



FALL UNDERGRADUATE RESEARCH FAIR

Information Booklet

Thursday, October 27, 2022
Jordan Hall of Science
University of Notre Dame



UNIVERSITY OF
NOTRE DAME

SCIENCE

College of Science – Fall Undergraduate Research Fair 2022

Welcome!

The purpose of this event is to provide science students with an opportunity to get many of their questions answered about undergraduate research. Not only about how to get more involved in research, but also how to get more out of the research experience itself.

Throughout and beyond the College of Science, there are many different ways in which students can get involved in research. Often it's just a question of looking in the right places and being persistent in the hunt for the right opportunity. However, getting the right opportunity is also about getting as much information as possible from a diversity of sources. This could be as simple as a fellow student but there are many organizations, institutes, and centers on campus that are also more than willing to help a student find and support their research endeavors. Furthermore, there are many ways for students to get even more out of their research experience, through publishing and presenting their research to their peers.

Through a combination of listening to speakers, poster presenters, and representatives from various institutions, students should be able to get some ideas about how best to get started looking for research opportunities. Also, students should be able to see how they can add value to their research experience by participating in other related activities. The sooner a student begins the search, the sooner they will be able to start participating in undergraduate research and getting the most from that experience!

Thursday Oct 27th, 2022 | Jordan Hall of Science

6 – 7 pm: Phi Beta Kappa Lecture, **105 Jordan**

Joseph Francisco, Ph.D., Distinguished Professor, University of Pennsylvania
President of the American Chemical Society (ACS)

7 – 8 pm: Information tables and research posters, **Galleria**

8 – 9 pm: Undergraduate Research Internship Information Night, **101 Jordan**

T. Mark Olsen, Ph.D. Associate Teaching Professor, Department of Biological Sciences

Undergraduate Research Opportunities in Chemistry, **105 Jordan**

Steven Wietstock, Ph.D., Teaching Professor, Department of Chemistry & Biochemistry

Information Tables – Jordan Galleria

Berthiaume Institute for Precision Health | precisionhealth.nd.edu

Institute for Precision Health is a community of affiliated researchers who tackle a wide range of biomedical and environmental health through innovation, invention, and real-world applications.

IPH awards two undergraduate Feinstein Institute for Medical Research (FIMR) – Precision Medicine Research Fellowships. These fellowships are competitive awards given to highly qualified undergraduate and graduate students from Notre Dame that enable them to spend eight weeks in summer residence conducting laboratory and clinical research at the Feinstein Institute in Manhasset, New York. The fellowships are concurrent with FIMR’s existing visiting scholars program, which takes place from approximately June 1 to July 31 each year. Each student receives a stipend to cover daily living expenses. The cost of transportation to and from FIMR and their home or campus is covered (within reason and subject to approval). The Feinstein Institute provides apartment housing on the institute’s campus, which is a 30-minute train ride from New York City, at no cost to the fellows. These fellowships afford Notre Dame Students an opportunity to experience hands-on research in a world-class setting.

Contact: Corrine Hornbeck chornbec@nd.edu, Administrative Assistant

Eck Institute for Global Health | globalhealth.nd.edu

The Eck Institute for Global Health (EIGH) is a university-wide enterprise that recognizes health as a fundamental human right and endeavors to promote research, training, and service to advance health standards for all people, especially people in low and middle-income countries, who are disproportionately impacted by preventable diseases. The EIGH is a cross-disciplinary group of faculty whose research and teaching are dedicated toward finding and implementing solutions to global health challenges. Over 85 faculty serve the Institute’s global mission to promote research, training and service. Education and training opportunities within the EIGH include the Global Health Case Competition, the Master of Science in Global Health program, and the Global Health Research Associate program. The EIGH also offers funding for research and travel for faculty and students including graduate student fellowships, Travel Grants for Research, and the Undergraduate Research Support Program.

Contact: Kelly Thomson kthomson@nd.edu, Institute Coordinator

Flatley Center for Undergraduate Scholarly Engagement (CUSE) | cuse.nd.edu

The Flatley Center for Undergraduate Scholarly Engagement, or CUSE, guides Notre Dame undergraduates in the process of scholarly discernment and advises them on how best to identify or create opportunities for experiential learning, especially research; secure University and external funding to support such opportunities; and prepare competitive applications for national fellowships, all with the aim of transforming themselves and their communities in the pursuit of human flourishing and the common good.

Contact: Kathleen Schuler cuse@nd.edu, Assistant Director for Student Engagement

Harper Cancer Research Institute | HarperCancer.nd.edu

Investigators in the Harper Cancer Research Institute (HCRI) are dedicated to conducting innovative and integrative basic cancer research that confronts the complex challenges of cancer. HCRI utilizes an interdisciplinary approach to cancer research. Students in our labs work across scientific fields on project collaborations. Over sixty HCRI faculty members bridge the College of Science, College of Engineering, College of Arts and Letters, and the Indiana University School of Medicine-South Bend. Some of the research projects currently taking place on campus involve using nanotechnology to better target chemotherapeutics, searching for new cancer markers and targets, reducing side effects of chemotherapy, and developing less expensive and more accurate diagnostics. Research cures cancer.

Contact: Angela Cavalieri cavalieri.2@nd.edu, External Relations and Special Events Program Coordinator.

Hillebrand Center for Compassionate Care | compassionatecare.nd.edu

The Hillebrand Center at Notre Dame works to restore the spirit of compassion in healthcare by advancing the application of the science of compassion at every level of medical training and practice to transform clinician well-being and patient care.

Contact: Rose Carroll rcarrol4@nd.edu, Operations and Strategic Coordinator

Indiana University School of Medicine – South Bend | medicine.iu.edu/southbend

Indiana University School of Medicine – South Bend (IUSM-SB) is a regional campus of the Indiana University School of Medicine. This four-year regional campus is located on the corner of Angela Blvd. and Notre Dame Avenue across from the main entrance to the University of Notre Dame (UND) campus. Our campus offers research opportunities for undergraduates in the basic sciences, Biology, Chemistry, and Biochemistry with an emphasis on medically related research projects in cancer, infectious disease, and neurosciences. The research programs are led by IUSM-SB faculty members who have adjunct ND Faculty positions and consist of ND undergraduates, ND graduate students, and IUSM-SB post-doctoral fellows and technical staff. Information on research opportunities and the various laboratories can be found at medicine.iu.edu/southbend/research/research-faculty

Contact: Jenifer Prosperi jprosper@nd.edu or jrprospe@iupui.edu, Associate Professor

Institute for Scholarship in the Liberal Arts (ISLA)

The Institute for Scholarship in Liberal Arts provides grants to students who wish to pursue independent research or creative projects. Together with the College of Science, ISLA also offers the DaVinci Multidisciplinary Summer Grants for those students who wish to engage in research or creative projects that cross the traditional boundaries between the sciences and the liberal arts. These grants are open to College of Science/Arts and Letters double majors as well as those students who have a minor in the College of Arts and Letters.

Contact: Sevda Arslan sarслан@nd.edu, Program Manager

Kellogg Institute for International Studies

The Kellogg Institute for International Studies engages an interdisciplinary community of scholars in research and education on the critical challenges of democracy and human development around the globe. Kellogg Institute student programs allow exceptional undergraduates to focus and develop their international interests and scholarly abilities. Research grants, fellowships and internships complement the Kellogg International Scholars Program, which matches students with faculty in a unique research perspective. Internships and fellowships provide undergraduates with hands-on experiences in the developing world that can be transformative. Such encounters prepare students for the International Development Studies minor and for independent field research. Students can present their research at the annual Human Development Conference in the spring. More information about the Institute can be found at kellogg.nd.edu

Contact: Holly Rivers hrrivers@nd.edu, Associate Director

Rachel Thiel rthiel@nd.edu, Program Coordinator

Meruelo Family Center for Career Development | undergradcareers.nd.edu

The Meruelo Family Center for Career Development provides undergraduate students with career counseling and career development services, self-assessments, workshops, career fairs, and mock interviews, in addition to other services. We encourage students to take ownership of their career direction, and be willing to devote the time and energy necessary to conduct a successful search for jobs, internships, fellowships, and/or the identification of graduate school programs. Students have the opportunity to utilize our online databases, including Handshake, to pursue postgraduate opportunities, sign up for interviews, and conduct career-related research.

Contact: Karen Manier kmanier@nd.edu, Career Counselor and Assistant Director

Museum of Biodiversity | biodiversity.nd.edu

The Museum of Biodiversity, located near the northern end of Jordan Hall, showcases the Department of Biological Sciences' extensive collection of fossils, amphibians, fishes, birds, mammals, and insects that have been collected over the last 150 years. As part of the museum, the herbarium preserves the scientifically important collection of dried and pressed plants of the Greene-Nieuwland Herbarium. There are many opportunities for undergraduate research projects including identification and organization of specimens contained in museum collections, development of databases of plants and animals and their distributions, identification of rare, endangered, or invasive species, and development of thematic displays. Projects can be supported by the Robert E. Gordon Museum of Biodiversity Undergraduate Research Support Fund.

Contact: Barbara Hellenthal bhellent@nd.edu, Curator

Ron Hellenthal Ronald.A.Hellenthal.1@nd.edu, Director and Emeritus Professor.

Nanovic Institute for European Studies | nanovic.nd.edu

The Nanovic Institute for European Studies is committed to enriching the intellectual culture of Notre Dame by creating an integrated, interdisciplinary home for students and faculty to explore the evolving ideas, cultures, beliefs, and institutions that shape Europe today. We help students from the College of Science plan and conduct focused, original scientific research in Europe. We support high-quality European internships in laboratories and other scientific settings and make it possible for you to immerse yourself in local languages, to live among Europeans, and to see the world from a different perspective. Our students return to Notre Dame transformed with a new sense of confidence, awareness, and maturity that helps them to succeed. Note that science internships should have some European policy, culture, or other aspects to be most competitive for Nanovic funding. Students are welcome to visit for advice on applications and opportunities. For more information on the Nanovic Institute and our undergraduate grant programs, please go to nanovic.nd.edu.

Contact: Anna Dolezal adolezal@nd.edu Student Programs and Assistant Manager

ND Energy | Center for Sustainable Energy at Notre Dame | energy.nd.edu

ND Energy's mission is to build a better world by creating new energy technologies and systems and educating individuals to help solve the most critical energy challenges facing our world today. ND Energy engages undergraduate students in energy-related research and education programs, including the Vincent P. Slatt Fellowship for Undergraduate Research in Energy Systems and Processes, the Energy Studies Minor, and the Student Energy Board. These programs prepare students to become successful leaders who understand the complexities of society's energy challenges and the global energy economy. Learn more at energy.nd.edu.

Contact: Anne Berges Pillai apillai@nd.edu, Education and Outreach Associate Program Director

Barbara Villarosa bvillaro@nd.edu, Business and Communications Program Director

Notre Dame Nanoscience and Technology | nano.nd.edu

Notre Dame Nanoscience and Technology (NDnano) promotes collaborative research in science and engineering. The Center's 80+ affiliated faculty members work to address unsolved scientific and technical questions with an aim to promote the greater good.

Each year, NDnano awards several paid fellowships to undergraduate students who will spend 10 weeks of their summer engaged in an [on-campus research project](#) mentored by one of the Center's faculty. To date, nearly 300 students from Notre Dame and several other universities in the U.S. and abroad have participated in the program, gaining valuable research skills and experience.

