
# FALL UNDERGRADUATE **RESEARCH FAIR**

## INFORMATION BOOKLET

Thursday, October 27, 2016
Jordan Hall of Science

UNIVERSITY OF
NOTRE DAME
College of Science

# College of Science – Fall Undergraduate Research Fair 2016

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!

**Schedule and Table of Contents**

## Information Tables - Jordan Galleria

**Career Center (careercenter.nd.edu)**

The Career Center provides undergraduate students with career counseling and career development services, self-assessments, workshops, presentations for academic departments, 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 Go IRISH, to pursue postgraduate opportunities, sign up for interviews, and conduct career-related research.

Contact: Robyn Centilli (Robyn.O.Centilli.1@nd.edu) and Justin Rice (jrice4@nd.edu).

**Center for Nano Science and Technology (nano.nd.edu)**

ND*nano* is a world-class, collaborative research center that includes faculty from seven departments across the colleges of Engineering and Science. The Center is focused on developing, characterizing, and applying new nanotechnology-based materials, processes, devices, and solutions that will better society. Each year, NDnano awards several paid fellowships to undergraduate students who spend 10 weeks of their summer engaged in a research project, mentored by an ND*nano* faculty member in science or engineering. Summer 2017 will mark the NURF program's ninth year. To date, nearly 200 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. The 2017 application process will open the first day of classes in January.

Contact: Heidi Deethardt (deethardt.1@nd.edu), Administrative Assistant.

**Center for Research Computing (crc.nd.edu)**

The Notre Dame's Center for Research Computing (CRC, crc.nd.edu), a joint effort of Notre Dame Research, Information Technologies (OIT), and Notre Dame Colleges, supports the research agenda of the University through high availability of managed computing assets and research and engineering staff with expertise in the application of these resources to multi-disciplinary research interests. CRC is a unique, interdisciplinary environment, where strong groups of computational scientists and research programmers work side by side with scientists, engineers, mathematicians and scholars in the arts, humanities, and business and economics to create new computational approaches to research. The CRC, with forty staff and faculty members, is a major research and research support enterprise that is anxious to work with undergraduate students.

Contact: Kallie O'Connell (koconne8@nd.edu), Communications.

**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. Programs within the EIGH include the professional degree of Master of Science in Global Health, dual degree program with Indiana University School of Medicine, and the Global Health Research Associate program. The EIGH also offers funding for faculty members including graduate student fellowships, Pilot Project Grants, Building Multidisciplinary Teams Grants, Travel Grants for Research and Training, Building Institutional Partnerships Grants and an Undergraduate Research Support Program.

Contact: Sarah Craig (Craig.20@nd.edu), Communications.

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

CUSE has a mission to promote the intellectual engagement of Notre Dame students through (1) creating opportunities for undergraduate research, scholarship, and creative endeavors in all colleges by connecting students to resources such as faculty mentors, projects, funding, and venues for presenting and publishing their work undergraduate research and (2) encouraging and facilitating applications for national fellowships like the Rhodes Scholarship, National Science Foundation Graduate Research Fellowship, Truman Scholarship, and Goldwater Scholarship.

Contacts: Yvonne Mikuljan (ymikulja@nd.edu), Assistant Director of Undergraduate Research, or Jeffrey Thibert (jthibert@nd.edu), Associate Director.

**First Year of Studies (fys.nd.edu)**

First Year of Studies (FYS) supports and promotes research in two ways. First, through the ND Ignite Research Fellowship, for which FYS can award up to $1000 to current first year students to conduct research or present at a conference during their first year or summer between freshman and sophomore years. Second, through a one-credit class (FYS 10406 Introduction to the Research Process) which is offered during the spring semester as a way to help current first year students understand how the research process works to better prepare them for possible research opportunities during their time at Notre Dame.

Contact: Sean Wernert (swernert@nd.edu), Director of ND Ignite; Darlene Hampton (dhampto1@nd.edu), Coordinator of ND Ignite Research Initiative.

**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, and developing less expensive and more accurate diagnostics. Research cures cancer.

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

**Hesburgh Libraries (library.nd.edu)**

The Hesburgh Libraries system is a diverse system comprised of the main Hesburgh Library and eight branch libraries, including the O'Meara Mathematics Library in Hayes-Healy, the Engineering Library in Fitzpatrick, the Chemistry-Physics Library in Nieuwland, the Mahaffey Business Library in Mendoza, and the Architecture Library in Bond Hall. In addition, the Hesburgh Libraries' Center for Digital Scholarship (CDS) leverages digital library expertise (e.g., GIS, data management planning, and statistical analysis) and state-of-the-art technologies (such as LaTeX, R, and MATLAB) to help manage and accelerate the research process. In an effort to further its core mission of "connecting people to knowledge," the Libraries offer a vast array of expertise, services, resources and spaces to ensure the academic success of the undergraduate student community. Whether through the expertise of subject librarians and specialty services or the access to various sources of knowledge, we continuously evolve to meet the ever-changing needs of students in the 21st century. The Hesburgh Libraries provide critical support for your research, including access to thousands of online databases, journals, DVDs, books, maps, and more. Librarians are prepared to assist you with your research through individual consultations, or library workshops and in-class instructional sessions. In addition, we offer Undergraduate Library Research Awards (ULRA) program designed to honor students who best leverage the integrated suite of library services throughout their research process.
Learn more:
Hesburgh Libraries: library.nd.edu
Center for Digital Scholarship: library.nd.edu/cds
Contact your subject librarian: library.nd.edu/subjects
Download Subject Librarian Guide: http://library.nd.edu/about/subjects/Selectors.pdf
Ask-A-Librarian Service: asklib.nd.edu
Register for a workshops: http://library.nd.edu/about/workshops.shtml
Undergraduate Library Research Award: library.nd.edu/ulra

Contact: Parker Ladwig (ladwig.1@nd.edu), Mathematics and Biology Librarian, or Thurston Miller (tmiller5@nd.edu), Chemistry and Physics Librarian.

**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), Assistant Professor.

**Institute for Scholarship in the Liberal Arts (ISLA, isla.nd.edu)**

The Undergraduate Research Opportunity Program (UROP) provides grants to students who wish to pursue independent research or creative projects. The UROP program, which is open to any student pursuing a major or a minor in the College of Arts and Letters, offers four major types of grant: the Conference Presentation Grant; the Research and Materials Grant; the Senior Thesis Grant; and the Summer Grant. Students who wish to apply must submit a proposal, budget and a letter of recommendation to urapply.nd.edu. Together with the College of Science, UROP also offers Science, Arts and Letters, and Engineering students 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: Karla Cruise (kcruise@nd.edu), Assistant Director.

**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 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 and Latin American Studies minors 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 (hrivers@nd.edu), Associate Director, or Rachel Thiel (rthiel@nd.edu), Program Coordinator.

**Minor in Sustainability**

The Minor in Sustainability is open to Notre Dame students in all majors and include courses drawn from all five undergraduate colleges and the Law School. Through a multidisciplinary approach, the minor prepares students to serve as leaders in their communities - local, national, and international - by making constructive contributions to the development of more sustainable practices in their own personal and professional lives, the lives of others, and the lives of future generations. Through the Sustainability & Stewardship Alumni Network, we connect students with Notre Dame alumni in a wide variety of sustainability careers and assist students in identifying internships, study abroad programs, and graduate schools that match their interests. The minor also supports undergraduates, graduate students, and faculty who are interested in conducting research in sustainability by connecting them with relevant community partners, government agencies, and national and international research programs.

Contact: Rachel Novick (rnovick@nd.edu), 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.

Contacts: Barbara Hellenthal (bhellent@nd.edu), Curator, and 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 your 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. For more information on the Nanovic Institute and our undergraduate grant programs, please go to nanovic.nd.edu/grants-and-fellowships/undergraduate-students, or contact Jen Fulton.

Contacts: Jen Fulton (jfulton@nd.edu), Student Coordinator.

**NDiscovery (DiscoverResearch.nd.edu)**

NDiscovery is a student run project seeking to foster better connections between faculty and undergraduate students interested in research. We have developed an online database with research opportunities integrated across areas of study within the College of Science. The website is geared towards helping students starting their endeavors into research here at Notre Dame, so it includes information on the process of joining a lab, descriptions of different fields of study, and a section of FAQs answered by experienced students. In addition to spreading the word about this new resource available to students, we are looking for students interested in joining our team to help maintain the website and keep the information updated.

Contacts: Luke Hamel (lhamel@nd.edu) and Nicole Handa (nhanda@nd.edu), Project Managers.

**ND Energy (Center for Sustainable Energy at Notre Dame, energy.nd.edu)**

ND Energy is a University Research Center whose 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 educational opportunities through programs such as the Slatt Endowment for Undergraduate Research in Energy Systems and Processes, the Energy Studies Minor, and the Student Energy Board. These programs help prepare students to become successful leaders who will understand the complexities of society's energy challenges and make a difference in the global energy economy. Learn more at energy.nd.edu.

Contact: Anne Berges Pillai (apillai@nd.edu), Education and Outreach Associate Program Director, or Barbara Villarosa (bvillaro@nd.edu), Business and Communications Program Director.

**Notre Dame Environmental Change Initiative (environmentalchange.nd.edu)**

The Notre Dame Environmental Change Initiative (ND-ECI) is tackling large scale environmental challenges such as land use, invasive species, and climate change. The goal of ND-ECI is to provide solutions that minimize the trade-offs between human welfare and environmental health, and to discover win-win solutions where they are possible. Our faculty are from many academic departments and colleges, and work together to provide translational, applicable solutions to answer society's grand environmental challenges. Undergraduate students working with ND-ECI faculty have the opportunity to take advantage of our Linked Experimental Ecosystem Facility (ND-LEEF), located a few miles north of campus at St. Patrick's County Park. ND-LEEF is a globally unique research facility that is home to two constructed experimental watersheds and over 20 acres of land available for terrestrial research projects. Each experimental watershed consists of an interconnected pond, stream and wetland which can each be manipulated to test ecological hypotheses. Through ND-LEEF, undergraduates would also have the opportunity to participate in a very engaged education and outreach program with K-12 and adult learners across the community. In addition, ND-ECI in partnership with the Center for Research Computing

houses the Geospatial Analysis Laboratory (GAL) to connect the ND Community with Geographic Information Systems and Remote Sensing (GIS/RS) technology and resources. ND-ECI is also home to the Global Adaptation Index (ND-GAIN), the world's leading Index showing which countries are best prepared to deal with global changes brought about by overcrowding, resource-constraints and climate disruption. The Index ranks 177 countries annually based on how vulnerable they are and how ready they are to successfully implement adaptation solutions. It includes analytic tools for examining trends, playing out scenarios, and investigating components over time. The ND-GAIN team is now working at the city level as well. To date, ND-ECI has funded over 50 undergraduates to work with faculty and staff on research and projects related to the current programs in environmental change. For more information on the faculty, research, and resources of ND-ECI, please visit our website environmentalchange.nd.edu/.

Contact: Joanna McNulty (jmcnulty@nd.edu), Business and Program Manager or Brett Peters (brett.w.peters.48@nd.edu), Assistant Director of ND-LEEF.

**ND International (international.nd.edu)**

International research is alive and well at Notre Dame International. Semester or academic year long programs, especially in Ireland and Australia, have a history of offering excellent undergraduate research opportunities while exploring a new culture in the classroom. NDI also facilitates international travel expertise for all ND students, faculty and staff with an on-line registration and travel resources. Susan Soisson will also be on hand to answer questions on the travel registration process for international ND sponsored travel. Representatives from NDI look forward to discussing international opportunities with you! Of special note, three students will be presenting at the fair on their research done while studying abroad at University College Dublin. Savannah Kounselis (Investigating Different Cell Lines in Modeling Cystinosis) and Kelly O'Shea (Mitocondrial Protein Release During Programmed Cell Death) and Emily Fortner, ('Neuroprotective effects of cannabidiol on LTP in an in vitro model of Alzheimer's disease: Possible effects via the 5HT1A receptor inC57Black6 mice')

Contacts: Kathleen Opel, Director of Study Abroad (kopel@nd.edu), Paula Worhatch, Notre Dame International (NDI) Office Manager (pworhatch@nd.edu), and Peggy Weber, Associate Director, NDI Study Abroad (mweber@nd.edu). All offices are in 105 Main Building (574-631-1138).

**Notre Dame Research Compliance**

Researchers at Notre Dame advance human understanding through research, scholarship, and creative endeavor in order to be a repository for knowledge and a powerful means for doing good in the world. The University of Notre Dame's research compliance program provides information, guidance, expertise, and administration support in order to meet the laws, rules, and policies governing research in the most efficient and effective way. Notre Dame Research is responsible for 1) communicating procedures and responsibilities to individual researchers through timely and appropriate education; 2) upholding University researchers to the highest of standards, including understanding the responsibilities of research; and 3) designing standards and policies that effectively enable researchers to meet federal and

institutional requirements. Information is available for work with both humans and lab animals, biosafety, conflict of interest, and research misconduct.

Contact: Dr. Cindy Bergeman (cbergema@nd.edu), Nakesha Alexander (compliance@nd.edu).

**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.

Contacts: Daniel Pape (daniel.j.pape.1@nd.edu) and Luke Maillie (luke.p.maillie.1@nd.edu), Editors.

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

Celebrating 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 consists of two 9½ week, 3 credit summer programs. The first, UNDERC-East, is located on over 8000 acres of university-owned forest in northern Wisconsin and the Upper Peninsula of Michigan. The second summer of the program, UNDERC-West, takes place on the grasslands and montane forests of the Flathead Reservation in western Montana. Each course is composed of a set of modules (East: insect, forest, aquatic, and vertebrate ecology; West: environmental history tour, grassland/wildlife, montane, and Native American ecology) as well as an independent research project for each student mentored by a faculty member or graduate student. Admission to East is open to sophomores and above, while West requires previous participation in East. Apply by early November on the UNDERC webpage and decisions are announced in early December to enroll in the preparatory course (1 credit, Spring semester).

Contacts: Michael Cramer (mcramer@nd.edu), Assistant Director-East, David Flagel (dflagel@nd.edu), Assistant Director-West, and Gary Belovsky (belovsky.1@nd.edu), Director.

# Research Abstracts

**The primacy effects of seasonal shifts on the foraging behavior of wild-caught woodland deer mice (*Peromyscus maniculatus gracilis*)**

Dominic Acri
Major: Neuroscience and Behavior
Advisor: Michael J. Cramer, Dept. of Biological Sciences and
Environmental Research Center, University of Notre Dame

This study explores the immediate shifts in foraging behavior of woodland deer mice (*Peromyscus maniculatus gracilis)* caused by sudden onset of fall weather. The immediate effects of a shift in seasonality include a significantly delayed onset of nocturnal activity, but do not include a shift in offset of nocturnal activity. A study on deer mice has shown the species-specific feeding preferences (Cramer 2014); our study found that such preferences are altered after experimental seasonal shifts. Under the stress of a shift in seasonality, *P. m. gracilis* show an increased preference for *Acer saccharum* seeds. Further analysis of foraging behavior, through an index which calculates the probability that uneaten seeds were handled, suggests that *P. m. gracilis* are more likely to handle *A. saccharum* seeds under fall conditions. The shift in foraging behavior caused by the primacy effects of seasonal shifts supports the hypothesis that these foraging behaviors have an underlying seasonal rhythm.

***What inspired you to participate in undergraduate research?***
Studying neuroscience at Notre Dame has given me the opportunity to explore many of my interests. After studying circadian biology in a laboratory at Notre Dame, I chose to branch out and apply what I had learned to an undergraduate research experience involving field biology.

***How did you get your research position, and what preparation did you undertake for it?***
I spent the summer 2016 at the University of Notre Dame Environmental Research Center's East location in the Upper Peninsula of Michigan. The practicum in Field Biology course included time for a independent research project, and I chose to combine my prior work in Circadian Biology (in the Duffield Laboratory, UND) with what I had learned about field research.

***Where was your research experience located?***
UNDERC-East, a laboratory site owned by Notre Dame on the boarder of the Upper Peninsula of Michigan and Wisconsin.

***What did you get out of your research experience?***
I spent 10 weeks in an intensive field ecology practicum with students from Notre Dame, St. Mary's and a dozen other institutions. My experience helped me realize how my studies can be applied to my other interests, such as wildlife conservation and fieldwork. Being able to design my own project helped me to realize everything a career in research has to offer.

**Single or Double Hydrogen Atom Abstraction from a Palladium Bis(aminophenol) Complex**

AnnaMaria Arostegui
Major: Science Pre-professional
Advisor: Seth Brown, Dept. of Chemistry and Biochemistry, University of Notre Dame

The bis(aminophenol) complex ($^t$BuClip$H_2$)Pd ($^t$BuClip$H_4$ = 4,4'-di-*tert*-butyl-2,2'-bis(3,5-di-*tert*-butyl-2-hydroxyphenylamino)biphenyl) undergoes a $2H^+/2e$ oxidation, forming the bis(iminosemiquinone)palladium complex ($^t$BuClip)Pd. When undergoing redox reactions, these complexes are oxidized and reduced at the ligands, and deprotonated or protonated at the nitrogens, keeping the palladium consistently in the +2 oxidation state. Previous experiments with hydrazobenzene have suggested that the hydrogen atoms add to ($^t$BuClip)Pd in a concerted fashion. In order to determine whether this concerted addition is general, a series of reactions were performed with the reduced form of the complex, ($^t$BuClip$H_2$)Pd, and nitrosobenzene. When the reaction was performed under more diluted concentrations of PhNO, sigmoidal kinetics were observed. It was observed that the addition of the product PhNHOH increases the reaction rate even under conditions where PhNO reduction is effectively complete. At high concentrations of added PhNHOH, incomplete oxidation of ($^t$BuClip$H_2$)Pd was observed, but the data could not be fit to a simple $K_{eq}$ expression. A possible explanation for this observation is conproportionation of ($^t$BuClip)Pd with ($^t$BuClip$H_2$)Pd to form ($^t$BuClipH)Pd. Inclusion of conproportionation did result in consistent equilibrium values for nitrosobenzene reduction. Preliminary kinetic studies of reactions with the simple single H-atom abstractor TEMPO will also be discussed.

***What inspired you to participate in undergraduate research?***
"I wanted something more than just my typical classes—something exciting yet academic. Research seemed like the perfect option since it is both adventurous and prestigious."

***How did you get your research position, and what preparation did you undertake for it?***
"I had been a student in professor Brown's Introduction to Chemical Principles class freshman year and enjoyed the class quite a bit. When I was questioning how one goes about finding research at Notre Dame, I thought it best to send him an email asking for his insight. We scheduled a meeting, and discussed research on campus. Later that year he offered me a position in his lab!"

***Where was your research experience located?***
"The University of Notre Dame"

***What did you get out of your research position?***
"My research position has given me the opportunity to explore new territories and be able to call something my own work. This is something that I am extremely grateful for."

**Detecting Cardiac Abnormalities on the Electrocardiomatrix**

Alex Arreguin
Major: Science Preprofessional Studies
Advisor: Jimo Borjigin, Department of Molecular and Integrative Physiology,
University of Michigan, Ann Arbor, MI

Heart disease is the leading cause of death in the United States and the entire world. Arrhythmias, or improper beating of the heart, can cause heart disease by damaging the heart's electrical system. Arrhythmias are traditionally detected manually on the electrocardiogram (ECG), a painless test that records the heart's electrical activity; however, detection of arrhythmias on the ECG is very slow. Therefore, the diagnosis of cardiac arrhythmias needs to be more accurate and less complicated. A new method developed in house called the Electrocardiomatrix (ECM) is an effective and precise way to characterize arrhythmias. The ECM displays long periods of cardiac signals that capture every heartbeat in a compact manner. This new method is intuitive and allows for single-glance visualization of changes in heart rate and heartbeat structure. Application of the ECM in clinical practice would allow for more speedy and accurate diagnosis of heart conditions. Therefore, it is important for physicians to have access to a library of resources that allows them to understand the appearance of arrhythmias on the ECM. An online library of cardiac abnormalities was created to demonstrate how the ECM facilitates analysis of cardiac signals traditionally predicted by the ECG. Specifically, several databases of cardiac abnormalities were analyzed using the ECM, and different types of cardiac abnormalities were differentiated and organized into the online library.

