zhan on using deep learning to improve the analysis of medical images. Currently a Ph.D. student at the University of Texas at Austin, he is now researching ways to use machine learning to accelerate the memory interface in computer hardware.

IVRIS RAYMOND – An honors computer engineering graduate in spring 2023, Raymond conducted undergraduate research with Alexander Nelson, assistant professor of computer science and computer engineering, with the support of an Honors College Undergraduate Research Grant. Raymond will pursue a Ph.D. at the University of Michigan in the fall, researching heterogeneous computer architectures for novel devices. She plans to pursue a career in academia after her graduate studies.

JOSEPH ROLL – An honors graduate in spring 2023 in physics (computational concentration) and mathematics (pure concentration), Roll performed undergraduate research with Salvador Barraza-Lopez, associate professor of physics, and will attend the University of Texas at Austin to pursue a Ph.D. in physics researching theoretical condensed matter physics. He plans to pursue a career in academia working as a physics professor.

SANIDHYA TRIPATHI – A cum laude graduate in biomedical engineering in May 2022, Tripathi conducted undergraduate research in the lab of Narasimhan Rajaram, associate professor of biomedical engineering. Currently a Ph.D. student in biomedical engineering at the University of Texas at Austin, he is developing optical imaging technologies to aid in the detection and treatment of skin cancer. He plans a career in academia or industry working at the intersection of biotech and business.

JARROD VARNELL – A summa cum laude U of A graduate in biology and biochemistry in 2022, Varnell studied the genetics underlying butterfly mate preferences with Erica Westerman, associate professor of biology. Currently a Ph.D. student in evolutionary biology at Cornell, he researches the genetic and neurobiological factors underpinning behavioral and wing pattern phenotypes in butterflies. In the future, he hopes to establish his own lab at an institution where he can continue researching the molecular bases for behavior.
The Rhodes Scholarship, one of the world’s most prestigious awards, covers all expenses associated with graduate study for two to three years at Oxford University. Every year, 32 American Rhodes scholars are selected, while award numbers vary for other countries. Students of all disciplines are encouraged to apply.

EILEEN "ALEX" ALVAREZ – An honors graduate in spring of 2023 with majors in international and global studies and political science, Alvarez was named a 2023 Rhodes Scholarship finalist. Alvarez made her mark as a senior resident assistant, an intern for Search for Common Ground, an organizer of Fight Forward-Arkansas, and an active member for several campus committees. In graduate school, she plans to study global governance and diplomacy, eyeing a future in non-profit advocacy, and eventually, a faculty position in political science or international affairs, focusing on human rights for minoritized communities.

The Schwarzman Scholarship, a highly selective international scholarship that offers students the opportunity to earn a one-year master’s degree in Global Affairs at Tsinghua University in Beijing. Founded by American financier Stephen A. Schwarzman, the program aims to foster future global leaders with firsthand understanding of China. Scholars are selected based on their leadership potential, strength of character, and academic ability, and they are expected to contribute to increased understanding between China and the rest of the world.

J.P. GAIRHAN – A 2019 graduate and honors student in African and African American studies, history, and political science, Gairhan was named a 2023 Schwarzman Scholar, securing a full scholarship for global affairs graduate study at Tsinghua University in Beijing. Originally from Cabot, Gairhan has served in various leadership roles and worked domestically and internationally, including as a Fulbright English teaching assistant to Botswana and an AmeriCorps VISTA volunteer. He plans to pursue a career with the U.S. Agency for International Development, focusing on youth development and education.

The Truman Scholarship (created by Congress in 1975 as a living memorial) awards $30,000 for post-graduate study to students pursuing careers in public service. Students apply during their junior year. They are selected first as finalists, then after a rigorous interview process, may be selected as Scholars. Funds are awarded when a student enters graduate school.

ANNA MATHIS – An agricultural education, communications and technology major, Mathis was awarded the prestigious 2023 Harry S. Truman Scholarship. She is committed to rural and international agricultural development, particularly food security. Involved in community service and food security programs, she aspires to work on rural and agricultural policy in Washington, DC, and international agriculture development nonprofits before returning to Arkansas to focus on equitable food systems. The scholarship will fund her master's degree in global development and agricultural economics, furthering her ambition to champion rural America.
The Udall Scholarship Foundation (created in honor of Morris K. and Stewart L. Udall) awards 55 merit-based scholarships of up to $7,000 and 55 honorable mentions to college sophomores and juniors each year. Students apply in the categories of the environment or in Native American healthcare or tribal policy (students in this latter category must be Native American).