Contact: Heidi Deethardt deethardt.1@nd.edu, NDnano Center Coordinator

Notre Dame Integrated Imaging Facility (NDIIF)

The Notre Dame Integrated Imaging Facility (NDIIF) is a state-of-the-art research core facility within Notre Dame Research that consolidates the University's imaging capacity and augments it with powerful new imaging

modalities. The NDIIF creates an interactive network of research groups who are connected by their interest in imaging technology and allows them to cross-fertilize ideas and form interdisciplinary collaborations. The Imaging Facility makes available to the Notre Dame science and engineering community an integrated suite of sophisticated microscopes and imaging stations that enable expert users to attack the most complex modern research problems and, equally important, resident professional staff (technicians and research specialists) to guide the non-expert users and allow them to conduct experiments that were previously beyond their limits. The NDIIF brings together two conceptually different groups of science and engineering researchers, the inventors who design new materials and techniques and seek research problems that will test their inventions, and the discoverers who are always looking for improved technologies that can better test their hypotheses of how things work. Learn more at imaging.nd.edu/

Contact: Sarah Chapman VanHouten Sarah.Chapman@nd.edu, Associate Director

Reilly Center

The John J. Reilly Center at the University of Notre Dame offers graduate and undergraduate programs and fosters scholarly conversation at the intersections between the humanities and social sciences, and the sciences and medicine.

Contact: Anna Geltzer ageltzer@nd.edu, Associate Director

Scientia | scientia.nd.edu

Scientia, ND's own student-run Undergraduate Journal of Scientific Research, is looking for student reviewers and news writers for this year's publication. Reviewers should have some research experience and be interested in reading, critiquing, and commenting on student research writing. News writers can be from any discipline and must simply want to write about some of the important and interesting things happening in the College of Science.

Contact: Emily Hunt ehunt6@nd.edu, Alex Noble anoble3@nd.edu

University of Notre Dame Environmental Research Center (UNDERC) | underc.nd.edu

Celebrating over forty years of environmental education and research, UNDERC provides students with a unique opportunity to not only take part in hands-on field courses in environmental biology, but also the chance to gain invaluable experience in field research. UNDERC provides two opportunities to promote understanding of field biology and how field research is conducted through 10 weeks in the wilds. Our Track 1 opportunity is designed for students wanting to gain initial experience in field biology where they can gain an introduction to the concepts and methodology while conducting a collaborative research project with other students in the program. Our Track 2 opportunity is designed for undergraduates with prior research experience at UNDERC (including Track 1) or elsewhere that would like to conduct an independent research project under the mentorship of UNDERC scientists. Each Track would include housing, travel between the Notre Dame campus and UNDERC, and a stipend.

Contact: Michael Cramer mcramer@nd.edu, Assistant Director

Poster Abstracts

Examining the Effect of Redundant Encoding Cues within an Episodic Memory Behavioral Task Between Young and Older Adults

Margaret Allen

Major: Neuroscience and Behavior

Advisor: Dr. Joshua Koen, PhD, Department of Psychology, University of Notre Dame Coauthors:

Episodic memory, or memory for unique experiences, is an important feature of human memory. Episodic memory is most commonly measured using a recognition memory test in which participants identify stimuli they studied as ‘old’ and those they have not as ‘new’. Memory on these tasks can be supported by recollection (i.e., retrieval of specific details about an event) and familiarity (i.e., a general feeling that an event has been experienced in the past). Age-related declines in recollection are often observed on source memory tests which require participants to recall a single, controlled detail. Previous literature suggests that these source memory deficits are not consistently observed. The mixed findings may be due to across-study differences in the redundancy of source features. Thus, the current study seeks to investigate how encoding factors impact episodic memory using redundant cues surrounding semantic judgments made on a list of words. In this study, 48 young (age 18-30) and older (age 65-80) adults will study nouns in high redundancy and low redundancy conditions. The high redundancy condition will have multiple unique features which overlap with the same semantic judgment (e.g., a red square signals a shoebox judgment should be made with the right hand), allowing memory for one feature to lead to memory for all. The low redundancy condition will have single unique features which will not reinforce one another. Source memory performance will be analyzed with a 2 (age group) x 2 (redundancy) mixed factorial analysis of variance. It is predicted that age differences across the tasks will be present, specifically that young adults will have increased source memory accuracy within the task compared to older adults. However, it is anticipated that the high redundancy condition will minimize age-related differences, as older adults will perform better in the high redundancy condition compared to the low redundancy. Therefore, this study can reveal how multiple cues for a singular stimuli may potentially benefit human episodic memory when examining deficits due to aging.

What inspired you to participate in undergraduate research?

“I first became involved in research as I wanted to develop my scientific skills in application to novel discoveries and questions outside of a lecture environment. I knew that I wanted to pursue postgraduate scientific studies (medical school), so I wanted to begin to develop research skills as an undergraduate in preparation for future goals. Research can be challenging, but the takeaways and development as a student is very impactful.”

How did you get your research position, and what preparation did you undertake for it?

“During my sophomore year of studies at Notre Dame, I reached out to the MAC Lab to join as I felt that the research methods and goals fit my academic interests. I had a little over a year completed within my academic studies which allowed me to have background skills in critical thinking, scientific inquiry, and basic research methods from laboratory courses. Once accepted, I began to read the past publications from the lab and review the common methods used so I could better understand and assist within the current studies and overall lab goals.”

Where was your research experience located?

“Memory, Aging, and Cognition Lab, University of Notre Dame”

What did you get out of your research experience?

“I learned how to conduct scientific research in a team setting of PhDs, graduate students, and other undergraduate students. Scientific teamwork is incredibly important, so this is a great skill to develop early on.

The Role of FOXA1 in Prostate Cancer Aggression and Cytoskeletal Morphology

Ariana Arce
Biological Sciences

Advisor: Xin Lu, Department of Biological Sciences, University of Notre Dame Coauthors: None

Prostate cancer is the most common cancer found in men across the world, with mutations of the FOXA1 transcription factor being some of the most common mutations that affect an individual's overall prognosis. However, the specific role that FOXA1 plays in an individual's prognosis is not well understood. This study aims to develop a deeper understanding of the role the 3 most common FOXA1 mutations play in the progression of prostate cancer. Using live cell imaging and Lumaquant analysis, it is clear that the FOXA1 mutants cause an increase in cell to cell communication, an increase in cell velocity, and faster growth. Analysis of the collected images also shows that there are significant cytoskeletal changes. To understand which cytoskeletal pathways have been affected, a pathway analysis as well as gene analysis via qPCR were performed on 13 genes related to pathways the Sonic hedgehog pathway, axon guidance, and cell motility. Preliminary results conclude that there could be some significant changes in gene expression relating to all 3 pathways.

What inspired you to participate in undergraduate research?

I love the process of research, especially in relation to medicine and biomedical sciences. I find it extremely rewarding to know that the research I'm doing on prostate cancer could have some kind of effect on how patients get treated.

How did you get your research position, and what preparation did you undertake for it?

I joined the Lu Lab in the fall of 2020 and I've been working alongside my grad student mentor Orson Liu since I started. I took over the FOXA1 project this summer which was really lovely because I was already familiar with the project and got to lead it in a new direction when I took over.

Where was your research experience located?

University of Notre Dame

What did you get out of your research experience?

I further confirmed that I love the process of researching and it cemented in my mind that grad school is the next right decision for me. I also became so much more confident in myself as a scientist which has made the process of research even more fun.

**Effects of Kinase Inhibition on the Formation of Biomolecular Condensates,
Microtubule-Regulating Structures Composed of Plus-End Tracking Proteins**

Noah Baca

Major: Biological Sciences

Advisor: Holly Goodson, Dept. of Chemistry and Biochemistry, University of Notre
Dame

Co-authors: None

Microtubule plus-end tracking proteins (+TIPs) are a family of structurally distinct and evolutionarily conserved proteins that accumulate at and dynamically track the growing end of cellular microtubules (MTs). +TIPs will generally affect the shape and position of microtubule networks and thus have a significant impact on important cellular processes such as cell division, motility, and morphogenesis. In a recent study, the Goodson lab has shown that +TIPs can bind to other +TIPs to form biomolecular condensates, membraneless structures within the cell organized by energy-dependent interactions of macromolecules. Biomolecular condensates and the +TIPs that compose them can regulate the growth and decay of MT ends and are thus critical modulators of important cell processes. To examine the regulatory properties of +TIP biomolecular condensates, kinases that control the activation or inactivation of known +TIPs were inhibited via drug treatment. The effects of varying concentrations of wortmannin and SB216763 have been tested in cells that overexpress the plus-end tracking protein CLIP-170. Drug experimentation studies are ongoing to develop a comprehensive model that relates kinase inhibition, condensate formation, and MT growth.

What inspired you to participate in undergraduate research?

My dream as a kid was to be a scientist, and so I was always looking to be a member of a research lab while in college. There is something so inherently special about the process of complex experimentation and study that drove me towards research.

How did you get your research position, and what preparation did you undertake for it?

During the COVID-19 pandemic, research opportunities at the university were few and far between. I sent emails constantly to nearly every PI in the College of Science until I found a lab that was willing to accept me. My persistence paid off. In terms of preparation, I worked hard both in key courses applicable to my field of study (e.g., Biochemistry) and undertook a semester of library research (reading scientific papers) in order to prepare me for lab work.

Where was your research experience located?

The University of Notre Dame

What did you get out of your research experience?

Dedicating a continuous chunk of time to research before my hopeful matriculation to medical school has allowed me to lay the foundation for a career as a physician scientist. I have developed tremendously, both in my technical skill in the lab and in virtues such as exploration, inquisition, and curiosity. Furthermore, I have learned how to operate independently, and how to think creatively in a scientific setting.

Efficacy of rAAV9 Gene Therapy in treating mice with Non-Ketotic Hyperglycinemia

Adviti Bali

Major: Biochemistry

Advisor: Dr. Kasturi Haldar, Dept. of Biological Sciences, University of Notre Dame

Coauthors: Caroline Bickerton, Shaun Calhoun, Prasad Padmanabhan, Alejandro Lopez

Ramirez, Suhail Alam, Kasturi Haldar

Nonketotic hyperglycinemia (NKH) is a rare neurometabolic disorder caused by autosomal recessive defects in the genes encoding the glycine cleavage system (GCS), resulting in elevation of glycine in the blood and brain. Severe disease manifests within the first two weeks of life and causes epileptic seizures, hypotonia, and developmental delays. 85% of NKH cases stem from a genetic defect in Glycine decarboxylase (Gldc), which encodes the GLDC or P-protein that catalyzes the first step of glycine cleavage. We used CRISPR-Cas9 technology to genetically engineer mice with the p.A394V mutation (mouse orthologue to a prevalent patient mutation p.A389V) to deliver the first mutation-based mouse model with significant cerebral and systemic disease (Farris et al., 2021). Due to the early development of severe phenotypes, we investigated gene therapy intervention for NKH. We designed a novel AAV9 viral vector recombinant with a copy of wild-type Gldc driven by constitutive promoter to examine consequences for systemic metabolic and severe neurological disease as well as death from NKH in an age-dependent way. Mutant mice, post-weaning (P25 – P36) injected systemically with rAAV9 virus particles and tracked for 5 months post-injection showed significantly decreased plasma glycine levels compared to their control counterparts. To address severe neurogenic outcomes and survival, pre-weaned mice (P0 – P2) were injected with rAAV9 virus particle dose adjusted for mice age and weight. Our results show a significant increase in recovery of NKH mutants from cerebral disease as well as survival (as measured at P60, when the mice are adults). Our studies suggest that rAAV9 gene therapy has the potential for treating both neurological and metabolic disruptions characteristic of NKH disease.

What inspired you to participate in undergraduate research?

I have always been interested in rare diseases since they do not get the recognition they deserve. The lack of awareness and research on rare diseases drove me toward it.

How did you get your research position, and what preparation did you undertake for it?

I have been a part of the Haldar Lab since 2020. COVID disrupted my benchwork and for some part of the time, I could only undertake computational analyses of metabolomic changes in NKH mutant mouse plasma. In total, I've spent four academic semesters and two summers doing metabolic and gene therapy research in preclinical mouse models of NKH.