***What inspired you to participate in undergraduate research?***
As a pre-medical student, I became interested in biomedical research because it allows for the translation of research findings into medical practice and meaningful health outcomes.

***How did you get your research position, and what preparation did you undertake for it?***
After reading my research mentor's papers, I became interested in her research and applied to a summer research fellowship that allowed me to work in her lab. I prepared for the fellowship by reviewing the papers produced by the lab.

***Where was your research experience located?***
University of Michigan

***What did you get out of your research experience?***
Working in a research lab was a great learning opportunity. I obtained exposure to conducting research and gained experience in a career that I hope to pursue in the future.

**The Effects of Two Common Pharmaceuticals and Increased Nutrient Concentrations on Algal Biofilms in a Midwestern Stream**

Elizabeth M. Berg
Major: Environmental Science
Minor: Sustainability
Mentor: Sara Benevente, Dept. of Biological Sciences, University of Notre Dame

Biofilms operate as biological filters within stream ecosystems, removing nutrients as water travels downstream. Excess nutrients in headwater streams often lead to dead zones at mouths of rivers, decreasing biodiversity and fishery yields there. Previous studies suggest urban pollutants, nearly ubiquitous in watersheds, have negative effects on biofilm growth. This study examined the combined effect of two nutrients (nitrogen [N] and phosphorous [P]) and two common pharmaceutical pollutants (caffeine and ibuprofen) on autotrophic biofilm growth in a forested Midwestern stream. Based on a modified nutrient diffusing substrata methodology, pharmaceutical diffusing substrata (PhaDS) were comprised of agar containing nutrients (N, P) and/or pharmaceuticals (caffeine, ibuprofen) and fritted glass discs. The PhaDS were left to incubate for 17 days before chlorophyll *a* analysis. Mean chlorophyll concentration on PhaDS treated with nitrogen (6650 $\mu g \bullet m^{-2}$) was more than twice as high as the control (3096 $\mu g \bullet m^{-2}$, $p < 0.05$). The mean of phosphorous treatments was higher than the control (3187 $\mu g \bullet m^{-2}$), yet not significantly different ($p > 0.05$). Additions of ibuprofen and caffeine resulted in chlorophyll *a* concentrations of 5293 $\mu g \bullet m^{-2}$ and 5478 $\mu g \bullet m^{-2}$, respectively, and did not differ significantly from the controls ($F_{3,45} = 2.77$, $p > 0.05$). The results suggested the stream was nitrogen-limited, and neither ibuprofen nor caffeine hindered the biofilm's ability to process excess nutrients in a stream.

***What inspired you to participate in undergraduate research?***
"I wanted to get involved in research in order to be more sure about my path after Notre Dame. I believed that I wanted to go to graduate school, but researching over the summer made me more certain that it was what I wanted to do."

***How did you get your research position, and what preparation did you undertake for it?***
"I conducted research at UNDERC-East, which is a program through Notre Dame for undergraduates. Applications are typically due in November. Preparation took place the spring semester before going to UNDERC when we had a weekly class meeting to talk about the program."

***Where was your research experience located?***
"University of Notre Dame Environmental Research Center (UNDERC)- East, located on the border of northern Wisconsin and the Upper Peninsula of Michigan"

***What did you get out of your research experience?***
"This research gave me experience working independently on a project designed entirely by me. It gave me a taste of what graduate school will be like and what it is like to work in field ecology, both the good sides and the bad."

**Open Science Framework Improves**
**Distributed Pharmaceutical Analysis Lab (DPAL) Operations**

Margaret Berta
Majors: Biochemistry and Political Science
Advisor: Marya Lieberman, Dept. of Chemistry and Biochemistry, University of Notre Dame

Substandard pharmaceuticals are a widespread problem in developing countries. Often, Medical Regulatory Authorities (MRA) are unable to maintain post-market quality control. To aid in pharmaceutical analysis, the Distributed Pharmaceutical Analysis Lab (DPAL) was established. DPAL is a collaborative program that utilizes high performance liquid chromatography (HPLC) capacity at academic institutions in the United States to quantify the amount of active pharmaceutical ingredient in samples from Kenya. Substandard medications are reported to regulatory agencies, and results are potentially used to take legal action against manufacturers. Therefore, DPAL must maintain standard operating procedures (SOPs), verify the analytical procedures at participant institutions and employ a secure means of sharing data. To standardize the program, electronic forms and templates were created to be used in conjunction with a revised SOP. The Open Science Framework (OSF), a free research project management site, was used for transparent data sharing and communication among DPAL participants. The SOP and the use of OSF has organized DPAL into a secure program which is able to grow and increase its analytical power to serve the developing world.

***What inspired you to participate in undergraduate research?***
"It is exciting to understand how concepts learned in class are applied to the real world and can be utilized to make positive change."

***How did you get your research position, and what preparation did you undertake for it?***
"I have been a member of the Lieberman lab since 2013, and I wanted to continue my academic year research in the summer to expand the scope of the project. I applied for grants at the Center for Undergraduate Scholarly Engagement (CUSE) and received funding from the First Year of Studies, College of Science and CUSE for my research.

***Where was your research experience located?***
"University of Notre Dame"

***What did you get out of your research experience?***
"The opportunity to work with new collaborators and travel to participant institutions. I learned how to write program policies and grants, manage scientific legal considerations, and enact functional operating procedures.

**Membrane Antigen Viability After Conjugated Pigment and Immunofluorescent Staining of SKBR3**

Christopher Boldt
Major: Science Pre-Professional
Advisor: Erik Gerdtsson, Kuhn Lab Bridge Institute,
University of Southern California, Los Angeles, CA

Fine needle aspiration (FNA) cytology is frequently the first diagnostic approach to lung and breast lumps in many hospitals. FNA's often result in a very limited number of cells of significant diagnostic value. In the clinical setting pigment staining is routinely used on these samples. From a research perspective it would be desirable to have the option to use the same samples to further characterize the protein expression of the cells using immunostaining techniques. However, the effectiveness of both in concert was uncertain, due to the belief that the pigment stain could damage the highly specific membrane antigens. A conjugated staining procedure was suggested, consisting of pigment staining, followed by immunofluorescence staining to determine the viability of epithelial membrane antigens. High-Resolution Images were captured with the Nikon Eclipse 80i microscope and quantified by Image Pro Analyzer, which determined the signal intensity of fluorescence for each condition. Qualitative and quantitative data suggest that two common pathological pigments were not deleterious to membrane antigens. In addition, biochemical analysis showed that these results were stain dependent, as the Papanicalou stain barred antibody binding. There was no significant intensity difference ($p < 0.5$) between cells kept wet or dry, allowing for asynchronous staining. Pathological samples could potentially be used alongside revolutionary cell imaging techniques such as Imaging Mass Cytometry (IMC), that utilizes a highly multiplexed metal labeled antibody staining procedure, to provide clinicians with unparalleled biochemical insight from a single FNA. The ability to quickly and effectively identify cancerous cells within an FNA sample through a conjugated staining protocol could provide clinically useful information as well as aid in our understanding of immunocytochemistry.

***What inspired you to participate in undergraduate research?***
The opportunity to make a difference now, as an undergraduate, through applying what I have learned in an effort to improve the lives of millions who fight cancer inspired me to participate in undergraduate research.

***How did you get your research position, and what preparation did you undertake for it?***
Networking is the key to landing a research position outside of Notre Dame. The common application process to various "Non-University" labs was simply not what I was looking to study, financially burdensome, and too far from home. I found an incredible program at the University of Southern California and did everything I could to convince them to accept a Notre Dame student.

***Where was your research experience located?***
University of Southern California

***What did you get out of your research experience?***
I spent an incredible summer at the Bridge Institute at USC, where I made new friends who shared in the same zeal to beat cancer! The Bridge's paramount mission is to promote interdisciplinary research as a means of tackling a problem like cancer from every possible angle. This unique emphasis has shaped my perspective on my studies here at Notre Dame, particularly my interest in interdisciplinary classes, and has inspired me to utilize my unique skill set, in concert with scholars of other disciplines, to solve seemingly impossible problems.

**RGD-Embedded Depsipeptides: Enantioselective Synthesis of a Key Precursor**

Danielle A. Boley
Major: Biochemistry
Advisor: Jeffrey N. Johnston, Department of Chemistry, Vanderbilt University, Nashville, TN
Coauthors: Suzanne M. Batiste

Arginylglycylaspartic acid (RGD) is a tripeptide cellular recognition sequence that interacts selectively with cell surface receptors, called integrins. These interactions are known to induce cell signaling pathways that are important in several pathological processes. The current understanding of protein-integrin interactions has influenced the development of macrocyclic peptide drugs with RGD motifs. Although synthetic methods have been developed to produce these molecules, using them to create RGD cyclic peptides and depsipeptides still poses a significant challenge. We propose a strategy to produce cyclic RGD depsipeptides that uses a combination of enantioselective synthesis and Umpolung Amide Synthesis (UmAS). This approach achieves the broadest possible scope while overcoming preparative synthetic challenges. This synthesis includes an enantioselective Henry addition of bromonitromethane into an aliphatic aldehyde, followed by coupling of the bromonitroalkane product with a dipeptide, L-Orn(Z)-Gly-OMe, using UmAS. Preliminary results have established a successful synthesis of the necessary catalyst, production of amide product, and coupling of amino acids. Future work includes saponification and subsequent coupling with an Asp-containing tridepsipeptide. The resulting hexadepsipeptide will then be used in the synthesis of large RGD macrocycles, which could be medically important in the future since integrin-related drugs have the potential to treat heart disease, cancer, and autoimmune diseases.

***What inspired you to participate in undergraduate research?***
"I would like to attend graduate school and become a scientist, so I chose to participate in undergraduate research to help me determine my research interests for graduate school and gain skills that will benefit me in the future."

***How did you get your research position, and what preparation did you undertake for it?***
"I applied for the Vanderbilt Research Experience for Undergraduates in Chemical Biology program at the end of January 2016 and was accepted by the beginning of March. Since I was new to organic chemistry research, I read journal articles that Dr. Johnston's lab had published recently."

***Where was your research experience located?***
"Vanderbilt University."

***What did you get out of your research experience?***
"I learned a new skill set that was different from my bioanalytical chemistry background and realized that my favorite part of organic chemistry was the analysis of products by spectroscopy."

**Role of Chaperone Protein ERp29 in Insulin Trafficking and Maturation**

Margaret Brecker
Major: Biology and Sociology
Advisor: Ron Rubenstein MD PhD, Director, Cystic Fibrosis Center,
The Children's Hospital of Philadelphia, Philadelphia, PA
Coauthors: Laurence Suaud, PhD, Christine Ferrara, MD, PhD, Yann Bikard, PhD

Dysfunctional protein folding in pancreatic beta cells may contribute to the development of both type 2 diabetes (T2D) and cystic fibrosis related diabetes (CFRD). Insulin folding and maturation is a tightly regulated process; however, a fundamental gap in our understanding of insulin biogenesis is the mechanism by which a pool of proinsulin is directed to the Golgi for processing and cleavage to insulin, while another pool remains unprocessed and is secreted as proinsulin. ERp29 is a luminal endoplasmic reticulum resident protein that is expressed ubiquitously in mammalian tissue. Our group previously demonstrated that ERp29 promotes biogenesis of both the cystic fibrosis transmembrane conductance regulator (CFTR) and the Epithelial Sodium Channel (ENaC). Interestingly, human insulin biogenesis parallels that of ENaC in that both undergo cleavage in the Golgi, a process that for ENaC appears to be regulated by ERp29. As human proinsulin contains a putative recognition motif for ERp29, $^{48}$F-F-Y$^{50}$, we hypothesize that ERp29 interacts with proinsulin and has an integral role in directing proinsulin to the Golgi for cleavage into insulin and C-peptide. This hypothesis was initially supported by preliminary data demonstrating that overexpression of wild type ERp29 increased insulin secreted by INS-1 rat beta cells, while expression of a non-functional ERp29 (C157S) inhibited insulin secretion. To investigate the potential association of ERp29 and proinsulin in these cells we used a co-immunoprecipitation approach. Our data demonstrate that ERp29 co-precipitates, and therefore associates with both proinsulin and preproinsulin, consistent with our hypothesis that ERp29 regulates the maturation of insulin. Our group previously demonstrated that treatment of lung epithelial cells with 4-phenylbutyrate (4PBA) increases the expression of ERp29. We therefore investigated the effect of 4PBA treatment on INS-1 cells and found that incubation with 1 mM 4PBA resulted in an ~30% increase in ERp29 expression as early as 4 hours post-treatment. Interestingly, while 4PBA treatment appears to increase the total insulin content in pancreatic beta cells, our preliminary data suggest that treatment with 4PBA also elevates the proinsulin:insulin ratio in whole cell lysates. Further investigation of the role of ERp29 in insulin processing could provide fundamental insight into the mechanisms of insulin biogenesis, while demonstrating whether or not ERp29 is a viable target for treatment of both T2D and CFRD.

***What inspired you to participate in undergraduate research?***
"My cousin, Sarah, was diagnosed with cystic fibrosis when she was two-years-old. She is now fourteen and is my inspiration. Because of Sarah, I had been considering a career in research for years but was not aware that undergraduate research was as readily available as it is. I was scared to dive into research, but I had a few excellent upperclassmen mentors to lend a hand and some advice when it was needed."

***How did you get your research position, and what preparation did you undertake for it?***
"Dr. Rubenstein is one of the pediatric pulmonologists who treats my cousin. In the fall of my freshman year, I sent Dr. Rubenstein an email explaining who I was and why I was interested in

research, particularly cystic fibrosis research. He offered me an interview and eventually a position in his lab as an intern for the summer. To prepare, I reviewed the lab's recent publications and the research techniques I had learned in my introductory biology lab courses."

***Where was your research experience located?***
"The Children's Hospital of Philadelphia (CHOP)"

***What did you get out of your research experience?***
"My two summers of research at CHOP were instrumental for my maturation as a scientist, a student, and an individual. My laboratory skills substantially improved, while my critical analysis and problem solving skills were tested and developed. I learned how to think like a scientist through immersion into the field, and I fell in love with it. Outside of personal skills and development, I gained an incredible mentor in Dr. Rubenstein and made connections with some brilliant researchers and physicians at both CHOP and Penn. My love of research after my first summer at CHOP inspired me to seek undergraduate research at Notre Dame. I now am involved in retinal regeneration research in the Hyde Lab and plan to apply to MD/PhD dual degree programs."

**Sensitivity of marsh elevation to biological characteristics of *Schoeonoplectus americanus***

Caitlin Broderick
Major: Biological Sciences
Advisor: Jason McLachlan, Department of Biology, University of Notre Dame

The Marsh Equilibrium Model (MEM) uses physical inputs and biological characteristics of dominant plants to predict elevation trends in coastal salt marshes in response to climate change. Previous studies have found genetically based phenotypic differences in the marsh sedge *Schoeonoplectus americanus* in response to salinity, CO2 and inundation. Right now, it is unclear how strongly these biological characteristics affect MEM predictions. I conducted a one-at-a-time sensitivity analysis on the MEM and hypothesized that (1) stem density (SD) and (2) the belowground to aboveground standing biomass ratio (BG:AG) would have large effects on marsh elevation and stability predictions. For each of 18 variables I gradually changed the input value while holding the rest constant and evaluated its effect on elevation output. I found that increases in SD predicted faster marsh recovery from a collapse, while increases in both SD and BG:AG delayed the year of marsh elevation collapse. But I found that the model was most sensitive to changes in the 'refractory fraction', a proxy for lignin content. Because of my results, while our lab has not monitored lignin in previous experiments, future studies will include lignin analysis to better predict marsh elevation and stability over the next century.

***What inspired you to participate in undergraduate research?***
"I was interested in ecology and wanted to pursue a different opportunity in science outside of introductory laboratory classes. Experiences for medical school applications were an important factor at the time, but I soon decided against a pre-medicine path and instead made research a main component of my undergraduate career."

***How did you get your research position, and what preparation did you undertake for it?***
"I wanted to work for pay in a research lab my freshman year, so I researched the lab pages of Notre Dame faculty who were conducting research. I was hired to enter survey notes into an electronic database. About a year later, my advisor agreed to assist me in a more independent research project on Midwestern forests and savannas. But this summer's work was pretty different than my previous work in a lab, so I had to read a lot of literature in order to understand the most important questions and methods related to salt marsh ecology."

***Where was your research experience located?***
"University of Notre Dame"

***What did you get out of your research experience?***
"This summer improved my skills in searching literature, generating questions, understanding and adapting existing protocols, working with model and employing new field techniques. My summer work helped me better understand the relationship between the fields of ecology andevolution and how, in a changing world, the fields will become more integrated."

**Reconstruction of Top Quark Pair and Higgs Production**

John Charters
Major: Honors Physics, Honors Mathematics
Advisor: Kevin Lannon, Dept. of Physics, University of Notre Dame
Coauthors: Marybeth Beydler

In 2012, the Large Hadron Collider (LHC) detected a particle that is consistent with the Higgs boson, as predicted by the Standard Model. Since this incredible discovery, physicists at the European Organization for Nuclear Research (CERN) have continued to verify the properties of this particle and confirm its identity. The Higgs boson gives other particles their masses; the strength of the interaction between the Higgs field and a particle is expressed in terms of its coupling constant. One coupling of interest, that experimentalists have yet to measure directly, is with the top quark. The top quark is the most massive elementary particle. The fact that it is heavier than the Higgs boson implies it is impossible to detect a Higgs decay into a top quark. The alternative is to measure the production of a Higgs in association with a top quark pair (ttH). This poster focuses on the same-sign dilepton signature of ttH production as a compromise between the rarity of the signature and a low level of background. The decay process is quite complex. Therefore, a Boosted Decision Tree (BDT) is used to increase the sensitivity of the analysis. The performance of BDT reconstruction is presented, including causes for wrong assignments of final states in order to improve accuracy.

***How did you get your research position, and what preparation did you undertake for it?***
"I received funding through the College of Science Summer Undergraduate Research Fellowship (COSSURF). I participated in an REU the previous summer, after my freshman year, and I decided to continue the research this past summer. Preparation included becoming familiar with the new software I'd be working with."

***Where was your research experience located?***
"University of Notre Dame."

***What did you get out of your research experience?***
"I gained a lot of experience in terms of speaking to professionals in this field via online meetings that were held weekly. I gained more familiarity with coding

**Field Study to Inform Biological Conservation: Resource tradeoffs of the endangered Karner blue butterfly (*Lycaeides melissa samuelis*)**

Sophia Chau
Major: Environmental Sciences
Advisors: Stuart Jones, Dept. of Biological Sciences, University of Notre Dame
Jessica Hellmann, Institute on the Environment, University of Minnesota, St. Paul, MN, and
Lainey Bristow, Dept. of Biological Sciences, University of Notre Dame

Climate change and loss of oak savanna habitat threaten the Karner blue butterfly (KBB), an insect native to the Midwest and Eastern U.S. and Ontario, Canada. KBB larvae only feed on wild blue lupine, while adults must obtain nectar elsewhere because lupine lacks nectar. Understanding the resource tradeoffs that female KBBs face while laying eggs on lupine and foraging for nectar can inform habitat management for the species. In the field, females were observed twice as often as males on lupine, and over two-thirds of observed females were found on lupine. Males were observed on lupine at the same frequency as on nectar. Females may thus face a tradeoff between egg-laying and foraging time. Given that males do not lay eggs, it was unexpected that a third of males were observed on lupine. However, males may need to search for mates in lupine patches with females present. KBBs were further observed most often in patches with average densities of both lupine and nectar, and less often in patches with a high density of one resource but low density of the other. Thus, both lupine and nectar could act as limiting resources on KBBs. Managing habitats so that nectar and lupine are interspersed may decrease the necessary flight activity for both sexes, which could increase their reproductive success and longevity.

***What inspired you to participate in undergraduate research?***
"I wanted to contribute to environmental solutions and viewed research in the Hellmann lab as a first step to a career in conservation biology."