ALEX DAVIS – A Muscogee (Creek) Nation citizen, Davis is an agriculture business, pre-law junior with a minor in international economic development. An active campus leader, Davis works with the Indigenous Food and Agriculture Initiative and the U.S. Fish and Wildlife Service Directorate Resource Assistant Fellowship. She is focused on advocating for Indigenous agriculture and sustainable practices, with future plans to pursue environmental law, and ultimately, uplift the Muscogee (Creek) community in agricultural pursuits.

AMELIA SOUTHERN-URIBE – A Colombian American journalist, climate activist, and artist, Southern-Uribe is majoring in broadcast journalism and political science. They founded Zero Hour Arkansas, a climate justice organization and served as the director of southeastern chapters for This is Zero Hour. Southern-Uribe is committed to environmental justice, climate communication, and intersectionality and plans to be a climate communications coordinator, bridging the gap between policymakers and communities, and intend to pursue a master’s degree in environmental management to further these ambitions.

Students wishing to apply for any of these or other competitive scholarships or postgraduate opportunities should contact the Office of Nationally Competitive Awards through awards@uark.edu and visit awards.uark.edu for more information.
**Undergraduate Student - Research Blog**

**Working in a Biomedical Engineering Lab**

My name is David Heinrichs. I am a University of Arkansas student studying Biomedical Engineering. My mentor during my grant period has been Dr. Rebekah Samsonraj with the Biomedical Engineering department. In the future, I plan to attend graduate school and pursue a PhD.

In Dr. Samsonraj’s lab, I worked with Mesenchymal Stem Cells (MSCs), and I studied how they were affected when exposed to a class of drug called senolytic agents. When MSCs get older, they cease to divide and function. This is called senescence and senolytic agents can target and kill senescent cells while leaving younger cells to continue living. I wanted to find out if the younger cells left behind after senolytic treatment were still able to function normally, and I obtained promising evidence to support my objective. My research has real world significance in that, if senolytics only clear older cells, and don’t affect young cells at all, we can slow down the ageing process of stem cells so they can be more effectively used for regenerative medicine. I met my research mentor while I worked for her as a grader in a class she taught in Fall 2022. I had no research experience at that point and had no idea where to start in finding a topic. Dr. Samsonraj helped me immensely with finding a topic and submitting a research proposal. I learned a lot during my time in her lab, but the most important thing was that MSCs are living beings. Cells have their own microscopic needs, community, and even language. Thus, they need to be cared for, respected, and watched carefully if you want them to survive long-term. It was very easy to make a simple mistake, like leaving the cells in a saline solution, used to clean the cells, for 20 minutes when they should only be washed for a couple of minutes at most. That little mistake killed thousands of cells and set my progress back at least a week. All I could do was thaw out more cells and start the experiment over, learning from my mistake and using that week to catch up on other parts of my research.

Dr Samsonraj played a simple, but invaluable, role in allowing me the freedom to work at my own pace, while at the same time, meeting with me weekly to make sure I was on track and staying motivated with balancing school, life, and research at the same time. I would not have been able to get anywhere in my research without the other students I had the pleasure of working with in Dr. Samsonraj’s lab. I was trained by more senior members of the lab from cell culture to poster formatting, and I could use the training to help other students with their own research gaps. Everyone in her lab works synergistically to achieve more than any one of us could on our own. More importantly, my other lab peers genuinely like working together and are always available for help or advice.
Recently, I had the privilege to travel with some of my lab coworkers to Iowa for a conference where we all presented our research. We were able to attend sessions held by distinguished professors in academia and former students working in industry and entrepreneurial passions who came from Harvard, MIT, and other prestigious institutions. Talking with them provided amazing insight into what I want to do in the future after I graduate. We also got to talk with, and network with, other graduate and undergraduate students researching in adjacent fields. I even won third place in an undergraduate poster competition; competing against other students from around the country.

In the future, after graduation, I plan to take a break from everything and travel around the world for a while. When I get back to the US, my research experience will have inspired me to pursue a PhD in Biomedical Engineering. I hope to be able to continue working with stem cells and even expand my project into a dissertation throughout graduate school.
We are pleased to see the increasing visibility of the creative work published in the Inquiry Journal (please take a look at the dashboard of the Inquiry Journal). In addition to these statistics, it is now possible to track citations, attention in the news media, and even social media activity for individual items using the PlumX Metrics using this guide.

Worldwide viewership of the Inquiry Journal (Jan-May, 2023)