Where was your research experience located?

The University of Notre Dame.

What did you get out of your research experience?

An opportunity to step into the shoes of a graduate student and work on independent experiments. It gave me a chance to think and write scientifically as well as troubleshoot my experiments.

Analysis of the Crystallization of Fe_{77.5}B₁₅Si_{7.5} Metallic Glass

Konstantin Bauer

Major: Physics

Advisor: Professor Khachatur Manukyan, Dept. of Physics, University of Notre Dame Coauthors: none

The aim of this study was to examine the methods and behavior of the crystallization of the metallic glass Fe_{77.5}B₁₅Si_{7.5} after being exposed to either an argon ion beam or being annealed. The crystallization process was studied through the use of differential scanning calorimetry, x-ray diffraction analysis, transmission electron microscopy, and elemental dispersive spectroscopy. It was found that crystallization due to irradiation and due to annealing resulted in different structures of the crystallized material. The irradiated samples showed larger, more jagged and directional grains that seemed to originate at sites of short-range order. The annealed samples showed smaller, rounder grains that were scattered all over the material. Further, it was found that crystallization due to annealing takes place in two distinct steps: the first being surface crystallization (the initial formation of grains on the surface of the samples) and the second being the propagation of these grains throughout the samples. These differing structures will potentially reveal different mechanical properties and applications in future tests.

What inspired you to participate in undergraduate research?

I was interested to see what conducting research was like and wanted to see if it would be something that I enjoy. Further, I was interested to learn about the process of experimentation and applying knowledge and theory to data in order to obtain results and make discoveries.

How did you get your research position, and what preparation did you undertake for it?

Over winter break of freshman year, I looked on the Physics Department's website to read about what research different professors were doing. I found that Prof. Manukyan's research was interesting, sent him an email, and soon after started to do research with him. I continued to do research with him over the summer as a part of Notre Dame's Physics REU. My preparation included doing a couple lab safety modules and being trained on the different instruments I used to conduct research.

Where was your research experience located?

University of Notre Dame

What did you get out of your research experience?

I learned a lot about the ins and outs of the research process. Especially over the summer, I learned what the day-to-day process of doing research was like. I also gained a lot of experience in learning how to use certain apparatuses, and I also learned how to read and interpret many different types of data. Further, research has been a good way to learn about some topics I usually wouldn't get exposure to.

Investigating the Molecular Evolution of Dynein and the Dynactin Complex

Sarah Bohling

Major: Biochemistry

Concentration: Honors

Advisor: Holly Goodson, Dept. of Chemistry and Biochemistry, University of Notre Dame

The last eukaryotic common ancestor, LECA, is the progenitor of all eukaryotic organisms. We can learn about LECA through the study of early diverging organisms, and understanding the cell biology of LECA can provide insight into the cell biology of all eukaryotes. Red algae diverged from the lineage leading to green plants over 1 billion years ago. The cytoskeleton is essential for key cellular processes including cell division, intracellular transport, and cell motility. Therefore, learning more about the cytoskeleton of red algae could provide insight into the biology of LECA and thus into the function of cytoskeletal proteins in all eukaryotic cells. My work uses bioinformatic and computational biology approaches to identify the molecular motor cytoplasmic dynein and its accessory dynactin complex in both red algae and their phagotrophic sister phylum Rhodelphis. This work is interesting because until recently, plants (including red algae) were thought to completely lack cytoplasmic dynein/dynactin, and it was often assumed that these proteins were limited to the clade containing animals and fungi. Our work shows that dynein is found in Rhodelphis and several clades of red algae; consistent with this observation, several components of the dynactin complex are found in these organisms as well. This observation shows that cytoplasmic dynein existed in at least the common ancestor of plants and animals/fungi. Interestingly, some red algae (Atlantic *Porphyra umbilicalis* and its Pacific relatives) seem to be in the process of losing their dynein proteins, as the dynein motor is present, but divergent, and dynactin complex proteins are either difficult to recognize or absent. Future studies will look at the relationship between dynein and dynactin complex proteins in red algae and other divergent organisms to gain a better understanding of the cell biology of LECA.

What inspired you to participate in undergraduate research?

Designing my own experiment in the Biology M2E Research Experience my Freshman year inspired me to join a research lab as I was excited to design my own experiments to answer questions that I am interested in.

How did you get your research position, and what preparation did you undertake for it?

I joined the Goodson Lab Group in December of 2020 after reading about the research being done by the Goodson Lab online and sending a few emails stating my interest in joining the lab and my desire to work with the Goodson Lab on the molecular evolution project. In preparation for beginning research, I read all of the published papers by the Goodson Lab relating to the molecular evolution project, as well as asked for reading recommendations from Dr. Goodson, so that I could gain an understanding of what progress has been made on the project and what questions we currently are addressing. I continued my academic-year research through the summer of 2021 and the summer of 2022 with the support of the Notre Dame COS-SURF 2021 grant and COS-SURF 2022 grant.

Where was your research experience located?

My research was located in the Goodson Lab at the University of Notre Dame!

What did you get out of your research experience?

I spent two amazing summers at Notre Dame and grew as a scholar through gaining an understanding of how to formulate research questions, design experiments, problem solve, use key laboratory techniques, operate common laboratory machinery, write grant proposals, and present my research via an academic poster presentation. My research in the Goodson Lab also helped me discern my future career plans as I am planning to pursue a Ph.D. in the general field of biochemistry!

COVID-19 Isolation and Marital Relationships: What Coping Mechanisms Led to Better Daily Affect in Marriage?

Grace Bradley

Major: Neuroscience and Behavior

Advisor: Dr. Cindy S. Bergeman, Dept. of Psychology, University of Notre Dame

Coauthors: none

The novel coronavirus (severe acute respiratory syndrome coronavirus 2 or SARS-CoV-2, better known as COVID-19) spread worldwide beginning in late 2019, causing a pandemic that completely shut down several countries. This rapidly changed the normal routines of 95% of Americans' lifestyles and caused an increase in daily stress, attributed to the world's instability of not knowing what long-term impact COVID-19 would have. Prolonged stress has a negative impact on overall health and longevity. Because of this, researchers wanted to see how the combination of pandemic worry and previously-existing stress would impact daily affect. This study researched the specific impacts of COVID-19 pandemic stress and marital relationships during the COVID-19 lockdown period starting in August 2020 through the present. This research is important because it could help predict how couples react to severe stress and what qualities and coping mechanisms could best preserve a marriage and increase daily affect. We hypothesized that the participants who used healthier coping mechanisms, such as prayer or exercise to deal with stress, would have higher daily affect. In turn, these levels of higher daily affect were predicted to lead to lower levels of perceived stress and pandemic worry. The culmination of these values was expected to lead to happier marital relationships and lower instances of arguments or domestic violence. The measurements of the research studied the connections between pandemic worry levels, daily positive or negative affect, and coping mechanisms. Further, the strains on marital relationships measured during the pandemic were correlated with the coping mechanisms that were used, documented in the Notre Dame Health and Well-Being Global Questionnaires and COVID Daily Diaries. We expected overall increased positive effect levels seen in the data because participants from the Spring 2022 Data Wave 5 were currently in the tail-end of the pandemic, where most, if not all, masking and social distancing protocols were ending. The study also predicted that participants with healthier coping mechanisms, such as discussing apprehension or using prayer or exercise to reduce stress levels, would have better marital relationships throughout similar high-stress situations, resulting in fewer domestic violence incidents.

What inspired you to participate in undergraduate research?

"I love Neuroscience and Behavior because it allows me to understand why people behave the way they do. I wanted to further pursue this by looking at coping behaviors during the COVID pandemic in my lab!"

How did you get your research position, and what preparation did you undertake for it?

"In the winter of 2020, I began looking for research labs that would be open, as the COVID pandemic had largely closed the research labs on campus. When I was researching potential labs in wellbeing, I asked to set up a meeting with Dr. Bergeman to discuss my participation in the lab."

Where was your research experience located?

"University of Notre Dame"

What did you get out of your research experience?

"I had a wonderful three semesters at Notre Dame, as well as this past summer and this fall and spring! I loved meeting the lovely women in my lab, discussing the different facets of the scientific method. Additionally, I learned how to take a passing question and turn it into an entire senior thesis with empirical results."

Radiation Hydrodynamics Modeling With High-Order Implicit Shock Tracking

Evan M. Bursch

Majors: Physics, Philosophy, Theology

Advisors: Matthew J. Zahr, Ryan G. McClarren, Dept. of Aerospace and Mechanical Engineering, University of Notre Dame

Coauthors: M. J. Zahr, R. G. McClarren

Traditional methods for modeling radiation hydrodynamics can present problems when encountering discontinuities. By leveraging shock tracking, an alternative method to shock capturing, we aim to generate a mesh such that element faces align with shock surfaces and other non-smooth features to perfectly represent them with the inter-element jumps in the solution basis, e.g., in the context of a finite volume or discontinuous Galerkin (DG) discretization. These methods lead to high-order approximations of high-speed flows and do not require nonlinear stabilization or extensive refinement in non-smooth regions. Once the mesh tracks the nonsmooth features, the high-order solution basis approximates the remaining smooth features.

In this talk, we demonstrate the viability of radiation hydrodynamics modeling using the High-Order Implicit Shock Tracking (HOIST) method that re-casts the geometrically complex problem of generating a mesh that conforms to all discontinuity surfaces as a PDE-constrained optimization problem. The optimization problem seeks to determine the mesh's flow solution and nodal coordinates that simultaneously minimize an error-based indicator function and satisfy the discrete flow equations. A DG discretization of the governing equations is used as the PDE constraint to equip the discretization with desirable properties: conservation, stability, and high order accuracy. By using high-order elements, curved meshes are obtained that track curved shock surfaces to high-order accuracy. The optimization problem is solved using a sequential quadratic programming method that simultaneously converges the mesh and DG solution, which is critical to avoid nonlinear stability issues that would come from computing a DG solution on an un-converged (non-aligned) mesh. The method is used to solve several well-known problems in radiation hydrodynamics including subsonic Marshak waves and radiation shock solutions.

What inspired you to participate in undergraduate research?

I am passionate about exploring new areas of physics in general, but I am especially interested in nuclear fusion. I firmly believe it is the future of our world's energy and space travel needs and the progress being made should be both encouraging and inspiring to everyone.

How did you get your research position, and what preparation did you undertake for it? I emailed a number of Notre Dame professors hoping to find someone to do nuclear fusion research. After a number of meetings and recommendations, I was able to connect with Professor McClarren and Professor Zahr.

Where was your research experience located?

University of Notre Dame

What did you get out of your research experience?

Throughout my research, I have learned a great deal about what it means to be a researcher. This includes computational skills, reading journal articles, writing proposals, and presenting at conferences. Both of my research advisors have been fantastic mentors and I am very grateful for the opportunity to work with them.

What the heck does a honey bee do with a non-hexagonal cell?

Gabriela Cano

Major: Biological Sciences

Advisors: Michael L. Smith and Peter Marting, Dept. of Biological Sciences, Auburn University

Coauthors: Olivia Smith

Honey bees are some of nature's best known architects. Their nests are built for maximum stability and storage but with the least amount of materials necessary. Their regular hexagonal comb shape is designed to fulfill these requirements, but on occasion, there are factors that affect the integrity of the structure. These factors include when combs built by different bees have to be merged, accounting for the size difference between drone and worker comb, and building around irregular surfaces in their natural environments. To account for these factors, bees will build irregularly shaped cells with 4, 5, 7, or 8-sided cells. Since bees use their comb for storage, the purpose of this study was to elucidate what these irregular cells were being used for. Using a variety of labeling programs, the contents of the cells were identified and imported into a Python dataframe for further analysis. The results of the study indicated that 4 and 8-sided cells are never used for any storage. The 5 and 7-sided cells were used more variably. Through this study, it was determined that bees still use these irregularly shaped cells despite their "imperfections."