***How did you get your research position, and what preparation did you undertake for it?***
"I learned about Dr. Hellmann's research through a course I took with her and reached out to her for opportunities. During the school year, I learned as much as I could about the KBB through studying the literature and working alongside a Notre Dame graduate student, reached out to Dr. Jones for guidance on ecological modeling, and planned out my field study by speaking with land managers and field ecologists. I also applied to the Notre Dame College of Science Summer Undergraduate Research Fellowship to fund my research."

***Where was your research experience located?***
"University of Notre Dame and Sandhill Wildlife Area, WI."

***What did you get out of your research experience?***
"Affirmation that a career in conservation biology is a good fit for me! I worked on a question that fascinated me, developed into a more independent researcher, and really enjoyed observing butterflies in the field. I developed skills and gained collaborators that have better prepared me to pursue graduate studies."

**The effect of fatty acids on biofilm formation by *Staphylococcus aureus***

Emma Cooper
Major: Biological Sciences
Advisor: Jennifer Mitchell, University College Dublin, Dublin, Ireland

*Staphoccocus aureus* (*S. aureus)* is a gram-positive microorgnonism that is a comensal skin bacteria in humans. 20% of the population is colonized with *S. aureus* and it can easily cause opportunistic infections. One of the virulence characteristics of the microorganism is its ability to form biofilms. Biofilm infections can be hard to treat due to decreased antibiotic penetration, the altered physiology of organisms in biofilm, and antibiotic neutralization. Certain growth factors, such as fatty acids, are important to research as they may inhibit and thus help fight *S. aureus* biofilm formation. In this study, microtiter plate biofilm assays as well as microscopic examination were conducted to measure *S. aureus* biofilm formation under the presence or absence of various chemical and fatty acid conditions in order to determine which conditions promote or inhibit biofilm formation. It was found that glucose and NaCl promote *S. aureus* biofilm formation, while ethanolamine inhibits biofilm formation. 30% EtOH does not inhibit biofilm formation. Additionally, the growth of *S. aureus* in the presence of fatty acids has a variable effect on biofilm formation, depending on the fatty acid. Oleic acid promotes *S. aureus* biofilm formation and aarachidonic acid does not inhibit biofilm formation as much as myristic acid and docosahexaenoic acid.

***What inspired you to participate in undergraduate research?***
"I knew that I wanted to apply what I was learning in class on a deeper level in order to gain a deeper and more full understanding of the science that was so interesting in the classroom."

***How did you get your research position, and what preparation did you undertake for it?***
"For this research project specifically, I enrolled in the Introduction to Research course while I was studying abroad at University College Dublin in Dublin, Ireland during the Spring of 2016. I evaluated all of the research that I was interested in and then reached out to the professors who were conducting the research and asked them if I could conduct a research project in their lab. In this way, I was able to find the beset fit for my interests and the professor's needs."

***Where was your research experience located?***
"School of Biomolecular and Biomedical Sciences, University of College Dublin in Dublin, Ireland."

***What did you get out of your research experience?***
"An understanding of how Irish laboratories run and how their graduate programs are organized. I also gained new friends, colleges, and a great mentor in Dublin, Ireland. This research experience will be useful when moving forward with my medical degree because I now have a deeper understanding of how crucial scientific and medical discoveries actually occur.

**Pileup and Truncation Studies for the Proposed CMS L1 Track Trigger Upgrade**

Benjamin Cote
Major: Physics and Mathematics
Advisors: Kevin Lannon and Michael Hildreth, Dept. of Physics, University of Notre Dame
Coauthors: Ryan Kim

In order to undertake experiments with higher energy proton collisions, the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland is scheduled for an update in the near future. With these higher luminosity events, there will be an addition of glancing collisions that produce data which is physically uninteresting. This data, known as pileup, is particularly troubling for the Compact Muon Solenoid (CMS) detector and, thus, the CMS detector must be upgraded to accommodate it. This upgrade includes the implementation of a Level-1 (L1) Track Trigger. This L1 Track-Trigger is composed of field-programmable gata array (FPGA) technology which implements a track reconstruction algorithm. The research conducted involves an FPGA emulation code which runs over simulated events in order to characterize the anticipated performance of this L1 Track-Trigger. Understanding how this FPGA emulation code reacts to realistic conditions and limitations gives vital insight into how the actual FPGAs would perform in the upgraded LHC. This research primarily focuses on the limitations to time and memory associated with the physical trigger known as truncation. Characterizing the performance of the emulation code under the conditions of pileup and truncation is essential in preparation for the actual implementation of the L1 Track Trigger.

***What inspired you to participate in undergraduate research?***
"For the first year of college, I struggled figuring out what I wanted to do with my future. With a physics degree, I knew one path would be to pursue professorship and that undergraduate research was part of this path. As such, I decided I wanted to be a professor and began undergraduate research."
***How did you get your research position, and what preparation did you undertake for it?***
"I have been researching under Professors Lannon and Hildreth since the spring of 2016 and they taught a research course that semester to prepare us for the research to come. The research submittal was a combination of ongoing projects from academic-year research and new projects suggested by our greater multi-university team. The Notre Dame College of Science Summer Undergraduate Research Fellowship funded the research done through the Department of Physics Research Experience for Undergraduates."
***Where was your research experience located?***
"All research has taken place at the University of Notre Dame."
***What did you get out of your research experience?***
"I had a wonderful summer devoted to research. I made several friends from all over the country that I hope to see at some point in my future studies. I learned valuable lessons about what it's like to have a regular work day centered around research. I also learned what it is like to work more closely with collaborators from other universities. It was a great experience in presenting my research both on paper and in person and the summer gave me a better picture of what graduate student life would look like."

**Impact of Forest Disturbances in Upper Midwest on Forest Structure and Leaf Area Index**

Melissa Cross
Major: Science Business
Advisor: Adrian Rocha, Dept. of Biological Sciences, University of Notre Dame

Upper Midwestern forests have experienced significant disturbances, particularly during the 18th and 19th centuries. As forests regrew, species composition shifted resulting in second growth forests with very different characteristics than their historic counterparts. This shift in species composition has repercussions for many physiological processes, in particular leaf area index (LAI), which can impact both large and small-scale climatic processes. To this end, LAI was measured with a LAI-2200C Plant Canopy Analyzer twice a month throughout the summer of 2016 and averaged to calculate stand-level LAI of both a second growth forest, Willow Creek, and a primary growth forest, Sylvania Wilderness. Past studies suggest that stand age is negatively correlated to canopy heterogeneity, so it was expected that Sylvania would have a lower LAI than would Willow Creek. Species composition, tree height, and diameter at breast height (dbh) measurements were also collected at both sites to understand forest composition differences between the second growth and primary growth sites. The comparison of Sylvania's and Willow Creek's LAI showed Sylvania to have a significantly higher LAI in both May and June, in part due to the presence of evergreen trees at Sylvania. This difference in LAI reversed throughout the course of the summer, with the LAI at Willow Creek surpassing that at Sylvania in mid-summer. Studies are ongoing to explore the influence of changes in LAI on stand sap flux and to look at LAI differences between these two sites over a larger timescale.

***What inspired you to participate in undergraduate research?***
"I have always been interested in learning more about large scale ecosystem effects and realized undergraduate research would be a great way to expand my knowledge and improve my analysis skills."

***How did you get your research position, and what preparation did you undertake for it?***
"I was in General Ecology lecture with Professor Rocha when I found out about a project one of his graduate students was undertaking and found it very interesting, so I stopped by office hours and asked if there were any opportunities for undergraduate research in the Rocha lab. My summer research position stemmed from opportunities within Rocha's lab, and I was given the chance to run my own experiment. After submitting a research proposal based on the research I had conducted during the academic-year, the Notre Dame College of Science Summer Undergraduate Research Fellowship provided funding for my research."

***Where was your research experience located?***
"At the University of Notre Dame Environmental Research Center in Northern Wisconsin."

***What did you get out of your research experience?***
"I had the opportunity to make friends from a variety of universities, learn about the research process, write grants, and interpret results."

## Deep Learning for Particle Physics

Colin Dablain
Major: Physics
Advisor: Kevin Lannon, Dept. of Physics, University of Notre Dame

The particle colliders employed by high energy physicists to probe the properties of the fundamental constituents of matter produce an astounding volume of collisions, and, consequently, data. Identifying the particles in a particular collision involves solving signal-background classification problems that are intractable for humans. To solve these classification problems, various machine learning methods are typically employed; though no particular machine learning method has yet proved markedly superior to the others. Recent work by machine learning researchers on the field of deep learning, particularly on deep neural networks, has produced state-of-the-art results on image recognition and natural language processing tasks. The scope of my work has been to use simulated collision data from the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC) to train deep neural networks with the goal of producing statistically significant results on a dataset of collisions in which proton-proton collisions produce two top quarks and a Higgs Boson.

***What inspired you to participate in undergraduate research?***
I love computer science, and the opportunity to combine computer science and physics was a neat opportunity for me.

***How did you get your research position, and what preparation did you undertake for it?***
I have been working with Professor Lannon since the Fall of 2015; I had Professor Lannon for my introductory physics majors classes and he offered me a position during the summer between my Freshman and Sophomore years.

***Where was your research experience located?***
University of Notre Dame

***What did you get out of your research experience?***
I had a great time working on campus over the summer, and the experience improved my critical thinking skills.

**Characterization of small RNA binding properties of *E. histolytica* Argonaute proteins**

Lauren Davancaze
Biochemistry Major
Advisor: Upinder Singh, Dept. of Infectious Diseases and Geographic Medicine,
Stanford University, Stanford, CA

*Entamoeba histolytica* causes amebiasis, and is the second leading cause of parasitic death worldwide. The molecular mechanisms for parasite invasion and stage conversion are not fully understood. Recently, an active RNA interference pathway has been found and shown to provide a way for studying gene function in this important organism. *E. histolytica* contains three Argonaute proteins, which associate with an abundant population of small RNAs. To further explore the mechanisms of gene silencing in this organism, genetic mutants were generated targeting the key amino acid residues in conserved regions of the critical PAZ and Piwi domains of the three *E. histolytica* Argonaute genes. All mutant cell lines were examined by Western blot for protein expression and immunofluorescence for cellular localization. Once expression had been confirmed, the proteins were immunoprecipitated and sRNA binding activity was determined by pCp labeling. Our results indicate no detectable sRNA binding due to mutation of the AGO2-1 and AGO2-3 PAZ domain, which is known to function as the binding pocket. Further study will investigate mRNA cleavage and its RNAi silencing effects, with implications for designing an efficient genetic tool to study parasite biology and disease transmission.

***What inspired you to participate in undergraduate research?***
"I love exploring the scientific mechanisms behind the internal processes of biological organisms. The process of discovery is fascinating, and I enjoy investigating difficult questions in a lab setting. I have always appreciated the opportunity to be a part of the scientific community in its quest for knowledge, particularly as pertaining to treatments for disease."

***How did you get your research position, and what preparation did you undertake for it?***
"I know Dr. Singh through a family connection, and asked to join her lab over the summer. After sending her my resume and references, and interviewing on the phone, she accepted me into the lab. I prepared by reading journal and review articles on the research subject."

***Where was your research experience located?***
"Stanford University, Palo Alto, CA"

***What did you get out of your research experience?***
"I learned how to conduct research at a high academic level, how to use current biological methods to obtain and analyse results, and how to read and write using scientific language. By the end of the summer, I gained a sense of ownership for running my own project, as well as a notion of how much I enjoyed working in a lab for an extended period of time. While parasitic biology is not the specific field I am looking to enter, my summer experience provided a solid foundation for future scientific research endeavours."

**Impact of Electrical Failure on Patient Surgical Outcome**

Michael DiGaetano
Major: Science-Business
Advisor: Abigail Mechtenberg, Dept. of Physics, University of Notre Dame

Although the detriment of electrical failure at healthcare facilities is significant, little progress has been made in the way of quantification of associated additional risks to patient outcome. Obtaining energy failure data over the course of a year from published research journals, we measured voltage and current readings in order to model three types of risk associated to the patient: low, medium, and high impact. Sensitivity analyses were performed while looking at two medical procedures of interest: oxygen delivery and scheduled surgery. Although data collection has been lagging in relation to cause of patient death due to electrical failure, experts often suggest backup flashlights. However, we find that without proper electrical technology and prolific data collection, statistical probabilities can be used to assist in quantifying risk and explaining those deaths that are reported. We estimate the number of patient deaths associated with additional patient risk due to electricity failure. Our results suggest that building medical energy reliable on-demand backup energy systems should be a global health priority

***What inspired you to participate in undergraduate research?***
This research provided me with the opportunity to bridge and integrate multiple fields including my major Science-Business, my physics coursework, and my clinical experience. To be able to integrate different aspects of science as well as other fields outside the college of science became a new flavor and a novel aspect of my college experience.

***How did you get your research position, and what preparation did you undertake for it?***
Coming out of my junior year and having just finished coursework with Dr. Mechtenberg, I wanted to take my final project to the next level and look at the impact of electricity, or in this case electrical failure, on patient outcome. In conducting the research, we looked at annually collected data for the electricity usage and shortages in the region or area of interest.

***Where was your research experience located?***
University of Notre Dame

***What did you get out of your research experience?***
By conducting this research, I have greatly improved upon my ability to integrate many different fields and to be able to effectively communicate with vastly different disciplines.

**Using Deep Neural Networks to Analyze Collisions in High Energy Physics**

Matthew Drnevich
Major: Physics and Honors Mathematics
Advisor: Kevin Lannon, Dept. of Physics, University of Notre Dame

At the forefront of experimental particle physics is the Large Hadron Collider in Geneva, Switzerland. There, protons collide at nearly the speed of light with a rate of over 40 million collisions per second. Due to computing and resource limitations, the raw data that these collisions produce cannot be recorded at such a rate. Furthermore, within this data is an incredibly small subset of collisions that are particularly useful for helping us prove or discover theories in physics. To use an analogy, you can imagine that each particle of sand on a beach is one collision and the goal is to find the rare set of particles that have a specific orange-red tint. The detector uses analysis methods to first remove all of the sand that is obviously not red or orange. Then, the remaining sand is analyzed by more complex analysis tools on a larger computing grid to isolate the sand that includes both red and orange characteristics. Finally, an analysis method needs to be used to discern one reddish-orange sand particle from another. Due to recent advances in machine learning, there is reason to believe that using deep learning techniques, such as neural networks, could improve the accuracy of isolating such events. One such exotic collision, the production of a Higgs boson paired with a top quark, is of particular interest to us. This research into a better algorithm should enable us to analyze these collisions more efficiently and accurately than current methods.

***What inspired you to participate in undergraduate research?***
I am very interested in working on problems on the forefront of science and potentially developing new or better solutions to these problems. In addition, working with talented scientists always encourages me to think deeper and grow intellectually, particularly in my field of interest.

***How did you get your research position, and what preparation did you undertake for it?***
My research advisor mentioned the opportunity to me, and I submitted an application to the program. My summer research ended up being a continuation of the research that I engaged in during the year, so there was not any additional preparation required.

***Where was your research experience located?***
University of Notre Dame

***What did you get out of your research experience?***
The summer was an exciting time to really dedicate my time to our research, while also working more intimately with other collaborators and intellectuals in general. It was a great opportunity to experience the environment surrounding full-time research and it further helped develop my plans and goals.

## GDNF Expression in *Ambystoma mexicanum* During Hind Limb Regeneration

Samuel Eallonardo
Major: Biological Sciences
Advisor: Randolph Christensen, Department of Biology, Coe College, Cedar Rapids, IA

Axolotl salamanders, *Ambystoma mexicanum,* are capable of remarkable feats of regeneration, including the regeneration of limbs, tails, spinal cords, and parts of the brain. Increased understanding of the operation of regenerative processes promises to help improve wound treatments in humans. Limb regeneration is dependent on the presence of a function nerve, but the signaling between the nerves, glial cells, and regenerating tissue is not well understood. This study investigated Glial Derived Neurotrophic Factor (GDNF) as a potential factor involved in such signaling. We characterized GDNF levels in samples of regenerating Axolotl left hind limbs with semi-quantitative RT-PCR and western blotting to establish a spatiotemporal localization profile. Our results show an increase in GDNF expression during the medium and late bud stages of regeneration. The presence of netrin, a neurotropic factor, was also detected by western blot in the medium and late bud stages. This expression pattern suggests that GDNF is not involved in the innervation dependence of regeneration, which occurs in earlier stages, but does suggest a role for GDNF in the process of regenerating neural connections in the new limb.

***What inspired you to participate in undergraduate research?***
I was inspired to pursue undergraduate research as part of a long standing ambition to complete original scientific research and work to understand the complex functioning of living organisms.

***How did you get your research position, and what preparation did you undertake for it?***
I got my research position through Coe College's REU program. I was required to apply, providing information on my experience, my career goals, and references. My previous undergraduate research and experience in teaching labs gave me the necessary technical background for this experience. My work in preparing primarily involved reading literature to gain an understanding of my project and how it is situated relative to the larger field.

***Where was your research experience located?***
Coe College, Cedar Rapids, IA

***What did you get out of your research experience?***
This summer research provided me with the opportunity to broaden my experience in biology by undertaking intensive study of an area I would not otherwise be exposed to. In addition, being responsible for my own, independent project will help me prepare for graduate work.

**Sepsis leads to cognitive impairment of place cell formation in the Hippocampus**

Richard Felli
Major: Biochemistry
Advisor: Patricio T. Huerta, Laboratory of Autoimmune and Neural networks, The Feinstein Institute for Medical Research, Manhasset, NY

Sepsis is the leading cause of hospitalized related deaths in America. The disease affects approximately 750,000 patients annually, killing more than half its patients within the first 5 years of diagnosis. Of those who survive, 25% suffer cognitive impairment, such as inhibiting the capacity to learn, degrade memory, and synaptic plasticity. More specifically degradation of N-methyl-D-aspartate receptors (NMDAR) in the hippocampus degrades, therefore affecting place cell activity, or the amount a neuron fires when stimulated by a local distal cue. In order to better understand this phenomenon, BalbC mice underwent a cecal ligation puncture (CLP) procedure to induce first induce sepsis. The brain activity of these mice was then compared to the brain activity of mice that underwent a sham procedure (a control). Electrodes were implanted into the CA1 area of the hippocampus in each mouse's head through surgery. Afterwards, the mice were habituated to the experiment's environment, and subsequent trials were ran 10 minutes at a time to track neuronal activity. Our model suggests that sepsis decreases the amount of hippocampal cell firing, therefore decreasing the place cell formation in CLP mice.

***What inspired you to participate in undergraduate research?***
No matter whether you want to get into research, go to industry, or go to medical school, research should be the first step every science undergraduate takes to reach their goals. While learning from the classroom and from class labs is necessary, working in a research lab provides you with the opportunity to make new discoveries. As an aspiring doctor, I got involved in medical research I felt like the discoveries I was making in the laboratory could contribute to a future treatment which could help save the life of a patient. Although the research I do will have a minimal effect, if any now, eventually I will become more adept in analyzing results which could lead to patient saving treatments.

***How did you get your research position, and what preparation did you undertake for it?***
During my freshman year the Advanced Diagnostics & Therapeutics (AD&T) department at the University started their Precision medicine research fellowship. I was immediately interested because precision medicine is a relatively new field budding with potential. As soon as AD&T sent out the application, I started immediately, and thankfully got it.
As far as preparation goes, my PI (principle investigator) at the institute I work at had to teach me certain protocols for his lab experiments.

***Where was your research experience located?***
The Feinstein Institute for Medical Research, Manhasset, NY.

***What did you get out of your research experience?***
I got the unique experience of working at a medical institute. In addition to working in the lab I had the opportunity to take an immunology class that facilitated my understanding of the research I was doing. Additionally, this summer experience served as a great networking opportunity for me. As a recipient of the fellowship I got to meet with the president of the institute Dr. Kevin J. Tracey, who essentially founded the field of bioelectric medicine, along with some other researchers at the top of their field. To get a research position at the institute is competitive, but if I ever want to work at the lab again over the summer again, or even work at another lab in the institute I have the option to do so.

**Data Post-Processing Pipeline Development for the Foundation Supernova Survey**

Michael Foley
Major: Physics and Mathematics
Advisor: Dan Scolnic, Kavli Institute for Cosmological Physics,
University of Chicago, Chicago, IL
Coauthors: Ryan Foley, Department of Astronomy and Astrophysics, University of California Santa Cruz, Santa Cruz, CA, and Armin Rest Space Telescope Science Institute.

A major limiting factor in Type Ia supernova (SNIa) cosmological analyses is the heterogeneity and systematic uncertainties of the current low-z SNIa sample. The Foundation Supernova Survey aims to improve upon this by utilizing the extremely well calibrated Pan-STARRS telescope to obtain a large, high-fidelity, and homogeneous sample. Already the largest low-z SNIa sample on a single system, systematic uncertainties of Foundation are 2-3 times lower than those of previous surveys. A major component of Foundation is the data post-processing pipeline, which allows us to compile, fit, and analyze data nearly in real time. We present the development process and results of this pipeline, its effects on the calibration of Foundation, and the implications Foundation holds for cosmology over the next decade.

***What inspired you to participate in undergraduate research?***
I have always been interested in astronomy, and undergraduate research enables me to participate in science at the cutting edge of knowledge while furthering my education. Also, I couldn't pass up the opportunity to study and analyze supernovae.

***How did you get your research position, and what preparation did you undertake for it?***
I have worked with Professor Crepp and Professor Mathews on projects involving extensive programming. Professor Garnavich was kind enough to put me in contact with some of his colleagues at University of Chicago working on a project in which my coding experience would be helpful. After submitting a research proposal detailing the project, the Glynn Family Honors Program provided funding for my summer experience.

***Where was your research experience located?***
University of Chicago Kavli Institute for Cosmological Physics

***What did you get out of your research experience?***
I gained an awesome summer experience in Chicago, new friends, and potential collaborators from across the country. I learned about conducting an astronomical survey, working with a large group of collaborators, and analysis and interpretation of large amounts of data. It provided a solid foundation for future undergraduate research and graduate studies.

**Investigating The Role of Rab11b Mediated Recycling Pathway in Breast Cancer Brain Metastasis: Generation and Expression of pSNAP-Rab11b constructs**

Ruying Gao
Major: Biological Sciences
Advisor: Siyuan Zhang, Department of Biological Sciences, University of Notre Dame

Breast cancer brain metastases are a pressing clinical problem, with 30% of breast cancer mortality attributable to brain metastasis. However, the metastasis mechanism is not yet clearly understood. Crosstalk between the disseminated tumor cell and the metastatic microenvironment is known to be critical for tumor cell metastatic success. Previous research in my mentor Dr. Zhang's lab showed that the endosomal recycling mediator Rab11b is strongly up-regulated between the single breast cancer cells and the proliferative brain mets. The loss of Rab11b is also revealed to reduce tumor size and metastasis to the brain. Therefore, we hypothesized that the Rab11b-mediated recycling pathway facilitates breast cancer brain metastatic outgrowth. To dissect the role of Rab11b in regulating the process, I aimed at characterizing the recycling pathway in this project. A novel tagging tool, Snap-tag technology, was utilized to generate the wild-type, constitutively active and dominant negative Rab-Snap plasmid constructs. MDA-231 human breast cancer cells was then transfected with the constructs using liposomes and selected for Rab11b expression using puromycin. In the following semesters, I will continue my study by characterizing the effect of the Rab11b constructs generated on recycling of the transferrin receptor and determine if modulation of Rab11b-mediated recycling affects the proliferation of breast cancer cells when co-cultured with primary glial cells.

***What inspired you to participate in undergraduate research?***
"Having had some exposure to cancer research while I was in high school, I think doing research is a lot of fun. It is very cool when you look at the little cells under the microscope and think about how much power they have. So I continued."

***How did you get your research position, and what preparation did you undertake for it?***
"I sent Dr. Zhang an email expressing my interest in his project and had a one-hour meeting with him at the end of the fall semester. After shadowing in the lab for a semester, I submitted a research proposal and received HCRI-Summer Undergraduate Research Fellowship for the project."

***Where was your research experience located?***
"Harper Cancer Research Institute across the street!"

***What did you get out of your research experience?***
Be patient, organized, and open-minded. And have fun!

**Perceptions and experiences of stress and social support in long term ovarian cancer survivors: A qualitative analysis**

Jessica Gibson
Major: Neuroscience and Behavior
Advisors: Susan K. Peterson, PhD, MPH, and Eileen H. Shinn, PhD, Dept. of Behavioral Science, University of Texas MD Anderson Cancer Center, Houston, TX

Ovarian cancer is the eleventh most common cancer in the United States, but is the fifth leading cause of cancer deaths. Less than half of all women diagnosed with ovarian cancer survive for more than five years. Due to its high fatality, relatively little is known regarding the psychosocial aspects of long-term survival in ovarian cancer. This study identified attributions and perceived meaning of experiences related to long-term survival in a sample of long-term survivors of high-grade serous ovarian cancer (HGSOC), specifically in the context of stress and social support. Twenty-three women were recruited from a larger group of participants in a survey study to complete a semi-structured telephone interview regarding stress, social support, spirituality and health behaviors experienced since their diagnosis with ovarian cancer. All were diagnosed with HGSOC at least ten years prior to the interview. Many were married and generally reported positive spousal support. A greater proportion of women that had more than one recurrence reported a lack of spousal support than women with one or no recurrences. Women with multiple recurrences and those with one or no recurrences reported similar stressors. The study suggested the hypothesis that the degree to which a patient engages in social support, and the quality and source of the social support, may affect disease prognosis for ovarian cancer patients.

***What inspired you to participate in undergraduate research?***
"I have always been a curious person and the type to ask questions that didn't yet have answers. Research gives me the opportunity to find those answers firsthand."

***How did you get your research position, and what preparation did you undertake for it?***
"I applied to the program after finding out about it through the College of Science here at Notre Dame. Part of what got me the position was the research I had already conducted in a neuroscience lab here. To get the position in that lab, I sent one of the grad students an email about why I wanted to join. Luckily, they were looking for more RAs and I began working in the lab at the start of the following semester."

***Where was your research experience located?***
"MD Anderson Cancer Center"

***What did you get out of your research experience?***
"An excellent mentor-mentee relationship. Dr. Peterson helped me to make the experience exactly what I wanted, giving me freedom to analyze a set of data, setting up opportunities to work with EEG and helping me with career discernment. I learned how to conduct qualitative analysis, put my data into a publishable format and improve upon hiccups in the creation of protocols."

**An Investigation of the Effects of Native and Introduced Grazing on Soil Nitrogen Levels and Exotic Species Prevalence in the Palouse Prairie of Western Montana**

Claire Goodfellow
Major: Biological Sciences
Advisor: David Flagel, Dept. of Biological Sciences and Environmental Research Center, University of Notre Dame

The Palouse Prairie grassland is one of the most endangered ecosystems in the United States. Primary threats to this ecosystem include agricultural conversion of land, invasive species, and the loss of biodiversity, all of which are closely tied to an abiotic soil community. I investigated the similarities and differences between native (*Bison bison)* and introduced (commercial cattle) grazing effects on exotic species prevalence and how this relates to soil nitrogen levels. Three different land types were assessed for this study: bison-grazed land, cattle-grazed land, and ungrazed land. I surveyed forbs and graminoids at each site in addition to taking soil samples. Grazing type was found to have no significant effect on either the amount of total nitrogen present in the soil or on the proportion of introduced:native species present in an area. However, nitrogen content was found to be an important factor in determining exotic species for both bison and cattle-grazed land, with the two land types displaying opposite effects along the same nitrogen gradient: cattle-grazed land increased exotic prevalence with an increasing soil nitrogen gradient, while bison-land decreased exotic prevalence. This study supports the role of the American bison as a keystone herbivore of the Palouse Prairie, and suggests that some sort of competition between native and exotic species is being mediated by herbivory. Further research is needed to dissect this herbivore's key role within this ecosystem and better inform effective land management strategies.

***What inspired you to participate in undergraduate research?***
"I love the entire process of research, from asking a question to designing and implementing a study to find its answer. Research is fun!"

***How did you get your research position, and what preparation did you undertake for it?***
"I applied to UNDERC-West through the UNDERC website, and was accepted. UNDERC-West is a second year program, so acceptance to and attendance of UNDERC-East (in Northern Wisconsin) is required for admittance to the program. This provided me with the basic skills necessary to carry out this project."

***Where was your research experience located?***
"On the National Bison Range in Western Montana, through the University of Notre Dame Environmental Research Center (UNDERC)."

***What did you get out of your research experience?***
"An awesome summer spent with great people, and the chance to conduct enjoyable research on the beautiful National Bison Range in Montana. This research provided a solid basis for my future graduate studies."

**Enhancing chemotherapy response by Foretinib, a cMet-VEGFR inhibitor in preclinical gastric cancer models**

Meghan Grojean
Major: Neuroscience and Behavior
Advisor: Niranjan Awasthi, Dept. of Surgery, Indiana University School of Medicine and Harper Cancer Research Institute, University of Notre Dame

Gastric cancer (GC) is the second most common cause of cancer-related death worldwide. It tends to be diagnosed in more advanced stages of the disease and lacks effective treatment options. With the current standard of care, the median survival time of a patient diagnosed with GC is about 10 months. Research focusing on improving the efficacy of chemotherapy drugs has a great potential to significantly improve the prognosis for gastric cancer patients. In gastric cancer, several growth factors and their receptors, including c-Met and VEGFR, are overexpressed and thus provide a potentially effective therapeutic target. Foretinib is a novel small molecule inhibitor of the c-Met and VEGFR pathways. In the present study, we evaluated a combination of foretinib and nab-paclitaxel (NPT), an effective chemotherapy agent, in *in vivo* and *in vitro* gastric cancer models. MKN-45 and Kato III human GC cells were cultivated in RPMI medium supplemented with 20% FBS at 37°C. Cells were treated with foretinib in combination with NPT, as well as with oxaliplatin, an analog of the current standard of care drug. Inhibition of cell proliferation was tested *in vitro* using WST-1 reagent. Western blots were used to test mechanism of action. Tumor volume, weight, and growth were tested in *in vivo* analysis using subcutaneous xenografts in mice models. Inhibition of MKN-45 cell proliferation was 67% when treated with 100nM NPT, 86% with foretinib, 89% with oxaliplatin plus foretinib, and 93% with NPT plus foretinib. Similar inhibition of cell proliferation was observed in Kato III cells. A decrease in phosphorylation of AKT, ERK, and PLC-γ was observed with foretinib treatment. Foretinib pre-incubation blocked HGF-induced expression of c-Met. A tumor growth experiment in NOD/SCID mice demonstrated inhibition in tumor growth when treated with NPT and foretinib, while NPT plus foretinib caused an additive effect. Net tumor growth, calculated by subtracting first day tumor volume by final day tumor volume, revealed the following: control (581.7 $mm^3$), Oxa (397.9 $mm^3$), NPT (229.9 $mm^3$), For (-82.6 $mm^3$), Oxa+For (-74.1 $mm^3$), NPT+For (-96.3 $mm^3$). These findings suggest that the anti-tumor effect of chemotherapy can be significantly enhanced by the c-Met/VEGFR pathway inhibitor foretinib, which might be a clinically relevant therapeutic combination.

***What inspired you to participate in undergraduate research?***
"I originally joined because I enjoyed my cell biology class. I began working with pancreatic cancer, but then shifted to a new project when I had the chance to take on a bigger role in the lab. Today, I am honored to research gastric cancer in memory of a close family friend who recently lost his fight with a gastrointestinal cancer."

***How did you get your research position, and what preparation did you undertake for it?***
"I joined the Awasthi lab in 2014 after reaching out via email. My first semester in lab was mainly spent getting to know the procedures. I have since worked during the school year for class credit and during summer 2016 thanks to a COS-SURF grant."

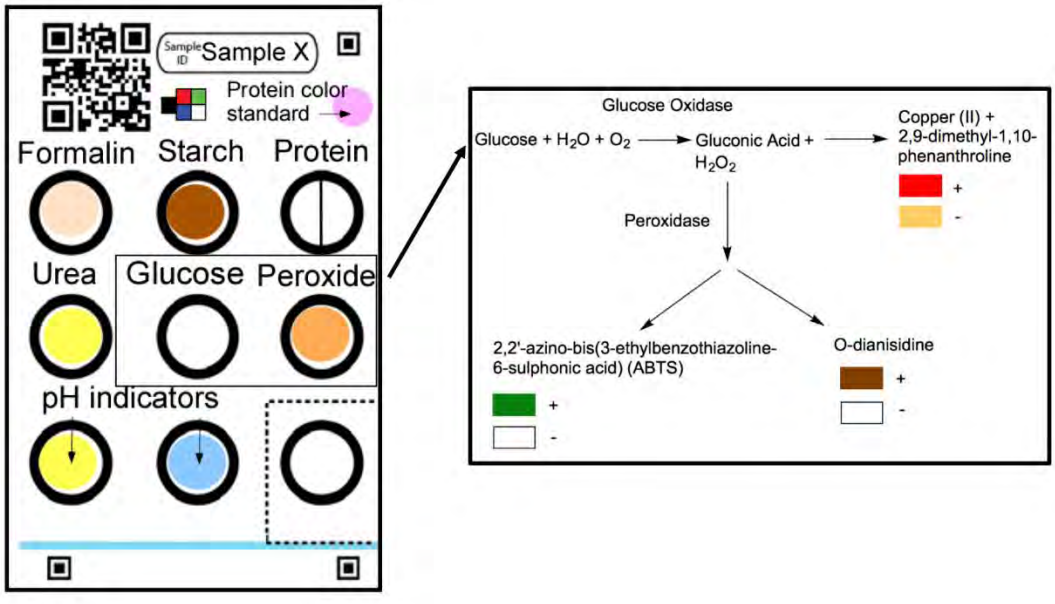
***Where was your research experience located?***
"Harper Cancer Research Institute (University of Notre Dame and Indiana University School of Medicine – South Bend)"

***What did you get out of your research experience?***
"A greater understanding of and appreciation for the process of research! I have grown so much in independent critical thinking, effective collaboration, and project planning skills."

**Detection of Sugar and Hydrogen Peroxide Adulterants in Milk with a Single Spot Test**

Valentine HenrydeFrahan
Major: Biochemistry
Advisor: Jamie L. Luther and Marya Lieberman, Dept. of Chemistry and Biochemistry,
University of Notre Dame

In developing countries, milk is diluted with water in order to increase the volume of saleable product. Bulk additives such as sugars, starches, and powdered polymers make the diluted milk taste and look more like normal milk, and bacteriocides such as formaldehyde, antibiotics, or hydrogen peroxide are added to retard spoilage. The chemical analysis of milk is a lengthy process that requires a laboratory. The poor availability of resources makes it hard to detect adulterated milk in developing areas. The goal of this project is to develop a field-friendly paper test card to detect adulterants with colorimetric assays. I am developing a spot test that can detect excess sugars or hydrogen peroxide in milk. Treatment of glucose with glucose oxidase produces hydrogen peroxide. In initial studies I have explored the use of copper (II) and 2,9-dimethyl-1,10-phenanthroline to detect generated peroxide. Alternatively, peroxide can also be monitored with horseradish peroxidase and various colorimetric substrates. It has been demonstrated by others that both enzymes are stable when stored on paper. I will explore use of peroxidase in combination with colorimetric substrates like 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) and o-dianisidine to detect peroxide in milk.



***What inspired you to participate in undergraduate research?***
Being able to apply concepts that I learn in class to real world issues is what inspires me. I enjoy being part of a group addressing a problem that affects millions of people across the world.

***How did you get your research position, and what preparation did you undertake for it?***
I started getting involved in research in January 2015, during the second semester of my sophomore year. I first worked for Dr. Michelle Joyce in the Mass Spectrometry and Proteomics facility before joining the Lieberman lab this semester.

***Where was your research experience located?***
University of Notre Dame

***What did you get out of your research experience?***
I have practiced researching skills and I have learned to communicate my results effectively. Being able develop a plan and troubleshoot for errors is also something that I have been able to build upon throughout my research experience.

**The Role of the Fibrinolytic System in Hypertensive Renal Injury**

Kristina Hollkamp
Major: Biochemistry
Advisor: Victoria A. Ploplis, Dept. of Chemistry and Biochemistry, University of Notre Dame

Hypertension is a prevalent health issue in the United States and around the world. Approximately 70 million American adults, nearly 30% of the U.S. population, suffer from hypertension. Despite these numbers, the effect of the fibrinolytic system in hypertensive renal injury is still poorly understood. This study investigates the effect of the fibrinolytic system in hypertensive renal injury, specifically the roles of plasminogen activator inhibitor-1 (PAI-1) and urokinase plasminogen activator **(**uPA). The study utilized a mouse model in which hypertension was induced by the infusion of angiotensin II (AngII) and aldosterone (Ald). There were four mice genotypes in the study: wildtype (WT), PAI-1 deficient (PAI-$1^{-/-}$), uPA deficient ($uPA^{-/-}$), and uPA mutant ($uPA^{m}$) in which uPA's ability to bind to uPA receptor (uPAR) was impaired. The harvested mouse kidney specimens were fixed in 4% paraformaldehyde, embedded in paraffin, and cut into 4 μm sections. To assess general morphology, the sections were stained with hematoxylin & eosin and were blindly assigned kidney injury scores. The amount of collagen deposition in the kidneys was assessed through picro-Sirius Red staining, leukocyte infiltration was assessed by staining kidney sections with common leukocyte antigen CD45, and quantitative Real-Time Polymerase Chain Reaction (qRT-PCR) experiments were performed to see the expression of genes associated with renal inflammation. The data indicate that hypertensive uPA deficient mice have higher levels of renal injury compared to hypertensive wildtype mice. Therefore, uPA has a beneficial effect in hypertensive mice. Research is ongoing to further characterize the role of uPA in protection against hypertensive renal injury.

***What inspired you to participate in undergraduate research?***
"I enjoy seeking answers to scientific questions and learning about the amazingly complex systems in the body. Undergraduate research allows me to apply the ideas that I learn in class to solve real-world problems."

***How did you get your research position, and what preparation did you undertake for it?***
"I have been a member of Dr. Castellino's research group since fall 2015. After submitting a proposal based on an extension of my research during the academic-year, the Notre Dame College of Science Summer Undergraduate Research Fellowship provided funding for my summer research."

***Where was your research experience located?***
"W.M. Keck Center for Transgene Research at University of Notre Dame"

***What did you get out of your research experience?***
"The opportunity to research full time during the summer was a wonderful learning experience that allowed me to make significant progress on my research project. I came to appreciate the scientific research process in a new light and was challenged with a different kind of learning in which the answers are often unknown."

## R-Process Nucleosynthesis in Simulations of Binary Neutron Star Systems

Zachary Huber
Major: Physics, Program of Liberal Studies
Advisor: Rebecca Surman, Dept. of Physics, University of Notre Dame

One key objective in the field of nuclear astrophysics is to explain the formation of the heaviest isotopes and their observed abundances in the solar system and galaxies. Rapid neutron capture (r-process) nucleosynthesis is a mechanism by which many of these isotopes may be formed in high energy astrophysical events such as supernovae or the collapse of binary neutron star systems. The aim of this project is to explore the effects that nuclear properties such as electron fraction, entropy, and the nuclear equation of state have on r-process nucleosynthesis that occurs during the collision of two neutron stars. Using simulation data of the collapse of binary neutron star systems of varying physical and nuclear properties from Just, et al. (2015) as the starting point for our calculations, we extrapolated the temperature according to various microphysical equations of state in order to build output files compatible with the XNet nucleosynthesis code which calculates the nuclear abundances. With these files, we then calculated several initial abundance patterns for individual trajectories within our data set.

***What inspired you to participate in undergraduate research?***
"I involved myself in undergraduate research because I wanted to have the chance to explore the side of physics that you could not necessarily learn in a textbook. I was also very curious about what my professors spent their time working on and found the descriptions of their projects interesting enough that I wanted to learn more."

***How did you get your research position, and what preparation did you undertake for it?***
"I met my current research advisor through class, but began working with her after meeting and talking at a prospective student event that I had volunteered to help out with for the department. Most of the preparation for my work over the summer involved on brushing up on the programming skills that I needed for my work."