What inspired you to participate in undergraduate research?

I have been interested in behavioral ecology since I was enrolled in the course, and through this opportunity, I was able to explore the research side of the subject.

How did you get your research position, and what preparation did you undertake for it?

I applied to the NSF Warm-Water Aquatic Ecology Research Experience for Undergraduates program and was matched with Dr. Smith and Dr. Marting to develop a research project surrounding bees and behavioral ecology.

Where was your research experience located?

Auburn University

What did you get out of your research experience?

I was able to meet a lot of new and very interesting people with a diverse set of skills and backgrounds! It was an incredible experience that taught me how to ask good research questions, and furthermore, how to investigate them thoroughly and efficiently. I also developed my presentation skills and ability to convey my research to a broad audience through outreach events in the program.

Production of Metastable fcc Cobalt

Advisor: Khachatur Manukyan

Cobalt (Co) is widely used as a material in technological devices and as a catalyst in chemical processes. Depending on which crystalline form it is in, face-centered cubic (fcc) or hexagonal close packed (hcp), unique electromagnetic properties arise. Using molecular dynamics (MD) simulations, this study aims to crystallize both bulk and nanoparticle Co material from amorphous solid to produce high yield fcc structures. An external fcc seed is used to promote fcc crystal growth in both structures and crystallized sphere seeds are placed within an amorphous nanoparticle to model nucleation sites. In the bulk structure, the final fcc percentage, after thermalizing at 1000K with an external seed, ranged from 77-97% depending on the pressure. In 3 of the 4 pressures (0.1, 1, 10, 100 MPa), this produced an additional 15-31% fcc fraction compared to thermalizing without the seed, indicating that the seed helps form fcc structure. In the nanoparticle with a 5 nm radius, the spherical seeds did not significantly influence fcc yield. In all of the nanoparticle simulations, approximately 49% fcc atoms were produced. The difference in fcc yield between the bulk structure and nanoparticle is likely a result of the disparate surface area to volume ratio between the structures which favors the hcp → fcc transition in the bulk case.

What inspired you to participate in undergraduate research?

I was very curious about the natural world and wanted to learn more about what research is actually like.

Where was your research experience located?

University of Notre Dame

What did you get out of your research experience?

I learned a lot about how the theoretical physics I learned in class is actually applied. Seeing some of the concepts I was learning in modern physics apply to machines and techniques such as X-ray diffraction and fluorescence was extremely cool. I also improved my listening skills and ability to ask important questions to understand a process. Overall, my analysis skills increased a lot.

Coping with COVID-19: The Relationship of Interpersonal Mindfulness and Parent Adjustment to the Pandemic

Jessica Davis

Major: Neuroscience and Behavior

Advisors: Julie Braungart-Rieker, Department of Human Development and Family Studies, Colorado State
Emily LaPorte, Department of Psychology, University of Notre Dame

Coauthors: Megan J. Moran, Samantha A. Murray, Emily LaPorte, Rachel G. Lucas-Thompson, and Julie Braungart-Rieker

Throughout the COVID-19 pandemic, parents and children alike have struggled to adapt to a new normal. The pandemic has introduced momentous changes to every aspect of parents' lives. One of the ways that parents sustain mental wellness is through the practice of mindfulness, which involves the focusing of one's attention on what one is presently experiencing in an open and accepting manner. Daily mindfulness practices have an extensive span of psychological benefits, such as diminished stress levels, reduced emotional reactivity, and greater attention and better well-being. In my project, I will be examining the measures of the Interpersonal Mindfulness in Parenting Scale and the Coping with Pandemic Parenting author-developed question. This project seeks to investigate how parents cope with the added challenges associated with the COVID-19 pandemic, and if practices of interpersonal mindfulness in parenting are associated with parents coping with the pandemic. The Parenting in the Pandemic Study sample consisted of 217 caregivers, and it was open to any parent in the US with at least one child, aged 4-12. Analyses will be conducted with the Statistical Package for Social Sciences, using a regression analysis to measure associations between interpersonal mindfulness and parent adjustment to the pandemic.

What inspired you to participate in undergraduate research?

My undergraduate research experience provided me the opportunity to pursue my interests under the guidance of professors, leaders, and students, who possess much knowledge and understanding in human development and child psychology. I wanted to learn more about research in psychology, and learn how to effectively communicate my ideas to others.

How did you get your research position, and what preparation did you undertake for it?

I contacted Dr. Braungart-Rieker in the spring of 2020 and inquired about an undergraduate research position in her lab, Notre Dame Families and Babies Study (ND-FABS). She interviewed me, and I was enrolled as a research assistant in the lab August 2020, where I have worked since. In the spring of 2022, I applied and was selected to the Neuroscience and Behavior Honors Program with the support of Dr. Braungart-Rieker and Dr. Sunny Boyd. For this program, I must complete a written thesis and present my thesis findings at a scientific conference. I hope to present my thesis research at FURF.

Where was your research experience located?

University of Notre Dame, William J. Shaw Center for Children and Families, Notre Dame Families and Babies Study (ND-FABS)

What did you get out of your research experience?

Working as a research assistant in the FABS Lab has been such a rewarding experience. In my involvement with the lab, I have sharpened valuable skills that I will utilize in my future, as well as developed many critical-thinking skills. My collaboration and communication skills have greatly improved in interviewing and guiding families during our visits. Working with kids has certainly helped me to be more adaptable, patient, and emotionally responsive. Through my experiences in the lab and working with families, I have realized that interacting with children brings me great joy, and I thoroughly enjoy working with people.

Empirical Measurement Comparison Between CT Scan Imaging and 3D Angio Imaging Technology.

Vivienne Dragun

Major: Biochemistry

Advisor: Dr. Fernando Boccalandro, Dept. of Cardiology, Odessa Regional Medical Center

Coauthors: none

In the past, most non-invasive heart imaging has been done using CT scans. However, these scans are less detailed than desired, and compared to newer 3D angiography technology, the CT images are bulkier to work with because they cannot capture all angles at the same time. Also, the 3D angiography imaging can be manipulated better after patient imaging has occurred, allowing the doctor to view and understand the affected veins or arteries better than with a traditional CT scan. However, to date, the CT scan is known to be the most empirically accurate type of imaging for cardiovascular studies, and the measurements that are gathered from CT scans are widely acknowledged as correct. This project studied the variation in measurements found between 3D angiography images and the CT scan images of the same patient. The Results showed that although the measurements given by each imaging technique were significantly similar ($r^2 > 0.97$) in most of the angles, the measurements of the ICA, or invasive coronary angiography, were not significantly similar ($r^2 < 0.97$). Thus, it was concluded that the 3D imaging is close to being as accurate in measurement as the CT scans, but the technology is still not quite as consistent, and thus the CT scans are still necessary for accurate measurements.

What inspired you to participate in undergraduate research?

I wanted to learn more about how translational research within a hospital takes place and wanted to explore this environment further.

How did you get your research position, and what preparation did you undertake for it?

I got in contact with my advisor, Dr. Fernando Boccalandro, during the spring semester of my sophomore year, as I knew that he conducted interesting research near my hometown. When I asked him if I could participate in research with him over the summer, he agreed.

Where was your research experience located?

Odessa Regional Medical Center in Odessa, Texas

What did you get out of your research experience?

I gained a deeper understanding of what it looks like to do research while simultaneously working as a medical doctor, which was very exposure and experience. I am looking into working in a similar medical field in my future, so experiencing it firsthand was very eye opening!

Examining the Myocardial Contribution of Adamts5 in Valve Development

Isabella Garcia, University of Notre Dame

Dr. Christine B. Kern

MUSC Summer Undergraduate Research Program

Department of Regenerative Medicine and Cell Biology, Medical University of South Carolina, Charleston,
South Carolina

Background – Congenital valve disease derived from developmental malformations, resulting in clinical presentations such as valvular stenosis and regurgitation, can result in increasingly complex cardiac disease or mortality – with no therapeutic courses of treatment currently available. Versican, a proteoglycan critical in the development of valve cusp from the intercalated cushion of the provisional extracellular matrix, is traditionally cleaved by its protease complement, ADAMTS5, for the remodeling of valves during development. It is clinically observed that excess aggregate versican is an associated factor of human fatality from valvular malformation. Appreciating the novel understanding of myocardial contribution to cusp development, as recently published by Kern et al. (2018), the deficiency of ADAMTS5 in cardiomyocytes could be determined through the exploitation of the discovered presence of Tnnt2-Cre derived cells in developing valves, a reporter not previously associated with mesenchymal cells.

Methods – Lineage tracing of cardiomyocytes was performed using Troponin T(Tnnt2)-Cre in tandem with the TdTomato-EGFP reporter in Adamts5^{-/-} mice and Adamts5^{+/+} littermates. For conditional myocardial deletion of ADAMTS5 the Adamts5 floxed allele was used in combination with the Tnnt2-Cre. Recombined (Tnnt2-Cre; Adamts5^{fl/fl}) and wild-type hearts at E14.5 and E17.5 were dissected, paraffin embedded, sectioned, and Hematoxylin and Eosin tissue stained for visual morphological analysis. Immunohistochemistry and confocal microscopy were used to identify versican, EGFP and myocardial cells in heart sections. Amira™ Software was used to generate three-dimensional models of pulmonary and aortic valves from histological sections.

Results – Of the E17.5 Tnnt2-Cre; Adamts5^{fl/fl} Amira™ reconstructions conducted, morphological visual distinctions are detected when compared to their wild-type littermate, including a bicuspid presentation of the aortic valve. However, volumetric measurements did not deviate significantly between the groups. Of the reconstructed E14.5 Tnnt2-Cre; Adamts5^{fl/fl} mice, valve volumes did not deviate significantly between the littermates. However, there is a visually apparent bicuspid aortic valve presentation in a selected wild-type mouse.

Conclusion – In the specific deletion of ADAMTS5 in the myocardium of the developing outflow tract valves, apparent morphological variations occur, namely bicuspid aortic valves, but less significant valvular volume differences are present.

What inspired you to participate in undergraduate research?

Undergraduate research is the perfect platform to explore a niche area of your interest – for me that was human development and embryology. Dr. Kern facilitated my education through immersive problem solving in a rapidly evolving field.

How did you get your research position, and what preparation did you undertake for it?

I applied for the position through MUSC, and was matched with my PI based on my previous research experience.

Where was your research experience located? The Medical University of South Carolina
Charleston, South Carolina

What did you get out of your research experience?

I developed a new passion for human development and a cemented idea of what my future career pursuits may be.

Investigation and Diagnosis of Errors in a Model of Environmental Change

Hayden Gallo

Major: ACMS w/ a concentration in Biological Sciences

Advisor: Jason McLachlan, Dept. of Biological Sciences, University of Notre Dame

Coauthors: Alyssa Willson, PhD Candidate McLachlan Lab, University of Notre Dame

Forest gap models comprise a class of ecological models that simulate the response of forest composition and individual tree recruitment, growth, and mortality to changing climate. Previous work has shown that using species-specific biomass data in conjunction with a forest gap model, LINKAGES, can offer improvements on the understanding of forest composition and structure over long timescales (i.e., decades to centuries). However, LINKAGES systematically underpredicts aboveground biomass when compared to data. This causes the model predictions of forest stand structure and function to be unreliable. Investigations into the model data framework were conducted to understand this persistent negative bias in LINKAGES simulations. To understand and attempt to correct the bias present in the simulations run by LINKAGES a literature review was completed, allowing us to understand prior changes and improvements implemented in the model and to decrease bias. Various forms of uncertainty were systematically explored to understand which sources contributed the most uncertainty to the model. Understanding the effects of these processes and interactions informed changes to the model including changes to allometric equations, spin-up time, and leaf area index. The method by which tree diameter is related to tree height (allometry) was found to have significant impact on aboveground biomass, whereas the length of model spin up did not produce changes to the bias of aboveground biomass.

What inspired you to participate in undergraduate research?

I was inspired to participate in undergraduate research to be able to use the principles and knowledge I have gained in the classroom and apply them to a set of questions and real world challenges.

How did you get your research position, and what preparation did you undertake for it?

I have been a part of the McLachlan lab since the Fall of 2021 and have participated in other projects. Moreover, I began work with the model LINKAGES in the Spring of 2022 and continued this work during the Summer of 2022.

Where was your research experience located?

University of Notre Dame

What did you get out of your research experience?

I gained a lot of invaluable research experience, collaborator interactions, and a summer of exciting opportunities. Furthermore, this opportunity has allowed me to discern my post graduation aspirations of graduate school.

Detecting a super-Nyquist lpDNO in X Leonis Using TESS Satellite Data Anousha Greiveldinger

Major: Physics (concentration in Astrophysics) and French

Advisor: Peter Garnavich, Dept. of Physics and Astronomy, University of Notre Dame

Cataclysmic variables are binary star systems where the primary star is a white dwarf. Some gas from the secondary star can pass through a gravitationally neutral point, so it falls toward the primary star. As matter accretes on the white dwarf, light can be emitted. Such oscillations in brightness occur in many binary star systems. These can occur at various frequencies, but high frequency oscillations can be tough to detect due to the rapid sampling rate required. The TESS short cadence mode can be used to detect some super-Nyquist frequencies, like dwarf novae oscillations (DNOs), in cataclysmic variables (CVs). We observed a super-Nyquist lpDNO at 118.5 seconds using TESS data of X Leonis (X Leo) at the 120 second cadence. This super-Nyquist detection technique can be applied to find DNOs and lpDNOs in other CVs, helping improve classification of these rapid oscillations.

What inspired you to get into undergraduate research?

“Mainly, I’ve always been really interested in space and astronomy. Reading about all the cool work that faculty here are doing got me excited about doing undergraduate research.”

How did you get your research position, and what preparation did you undertake for it? “I got into my research during my freshman year. I was unsure about how undergraduate research worked, but I looked at the bios of the astrophysicists at ND and emailed Professor Garnavich, letting him know my interest. After a meeting, he let me work with him! I got the College of Science Summer Undergraduate Research Fellowship and was able to continue my research over list last summer.

Where was your undergraduate research experience located?

University of Notre Dame

What did you get out of your research experience?

Getting the chance to use the Krizmanich telescope on the roof of Jordan has definitely been an amazing bonus of this research experience. It’s also given me the opportunity to meet several other students in the department and taught me how to process data and communicate my results.

It also has helped me figure out what life would be like in graduate school.

Common Tenrec (*Tenrec ecaudatus*) Skeleton Reconstruction

Common Tenrec (*Tenrec ecaudatus*) Skeleton Reconstruction

Gabriela Gunka

Major: Biochemistry and Anthropology

Advisors: Ronald Hellenthal and Barbara Hellenthal, Dept. of Biological Sciences, Museum of Biodiversity,
University of Notre Dame

Many of the specimens in the Museum of Biodiversity at the University of Notre Dame are rare and irreplaceable. If the destruction of the entire museum collection in the fire of 1879 taught us anything, it is to try and protect and preserve these valuable specimens for the next generation of students¹. Such is the common tenrec (*Tenrec ecaudatus*) skeleton which was acquired by the Museum in 1897 as part of the effort to rebuild the Museum collection after the devastating fire. Either the skeleton was originally incomplete, or perhaps, over the years of being used as a teaching aid in biology classes, it got damaged. It had a few bones missing; most significantly, it was missing its mandible (lower jaw). Restoring this skeleton to its former glory would allow it to be once again a useful teaching aid in biology classes, as well as a valuable display specimen in the Museum. Using images of existing skeletons found online and descriptions of the skeletal structure found in literature, the missing bones were sculpted from epoxy clay. Wire was used as necessary to stabilize the smaller parts, such as foot bones, and a mixture of acrylic paint was created to match the color of the parts made of clay to the rest of the skeleton. Carving and sculpting tools were used to create the fine details on the clay model of the mandible, such as the teeth and the mental foramen. All the parts were glued to the skeleton using superglue. The wooden base on which the skeleton is mounted was cleaned using 80% ethanol and then polished with a beeswax and mineral oil blend.

What inspired you to participate in undergraduate research?

I wanted to explore my interests in science beyond a typical classroom setting. The Museum combined both my interest in science and anthropology, so it was a perfect place to look for research opportunities.

How did you get your research position, and what preparation did you undertake for it?

I attended the Fall Undergraduate Research Fair in the Fall of 2020. It was on Zoom, and I joined the meeting for those interested in the Museum where I learned about the research opportunities and various cool projects students have done in the past. I started my first project in the Spring of 2021, which was the restoration of a tuatara (*Sphenodon punctatus*) skeleton.

Where was your research located?

Museum of Biodiversity, University of Notre Dame

What did you get out of your research experience?

I learned a lot of problem-solving skills, since every project is different and not all methods of sculpting new bones will work the same way for every skeleton. Most of it is done by trial and error. These projects also require a lot of patience, since clay parts can easily break, and small elements might be difficult to attach to the skeleton. I also learned a lot of facts about the animal itself and its skeletal structure so that I could determine what is missing in the given skeleton and how to reconstruct the missing elements as accurately as possible.

Methods for Comparing the Shack-Hartmann and Fernal Wavefront Sensors under Varying Levels of Scintillation

Ryan Hersey

Major: Physics

Advisor: Justin Crepp, Dept. of Physics and Astronomy, University of Notre Dame

Coauthors: none

The wavefront sensor (WFS) is a key component of the adaptive optics (AO) systems present in all ground-based observatories. Our group has developed and constructed a WFS which utilizes near field diffraction patterns to measure phase errors, called the Fernal WFS. Robustness in the face of strong scintillation conditions remains a major ground for comparison between our sensor and the industry standard Shack-Hartmann sensor. A 2019 experiment ran by our group found that the Fernal WFS could accurately create wavefront reconstructions at flux levels lower than that of the Shack-Hartmann by a factor of ~ 9 at a scintillation index value of $S = 0.55$. To expand upon the comparative work started during the 2019 scintillation experiment, we have developed a data analysis pipeline which allows for the automated collection and processing of much more robust, expansive data sets. It also allows for functional comparisons between the ShackHartmann and Fernal sensors at multiple values of scintillation. We will discuss the methods used in the pipeline and preliminary data produced by the pipeline.

What inspired you to participate in undergraduate research?

As a kid, I always enjoyed when my uncle would teach me how to use his telescope, a Dobsonian reflector. I have since been fascinated with telescopes and the tools of astronomy. I wanted hands-on experience with a team working to improve the instrumentation used in astronomy.

How did you get your research position, and what preparation did you undertake for it?

I have been working with Professor Crepp and his team since Fall 2021. I had emailed him because I was interested in astrophysics instrumentation. Preparation specific to this project included becoming proficient in Matlab and working with current graduate students to understand both the optical relay and existing code from a previous iteration of the experiment.

Where was your research experience located?

University of Notre Dame

What did you get out of your research experience?

First, I became confident in my ability to code in Matlab. Beforehand, I had only done serious work in Python. I also gleaned knowledge in both optical design and the physics of optics. Most importantly, I learned about standard imaging techniques and the procedures for image processing in the process of writing the pipeline code.

Photoinduced Changes in Colloidal 2D Lead-Halide Perovskites for Solar Cell Applications

Nathaniel Hiott

Major: Physics

Advisor: Prashant Kamat, Dept. of Chemistry and Biochemistry, University of Notre Dame

Coauthors: Jishnudas Chakkamalayath

Lead-halide perovskites are materials that show promising trends for future semiconductor research and light-harvesting applications. 2D perovskites exhibit unique bandgap tunability and enhanced stability compared to the 3D species. The wavelength of light absorbed by a 2D perovskite lattice can be adjusted by altering the number of 2D layers or the halide composition. The photostability of these 2D perovskites is vital for their use as light-harvesting devices, so it is beneficial to analyze their photoinduced properties in colloids. This study shows that single-layer ($n = 1$) mixed-halide (50% iodide and 50% bromide) 2D perovskites undergo a structural change under photoirradiation, forming $n = 1$ bromide perovskite. This suggests that the iodide is being expelled from the mixed perovskite and is photodegraded under continuous exposure to light. In dual-layer ($n = 2$) mixed-halide 2D colloids, photoirradiation induces the formation of pure $n = 2$ bromide and $n = 2$ iodide perovskites, which recover to the mixed-halide species when the solution is kept in the dark. The kinetics of the structural changes can be further explored to suggest explanations behind their unique properties. An understanding of these changes can enable future production of mixed-halide perovskites that can be used in tandem light-harvesting.

What inspired you to participate in undergraduate research?

My career goal is to help transition our energy systems toward renewable energy solutions. When I found Dr. Kamat's research into next-generation solar cells, I knew that this was a way I could combine my love of research with my passion for sustainability.

How did you get your research position, and what preparation did you undertake for it?

As I was searching for professors that did the renewable energy research I am interested in, I had a conversation with Anne Pillai at ND Energy about research groups that would match my interests. I joined the Kamat lab in the Spring of 2021, and I have received the ND Energy Slatt Fellowship to continue my research through two summer sessions.

Where was your research experience located?

The Notre Dame Radiation Laboratory

What did you get out of your research experience?

My summer research allowed me to complete the research project I have been working on for the past year, and I will be submitting a paper for publication this fall. I was able to work more independently on this project now that I have experience in my lab, and this is excellent preparation for my future graduate studies.

Bismuth Nanoparticle and Dipyridamole-loaded Electrospun Polymeric Scaffold as Radiopaque Bioresorbable Drug-Eluting Vascular Graft

Sarah Honegger, Erin San Valentin, Marvin Bernardino, Jossana Damasco, Karem Court, Biana Godin, Steven Y. Huang, and Marites P. Melancon

College of Biological Sciences, University of Notre Dame

Department of Interventional Radiology, The University of Texas MD Anderson Cancer Center Department of Nanomedicine, Methodist Research Hospital

Background: Arteriovenous grafts are used as an interventional access point for patients on dialysis. However, upon failure, graft placement can lead to neointimal hyperplasia (NIH). Anti-platelet and vasodilator drugs such as dipyridamole (DPA) mitigate NIH and long-term patency post graft placement. In addition, nanoparticles allow for visualization and long-term monitoring of these absorbable medical devices.

This study aims to develop a bismuth nanoparticle (BiNP) and DPA-loaded scaffold made of polycaprolactone (PCL) and polyethylene glycol (PEG). These scaffolds were tested for their efficacy as novel bioresorbable, radiopaque, drug-eluting vascular grafts.

Methods: BiNPs were synthesized via the thermal decomposition method and its size was determined by transmission electron microscopy (TEM). Solutions of PCL (80,000kDa), PEG (8,000kDa), BiNP, and DPA were electrospun into 3cm scaffolds, and physiochemical properties were characterized. Scaffolds were monitored over 6 weeks in terms of drug (UV-vis absorption) and nanoparticle (elemental analysis) released, tensile strength (MTESTQuattro universal testing system), and radiopacity (Bruker microcomputed tomography). Immortalized human vascular endothelial cells (EC-RF24) and vascular smooth muscle cells (MOVAS) were used to determine the scaffold's cytotoxicity using alamarBlue assay. Grafts were surgically implanted in rats to begin in vivo imaging and efficacy studies.