***Where was your research experience located?***
"My research is being conducted at the University of Notre Dame."

***What did you get out of your research experience?***
"My research has afforded me the opportunity to push and stretch myself in new directions. I've learned a great deal about an interesting field of physics and picked up new skills that will serve me well in my future academic work and beyond. It's also been a lot of fun. Spending the summer on campus doing research was a wonderful experience that allowed me to dig deep into my project while providing opportunities to meet many students and faculty."

**Real-time investigation of the influence of shear pressure and compression on mitochondria in single disseminated tumor cells during mechanical arrest under PTEN regulation**

Lan Jiang
Major: Biological Sciences
Advisor: Siyuan Zhang and Wendy Alvarez, Department of Biological Sciences, and Harper Cancer Research Institute, University of Notre Dame

Metastasis is the the most commonly life-threatening stage in breast cancer, affecting millions of women in the United States. One of the most critical stages in metastasis is mechanical trapping; a crucial point when circulating tumor cells (CTCs) enter a vessel with diameter smaller than that of a tumor cell. At this point, CTCs become arrested because they physically cannot go through the blood vessel due to their size. At this stage of metastasis, tumor cells experience mechanical stress from their surrounding environment, including shear stress and spatial compression. Previously, mechanical stress has been shown to increase tumor cell motility under 2D conditions. Unfortunately, it remains largely unknown how mechanical stress affects tumor cells during physical trapping and how these physical forces influence their metastatic potential at this stage of the metastasis cascade. One of the main barriers in current research of physical arrest of CTCs comes in the limitations of the traditional 2D and 3D culture systems that are available to study tumor cell behavior. Cell behavior is largely dependent on the physical cues imposed by the microenvironment, such as the stress and compression forces encountered during physical trapping. However in neither 2D nor 3D culture systems, shear pressure and mechanical compression can be applied to the tumor cells simultaneously, which renders these cell culture systems ineffective for the study of CTCs during physical arrest. To overcome these limitations, our lab designed and established a microfluidic device as an alternative model system to reconstruct both mechanical stress and spatial constraint experienced by tumor cells during physical arrest. To gain more insights on how mechanical stress may affect on tumor cells viability and bioenergetics during physical arrest, subcellular localization and activities of mitochondria are studied in the live tumor cells during physical trapping. Using microfluidic device to study cancer cell bioenergetics change during physical trapping could provide new insights in studying cancer cell behaviors during physical arrest.

***What inspired you to participate in undergraduate research?***
During my first year in Dr. Zhang's lab, I had to work very hard to perfect my bench skills through observations and repeated practice. During my journey in the lab, I realized research is not only a matter of curiosity, but also a matter of perseverance. Only with full attention to every single detail can one achieve reliable and replicable data. My research continues to shape me to be a hard worker who perceives self-limitations but always pursues the best outcome. Facing failed experiments, I never give up troubleshooting, figuring out the potential ways to improve and exploring alternative methods.

***How did you get your research position, and what preparation did you undertake for it?***
I have been a member of Dr. Siyuan Zhang's lab since the spring semester of my freshman year, due to my strong interest in cancer research. I spent my first year familiarizing with many different laboratory skills and techniques, such as cell culture, Western Blot, rt-PCR. Then I applied and was fortunate to receive the funding from Harper Cancer Research Institute for my

summer research last year. To further explore in the world of research, I joined the Biology honors program. In this group, I am able keep learning about new discoveries in scientific research and further develop critical thinking by attending the weekly research talk, led by research scholars and faculties. More importantly, by presenting and defending my own research, I improve the communication and presentation skills and gain new insights in my project.

***Where was your research experience located?***

Dr. Siyuan Zhang's Lab at University of Notre Dame and Harper Cancer Research Institute, South Bend, IN

***What did you get out of your research experience?***

My research experience made me recognize the importance of teamwork and multidisciplinary collaboration. In this project, by collaborating with engineering department, our lab was able to design and establish this new microfluidic device and use it to explore the understudied field, cancer cells physical arrest. Furthermore, through research I develop critical thinking, which enables me to quickly identify the problem and come up with creative solutions. In this process, I also recognize the importance of cancer research and its potential impact on human life.

**Synaptic varicosity change in Aplysia neuronal cell cultures in response to memory consolidation and protein synthesis inhibition**

Yoo Jin Jung
Major: Neuroscience and Behavior
Advisor: David Glanzman, Dept. of Integrative Biology and Physiology,
University of California Los Angeles, CA

Long-term memory (LTM) allows us to retain information about the experiences that make up our identity. As important as memory is, little is known about the exact mechanism for which memories are consolidated and stored. The Glanzman lab theorizes LTM storage in neurons via epigenetic changes in the DNA. In order to test this theory, they replicated sensitization of the siphon withdrawal response in sensory and motor neuron pairs from *Aplysia californica* with the application of serotonin, which lead to an increase in varicosity formation in parts of the sensory neuron interconnected with the motor neuron. They tested whether long-term sensitization brought on by sensitization training could be reinstated in *Aplysia* and in cell cultures with a short reminder training after the application of a protein synthesis inhibitor, anisomycin, that would inhibit varicosity formation following the original training. In behavioral experiments, *Aplysia* were able to regain sensitization memory following a short retraining period after protein synthesis inhibition. The next step will be to determine whether or not the varicosity numbers return to the enhanced level following the memory reinstatement protocol. Experiments are in progress to examine this important question.

***What inspired you to participate in undergraduate research?***
"I've always wanted to find a way to cure Alzheimer's Disease through research. Of course, I have to learn how to do research before I can pursue this dream, so undergraduate research is a must for me. I also love the way research challenges me to apply concepts I've learned in my science courses."

***How did you get your research position, and what preparation did you undertake for it?***
"I read about Dr. Glanzman's work on LTM storage freshman year and found it so interesting that I ended up meeting with him that summer to talk about his research. I decided to apply for a research grant through CUSE so I could do research in the Glanzman lab the following summer."

***Where was your research experience located?***
"UCLA, Gonda (Goldschmied) Center"

***What did you get out of your research experience?***
"I now have experience designing and running my own experiments, and have grown into a more independent scientist with much better data analysis skills than before."

**Parvalbumin Network and Neuroplasticity in the Auditory Cortex**

Ashley Kyalwazi
Major: Neuroscience
Advisor: Stephen Shea, Cold Spring Harbor Laboratory, Long Island, NY

Mice use ultrasonic vocalizations to communicate, however, the neural processing of these vocalizations by the auditory cortex (A1) is not well understood. Previous studies have reported long-term, experience-induced changes ('plasticity') in A1, after maternal experience and pup calls. Parvalbumin positive interneurons (PV+) constitute a major class of GABAergic inhibitory neurons in the cortex. Earlier studies from the Shea lab and others suggest that suppression of PV+ may initiate a period of elevated A1 plasticity in female mice during cohabitation with pups. Subsequently, PV+ mature to promote long-term memory consolidation and stabilization of A1 circuits. This particular project utilized chronic neuroimaging methods to monitor long-term changes in the A1 PV+ network of naïve female mice, following maternal experience. Selective labeling of PV+ was achieved by injecting PV-Cre mice with adeno-associated virus (AAV), expressing the calcium sensor GCaMP6 in a Cre-dependent manner. Functional images of sound-evoked spatiotemporal activity patterns in the A1 PV+ network of virgin females ('surrogates') were then obtained. The surrogate was then cohabited with a mother and her pups, and A1 activity patterns were monitored using a fluorescence-imaging technology. The neural circuits that regulate long-term, experience-dependent plasticity in A1 hold major implications for both learning and communication in several species.

***What inspired you to participate in undergraduate research?***
"Before coming to Notre Dame, I had not conducted research, nor had I received a lot exposure to science as a practice (i.e. in the laboratory). It was my inexperience that motivated me to become involved with research when the opportunity presented itself. Fortunate enough to attend an institution that emphasizes getting involved in Undergraduate research, my next goal became finding a lab that aligned with my academic and personal interests. Research in the Sheets lab at the Indiana University School of Medicine, South Bend has been an incredible experience and is a major reason why I chose to continue conducting research this past summer at Cold Spring Harbor Laboratory."

***How did you get your research position, and what preparation did you undertake for it?***
"I became involved with Undergraduate research at Notre Dame during the second semester of my freshman year. Systems neuroscience is a field that greatly interests me, and my continued work in the Sheets lab over in IUSM-SB equipped me with many skills and a deeper understanding of the brain that most likely contributed to my acceptance into the program. In preparation for my summer, I read the research papers written by my principal investigator, as well as many that were related to the ongoing experiments. I also added the other 19 participants in the CSHL-URP program on Facebook haha."

***Where was your research experience located?***
"Cold Spring Harbor Laboratory, Long Island, NY"

***What did you get out of your research experience?***
"At the end of my time at Cold Spring Harbor Laboratory, I had acquired many new skills such as craniotomies, GFP injections, in vivo calcium imaging, and behavioral training of rodents. Ten weeks devoted to science at CSHL enabled me to really formulate and test my own hypothesis with a variety of resources at my fingertips. I met nineteen other talented students in the program, each conducting his/her own research project, so it was nice to learn more about other disciples and the work that scientists at CSHL were doing across different fields. Additionally, I had the opportunity to attend a variety of lectures led by many scientists around the world. Outside of research, beach volleyball, free kayaking, and NYC trips were definitely highlights of my summer at CSHL."

## Coarse-Grained Simulation of Exciton Transport on Conjugated Polymers

Andrew Latham
Major: Chemistry and Applied and Computational Mathematics and Statistics
Advisor: Adam P. Willard Department of Chemistry,
Massachusetts Institute of Technology, Cambridge, MA
Coauthors: Elizabeth M. Y. Lee, Massachusetts Institute of Technology, Cambridge, MA

Organic solar cells may provide a crucial renewable energy source for the future. While they are advantageous because they are flexible and cheap to produce, more research is needed to improve their efficiency. Therefore, our research focuses on exciton transport on poly(3-hexylthiophene) (P3HT), a well-studied polymer due to its potential applications in organic solar cells. We have implemented a coarse-grained model to study the nuclear dynamics as well as an exciton model based on the electronic Hamiltonian and nuclear dynamics. These new models allow us to track and visualize exciton transport. Now, further work is necessary to completely quantify exciton dynamics and study the jumping of excitons between polymer chains.

***What inspired you to participate in undergraduate research?***
I wanted an opportunity to apply my skills in mathematics and chemistry to real world problems.

***How did you get your research position, and what preparation did you undertake for it?***
I joined Professor Gezelter's group at the University of Notre Dame in September 2014 and stayed at Notre Dame to do research in the summer of 2015. After the experience I had here, I tried to expand my experience by conducting research at another university. After applying to several programs, I decided to participate in the Amgen Scholars program at the Massachusetts Institute of Technology.

***Where was your research experience located?***
Massachusetts Institute of Technology

***What did you get out of your research experience?***
I gained valuable experience by joining a new research group, allowing me to examine their similarities and differences compared to the Gezelter group at Notre Dame. Furthermore, the program included graduate school preparation sessions to help me consider the necessary steps to apply.

## Cryptography and the Discrete Logarithm

Patrick LeBlanc
Major: Honors Mathematics
Advisor: Dennis Snow, Department of Mathematics, University of Notre Dame

Public key cryptography ensures the security of information transmitted over the internet, and more generally enables secure communication over insecure channels of information. This poster serves as an introduction to public key cryptography. We first detail the general procedure which public key cryptosystems follow. Public key cryptosystems are based on one-way functions: functions which are easy to compute given an input, but whose inverse is difficult to compute given an output. In particular, this research focusses on discrete exponentiation in the field of integers modulo a prime number, which is easy to compute going forwards with algorithms such as the fast-powering algorithm. However, its inverse the discrete logarithm is difficult to compute. In fact the problem of computing the discrete logarithm given an output is known as the Discrete Logarithm Problem, which is unsolved. Given that discrete exponentiation is a one-way function, we can use it to construct the Diffie-Hellman Key Exchange Protocol, which allows two parties to construct a symmetric key, and the ElGamal Public Key Cryptosystem, which is a public key cryptosystem. We prove that the Diffie-Hellman Problem – the problem of cracking the Diffie-Hellman Key Exchange Protocol – is no harder to solve than the Discrete Logarithm Problem, and that the ElGamal Public Key Cryptosystem is at least as hard to solve as the Diffie-Hellman Problem.

***What inspired you to participate in undergraduate research?***
I am naturally curious about mathematics, and love to ask and answer questions about mathematical subjects.

***How did you get your research position, and what preparation did you undertake for it?***
I participated in the SUMR Program for Summer 2016 and conducted research into public key cryptography with Professor Dennis Snow.

***Where was your research experience located?***
The University of Notre Dame

***What did you get out of your research experience?***
I learned how to conduct research in mathematics, which is significantly different from learning mathematics in the classroom. I also learned to how write long mathematical papers in LaTex and understand mathematical concepts I was not previously familiar with.

**Aging Impacts Ovarian Cancer Metastasis in FVB Mouse Allograft Model**

Annemarie K. Leonard
Major: Biochemistry
Advisor: Sharon Stack, Dept. of Chemistry and Biochemistry, University of Notre Dame,
Graduate Student Advisor: Elizabeth Loughran, Dept. of Chemistry and Biochemistry,
University of Notre Dame

Epithelial ovarian cancer (OvCa) is the most common subtype of ovarian cancer. OvCa often goes undetected until metastatic stages of the disease, contributing to the high mortality rate of OvCa patients. OvCa exhibits a unique form of metastasis initiated by the shedding of tumor cells or multicellular aggregates from the primary tumor into the peritoneal cavity. It has been observed that aging increases ovarian cancer risk in women, but no studies have investigated the effect on OvCa metastasis. To test the hypothesis that age increases the metastatic success of OvCa, a study was designed using young (3-6 months) and aged (20-23 months) FVB mice. Young and aged cohorts of mice were intraperitoneally injected with syngeneic RFP-tagged $PTEN^{shRNA}/KRAS^{G12V}$ cells, a mouse ovarian cancer cell line derived from the FVB obiductal epithelium. Live imaging was performed at 3 and 4 weeks post injection. At 5.5 weeks post injection, mice were sacrificed and abdominal organs were imaged. Using ImageJ, tumor burden analysis was carried by measuring both the tumor area and the intensity of the RFP-tagged tumor. The aged animals showed a significant increase in tumor burden in the omental fat band, ovaries, mesentery, gonadal left fat, stomach, and peritoneal injection site. Future studies will investigate factors that may be responsible for this increase.

***What inspired you to participate in undergraduate research?***
As an aspiring doctor, I desire to be on both ends of my career path; I not only want to obtain a mastery of the diagnostic skills in medicine, but also desire to contribute to making advancements in the field of medicine. I believe that participating in both the practice of medicine and contributing to the advancements in medicine will help me become the best doctor that I can be as I will have an understanding of problems from both a physician's and a researcher's perspectives. Since research is a vital component to making advancements in the scientific world, I was inspired to participate in undergraduate research so I can develop skills that will allow me to work on both sides of the medical field.

***How did you get your research position, and what preparation did you undertake for it?***
I have been a member of the Stack Lab since May of 2015, and I have loved every moment! I emailed a few professors toward the end of my freshman year. I received a few offers to meet with them and ultimately picked the Stack Lab. Labs for my courses freshman year really helped me to learn some basic skills prior to lab.

***Where was your research experience located?***
Harper Cancer Research Institute at the University of Notre Dame

***What did you get out of your research experience?***
Aside from two amazing summers at Notre Dame, new friends, and new collaborators, I also learned how to analyze data and perform an array of laboratory techniques such as mouse dissection and cell culture. My research experience in the Stack Lab is providing a solid basis for my future endeavors toward becoming a doctor.

**Computer and Technology Club as Social Performance Intervention for Adolescents with ASD and Their Peers**

Francesca Mancuso and Kathleen Nester
Major: Science Business; Communicative Sciences and Disorders
Advisor: Juhi Kaboski, Dept. of Psychology, University of Notre Dame

Although high functioning children with autism spectrum disorder (ASD) are often academically successful and integrated into general education classrooms, they still experience difficulty making friends, generalizing the social skills that they learn, and maintaining relationships. Such difficulties, if continued into adulthood without intervention, are likely to lead to social isolation, depression, and social anxiety as well as obstacles to higher education, employment, and personal relationships. This pilot study was based on previous studies that examined summer robotics and computer game camps as a social performance intervention. This current study adapted the camp into an after school club to generalize learned social skills in a more natural environment over a longer period of time. In the Computer and Technology (CAT) Club, we provided a series of technology related sessions which offered an engaging and supportive environment in which adolescents with ASD could practice appropriate social and collaborative skills with typically developing peers. All participants learned weekly "career skills" that were all relevant to important social skills. The primary goal of the club was to improve social anxiety and social skills for adolescents with ASD. The technology club highlighted strengths and shared interests of participants, rather than ASD or social deficits. All participants were viewed as equals within their partnerships of one typically developing student and one student with ASD.

***What inspired you to participate in undergraduate research?***
"I worked at a summer camp the year before entering the FUN Lab and a couple of my campers had ASD. This sparked my interest in learning more about ASD and working with teenagers with ASD."

***How did you get your research position, and what preparation did you undertake for it?***
"I have been a member of the FUN Lab since January 2016. I had heard good things about the lab from upperclassmen and reached out to Dr. Kaboski to learn more about the lab. After discussing the lab and my interests, I submitted an application for the lab and was accepted a week later. Before starting in the lab, I read a variety of articles on ASD and tried to

***Where was your research experience located?***
"University of Notre Dame"

***What did you get out of your research experience?***
"An exciting ongoing involvement in an interesting research study, new friesn and new collaborators. I also learned how to perform different assessments and my understanding of ASD has greatly expanded."

**Effects of Loss of Secretagogin in *Drosophila melanogaster***

Michael Markel
Major: Neuroscience and Behavior
Niamh O'Sullivan, Conway Institute of Biomolecular & Biomedical Research,
University College Dublin, Dublin, Ireland

Calcium is a cation imperative to the function of neurons. Calcium-binding proteins (CBPs) act as molecular markers of cell identity that maintain calcium homeostasis within the cell. Secretagogin is an EF hand CBP that is known to mediate the function of other CBPs in post-mitotic neurons. Its expression has been found in mammalian neurons within the Central Nervous System - particularly the cerebellum, hippocampus, and amygdala as well as neuroendocrine cells, where it has been postulated to play a role in development. However, knowledge of secretagogin is limited *in vivo*. Therefore, the aim of this project was to study the *Drosophila melanogaster* ortholog of secretagogin, Cbp53E, in order to gain a better understanding of how secretagogin functions in neuronal development and function *in vivo*. Flies were crossed to have a secretagogin knockdown. Once the expression of secretagogin was diminished, these flies were compared to controls to see how they differed experimentally. Secretagogin RNAi flies had noticeable differences compared to controls. Characteristically, they had darker pupae, limited locomotion as larvae, and a very low survival rate as adults. Thus, it can be concluded that secretagogin plays a vital role in development and that further studies are necessary.

***What inspired you to participate in undergraduate research?***
I was inspired to participate in research because I wanted hands-on learning. One learns all about laboratory techniques and the ideas of the scientific theory in biology classes, yet only in a lab answering your own question can it truly become real. Undergraduate research allowed me to ask a question that I thought was interesting and gave me the insight on how to answer that question.

***How did you get your undergraduate research position, and what preparation did you undertake for it?***
I was able to participate in undergraduate research while studying abroad through a course offered to international students at the institution where I took my science classes. They sent out a preliminary survey to assess our interests and matched us with a mentor. My time in research counted as one of my classes.

***Where was your research experience located?***
University College Dublin Dublin, Ireland

***What did you get out of your research experience?***
I learned an extensive amount of information about neuroscience, a subject that I love. Under the direction of my research mentor, Dr. Niamh O'Sullivan, I was able to delve into the functioning of neurons. Moreover, I was able to experience scientific inquiry through a different cultural lens. Overall, this experience made me a much more disciplined and curious student.

**A 3D matrix model to understand the role of CAFs in determining the EMT properties of lung adenocarcinoma cells**

Bradley Martin
Major: Neuroscience and Behavior
Advisor: Jonathan M. Kurie, Department of Thoracic/Head and Neck Medical Oncology, University of Texas MD Anderson Cancer Center, Houston, TX
Coauthors: Neus Bota, Priyam Banerjee, Jacob Albritton, Jordan Miller

Metastasis strongly contributes to the high likelihood of death from lung cancer. Therefore, it is necessary to understand the mechanisms behind metastasis. In EMT driven metastasis, cells lose their attachments and apical-basal polarity and gain motility and the ability to invade. Recent research has implicated that cancer associated fibroblasts (CAFs) in the tumor microenvironment might communicate with epithelial cells and facilitate EMT-driven metastasis. This study uses a 3D matrix approach to study the spatio-temporal variation of EMT protein markers in the course of EMT-driven metastasis. For this purpose, tumor cell aggregates were stained, both in the presence or absence of CAFs, for EMT markers and each marker expression level was quantified. The results indicate that CAFs inhibit the mesenchymal EMT marker vimentin and moderately upregulate the epithelial EMT marker e-cadherin in tumor cell aggregates. This data suggests that CAFs have a propensity to induce tumor cell MET, which warrants further investigation. Preliminary data when these tumor cell aggregates were placed in the ECM mimicking compound, Matrigel, suggests a collective cell migration pattern in metastasis. As a whole, these results highlight potential therapeutic approaches towards metastatic lung cancer, by targeting CAFs and their role in EMT-driven metastasis.

***What inspired you to participate in undergraduate research?***
"I enjoy thinking critically in a step-wise manner in order to come to a conclusion. I am especially interested in using scientific research to come to a better understanding of medicine, allowing better detection, treatment, and prevention of human diseases."

***How did you get your research position, and what preparation did you undertake for it?***
"I have been a member of the Tessier Lab at Harper Cancer Center since Fall of 2015 so I had experience in the lab. By the time of this summer research, I had completed upper-level science courses and I had taken an Intro to Undergrad Research course. I received funding from the College of Science by applying for the MD Anderson UND Joint Program."

***Where was your research experience located?***
"The University of Texas MD Anderson Cancer Center in Houston, TX"

***What did you get out of your research experience?***
"Valuable experience living and working on my own in the big city of Houston. I became more confident interacting with research professionals and became proficient with 3D cell culture, microscopy, and quantification, all while working in the impressive Texas Medical Center."

**Characterization of Alterations in Protein Levels Induced by Neoadjuvant Chemotherapy Treatment in Patient-Derived Xenograft Models of Triple Negative Breast Cancer**

Daniel P. McKee
Major: Science-Business
Advisor: Helen Piwnica-Worms, Department of Experimental Radiation Oncology,
University of Texas MD Anderson Cancer Center, Houston, TX
Coauthors: Gloria Echeverria

While one-half of patients with triple negative breast cancer (TNBC) will respond well to standard neoadjuvant chemotherapy (NACT) the other half of patients will retain a residual cancer burden. This residual cancer can often leads to increased incidence of metastasis and increased mortality compared to patients who achieve complete pathologic response after NACT. To understand the changes occurring in protein levels in response to treatment, functional proteomic analyses of tumor samples before and after AC were performed. The goal of these analyses is to detect molecular differences between the tumor before treatment and the residual tumor after AC. A reverse phase protein array identified many proteins with significant differences in expression in response to AC treatment. IHC was used to validate the results and to characterize the localization of protein expression within tumor and stromal cells. Further, co-IF was performed to determine whether proteins of interest were expressed in tumor or stromal cells. The results from IHC and IF indicate that the residual tumor exhibits changes in protein levels compared to the vehicle and regrown tissues. These alterations in protein levels may indicate adaptive mechanisms become up-regulated to allow tumor cells to survive therapy.

***What inspired you to participate in undergraduate research?***
I knew that my aspirations of going to medical school could only be fulfilled if I went beyond the classroom and challenged myself in a professional laboratory setting. Even though my semester at school have been very busy, finding multiple opportunities to research over the summer has enhanced my understanding of cancer biology and the world of medicine.

***How did you get your research position, and what preparation did you undertake for it?***
The Notre Dame-MD Anderson Cancer Center program was established here at Notre Dame three years ago. I applied to participate in this program last spring and was notified of my acceptance soon thereafter.

***Where was your research experience located?***
The University of Texas MD Anderson Cancer Center, Houston, TX

***What did you get out of your research experience?***
Researching over the summer gave me an unparalleled immersion into the world of medicine and a research opportunity at the country's leading cancer hospital.

**[Re]Evaluating the Cost of Electricity due to Deaths at Hospitals with Unreliable Energy Systems**

Brady McLaughlin
Major: Physics in Medicine
Advisor: Abigail Mechtenberg, Dept of Physics, University of Notre Dame

In the developing world, power outages add another constraint to healthcare facilities seeking to deliver quality healthcare that are already strapped for resources. The results of capacity shortages can range from postponing accurate diagnosis, due to failure of diagnostic equipment like x-rays, to the more directly deadly results, due to failures of life-saving equipment such as ventilators. While analysis of such capacity shortages is abundant for regions throughout the developing world, there is, to the knowledge of these others, currently no analysis that connects capacity shortages to effects on human life. Since what policy makers and health officials alike use as a metric for determining which policies and programs will be effective is morbidity and mortality, elucidating this link between power outages and the direct burden on patients is necessary to demonstrate that policies to minimize power shortages are necessary. We do this by modeling current data and adding in value of a statistical life according to the region the data was taken from. The cost-effectiveness of these programs are then demonstrated by simulating what locally designed and constructed generators would cost and comparing that the amount of money that a government would traditionally spend to save a statistical life.

***What inspired you to participate in undergraduate research?***
I choose to participate in undergraduate research because it lets me apply what I learn in my classes, contribute to human knowledge, and serves as a great way to think about and concretely answer questions that can improve how we live.

***How did you get your research position, and what preparation did you undertake for it?***
I have researched under Dr. Mechtenberg since January of 2016, so the summer work naturally progressed out of what I had been working on during the school year. This meant that much of what I needed to know to research effectively was something I'd already known, between that experience and my introductory physics courses.

***Where was your research experience located?***
University of Notre Dame

***What did you get out of your research experience?***
Doing research over the summer I learned how to think and operate more independently than in a typical lab course, since I was going to answer questions without a previously known solution. I also improved my ability to think freely and follow up on leads on my own, as well as greatly increased my acquaintance with scientific literature.

**Investigation of Mate Choice and Sexual Maturity in Female Cichlid Fish**

Alina Nguyen
Major: Neuroscience and Behavior
Advisors: Allie Byrne, Biology Dept., Stanford University; Ryan York, Biology Dept., Stanford University; Russell Fernald, Biology Dept. Stanford University, Stanford, CA
Coauthors: Paul Tran, Biology Dept., Stanford University, Stanford, CA

How do animals use behavior to adapt to their social environments? How does this change over evolutionary time? Little is known about how behaviors evolve, partly due to a lack of understanding about the early stages of species diversification. Important drivers of this process are the acts of mate choice and reproduction. This study uses two recently diverged species of fish, *Mchenga conophoros* and *Copadichromis virginalis*, to study female mate choice. We developed a system for testing and recording female behavior in a high throughput manner. We find that female behavior varies widely amongst individuals of both species, suggesting that female choice may be more complex than expected. To study reproduction, *Astatotilipia burtoni* cichlids were used as model organisms. Females were injected with the hormones Ovaprim and hCG to induce sexual maturity. To assess the viability of the eggs, *in vitro* fertilization (IVF) was performed. The hormone injections resulted in a shortened ovarian cycle. Furthermore, IVF showed that ova extracted from these females are viable, and that hormone injections can safely induce sexual maturity. These insights pave the way for future studies looking to disentangle the role of mate choice and reproduction in the processes of behavioral evolution and speciation.

***What inspired you to participate in undergraduate research?***
"I wanted to get involved in the scientific community. Starting research as an undergraduate seemed like a good opportunity to do so. I wanted to learn the various techniques and methodologies used in basic science research that will prepare me for research in graduate school. Specifically, I became interested in animal behavior research as it combined my interests in neuroscience and ecology. I am intrigued by animal social behavior, their impact on the environment, and the neural basis underlying these behaviors. Combining both of these interests allowed me to explore a new and different field of biology."
***How did you get your research position, and what preparation did you undertake for it?***
"I applied to the Stanford Amgen scholars program. After my acceptance to this program, I was matched to a research lab that fit my interests in neuroscience and animal behavior. My preparation consisted of lab safety trainings and reading publications on animal behavior."
***Where was the research experience located?***
"Stanford University"
***What did you get out of your research experience?***
"I learned how to present scientific findings, networked with fellow scholars, cared for cichlid fish, designed behavioral assays, performed *in vitro* fertilization, and created novel protocols."

**Vortex lattice structures in anisotropic supercondcutors**

Maciej Olszewski
Major: Honors Math and Physics
Mentor: Morten Eskildsen, Dept. of Physics, University of Notre Dame

When a type-II superconductor is subjected to a magnetic field it is threaded by vortices, each carrying one quantum of magnetic flux. In materials with low vortex pinning to defects, the vortices will arrange themselves into a regular array known as the vortex lattice (VL) due to their mutual repulsion. The VL depends sensitively on the anisotropy of the screening current plane, and in many cases undergoes a structural phase transition as the magnetic field and/or temperature is varied.
In material with a basal plane anisotropy the vortex-vortex interactions are depended on the angle and distance between two vortices. This creates a directionally dependent interaction potential that is crucial to the understanding of the lowest energy configuration of the VL. Using this concept, we created a molecular dynamics simulation that determines the most stable position of vortices for a given amplitude and orientation of the interaction anisotropy.

***What inspired you to participate in undergraduate research?***
"I wanted to have a chance to do more hands on work and get experience with doing actual research and working on topics that are currently in development."

***How did you get your research position, and what preparation did you undertake for it?***
"I became a member of professor Eskildsen's group in January of 2016 with the goal of working on this project. Profesor Eskildsen recommended this project as something that he was interested in and something that he thinks will have great results. I have been working on this project ever since."

***Where was your research experience located?***
"University of Notre Dame"

***What did you get out of your research experience?***
"I learned a lot of molecular dynamic simulations and how they can be used to compute difficult problems. I also learned a lot about making models and coding them, esp. On making code be more efficient. I also got a chance to go and work at LANL next summer."

**Plant-Pollinator Networks Change with Time in the Burnham Wildlife Corridor**

Angela Pantell
Major: Environmental Science
Advisor: Paula Tallman, Field Museum of Natural History
Coauthors: Chloe Takala (Roosevelt University) and Sarah Nolimal (DePaul University)

This study assessed restoration age as a possible mechanism for changes among pollinator presence over time in an urban environment. Plant and pollinator monitoring was performed in eight different sites of restored prairie throughout the Burnham Wildlife Corridor, a large natural area spanning Chicago's South Lakefront. Floral diversity and abundance, pollinator abundance, and plant-pollinator interactions were measured and compared across eight sites of ages ranging from zero to fourteen years. It was found that floral diversity did not correlate to the age of the site, or any other factors, but that floral abundance had strong positive correlations with age, pollinator abundance, and plant-pollinator interactions. This information can be expanded upon in more comprehensive studies in the future to further identify the underlying mechanisms between the increase in floral abundance and the accompanying increase in plant-pollinator interactions.

***What inspired you to participate in undergraduate research?***
I've always been very interested in research of different types. I think I want to pursue a career in environmental/ecological research, so I was looking for an opportunity to get involved in that kind of research and see if I liked it. I think research is a great to solve many of the world's problems, so I was excited to look for solutions to the problems that I'm passionate about.

***How did you get your research position, and what preparations did you undertake for it?***
I really wanted to work at the Field Museum over the summer, but their internship programs were only for juniors and seniors and I was a freshman. I reached out to a researcher at the Field Museum whose interests align with mine and she informed me about a new research program that they were starting this summer and encouraged me to apply. I didn't need to prepare very much for the research because the first half of the program was an intensive seminar where we learned all of the background knowledge we would need in order to conduct our research projects.

***Where was your research experience located?***
The Field Museum of Natural History, in Chicago.

***What did you get out of your research experience?***
I absolutely loved this research experience. My program was centered around urban ecology, so I learned so much about this fascinating field that I had previously known nothing about. I was also used to performing, presenting, and writing about medical research, so I found it very useful to learn how to do these things with ecological research. Additionally, I met so many amazing people in the field who inspired me to continue to pursue my work and who now serve as a wonderful network for me as I continue to dive deeper into this field.

**Suppression of molecular circuit of multi-ciliate differentiation is critical for choroid plexus carcinoma development**

Phillip Petrasko
Major: Science-Business
Advisor: Haotian Zhao, Sanford Research, Sioux Falls, SD
Coauthors: Li Li and Haotian Zhao

Choroid plexus (CP) tumors are rare primary brain tumors predominantly found in children. While surgery is the primary treatment for the mostly benign CP papilloma, safer and more effective therapies are yet established for CP carcinomas which are frequently lethal. Multiple factors such as TP53 mutations, abnormal NOTCH signaling, recurrent genomic and epigenetic alterations have been described in CP carcinomas. Accurate preclinical models that recapitulate human diseases are of vital importance to understand underlying mechanisms of CP tumors and to evaluate potential therapeutics. We showed that sustained Notch1 expression or constitutive Sonic Hedgehog (Shh) signaling drives the formation of CP papilloma. Vertebrate Shh signaling depends on the primary cilium. Unlike CP epithelial cells, which possess multiple primary cilia, tumor cells in our animal models are characterized elevated Notch pathway activities and a solitary primary cilium that critically mediates pro-proliferative Shh signaling, suggesting a synergistic interaction where Notch-mediated suppression of multi-ciliate differentiation allows Shh-driven proliferation of CP tumor cells. Indeed, constitutive activation of both pathways leads to aggressive CP carcinoma in mice. Molecular and histology analyses revealed that these murine CP tumors closely resemble their human counterparts, which also display aberrant SHH and NOTCH signaling, suggesting they may represent potential therapeutic avenues. Consistently, treatment with vismodegib, an FDA-approved Shh pathway inhibitor, suppressed CP tumor growth. Importantly, most human CP tumors, especially aggressive papillomas and carcinomas, consist of tumor cells with a solitary primary cilium. CP tumors in mice and humans exhibit a distinct repression of a conserved molecular circuit of multiciliate differentiation, though it exhibits a dynamic expression during roof plate/CP development. Together, these results indicate that maintenance of a solitary primary cilium is crucial for CP tumor development, whereas formation of multiple cilia subsequent has tumor suppressor functions and represents a novel therapeutic target in CP tumors.

***What inspired you to participate in undergraduate research?***
"I wanted to learn more about what it takes to have a career in research, and I wanted to learn and perform the various techniques and procedures that are used in research labs. In addition, helping to further a cause such as children's cancer treatment is a great inspiration."

***How did you get your research position, and what preparation did you undertake for it?***
"I spent some time researching the opportunities available for freshman and the hospital in my hometown had a summer undergraduate research experience that accepted applications from all undergraduates. I filled out an application and asked some of my peers to review my writing responses before submitting the application. I was excited when the program directors offered me an interview and ecstatic when I was offered a position in Dr. Zhao's lab. Before the program began, I spent part of my summer reading some journals and publications to better understand the science behind the research I would be assisting within Dr. Zhao's lab."

***Where was your research experience located?***
"Sanford Research in Sioux Falls, South Dakota."

***What did you get out of your research experience?***
"I learned more than I could have hoped for! I was able to meet and interact with the amazing researchers and collaborators at Sanford Research, as well as develop some laboratory skills I will most certainly use in my future research endeavors. I also developed a better understanding of the skills and language needed to work efficiently in a research setting."

**Autonomy Support in Mother-Child Reminiscing Conversations and Child Cortisol Regulation**

Megan Pogue
Major: Biological Sciences
Advisor: Kristin Valentino, Dept. of Psychology, University of Notre Dame
Coauthors: Ruth Speidel

This study examines the relationship between maternal provision of autonomy support in reminiscing conversations and the cortisol regulatory pattern of their children. This was accomplished through analysis of recorded emotional reminiscing conversations between mothers and their children and the collection of their child's diurnal salivary cortisol levels. The population for this project consisted of balanced numbers of mothers named as perpetrators of maltreatment and non-maltreating mothers from the community, each subgroup matched in race, socioeconomic status, and educational achievement. This project was conducted in the context of an intervention study being executed by Dr. Kristin Valentino, Director of the Development and Psychopathology Laboratory at the University of Notre Dame. Dyadic reminiscing videos of four past emotional events were obtained from Dr. Valentino's laboratory. A nine point coding scheme for maternal autonomy support was developed from Cleveland and Reese, 2005, and reliability on this scale was obtained by two independent coders with a correlation statistic of $\alpha = 0.83$ on 20% of the data. Saliva samples were collected from children at waking, mid-day, and in the evening on two consecutive days at home and assayed for cortisol. Analysis found that mothers from the maltreating population were significantly less autonomy supportive than non-maltreating mothers ($p=0.018$). No significant findings were found on analysis of the cortisol data. A significant correlation was found between maternal provision of autonomy support child emotional lability/negativity ($p=0.045$). These findings substantiate that the negative effects of child maltreatment may be compounded by the lack of maternal aid in the child's development of independent emotional regulation skills.

***What inspired you to participate in undergraduate research?***
I wanted to combine my outside interests with the work that I had been doing for the past several years at the Development and Psychopathology laboratory.

***How did you get your research position, and what preparation did you undertake for it?***
I have been a member of the Development and Psychopathology laboratory for the past two years, and after working to develop a plan with the Laboratory Director and a graduate student, I submitted a proposal to the Da Vinci Grant program.

***Where was your research experience located?***
University of Notre Dame

***What did you get out of your research experience?***
It was rewarding to get to participate more actively in the work being done at the lab and gain a better understanding of the research process. My time at the lab over the summer solidified my interest in research on maltreatment and encouraged me to pursue a directed readings course on the topic in the fall.

**Comparing the F-Spin Mass Model to Other Mass Models in the Z = 60 Range**

Sam Porter
Major: Physics and Mathematics
Advisor: Ani Aprahamian, Dept. of Physics, University of Notre Dame
Coauthors: Ani Aprahamian and Andrew Nystrom

Nuclear masses and binding energies play an important role in nuclear science and the applications of nuclear science such as nuclear astrophysics. The reliable prediction of nuclear masses far from stability is particularly important for a better understanding of the rapid neutron capture process. We are exploring the implementation of a semi-empirical mass model based on the concept of F-Spin in nuclei. This model incorporates the evolution of shape in various regions of the chart of nuclides. Here, with the intent of better predicting nuclear binding energies near the bounds of our experimental knowledge, the F-Spin mass model uses a 9 parameter quadratic equation dependent on the third projection of F-Spin and proton number to evaluate the microscopic portion of all nuclear binding energies. We divide the known 2317 isotopes into 14 different zones for fitting purposes, we are able to generate predictions for nuclear masses in the order of 324 keV. The F-Spin model is then compared with a number of other mass models in the Z = 60 region to determine the variations in nuclear structure.

***What inspired you to participate in undergraduate research?***
I've always had an interest in attending graduate school in physics, and I knew getting involved early in research was a great start.

***How did you get your research position?***
I've been a member of Prof. Aprahamian's research group since the beginning of this calendar year. One of my friends in the Knights of Columbus was also a Physics major doing research for her as well, and helped me get connected with her. After doing some preliminary study of Nuclear Physics, I started working with Nuclear Mass Models this summer.

***Where was your research experience located?***
University of Notre Dame

***What did you get out of it?***
I absolutely loved my research experience! It was unbelievably fun to stay on campus for the summer and not only interact with the fellow physics researchers from different universities, but also with other friends here for various reasons. Research provided me a great basis to learn purely on my own volition, which gave me a new love for university education and, specifically, nuclear physics.