Results: BiNP size was $3.44 \text{ nm} \pm 0.59 \text{ nm}$ as determined by TEM. Morphology and physiochemical properties of the scaffolds varied. Fiber diameter increased with the addition of BiNP and DPA (PCLPEG-BiNP-DPA: $2.53 \pm 0.64 \text{ } \mu\text{m}$ vs. PCL-PEG: $1.56 \pm 0.59 \text{ } \mu\text{m}$). Mechanical strength decreased with the addition of BiNP (PCL-PEG: $6.28 \pm 2.77 \text{ MPa}$ vs. PCL-PEG-BiNP: $2.12 \pm 0.42 \text{ MPa}$). DPA-loaded grafts released ~38% of the drug over 7 days (PCL-PEG-DPA: $38.03\% \pm 1.0\%$ vs PCL-PEG-BiNP-DPA: $35.42\% \pm 3.4\%$), which increased to ~70% release over twelve weeks (PCL-PEG-DPA: $69.75\% \pm 1.6\%$ vs PCL-PEG-BiNP-DPA: $66.05\% \pm 3.5\%$). BiNP-loaded grafts released between 3-5% of the total BiNP within the first twelve weeks, which correlated with a radiopacity loss of only 16.6% over the twelve week trial period (PCL-PEG-BiNP-DPA: $1001.2 \pm 111.8 \text{ HU}$ at week 0 vs. PCL-PEG-BiNP-DPA: $834.7 \pm 36.8 \text{ HU}$ at week 12). EC-RF24 and MOVAS remained viable in the presence of BiNP and DPA treated media. The presence of DPA in grafts increased blood lysis by about 2% (PCL-PEG-DPA: $1.86\% \pm 1.1\%$ vs PCL-PEG-BiNP-DPA: $2.54\% \pm 0.5\%$).

Conclusion: Trilayer scaffolds made of PCL and PEG and loaded with both DPA and BiNP demonstrated increased radiopacity with no detrimental effects on epithelial or vascular smooth muscle cells, and an effective release of dipyridamole over time. These results confer its advantage for serial noninvasive imaging over time to assess degree of polymer resorption and potential for in vivo NIH inhibition.

Keywords: Bismuth, radiopacity, medical device

Advantages of Approximating Effective Field Theory Likelihood Functions of CMS Data Using Deep Learning

Shenghua Liu

Majors: Physics and Honors Mathematics

Advisor: Kevin Lannon, Dept. of Physics and Astronomy, University of Notre Dame

Coauthors: Sirak Negash

Recent work [1] in high energy particle physics has expanded the search for new physics through the use of standard model effective field theory (SMEFT). In that study, data from the Large Hadron Collider Compact Muon Solenoid (LHC CMS) experiment related to top quark production was analyzed to search for indirect evidence of new fundamental particles that may be too heavy to produce directly. Specifically, the 16 most relevant Wilson coefficients (WCs) in SMEFT were used to parameterize different types of new physics that may affect top quark production. A likelihood function (LF) was used to represent the agreement of the SMEFT to experimental data as a function of the 16 WCs. As such, the regions in the WC space of high agreement between SMEFT prediction and observation are of theoretical interest to efficiently compute and analyze. However, the analysis was only able to provide 1D and 2D scans of the LF because higher-dimensional scans are difficult to visualize and too computationally expensive (due to the curse of dimensionality). To enable efficient analysis of the LF in full 16D space, we trained deep neural networks (DNNs) to approximate the LF, which take little disk space and allow for fast evaluation. In this work, we report the accuracy of the DNN's predictions and the speed of evaluation, establishing it as a promising tool for SMEFT analysis. We also report on techniques that we found to be helpful for training DNNs. Finally, we present as an example analysis 1D and 2D frozen and profiled scans made from the DNN, which are in good agreement with the scans presented in Ref. [1].

[1] The CMS collaboration. et al., J. High Energ. Phys. 2021, 95 (2021).

[https://doi.org/10.1007/JHEP03\(2021\)095](https://doi.org/10.1007/JHEP03(2021)095)

What inspired you to participate in undergraduate research?

I have always wanted to discover what nobody has discovered before, and research is exactly that. I also felt that research would give a purpose to all the classes I had taken over the years.

How did you get your research position, and what preparation did you undertake for it? I reached out to Prof. Lannon after he gave an interesting seminar talk, and he accepted me into the project. I read chapters of a book on machine learning over winter break of 2020-2021 and several physics papers to gain background. In the spring, I applied machine learning to toy problems, which laid the foundation for the summer.

Where was your research experience located?

University of Notre Dame

What did you get out of your research experience?

Tons of technical skills, but more importantly, I learned that research is not a linear process— things can and will go wrong at times. But the excitement of exploring uncharted territory solidified my desire to attend graduate school. I also enjoyed a beautiful summer.

Formation and Destruction of CO in 3D Non-Equilibrium Galaxy Simulation Code RAMSESRTZ

Shenghua Liu

Majors: Physics and Honors Mathematics

Advisors: Harley Katz and Julien Devriendt, Subdept. of Astrophysics, University of Oxford

Coauthors: none

Galaxy formation and evolution are driven by a rich set of physical processes that interact to determine the physical state (temperature, pressure, chemical makeup, etc.) of galaxies. Numerical simulations are an important tool used to infer the underlying physical properties of galaxies from observed emission or absorption spectra. In particular, 3D models can capture the nonequilibrium dynamics of interstellar gas and stellar feedback, which allows more details to be revealed from spectra and enhances galaxy formation modeling from first principles. Even though many such models have been developed, the high computational cost forces them to make strong assumptions. The RAMSES-RTZ [1] code is one of the few that fully couples metal chemistry to radiation hydrodynamics and is fast enough to run cosmological simulations in full nonequilibrium. The goal of this project is to add carbon monoxide to RAMSES-RTZ, which allows us to analyze the CO-H₂ conversion factor in the context of a state-of-the-art simulation. This will in turn contribute to our knowledge of CO as a tracer for H₂, which is highly relevant to star formation. We report the level of agreement between our model run in 1D and existing 1D models with CO. We then present an example simulation of a dwarf galaxy with CO included.

[1]: Harley Katz, RAMSES-RTZ: non-equilibrium metal chemistry and cooling coupled to on-the-fly radiation hydrodynamics, *Monthly Notices of the Royal Astronomical Society*, Volume 512, Issue 1, May 2022, Pages 348–365, <https://doi.org/10.1093/mnras/stac423>

What inspired you to participate in undergraduate research?

I have always wanted to discover what nobody has discovered before, and research is exactly that. I also felt that research would give a purpose to all the classes I had taken over the years.

How did you get your research position, and what preparation did you undertake for it? I reached out to Prof. Julien Devriendt, one of my tutors during my study abroad (2021-2022), who kindly offered to ask his postdocs about potential undergraduate projects, and luckily Dr. Harley Katz had one. So, I started doing some literature research and building toy models in Python in the spring to prepare for the summer. I then applied and succeeded in securing the Career Center funding for the summer.

Where was your research experience located?

University of Oxford

What did you get out of your research experience?

New technical skills, but more importantly an excursion into a new field and new culture, which is still shaping what I want to do in graduate school. I also had a wonderful Oxford summer, with new friends and timeless memories.

Investigating the relationship between microenvironment and pH dynamics in normal breast epithelial cells

Regan Maronick
Major: Biochemistry

Advisor: Dr. Katharine White, Dept. of Chemistry and Biochemistry, University of Notre Dame Coauthors: none
Changes in intracellular pH (pHi) are necessary drivers of normal cell behaviors like cell migration, cell-cycle progression, and differentiation. However, dysregulation of cellular pH has become an emerging hallmark of cancer, with cancer cells having an increased intracellular pH (pHi > 7.4) and a decreased extracellular pH (pHe ~6.9) compared to normal cells (pHi ~7.2, pHe ~7.4). In addition to dysregulated pH, the extracellular matrix (ECM) of cancer cells becomes increasingly stiff due to increased production, secretion, and crosslinking of ECM proteins. While both dysregulated pHi and stiffening of the ECM have been correlated with cancer progression, the potential for molecular cues from the ECM to alter pHi (and vice versa) has not been explored. Here we use tunable-stiffness hydrogels to show that stiffening of the ECM drives a decrease in pHi in both metastatic lung and metastatic breast cancer cells (H1299 and MDA-MB-231) stably expressing a pH biosensor. We next sought to determine if the observed pHi-ECM stiffness sensitivity is a cancer-specific phenomenon. To do this, we generated a stable cell line of breast epithelial cells (MCF10A) expressing the pH sensitive biosensor and validated that the presence of the biosensor in cells does not alter the intracellular pH. We then repeated the pHi imaging experiments by plating these normal breast epithelial cells on tunable-stiffness hydrogels. These findings suggest that ECM stiffening feeds back to drive changes in pHi in metastatic and normal cell lines. Future work will explore the molecular mechanisms for this extracellular/intracellular crosstalk between mechanical stiffness and intracellular pHi. Importantly this work also establishes cancer-specific pHi dynamics that will inform new early detection and therapeutic strategies in metastatic cancer.

What inspired you to participate in undergraduate research?

Having the opportunity to explore an unanswered area of biochemistry has always been of interest to me, especially when the question at hand is related to fighting cancer.

How did you get your research position, and what preparation did you undertake for it?

I have been a member of the White lab since the spring of 2022. Having a semester under my belt in the lab was perfect for jumping into summer research, which I was provided funding for under the Harper Cancer Research Institute Undergraduate Research Fellowship.

Where was your research experience located?

Harper Cancer Research Institute, University of Notre Dame

What did you get out of your research experience?

The most important thing I learned was how to troubleshoot and re-approach an experiment that is not working. I also learned how to write grants and communicate my results to a group of scientists and the general public.

Insect Ecology: the effect of primary productivity on understory insect composition and abundance in the Michigan Northwoods

Elysa Ng May May

Major: Biological Sciences || Minor: Anthropology

Advisor: Chelse Prather, Associate Professor, Environmental Biology Program Coordinator University of Dayton

Coauthors: Chris Mix, Karis Cramer, Makyla Thomas

Abstract

The productivity of a forest is an important factor in driving the abundance of the insect community. The objective of this study was to find a relationship between understory insect abundance, composition and primary production, and if litter or understory vegetation biomass could explain this relationship. The hypothesis was that there will be a positive correlation between primary productivity and insect sampling sites.

Data was collected from five sampling sites in the Northwoods, where insects were collected with several methods including pan traps, sweep-nets and pitfall traps. Insects were then counted and identified based on their order. The biomass of the sites were calculated by collecting the leaf litter and the understory plants. Linear regressions were run between the total number of insects and primary production of the site which was based on mean faPAR values obtained from present LIDAR data. Analyses were also run between insect abundance and litter/vegetation biomass.

There was a significant negative relationship between site productivity and insect abundance.

This trend could be explained by the production values representing a measure of canopy cover. More canopy cover could leave less resource availability on the forest ground for understory insects. While litter biomass would positively correlate with insect abundance, the litter/vegetation values could not explain this negative relationship. Therefore it can be concluded that insect abundance is driven by several factors including plant diversity and structural diversity, but the sample size wasn't large enough and the study sites needed to be more heterogeneous for us to fully test this hypothesis.

What inspired you to participate in undergraduate research?

I have always considered the idea of going into graduate school, and I wanted to do as much undergraduate research as possible in Notre Dame. I wanted to try out different areas of research, so I know what I like and I don't like by the time I start my tentative grad school application.

How did you get your research position, and what preparation did you undertake for it?

I started by working in the Archie Lab throughout the summer of my freshmen year and throughout my sophomore year. I did different projects there, from parasite sampling in baboon feces to working on the scent project. Working in the Archie lab also gave me some experience with R Studio.

Where was your research experience located?

The Environmental Research Center (UNDERC), Department of Biological Sciences, is located in the Northwoods. The property is right by the Wisconsin-Michigan border.

What did you get out of your research experience?

I had one of the very best 10 weeks of my life. I was able to meet many new people of similar interest with me from Notre Dame and other universities, and I was really grateful to meet a community of people who are extremely passionate in what they do.

How people respond to changes in reported cases of SARS-CoV-2 during a wave of a new variant and how that affects different populations

Abigail Nguyen

Major: Applied and Computational Mathematics and Statistics, Minor: Data Science

Advisor: Alex Perkins, PhD, Dept. of Biological Sciences, University of Notre Dame

Coauthors: Alex Meyer, PhD, Dept. of Biological Sciences, University of Notre Dame

SARS-CoV-2 has been the third leading cause of death in the United States for the last two years. As SARS-CoV-2 evolves, it is difficult for scientists to predict where the pandemic is heading next which means it is beneficial to study several factors that may influence the trajectory such as the increase or decrease of risk behaviors. The focus of this study is to see how the public's perception of the epidemic through the knowledge of a variant's peak timing and trajectory affects the population's behavior and how that affects the cases in different populations and areas. Peak timing analysis on a county-level was conducted in order to observe the differences in Omicron case peaks across the United States. When looking at counties on the country level and state level, it was found that peak timings are generally earlier in counties with higher populations. Cross-coupled metapopulation models were used to model and observe how the disease spread among several different populations. Several scenarios were implemented to see how different behavioral changes affected factors such as peak timings, contact, and final fraction of susceptibles between these subpopulations. Studies observing the public's perception of SARS-CoV-2 are ongoing to better understand factors that influence the trends of this disease.

What inspired you to participate in undergraduate research?

I wanted to be a part of undergraduate research to explore new fascinating and relevant topics and to gain valuable skills that come from participating in research.

How did you get your research position, and what preparation did you undertake for it?

I got my position from reaching out to my professors that have labs in areas that I found interesting to me and were applicable to my major and asking them if they were willing to mentor me. To prepare for my research position, I created a research proposal for the Summer Undergraduate Research Fellowship which funded my project.

Where was your research experience located?

In the Perkins Lab at the University of Notre Dame.

What did you get out of your research experience?

I got to spend the summer at Notre Dame, and I learned new skills and how to conduct independent research while exploring new topics and interests!

Infection with Wild Type SARS-CoV-2 Combined with Vaccination Augments Neutralizing Antibody Levels Against Variants Including Omicron

Daniel O'Shea

Major: Biological Sciences, Economics

Advisor: James R. Baker Jr., Mary H. Weiser Food Allergy Center, University of Michigan

Coauthors: C. F. Schuler, J. Chen, J. P. Troost, P. Wong, K. Chen, W. Peng, C. Gherasim, D. M.

Manthei, R. Valdez, J. L. Baldwin, K. M. O'Shea, J. R. Baker

The degree of immunity against severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) variants provided by infection vs. vaccination with wild-type virus remains unresolved, which influences future vaccine boosters. Few studies involve a large-scale analysis of viral neutralization against Delta and Omicron variants in individuals only infected with Wild Type (WT) virus. We examined 653 subjects categorized by SARS-CoV-2 infection and vaccination status with sera collected three times at 3-to-6-month intervals between April 2020 and June 2021. Spike and nucleocapsid antibodies were detected via ADVIA Centaur® (Siemens) and Elecsys® (Roche) assays. The Healgen Scientific® lateral flow assay identified IgG and IgM spike responses. Pseudoviral neutralization was performed on all samples using HEK-293T cells infected with SARS-CoV-2-pseudotyped lentiviral particles for WT, B.1.617.2 (Delta), and B.1.1.529 (Omicron) variants. Linear mixed effects models of log-transformed IC50 values assessed the correlation of clinical testing with viral neutralization. Vaccination combined with prior infection led to the highest neutralization titers at all timepoints and with all variants. Omicron neutralization was lower overall as compared to both WT and Delta across all groups and timepoints, but particularly poor in only vaccinated individuals. Clinical testing for spike antibodies predicted Wild Type and Delta neutralization, but nucleocapsid antibody was the best predictor of Omicron neutralization. Patients having both infection and vaccination with WT virus had the highest neutralizing antibody levels against all variants, while vaccination alone had negligible activity against Omicron. This data helps to explain Omicron 'breakthrough' infections and supports the use of variant-specific SARS-CoV-2 boosters.

What inspired you to participate in undergraduate research?

I was inspired to participate in undergraduate research after working in a COVID-19 vaccine clinic the summer after my first year at Notre Dame. I wanted to get more involved in the fight against and understanding of COVID-19.

How did you get your research position, and what preparation did you undertake for it?

I reached out via a contact at the University of Michigan. After submitting a grant proposal based on my future research project, the Glynn Family Honors Program at the University of Notre Dame provided funding for my research.

Where was your research experience located?

University of Michigan, Ann Arbor

What did you get out of your research experience?

I had a great and fulfilling summer in Ann Arbor, making new friends and meeting innovators in a variety of different research fields. I also learned how to write grants, publish results, and think about data on a much larger scale. My research experience in the Mary H. Weiser Food Allergy Center provided a solid basis for my future research opportunities.

High-volume digital PCR to detect ultra-low density Plasmodium falciparum infections in a high transmission setting in Burundi

Zoe Postal

Major: Neuroscience and Behavior

Advisor: Cristian Koepfli, Dept. of Biological Sciences, University of Notre Dame

Coauthors: David Nyunkuri, Denis Sinzinkayo, Emma Troth, Colins Oduma, Mediatrice Barengayobo, Cristian Koepfli

The frequency and epidemiological relevance of ultra-low-density Plasmodium falciparum infections (<0.1 parasites/ μ L) is not well understood. These infections are often missed even by molecular diagnosis by PCR. The volume of DNA screened by PCR is crucial for the diagnosis of these infections. We combined a high-volume digital PCR with an assay targeting a multi-copy gene (varATS). We screened 32 μ L of DNA to reach a limit of detection of <1 parasite/100 μ L blood. We screened 392 clinical and 432 subclinical samples from a high transmission site in Burundi, and compared results to standard varATS, qPCR, and RDT (Rapigen Biocredit HRP2/LDH). Among clinical individuals, high volume-dPCR detected P. falciparum infection in 11/89 samples that were previously negative. Test positivity increased from 77.2% to 80.1%, and sensitivity of the RDT decreased from 83.5% to 82.0%. Among subclinical individuals, high-volume-dPCR detected infection in 15/206 samples that were previously negative. Test positivity increased from 52.3% to 55.8%, and sensitivity of the RDT decreased from 77.7% to 76.0%. In conclusion, screening by high-volume-dPCR vs. qPCR targeting a multi-copy gene results in a moderate increase in test positivity and population prevalence.

What inspired you to participate in undergraduate research?

Coming into Notre Dame I knew that I wanted to be a part of the Eck Institute for Global Health. I loved the goal of reducing worldwide health disparities and focusing on health as a human right. Dr Koepfli's lab offered me a chance to work with a diverse group of students all focused on public health and neglected diseases worldwide.

How did you get your research position, and what preparation did you undertake for it?

I joined Dr. Koepfli's lab in August of 2021. I spent 2 months learning how to use the various PCR techniques then began screening for my project. I spent 8 months screening samples (10/21 - 5/22) and 2 months analyzing data from the project (7/22 - 9/22). My research was partially funded by the Eck Institute for Global Health through the Undergraduate Research Program.

Where was your research experience located?

The University of Notre Dame

What did you get out of your research experience?

I have learned so much about the research process through working with Dr. Koepfli and the graduate students in his lab. I have a better understanding of the perseverance and cooperation required for international research. My project helped me understand how small gains in understanding can contribute to the overall body of knowledge on a topic.

Chronological and geographical analysis of *P. falciparum* genotypes from the Greater Mekong Subregion for four antimalarial resistant phenotypes

Megan Schmidt

Major: Science-Computing

Advisor: Michael T. Ferdig, Ph. D., Dept. of Biological Sciences, University of Notre Dame

Coauthors: none

The emergence and subsequent spread of clinical resistance to antimalarial drugs, specifically to artemisinin (ART) and its partner drugs in artemisinin combination therapies (ACT), is a major threat to the progress of malaria control and elimination targets. The Greater Mekong Subregion (GMS), the previous epicenter of emergence and spread of the prior frontline drug, chloroquine, reported cases of clinical resistance to ART and ACTs in the late 2000s. To understanding the complex emergence and spread of drug resistance in this region, we utilized over 2,500 publicly available short variant genotype samples obtained between 2001 and 2015 from 6 countries in the GMS to identify mutations linked to four different antimalarials: artemisinin, piperazine, chloroquine, and mefloquine. Allele frequency differences and Genome Wide Association Studies (GWAS) between resistant and sensitive samples were performed for each country and year to identify different SNPs unique to the genetic backgrounds present in each country.

Interestingly, mutations in *pfkelch13*, which is the molecular marker for artemisinin resistance, were not the sole driving force of emergence in most of the GMS countries analyzed. Candidate genes for each antimalarial have been identified as potential markers for emergence and resistance to their corresponding drugs. Timelines of top candidate genes with high allele frequency differences and significant GWAS peaks were then created for each country and drug, as well as protein models to help understand how the mutations may affect protein structure and function. Non-*pfkelch13* mutations that are linked to the emergence of ART resistance could be used as part of a predictive tracking method of emergence in Africa and Bangladesh, where resistance has not yet fully developed.

What inspired you to participate in undergraduate research? I have had a strong interest in research since high school and was very interested in participating in undergraduate research. I enjoy solving problems through coding and trying to answer broader aims of the lab. I enjoy working with the graduate students on their data analyses and helping collect wet lab data.

How did you get your research position, and what preparation did you undertake for it? I got my research position by cold emailing my advisor. My previous experience includes years of coding experience in multiple languages, taking an Intro to Biocomputing class, and undergoing wet lab training through our lab manager.

Where was your research experience located? University of Notre Dame

What did you get out of your research experience? I had a great time during my research experience, and I am still currently working in the lab. I am currently writing a paper on the work I would be presenting. Additionally, I have already had the opportunity to present parts of this part at other conferences. I have been able to help with other projects in the lab and help with the process of grant writing for a multi-institution grant.

On the Grind: Enteseal Changes of the Humerus and Activity Patterns of Bronze Age Arabia

Sarajane Smith-Escudero

Major: Anthropology, Latino Studies

Advisor(s): Lesley A. Gregoricka, Jaime M. Ullinger

Co-authors: Abby Sargent, Lesley A. Gregoricka, Jaime M. Ullinger

University of Notre Dame, University of South Alabama, Quinnipiac University

Located in present-day Ras al-Khaimah (UAE), tombs Unar 1 and Unar 2 date to the Umm anNar period (2700-2000 BCE). This study examines whether increasing social stratification and changing subsistence strategies led to occupational differences or sex-based activities, and if there was bilateral asymmetry in arm usage by analyzing enteseal changes of the humerus. Fibrocartilaginous entheses of adult humeri were scored for changes (scale: 0-2) based on the New 'Coimbra Method.' Sex of the proximal humerus was estimated by maximum vertical diameter of the head; data collected previously were used for sex estimation of the distal humerus. Statistical analyses were performed on the entheses' overall composite scores (n = 17 proximal humeri, n = 24 distal humeri) as well as variables with the highest sample sizes. The composite analyses yielded no statistically significant results (Mann-Whitney U, $p > 0.05$) comparing different entheses nor in enteseal changes between tombs, with only a few of the isolated variables resulting in significant differences (Fisher's Exact $p < 0.05$). The lack of significant difference led to rejecting hypotheses related to sex-based activity differences and differential burial based on occupation. The hypothesis that there would be no side asymmetry was supported. The lack of statistical significance could be due to small sample size, and does not signify that members of the group were performing the same activities; instead, it may suggest that the majority of activities required equal loading of both arms.