**Synthesis, Characterization, and Application of Copper Indium Zinc Sulfide Quantum Dots**

Alexander Robinson
Major: Chemistry
Advisor: Prashant Kamat, Dept. of Chemistry and Biochemistry, University of Notre Dame
Coauthors: Gary Zaiats, Dept. of Chemistry and Biochemistry, University of Notre Dame

In the past few decades, quantum dots have been studied widely for their interesting optical and electronic properties that include a tunable, narrow-band emission by size control which makes them promising candidates for photovoltaic and display devices. However, the more well developed quantum dots utilize heavy-metal or toxic elements, such as Pb and Cd. In this research, a heavy-metal free quantum dot system of Copper Indium Zinc Sulfide (CIZS) is characterized to gain a better understanding of its emission properties and its effectiveness as a material for LEDs. Beyond the low toxicity advantage, working with CIZS allows the control of optical properties by synthesis of non-stoichiometric compounds. In this work we examined effect of Cu/Zn ratio and ligand type on optical properties of CIZS quantum dots. Photoluminescence and time-correlated single photon counting measurements shows the existence of two compositionally dependent emission states within the quantum dot system. Moreover, the emission properties of the quantum dots were independent of the capping ligand, unless the ligand contained a conjugated system, such as phenol. Utilization of CIZS quantum dots in LEDs is still ongoing to produce efficient, long lasting, tunable devices.

***What inspired you to participate in undergraduate research?***
"I find it exciting to learn and discover new things that no one has found before. It is exciting in its own right knowing that you are at the frontier of human knowledge, pushing to gain new insight and not knowing what will be found."

***How did you get your research position, and what preparation did you undertake for it?***
"I became a member of the Kamat group in September of 2015, when I began delving into a new realm of knowledge that is quantum dot chemistry. My research advisor prepared me for my lab experience by giving me reading on the subject and introducing me to some of the lab techniques that are involved."

***Where was your research experience located?***
"University of Notre Dame"

***What did you get out of your research experience?***
"I learned more on the dynamics on being part of a research group and learning how research gets communicated to one another. My research experience certainly has made me understand the scientific process more and has provided me a foundation to help progress further into future graduate work."

**The Role of MESP1 in Directing Differentiation of Human Pluripotent Stem Cells to Cardiomyocytes**

Samuel Rudisill
Major: Neuroscience and Behavior
Advisors: Sunny Chan and Michael Kyba, Lillehei Heart Institute and Department of Pediatrics, University of Minnesota, Minneapolis, MN

Differentiation of pluripotent cells down the various cell lineages constituting the body is a highly specific process. Tracing its evolution back to primitive chordates, the transcription factor MESP1 has been identified as a key regulator of mesoderm patterning, particularly in generating the heart. While the effects of MESP1 expression are well studied, its mechanism of governing differentiation remains poorly understood. Using a doxycycline- inducible system in human pluripotent cells, we investigate the effects of different dosages of doxycycline on MESP1 expression and find the optimal treatment to induce its regulatory activity. We map the temporal expression profile of MESP1 and its targets to construct a timeline of cardiac differentiation and to decipher its mechanism. Defining the role and mechanism of MESP1 is crucial to understanding the process of cardiac differentiation and explaining how its dysregulation can lead to congenital heart defects.

***What inspired you to participate in undergraduate research?***
Participating in research provides me with an opportunity to apply what I learn in the classroom in a practical, meaningful setting before graduation and beginning my career. Undergraduate research is a valuable experience as it offers insight into the field of science and cultivates a greater appreciation for the effort needed to make scientific advances.

***How did you get your research position, and what preparation did you undertake for it?***
The Lillehei Heart Institute Summer Research Scholars Program has an online application, which I completed and submitted. I had heard of the program through a few of my peers, and I decided to apply. In preparation for this program, I met with my mentor prior to the start date to set forth a plan and expectations for the summer.

***Where was your research experience located?***
Lillehei Heart Institute, University of Minnesota

***What did you get out of your research experience?***
I gained an incredible experience in a unique field of study on the forefront of cardiac research. I learned how to interact in a large research team and present my progress on a biweekly basis to the lab, pushing me to be efficient and productive in my experiments. I was able to apply what I have learned from Notre Dame by producing a research poster and presenting at the Cardiopalooza symposium at the University of Minnesota. My experience at the Lillehei Heart Institute significantly improved my ability to work independently in a research lab, develop my own experiments, and analyze my results in a meaningful way.

**Analysis of Coupled Motion of Bunches from Electron Clouds Within the Cornell Electron Storage Ring**

Elliott Runburg
Major: Physics, Mathematics
Advisors: Mike Billing and Jim Shanks, Cornell Laboratory for Accelerator-Based Sciences and Education, Cornell University, Ithaca, NY

Cornell's electron/positron storage ring has been utilized for the study of the electron cloud effect. The electron cloud is generated when synchrotron radiation from the circulating trains of stored positron bunches strikes the walls of the vacuum chamber, creating electrons by photoemission. In this project we excited single bunches in the positron train for a short length of time and observed how their motion damps. The motion of the excited bunch drives oscillations in the electron cloud, which in turn excite subsequent bunches within the train. From these results we attempt to describe the coupling of the motion from bunch to bunch within the train.

***What inspired you to participate in undergraduate research?***
"I really enjoy the research environment, where I am able to apply what I've learned in class to novel problems, and participate in the scientific process."

***How did you get your research position, and what preparation did you undertake for it?***
"This position was part of an REU (Research Experience for Undergraduates) program offered at Cornell, so I got it through an application process. I was given a small amount of reading to do before I arrived in Ithaca this summer, and I was funded through by the NSF as part of the REU."

***Where was your research experience located?***
"Cornell University"

***What did you get out of your research experience?***
"I learned a ton, and feel extraordinarily prepared for future graduate work. From learning about accelerator physics, new ways to analyze data, and writing formal research papers, I feel like I really grew as a student and scientist this summer."

**A Study of the quality of CsI detectors and pulse-shape discrimination of scintillators for α-particles, ɣ-particles, and neutrons**

Kaitlin Salyer
Majors: Physics and French
Advisors: Grigory Rogachev and Joshua Hooker, Cyclotron Institute,
Texas A&M University, College Station, TX

This project studied the capabilities of two different scintillators, Cesium Iodide (CsI) and p-Terphenyl. First, the resolution of a CsI detector was investigated by exposing only very small areas of its surface at a time to an alpha source. Second, the abilities of p-Terphenyl to detect alpha particles, gamma particles, and neutrons were analyzed through pulse shape discrimination. p-Terphenyl is of particular interest because it will be used in the Mitchell Institute Neutrino Experiment at Reactor (MINER) at Texas A&M University for measuring background data. The information learned from conducting these tests will be useful in understanding and expanding the limits of the experiments in which these detectors will ultimately be used.

***What inspired you to participate in undergraduate research?***
Research in Notre Dame's High Energy Physics department is one of the experiences I have loved most about my time as an undergraduate student. I have really enjoyed learning more about what it means to be a scientist and to feel like I can help answer some of the most exciting questions of our time. I spent my summer exploring research in a different field of physics in a new location, which I enjoyed equally as much for the same reasons.

***How did you get your research position, and what preparation did you undertake for it?***
Because this research was conducted as part of a summer research program, I had to apply to do this work. In order to prepare us for our projects, the program coordinators organized for the other students in my program and I to have three lectures on the basics of Nuclear Physics.

***Where was your experience located?***
Cyclotron Institute, Texas A&M University

***What did you get out of your research experience?***
Through conducting this research, I developed skills in graphic design, 3D printing, and computer programming. The experience I had was so positive, that I have considered studying Nuclear Physics in graduate school. It also afforded me the opportunity to present my research at a national conference in early October.

**Damage to DNA Induced by $H_2O_2$ Produced During Atmospheric Pressure Plasma Jet Irradiation**

Harrison Schurr
Major: Physics in Medicine
Advisor: Sylwia Ptasinska, Radiation Laboratory, University of Notre Dame
Coauthor: Evan Panken

Atmospheric pressure plasma jets (APPJs ) have recently come onto the scene as a potential cancer treatment due to their effectiveness at destroying cancer cells while operating at room temperature. Plasma, the fourth state of matter, is ionized gas that contains a variety of radicals, photons, and free electrons. When a solution of DNA is exposed to an APPJ significant DNA damage is induced. That being said, the exact mechanisms causing this damage are not well known. Many research papers state that the $H_2O_2$ produced during irradiation is the main cause of DNA damage. Therefore, our research was aimed at understanding exactly how much DNA damage is induced by the $H_2O_2$ being produced during irradiation. The results of our investigation were contrary to the previously stated conclusions. Using amplex red assay kits the exact amount of $H_2O_2$ produced was determined. When this experimentally determined concentration of $H_2O_2$ was introduced into a DNA solution without irradiation no damage to DNA was observed. Our future research will examine other radicals that were previously stated to be biologically active and their effectiveness in DNA damage.

***What inspired you to participate in undergraduate research?***
"Problems in the world are proof that there are not enough people working to fix them. I got into research in hopes of fixing as many of the medical ones as I could"

***How did you get your research position, and what preparation did you undertake for it?***
"I had researched what Professor Ptasinska's lab researched and I had an idea of what I wanted to do so I just asked her if I could work in her lab and do the specific project I had in mind. She said it sounded like a good idea and gave me the position."

***Where was your research experience located?***
"The radiation laboratory at the University of Notre Dame"

***What did you get out of your research experience?***
"The most vital thing I have gotten out of my undergraduate research is the ability to solve problems on the fly. In a class room setting each problem you are faced with already has a standard procedure on how to solve it. In the lab you are faced with new and unique problems every day and you are the one who has to solve them. No one else can figure them out for you and no one has previously figured them out. It is my increased ability to solve these kinds of problems that I cherish the most form my research experience."

**Electron and Bit Studies for the Proposed CMS L1 Track Trigger Upgrade**

Patrick Shields
Major: Physics
Advisors: Kevin Lannon and Michael Hildreth, Dept. of Physics, University of Notre Dame
Coauthors: Tanner Leighton

The Large Hadron Collider (LHC) at CERN in Geneva, Switzerland will be upgraded in the mid-2020s to produce events at higher instantaneous luminosities, and therefore the Compact Muon Solenoid (CMS) detector will require an upgrade in order to handle the accompanying increase in collision events. This upgrade involves implementing a system capable of reconstructing charged particle tracks from the detector in real time using field-programmable gate array (FPGA) technology, known as a Level-1 (L1) Track Trigger. In order to study the expected performance of the trigger system, an FPGA emulation code has been developed which is capable of running over simulated events corresponding to the anticipated output of the upgraded LHC. However, there are limits to time and memory associated with the physical trigger – notably on the number of bits that can be used for certain quantities in the reconstruction calculations. Other considerations include non-ideal behavior of different types of particles in the detector – for example, the behavior of electrons as compared to muons. This research focuses on the implementation of realistic limits in the code and the study of more complicated electron events in order to prepare for the upgrades to the CMS detector and the LHC.

***What inspired you to participate in undergraduate research?***
"I've loved studying physics since high school, and so I wanted to find out what it meant to do real physics research, rather than just study it in class."

***How did you get your research position, and what preparation did you undertake for it?***
"I asked Prof. Lannon if I could help out in some way with his research back in the fall of 2014, and I was lucky enough to join his group that spring. This past summer, I had the wonderful opportunity to focus on this project for an extended period through the Notre Dame Physics Research Experience for Undergraduates program."

***Where was your research experience located?***
"University of Notre Dame"

***What did you get out of your research experience?***
"Over this summer and over the past few semesters, I have had the chance to experience firsthand what it is like to work on an actual ongoing physics experiment, and I have come to recognize the incredible amount of teamwork that goes into a large research endeavor such as this one."

**Characterization of Human Visual Disorders in Zebrafish**

Lillian Spatz
Major: Biology
Advisor: Diane C. Slusarski, Dept. of Biology, University of Iowa

Visual impairment disorders, such as cataracts, glaucoma, and retinal degeneration are becoming increasingly prevalent with the aging population. Modernized bioinformatics approaches have allowed for the identification of many candidate genes that may play a role in the development of these diseases. In order to investigate the several potential disease-causing genes involved in visual disorders, experimental testing must be efficient as well as accurate. The zebrafish has a visual system comparable to humans. Their quick development and ease of handling make the zebrafish a prime model system for the study of human visual disorders. The current study gives an overview of the available high-throughput assays for the analysis of congenital visual disorders in the zebrafish model. In situ hybridization experiments and H&E staining of tissue sections have been used to analyze changes in gene expression and morphology, respectively. The vision startle response assay has also been optimized and automated to study blindness. Some disorders, however, manifest as visual impairment rather than blindness. To analyze the genetics of these disorders, the optomoter response assay has been adapted, and quantification methods are being developed. Together, these high-throughput assays facilitate the efficient study of congenital visual disorders using the zebrafish model.

## *What inspired you to participate in undergraduate research?*

"Several students and faculty members expressed their enthusiasm for research, and I knew that conducting research as an undergraduate would help me discern my future career path."

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

"I applied into the Interdisciplinary Summer Undergraduate Research Program (SURP) and was matched with my research mentor in accordance with my interests. My research was funded by the Carver College of Medicine and the University of Iowa Graduate College."

## *Where was your research experience located?*

"University of Iowa"

## *What did you get out of your research experience?*

"I learned several techniques associated with zebrafish research, formed relationships with informative graduate students, gained experience communicating and presenting my research, received advice for applying to graduate schools, and enjoyed a summer in Iowa City!"

**Augmentation of response to chemotherapy by MEK inhibition in pancreatic cancer**

Alexis Stefaniak
Major: Science Pre-Professional Studies
Advisor: Niranjan Awasthi, Harper Cancer Research Institute, University of Notre Dame
Coauthors: Niranjan Awasthi, Harper Cancer Research Institute Dept. of Surgery; Meghan Grojean, University of Notre Dame College of Science; Sheena Monahan, Harper Cancer Research Institute Dept. of Surgery; Margaret Schwarz, IU School of Medicine Dept. of Pediatrics; Roderich Schwarz, Harper Cancer Research Institute Dept. of Surgery

Pancreatic ductal adenocarcinoma (PDAC) is a highly lethal cancer, with mortality closely paralleling incidence. It is expected to be the second leading cause of cancer-related deaths by 2030, in that it is associated with a very poor prognosis and a 5-year survival rate of 6%. Gemcitabine (Gem), a cytotoxic agent that inhibits DNA synthesis, remained the standard treatment for PDAC since 1997, despite limited clinical benefits. Recently, nanoparticle albumin-bound paclitaxel (Nab-paclitaxel, NPT) in combination with gemcitabine has shown efficacy in treating advanced PDAC. This combination is now the standard of care for PDAC. The mutationally activated KRAS gene is present in more than 90% of PDAC tumors, but direct targeting of this oncogene has proven clinically challenging. Therefore, alternative strategies focus on inhibition of downstream effectors in KRAS signaling pathways, such as the RAF-MEK-ERK (MAPK) signaling pathway that is a well-described mediator of KRAS-induced transformation and tumorigenesis. Trametinib (Tra) is a MEK inhibitor with antineoplastic activity. We evaluated the antitumor activity of standard chemotherapeutics with trametinib to define a novel therapeutic strategy for PDAC. In a peritoneal dissemination PDAC mouse model, median animal survival over the control treatment (20 days) was improved by the addition of NPT (33 days; 65% increase), Gem (26 days; 30% increase), NPT+Gem (39 days; 95% increase), and Tra (31 days; 55% increase). Survival was further increased by the addition of trametinib to each treatment: NPT+Tra (37 days; 85% increase), Gem+Tra (34 days; 70% increase), and NPT+Gem+Tra (49 days; 145% increase). Moreover, in subcutaneous PDAC xenografts, chemotherapy treatments with the addition of trametinib caused net tumor growth inhibition. The greatest tumor growth inhibition and tumor weight loss occurred with the NPT+Gem+Tra combination. *In vitro* studies of 3 PDAC cell lines demonstrated inhibition in cell proliferation by NPT+Gem, trametinib, and the combination treatment. Westerm blot analysis revealed that trametinib effects were accompanied by decrease in phospho-ERK and increase in apoptosis-related cleaved caspase-3 protein. These findings suggest that the antitumor effects of the standard chemotherapeutics can be enhanced through specific inhibition of components of the MAPK signaling pathway, which–clinically–may result in improved antitumor results.

***What inspired you to participate in undergraduate research?***
I always enjoyed the biology and chemistry labs required for my major, particularly because they provided a hands-on learning experience and allowed me to think about science in a more creative manner. Since Notre Dame offers a plethora of undergraduate research opportunities, I felt inclined to get involved with scientific research in order to challenge myself, gain insight into the overall research process, and partake in a long-term project. Furthermore, I lost my grandfather to pancreatic cancer and spent a lot of time at his bedside during the months leading up to his death. Pancreatic cancer is such an aggressive, devastating disease that has personal

relevance to my life, which is why I specifically sought out researchers working with pancreatic cancer.

***How did you get your research position, and what preparation did you undertake for it?***
Toward the end of sophomore year, I began looking into the researchers at Harper Cancer Research Institute and the main projects occurring in their labs. I chose a few researchers I was interested in, read some of their papers, and sent them emails expressing interest. After meeting with Dr. Awasthi, discussing his current research aims, and taking a tour of the lab, I knew it was the lab I wanted to be involved with.

***Where was your research experience located?***
Harper Cancer Research Institute (University of Notre Dame)

***What did you get out of your research experience?***
My undergraduate research experience has established a solid foundation for the research I plan on pursuing in my future as a medical student and, ultimately, doctor. I have been exposed to a variety of cell culture procedures and analytical methods, allowing me to gain confidence in laboratory technique. Furthermore, partaking in a long-term project, presenting my work, and gaining practice with writing abstracts and proposals has allowed me to better understand my research and how to clearly explain it to others.

**FFT Analysis in Energy Systems for Smart Grid Control using Multiple Storage Devices**

Robert Stiller
Major: Physics
Advisor: Dr. Abigail Mechtenberg, Dept. of Physics, University of Notre Dame
Coauthors: Dr. Abigail Mechtenberg

An FFT analysis of yearly power load and sources data results in unexpected key frequencies. These unique frequencies corresponds to specific storage devices. This analysis justifies clearly the need for hybridization of energy storage devices for optimal control of the smart grid. Furthermore, the juxtaposition of the FFT analysis of energy sources and loads yields a straightforward discussion about the disconnect between loads, storages, and sources. Unlike other research focusing on energy sources and/or power loads with one or two storage devices, this research shows clearly the need for an energy systems approach to storage, versus component-based approach. Future grids must include hybridization of storage to deal with noise versus vital system behavior and this FFT analysis seems promising moving forward.

***What inspired you to participate in undergraduate research?***
I love solving problems where there is not a definite right answer.

***Where was your research experience located?***
University of Notre Dame

***What did you get out of your research experience?***
I have become well versed in Python and learned how to break down problems so that they are easier to solve.

## Synthesis and Characterization of *p*FlipH$_4$, a Noninnocent Ligand

Daniel Swanson
Major: Science Pre-Professional and Economics
Advisor: Seth N. Brown, Dept. of Chemistry and Biochemistry, University of Notre Dame
Coauthors: Seth N. Brown

The redox activity of organometallic catalysts is traditionally localized at the metal center. These compounds are limited by the fact that the metal centers are only able to adopt a few stable oxidation states. To combat this problem, redox-active, or so-called noninnocent, ligands can be used in order to provide electron reservoirs that extend the usable redox range of metal-containing catalysts.

We wished to make a ligand containing two aminophenol moieties linked by a 1,1'-ferrocenebis(*p*-phenylene)diyl group, namely 1,1'-bis(*p*-(2-hydroxy-3,5-di-*tert*-butylphenylamino)phenyl)ferrocene, *p*FlipH$_4$. The ligand synthesis was initiated by Suzuki coupling of 1,1'-ferrocenediboronic acid or its pinacol ester with 2-iodonitrobenzene. The nitro compound was reduced and reacted with 3,5-di-*tert*-butylcatechol to produce *p*FlipH$_4$. The structural, spectroscopic, and electrochemical characterization of *p*FlipH$_4$ and attempts to metalate it with Group 4 or Group 10 metals will be discussed.

***What inspired you to participate in undergraduate research?***
I was in Dr. Brown's general chemistry class first semester freshman year and I thought he was an enthusiastic and compassionate man and I wanted to work for him. We do research on renewable energy techniques, which is a subject I am passionate about and wanted to learn more about. I also wanted to discern if I wanted to be a chemistry major.

***How did you get your research position, and what preparation did you undertake for it?***
I made an appointment with Dr. Brown after the class ended and asked him to explain what he does because I was interested in renewable energy. We talked for over two hours and then he offered me a position in his lab!

***Where was your research experience located?***
University of Notre Dame

***What did you get out of your research experience?***
I gained new friends including undergraduates and graduate students. I learned how to think critically in a chemistry environment and how to be a chemistry detective while trying to find compounds, devise syntheses, and analyze data. Oh, and we got free meals once a week!

**Groundwater reservoirs as a source for greenhouse gas emissions to the atmosphere**

Audrey Thellman
Major: Environmental Science with a concentration in Earth Science
Advisor: Grace M. Wilkinson, Dept. of Ecology, Evolution, and Organismal Biology, Iowa State University, Ames, IA
Coauthors: Grace M. Wilkinson

Previous studies established that lakes are sources of carbon dioxide ($CO_2$) to the atmosphere with a substantial portion likely coming from inputs of exogenously produced carbon transported to lakes through groundwater. However, direct measurements of groundwater $CO_2$ are sparse, preventing full validation of previously constructed lake $CO_2$ budgets. To directly measure the amount of dissolved inorganic carbon (DIC) in groundwater, wells were drilled around two seepage kettle lakes in the Upper Peninsula of Michigan that were the subject of a recent $CO_2$ budget study. The wells were sampled frequently during the ice-free season of 2016. Other measurements such as pH, dissolved oxygen, water level, and temperature were taken to determine potential factors that affect groundwater DIC concentrations. The DIC concentrations in groundwater support estimates made in previous studies, vary spatially and temporally, and are correlated with pH, temperature, and depth to water table level. By determining the carbon stored in groundwater, accurate estimates can be made to determine groundwater's role in the global carbon cycle.

***What inspired you to participate in undergraduate research?***
"Before I attended Notre Dame, I had always been interested in the scientific method. I loved the idea of asking questions and developing the means to answer that question with data or observations. Participating in research seemed to be a natural fit for me."

***How did you get your research position, and what preparation did you undertake for it?***
"I applied for a position through the University of Notre Dame Environmental Research Center (UNDERC) program. Once accepted, I was matched with an advisor to complete a research project with the aid of the Bernard J. Hank Family Endowment. Prior to arriving at UNDERC, I had been, and am currently involved in Dr. Jennifer L. Tank's lab on campus."

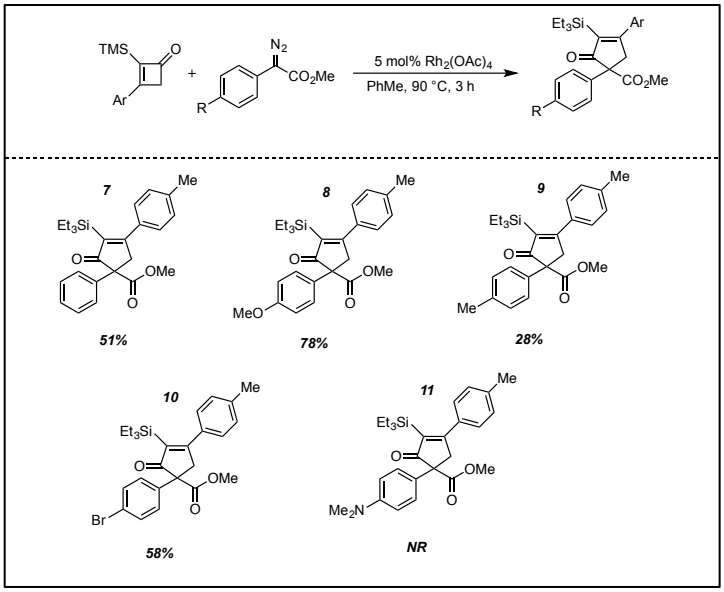
***Where was your research experience located?***
"The University of Notre Dame Environmental Research Center (UNDERC) located in Land O' Lakes, Wisconsin"

***What did you get out of your research experience?***
"My research experience gave me the tools necessary to evaluate a novel question that I was passionate about. Furthermore, it gave me the confidence to continue my quest for knowledge by asking similar questions related to my research topic, groundwater, in the lab I currently work in."

**A Rhodium-Catalyzed Formal [4+1]-Cycloaddition Approach Toward the Stereoselective Construction of Quaternary Carbons**

Tiffany Toni
Major: Biochemistry
Advisor: Brandon L. Ashfeld, Dept. of Chemistry and Biochemistry, University of Notre Dame
Coauthors: Kevin X. Rodriguez, Dept. of Chemistry and Biochemistry,
University of Notre Dame

Efforts have focused on the development of a rhodium-catalyzed formal [4+1]-cycloaddition to access privileged scaffolds of biological importance. This method requires the thermal ring opening of a cyclobutenone to generate a vinylketene in situ, which then undergoes a cyclopropanation event with a metal-carbenoid, followed by a ring expansion to construct a highly substituted cyclopentenone. The cycloadducts contain a synthetically challenging quaternary center embedded in a core pharmaceutically relevant scaffold that will form the basis for the discovery of novel anti-cancer chemotherapeutics. This approach has successfully been applied to synthesize cyclopentenone spirooxindoles and can be expanded to other donor-acceptor diazo compounds. The optimal conditions require an excess of cyclobutenone, likely due to decreased reactivity of the metal-carbenoid intermediates. This can be attributed to the elimination of the rigidity in ring structure in diazo oxindoles and reduced overall electrophilicity. Specifically, *p*-methoxy, *p*-methyl, *p*-bromo, and *p*-dimethylamino diazo oxindoles were tested. *p*-Methoxy had the highest yield of 78%, presumably because of the increased stabilization of the diazo substrate due to higher electron donation. *p*-Dimethylamino, on the other hand, yielded trace amount of product, perhaps because the amino group can interact with the rhodium catalyst, thus preventing the cycloaddition reaction. Further work involves testing the reactivity of heteraromatic substituted carbenoids and other metal catalysts.



***What inspired you to participate in undergraduate research?***
"I wanted to learn beyond the classroom, and once I started, I enjoyed it so much that I couldn't stop."

***How did you get your research position, and what preparation did you undertake for it?***
"I found my research position by reaching out to my organic chemistry professor, Dr. Brandon Ashfeld, about the possibility of joining his lab at the end of my freshman year. I made sure to look into the research the lab has produced in the past to make sure I had some background knowledge and was able to make sure it was a good fit for me. I have been an official member of the Ashfeld Group since August of 2015, including working full time this past summer thanks to the summer undergraduate research funding I received from the College of Science."

***Where was your research experience located?***
"University of Notre Dame"

***What did you get out of your research experience?***
"My time working in the Ashfeld lab has taught me many hands-on techniques, such as how to work with light and air sensitive reagents, how to appropriately scale up reactions, and how to use advanced pieces of equipment. Using these skills, I was able to help assemble a set of substrates to validate a novel [4+1] cycloannulation approach toward spirooxindole alkaloids, provide gram quantities of an FDA approved anti-seizure medication for reevaluation as a new breast cancer brain metastasis treatment, and currently, expand on a palladium catalyzed approach to 1,3 diene synthesis. Through the time spent in lab I was ultimately able to make great new friends and learn how to problem solve in the face of difficulties."

## Genome Editing and Transcriptomics for the Study of Schizophrenia

Adam Uppendahl
Major: Neuroscience and Behavior
Advisor: Dimitrios Avramopoulos, Institute of Genetic Medicine & Department of Psychiatry, Johns Hopkins University School of Medicine, Baltimore, MD

*DPYSL2* is a gene that is primarily expressed in the CNS and has vital functions in neuronal development, including microtubule stabilization, promotion of neurite outgrowth, and modulating signaling processes in the CNS. There is also evidence suggesting that *DPYSL2* is involved in schizophrenia (SZ). *DPYSL2* is regulated by the mTOR pathway, which has also been linked to CNS development, neuronal growth, maintenance, and proliferation. The disruption of mTOR signaling has been shown to affect neurotransmitters involved in SZ. Our laboratory has previously identified and implicated in SZ, a functional variant in the promoter of isoform B of the *DPYSL2* gene. The most common allele contains 11 CT dinucleotide repeats (11DNR), while the next most common allele, which we found associated with SZ, contains 13 CT dinucleotide repeats (13DNR). Previously our laboratory used CRISPR/Cas9 modified HEK293 cells and showed that the 13DNR variant has strong effects on *DPYSL2* expression, with a significant reduction in the production of the corresponding protein called CRMP2. This was accompanied by shortening of the natural HEK293 projections, and significant transcriptome changes overlapping with changes attributed to other SZ susceptibility genes, and opposite to those observed by exposure to antipsychotics. While these findings provided significant support for the involvement of *DPYSL2* in SZ, it important to examine this same modification in *DPYSL2* in cells more relevant to the disease. To develop a better understanding of the role of *DPYSL2* in SZ and neurodevelopment, we decided to introduce the 13DNR *DPYSL2* into induced pluripotent stem cells (iPSCs) which could be later differentiated into neuronal cell types for further analysis.

***What inspired you to participate in undergraduate research?***
"Research has allowed me to develop a holistic and detailed understanding of diseases that I find fascinating, and I love asking and answering novel questions in the lab."

***How did you get your research position, and what preparation did you undertake for it?***
"I worked in the Avramopoulos Lab through the Johns Hopkins Psychiatry Summer Training and Research (P-STAR) Program. I applied to be a part of this program in the early spring, and I was matched with this lab based on my research interests and experience."

***Where was your research experience located?***
"The Johns Hopkins University School of Medicine"

***What did you get out of your research experience?***
"An exciting summer exploring the city of Baltimore, new friends, and a new network of connections. I also learned about a field of research I was not familiar with, as I had no previous experience working in a genetics lab. This experience was great for helping me with my future studies and determining what I want to do after I graduate from Notre Dame."

## Neuroendocrine Stress Effects on Colonic Epithelial Dysfunction

Amy Wang
Major: Science Pre-Professional Studies
Advisor: Piotr Dorniak, Ph.D., Department of Gynecologic Oncology and Reproductive Medicine, The University of Texas MD Anderson Cancer Center, Houston, TX

Stress can be defined as the body's reaction to any stimulus that disrupts an organism's stability. Whereas short-term stress may result in processes to restore the organism's stability, prolonged or chronic stress may result in threatening effects on the human body. These effects include both nervous system stimulation and endocrine secretion. Stress has been connected to both irritable bowel syndrome (IBS) and irritable bowel disease (IBD), and IBD has been associated with cancer onset. The objective of the experiment was to identify the biological consequences of chronic stress in colon epithelium. Results revealed that chronic stress can produce colon epithelial dysfunction, specifically greater colon epithelial permeability and inflammation. Stress was found to reduce expression of tight junction genes ZO1 and ZO2, and these effects were abrogated by co-treatment with beta-blocker propranolol. Stress increased Claudin-2 protein expression in the colon in the epithelium. ADRB1 and ADRB2 were also found to be highly expressed under stress conditions. As chronic stress lead to colon cytotoxicity and microbiome imbalance, chronic stress resulted in conditions that predispose the abdomen to cancer proliferation. These results suggest beta blockers may prevent or treat chronic effects of stress on the colon epithelium, and thereby be utilized in the prevention and management of colon cancer.

***What inspired you to participate in undergraduate research?***
"My interest in research stems from my general fascination with science and a desire to gain a deeper understanding of the various processes that occur, on a molecular and cellular level."

***How did you get your research position, and what preparation did you undertake for it?***
"I had applied, and was accepted, to the MD Anderson-University of Notre Dame Joint Summer Undergraduate Research Program. I prepared for the summer by reading a number of review papers on topics relevant to my mentor's research."

***Where was your research experience located?***
"The University of Texas MD Anderson Cancer Center in Houston, Texas."

***What did you get out of your research experience?***
"My research experience this past summer has given me greater confidence in my skills as a researcher and reassured me of my interests in the clinical field as it applies to medicine. It allowed me the best opportunity to delve into cancer research as a field of interest, as well as see and understand how research translates to the clinical arena. I also made new friends in the process!"

**Inorganic Cesium Lead Halide Perovskite Solar Cells**

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

The growing energy demands of the world, along with the harmful effects of fossil fuels on the environment require the development of low cost, green energy sources. Solar energy has by far the most potential for powering the planet, but current solar technology is too costly to implement on a global scale. Organic-inorganic lead halide perovskite (primarily methylammonium lead iodide) solar cells have been promising as an alternative to traditional silicon in their efficiency and low product costs. However, the stability of these perovskites is a serious concern. A new class of fully inorganic cesium lead halide perovskites is currently being researched as a potentially more stable alternative to traditional methylammonium lead iodide. Therefore, efficient solid state solar cells using a cesium lead bromide film as the light absorber were produced. Cesium lead bromide nanoparticles were synthesized using a hot injection method. These nanoparticles were spin coated onto a TiO2 compact layer to produce a uniform perovskite film. A spiro-OMeTAD hole conductor was spin coated on top of the $CsPbBr_3$ layer. Finally, gold counter electrode contacts were deposited by thermal evaporation to complete the architecture. The champion cell obtained a power conversion efficiency of 2.7%.

***What inspired you to participate in undergraduate research?***
"I plan to spend my career studying solar materials and getting started in the lab as an undergrad is a great way to get valuable experience."

***How did you get your research position, and what preparation did you undertake for it?***
"As a sophomore I emailed Professor Kamat and asked him if he had any openings for undergrads. He was happy to get me started as soon as possible. I later submitted a research proposal for the NDnano fellowship and was able to work that summer. This past summer the Notre Dame College of Science Summer Undergraduate Research Fellowship provided funding for my research."

***Where was your research experience located?***
"University of Notre Dame"

***What did you get out of your research experience?***
"I learned how to conduct research, work with others, study literature, and discover new things. I hope to continue my research in graduate school."

**Electrical Plasmas for Biomedical Applications**

Elek Wellman
Major: Neuroscience & Behavior
Advisor: Sylwia Ptasinska, Radiation Laboratory and Dept. of Physics,
University of Notre Dame
Coauthors: Ek R. Adhikari, Sylwia Ptasinska
Radiation Laboratory and Dept. of Physics, University of Notre Dame

Atmospheric pressure plasma jets (APPJs) are currently investigated for their potential use as a clinical treatment method for cancer and abrasion therapies. The components of the ignited plasma, including radicals, charged particles and photons cause necrosis and/or apoptosis within exposed cells due to DNA damage. In order to study APPJ induced DNA damage, a helium plasma jet was used to create DNA breakage in an aqueous plasmid solution. The effects of the plasma pulse frequency of the jet on the aqueous DNA were evaluated. Agarose gel electrophoresis was utilized to evaluate the DNA damage in regards to single and double strand breakage. Our results show that an increase in frequency leads to a significant increase in single and double bond breakage.

***What inspired you to participate in undergraduate research?***
"I learn better through activities than listening in a classroom setting so I began undergraduate research to gain some hands-on experience in the field of science."

***How did you get your research position and what preparation did you undertake for it?***
"I contacted numerous faculty members to inquire about the experiments they oversee in their lab. After reading about the labs online and conversing with professors, I found a lab that suited my interests. To prepare, I read numerous articles that dealt with the plasma I worked with inside the lab."

***Where was your research experience located?***
"University of Notre Dame"

***What did you get out of your research experience?***
" I gained experience in how modern day research is conducted in addition to gaining hands-on experience within a lab group."

**Response of Western North American Birds to Black-Capped Chickadee (*Poecile atricapillus*) and Mountain Chickadee (*Poecile gambeli*) Mobbing Calls**

Madeline Wroblewski
Major: Environmental Science
Advisor: David Flagel, Dept. of Biological Sciences and Environmental Research Center, University of Notre Dame

Birds use alarm calls as an anti-predator strategy. One type of alarm call is the mobbing call, which functions to draw birds towards a predator for defense. Birds in the family *Paridae,* particularly the black-capped chickadee (*Poecile atricapillus),* are well-documented in eastern North America producing mobbing calls to which other species respond. However, far less research has been done on mobbing calls in western species. A playback experiment was used on the National Bison Range in western Montana to determine the response of western North American birds to black-capped chickadee mobbing calls, mountain chickadee (*Poecile gambeli*; a western species) mobbing calls, and a noise control. On average more individuals, agitated individuals, and species responded to the mountain chickadee call than the black-capped call, and individuals tended to spend more time near the speaker during mountain chickadee mobbing playback. However, because there was no difference in species diversity between treatments, this suggests only a few species responded consistently. While the pronounced response to mountain chickadee mobbing calls may be due to the potential greater ubiquity of mountain chickadees in western montane forests, the lack of diversity in responding birds and mild response suggests mobbing call recognition and response may not play a large role in western montane forests.

***What inspired you to participate in undergraduate research?***
I wanted to gain experience doing field research. It also gave me the opportunity to explore my interest in avian behavior and animal behavior in general.

***How did you get your research position, and what preparation did you undertake for it?***
I applied for UNDERC-West through Notre Dame. Participation in UNDERC-East is required to participate in UNDERC-West, and I took part in UNDERC-East the previous summer.

***Where was your research experience located?***
I did research on the National Bison Range near Charlo, Montana, which is in Western Montana.

***What did you get out of your research experience?***
I learned how to design and conduct my own study in a field setting. I also gained experience working on Federal land, and I gained valuable ecological knowledge of the western United States.

**Giant resonance multiple decomposition analysis (GRMDA): a program for studying nuclear incompressibility**

Yilong Yang
Major: Physics
Advisor: Umesh Garg, Dept. of Physics, University of Notre Dame

The equation of state (EOS) of infinite nuclear matter is mainly characterized by three quantities, of which the first two, the saturation density and the binding energy at the saturation density have been well-constrained, whereas nuclear incompressibility, which governs the curvature of EOS at saturation density still demands further study. The most direct method to experimentally determine the nuclear incompressibility is to measure compressional mode giant resonances. My research objective is to extract the resonance strength distributions by performing multipole decomposition analysis (MDA), a technique which serves to break down the nature of the nuclear response into contributions from different multipolarities. Within the frame work of a density dependent single folding optical model, I developed the Giant Resonance Multipole Decomposition Analysis (GRMDA) program to carry out MDA. The GRMDA program, as well as its application in obtaining the MDA for the experimental data of $^{40}Ca$, will be discussed in the poster presentation.

***What inspired you to participate in undergraduate research?***
"I want to experience the real vitality of science by exploring open-ended real-world challenges which, unlike text book problems, do not have standard solutions."

***How did you get your research position, and what preparation did you undertake for it?***
"I learned about this research opportunity with Prof. Garg from an undergraduate research info session sponsored by the Society of Physics Students (SPS). I began the research during the academic-year and extended it to the summer by applying for the Notre Dame College of Science Summer Undergraduate Research Fellowship."

***Where was your research experience located?***
"University of Notre Dame"

***What did you get out of your research experience?***
"The transition from a student to an independent researcher showed me the spirit of science - it is truly vigorous; it directly represents our visions of the nature; it connects every small discovery to the grand picture from which the universe uncovers itself. By studying topics in the dynamics of nuclear structure, I familiarized myself with an area of active research and became more prepared for my future career as an experimental physicist."

**Undergraduate Research Internship Information Night - Jordan 101**

Plenary speaker is Claire Kampman (Biological Sciences 2017). Claire will talk about the logistics of searching and applying to internship programs as well as her work on regulation of microtubule dynamics in Cystic Fibrosis Epithelial cells.

Lillian Spatz, (Biological Sciences 2018), participated in the Summer Undergraduate Research Program (SURP) at the University of Iowa (genetics.grad.uiowa.edu/program/surp) within the Department of Genetics. The program consists of about 20 students, 5 specifically in genetics). Lillian worked in Dr. Diane Slusarski's (biology.uiowa.edu/people/diane-slusarski) Zebrafish Lab, and looked at congenital visual disorders, specifically cataracts.

Meridith Balbach (Biological Sciences 2019), undertook an internship with the Indiana Clinical and Translational Sciences Institute (www.indianactsi.org). Meredith worked in the Indiana University School of Medicine with Dr. David Basile (physiology.medicine.iu.edu/people-in-physiology/david-basile-ph-d/), who studies the progression of acute renal failure to chronic kidney disease.