Funding Statement: This research was funded by a National Science Foundation Research Experiences for Undergraduates Award (#1852426).

What inspired you to do undergraduate research?

I am fascinated by past humans and what their lives were like, so I always jump at the opportunity to learn more about what they were doing. As humans, we are nothing without our past, our ancestors.

How did you get your research position, and what preparation did you undertake for it?

I applied for the only bioarchaeology NSF-REU in the country and was one of 8 accepted, so I made sure to brush up on my human osteology skills and think back to my bioarchaeology oriented courses.

Where was your research experience located?

University of South Alabama

What did you get out of your research experience?

I got to experience a place I had never been (Mobile, AL), and I made 7 new friends. I also got the experience of working in a lab other than Notre Dame's bioarchaeology lab (which I hold very near and dear to my heart), headed by Dr. Ullinger and Dr. Gregoricka, who have been in the field for a while and are always spearheading new, exciting research.

ACOD1 Expression and Regulation in Neutrophils

Eun Suh Sung

Major: Science PreProfessional

Advisors: Xin Lu and Yun Zhao, Department of Biological Sciences, University of Notre Dame

Coauthors: None

Lung metastasis is the principal cause of breast cancer-related mortality. Neutrophils have emerged as an important component of the tumor microenvironment (TME) and are known to support tumor proliferation and mediate immunosuppression. Currently, the results of my research group have demonstrated that aconitate decarboxylase 1 (ACOD1) is highly expressed in tumor-infiltrating neutrophils and promotes breast cancer lung metastasis by supporting neutrophil survival in the TME. My study focused on validating the expression and regulation of ACOD1 in tumor associated neutrophils. I firstly performed immunofluorescence staining with formalin-fixed paraffin embedded samples of human breast cancer. The results confirmed that ACOD1 is expressed in CD15+ cells but not PanCK+ cells in human breast cancer. This suggests that ACOD1 is specifically expressed in neutrophils but not cancer cells. To investigate the regulation of ACOD1 expression, I have established a mouse neutrophil model in vitro by differentiating neutrophils from a Hoxb8-transduced conditionally immortalized myeloid progenitor cell line. Using this system, I have identified that GM-CSF, a tumor-released cytokine, is essential for ACOD1 expression. I deployed multiple small molecule inhibitors of STAT3 and STAT5 to this model and confirmed that STAT5 but not STAT3 is involved in ACOD1 regulation. Overall, these results suggest that cancer cells upregulate ACOD1 and promote neutrophil survival through a GM-CSF/STAT5 axis. My research will continue to investigate ACOD1 function in neutrophils in breast cancer using *Acod1*^{-/-} mice. Ultimately, we aim to develop a strategy to enhance the effectiveness of immunotherapy by targeting ACOD1 in tumor-infiltrating neutrophils.

What inspired you to participate in undergraduate research?

After graduating from Notre Dame, I want to get my Master's in biotechnology and/or translational and clinical research. Thus, I wanted to gain early lab experience. The projects in the Lu lab interested me because they cover topics I am particularly interested in – cancer and immunology. Research in these fields covers many topics ranging from cell biology to molecular biology, thus I knew it aligned with my interests. I knew joining a lab would motivate me to think like a researcher and not just a student.

How did you get your research position, and what preparation did you undertake for it?

I started working in the Lu lab as a lab technician and did genotyping. However, after talking with other lab members and observing their work, I knew I wanted to be more involved in a project. Genotyping gave me basic lab skills; however, I was eager to learn how to turn a research question into a tangible study. Thus, after discussing with Dr. Lu, I got assigned to work with Yun. I applied and got accepted for COS-SURF which funded my research resources and stayed at Notre Dame over the summer.

Where was your research experience located?

University of Notre Dame

What did you get out of your research experience?

I gained many technical skills including cell culture techniques, qPCR, western blot, histology, immunofluorescence microscopy, flow cytometry, and working with mice models. Moreover, it was exciting to be surrounded by scientists so passionate about their research. It was insightful to talk to them and exchange ideas about the general field of cancer or specific lab protocols. Seeing how much I enjoyed working in the lab makes me more confident in my post-graduate plans.

The Development of Small-Molecule Inhibitors of Glycogen Synthase To Treat Cori Disease

Ian Tibbals

Major: Chemistry

Advisor: Richard Taylor, Dept. of Chemistry and Biochemistry, University of Notre Dame

Coauthors: none

Cori disease, glycogen storage disease type III, is an inherited disorder that results in the buildup of structurally abnormal glycogen in the body's cells. Caused by a mutation in the AGL gene that encodes the glycogen debranching enzyme, the disease is typically detected during infancy through symptoms such as an enlarged liver and low blood sugar levels. With current treatment options confined to dietary modifications, research has explored the potential of inhibiting glycogen synthase, and in turn reducing total glycogen accumulation, to alleviate symptoms of the disease more effectively. Collaborators at the Indiana University School of Medicine recently discovered a diaryl pyrazole that demonstrates strong inhibition of glycogen synthase in vitro, yet lacks the pharmacokinetic properties necessary for in vivo studies. Using the original synthetic route, several analogues of this lead inhibitor have been synthesized, with particular emphasis on altering substituents susceptible to metabolic oxidation. In order to produce a more diverse series of pyrazole analogues, a new synthetic route has also been pursued that employs palladium-catalyzed cross-coupling reactions. Through the biological evaluation of these compounds, more concrete structure-activity relationships of the current lead inhibitor will be obtained.

What inspired you to participate in undergraduate research?

I have always aspired to use my interests and skills to help others. Working in Dr. Taylor's lab has been a wonderful opportunity to apply my passion for organic chemistry toward research with an important biomedical purpose.

How did you get your research position, and what preparation did you undertake for it?

I have been a member of the Taylor research group since fall 2021 and worked full-time in the lab over this past summer. I initially reached out to Dr. Taylor during the spring semester of my sophomore year to express my interest in joining his group. Completing two semesters of organic chemistry prior to starting was very helpful in gaining a strong foundation in both theory and laboratory technique.

Where was your research experience located?

University of Notre Dame

What did you get out of your research experience?

During my time in Dr. Taylor's lab, I have learned how to use chemistry to address important, unmet biomedical needs, such as the development of therapeutic agents for rare diseases with no known therapy. In addition, I have strengthened fundamental laboratory skills and learned how to independently solve problems more effectively. My undergraduate research experience has motivated me to pursue a doctoral degree in organic chemistry, where I can continue to engage in research with a biomedical impact.

Christina R. Troll

Major: Biochemistry

Advisor: Katharine A. White, Department of Chemistry and Biochemistry, University of Notre Dame, Notre Dame, IN 46556 and Harper Cancer Research Institute, South Bend, IN 46617

Co-Authors: Caitlin E.T. Donahue, Lily G. Gile

Intracellular pH (pHi) dynamics control normal cell behaviors and increased pHi (7.2-7.6) has been shown to be necessary for cell polarization and migration. However, all previous work connecting increased pHi to these cell behaviors have been conducted on populations of cells and using non-specific pHi manipulation tools. The White lab has recently characterized

Archaeorhodopsin (ArchT) as a light-activatable tool to raise pHi (0.1-0.47) in single cells on the minutes to hour timescale. This has previously allowed the study of single cell behaviors like membrane ruffling and cytoskeleton remodeling. Here, we further that work and apply ArchT to investigate whether increased pHi is a sufficient driver of cell polarization changes and migration at the single cell level. To do this, we optimized a wound-healing assay using normal human retinal epithelial (RPE) cells and used it to assess effects of pHi in driving cell migration. We first show that we can monitor cell polarity changes as cells migrate in this model using a genetically encoded Golgi marker. Next, we show that in the presence of EIPA, a pHi-lowering drug, the RPE cells are not able to migrate effectively and do not fully close a wound. This suggests increased pHi is an important driver of cell migratory phenotypes in a wound-healing assay. In this assay we can quantify cell movement, speed, and directionality using quantitative image analysis pipelines. We next tested whether increasing pHi with ArchT could rescue cell migration in the EIPA-inhibited wounds. Our results explore for the first time whether increased pHi is a sufficient driver of single-cell cell polarization and migration. This work also has implications in understanding cancer cell behaviors as cancer cells have a constitutively increased pHi which is thought to drive increased metastasis but that we can now probe directly using our ArchT tool.

What inspired you to participate in undergraduate research?

I want to go to graduate school, so undergraduate research gave me a taste of what it is like.

How did you get your research position, and what preparation did you undertake for it? I got my research position by reaching out to my P.I. Dr. Katharine White, and I prepared for the role by reading some published papers on the subject matter and reviewing the presentation she sent me about potential projects that were available in her lab.

Where was your research experience located?

I work in the Harper Cancer Research Center.

What did you get out of your research?

I gain the knowledge and skills of how to design and perform experience. Additionally, I feel like I am accomplishing something that is important to the overall field of scientific research.

Effects of Increased Intracellular pH on Cytokinesis Defects

Natalie Waschbusch

Major: Biochemistry

Advisor: Katharine White, Dept. of Chemistry and Biochemistry, University of Notre Dame

Coauthor: Julia Spear, PhD candidate

It is estimated that in 2022 there will be ~2 million new cancer diagnoses in the US and over 600,000 Americans will succumb to the disease. An emerging hallmark of cancer is dysregulated intracellular pH (pHi), where cancer cells have a constitutively increased pHi (>7.4) compared to normal cells (~7.2). Previous work showed that pHi changes are necessary for regulating normal cell cycle progression in single cells, and that sustained high pHi shortens M phase duration. To investigate the impact that cancer-associated dysregulated pHi might have on cell division, we manipulated pHi (24 h) and calculated division rates and cytokinesis defects in normal epithelial cells as well as cancer cell lines. To determine whether we can cause these cancer-related defects in non-transformed cells, we manipulated pHi (24 h) in normal breast epithelial cells (MCF10A) and saw that increased pHi caused less cell divisions and increased cytokinesis defects including cleavage furrow failure, double nucleation, and >2 daughter cell formation. To study whether a sustained high pH could drive more cancer-like behaviors, we increased pHi in normal cells over a longer time scale (>72 h) and found entosis occurred, a cancer-related phenomenon where a cell is engulfed by its neighbor. Entosis almost never occurs in normal cells, but is a driver of polyploidy and aneuploidy early in cancer initiation and increases in genomic instability that are associated with aggressive tumors. This suggests that increasing pHi of normal cells can mimic cancer-like behaviors at the single cell level, further supporting that increased pHi may be driving or initiating cancer-like phenotypes. Future work will investigate the pH-sensitive proteins that are molecular drivers of the observed cytokinesis failures.

What inspired you to participate in undergraduate research?

I have always enjoyed learning about new scientific discoveries being made, and have had an interest in pursuing cancer related research.

How did you get your research position, and what preparation did you undertake for it?

I got my research position by reaching out to my PI over email, and was offered the position after an interview. Most of my preparation for my role came from reading about the research that was currently being done in the lab so that I could better understand how my work fit into the bigger picture. In addition, prior to starting research, there was extensive training from others in the lab on protocols, methodologies, and background of the research.

Where was your research experience located?

University of Notre Dame - Harper Cancer Research Institute

What did you get out of your research experience?

I have really enjoyed the research I have been doing in the White lab. Not only am I gaining valuable experience in lab and learning techniques, but it has also inspired a basic science curiosity in me. Troubleshooting problems, analyzing results, and planning the next steps of experiments have all challenged me intellectually and helped prepare me and inspire me for my future after Notre Dame.