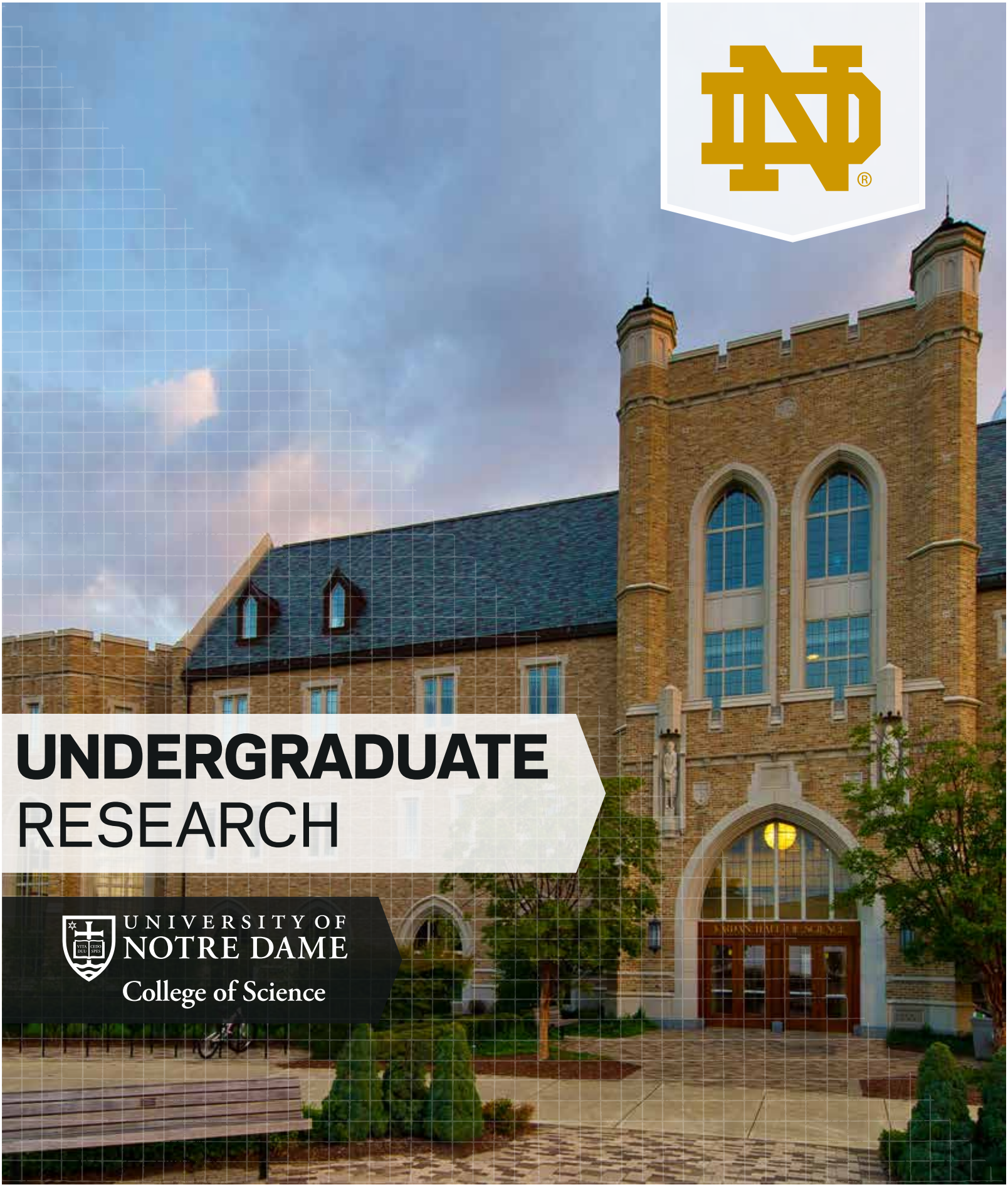

# UNDERGRADUATE RESEARCH

UNIVERSITY OF NOTRE DAME

College of Science

# LIVE OUT YOUR LOVE OF SCIENCE

UNIVERSITY OF NOTRE DAME
College of Science

Researchers in the College of Science conduct collaborative, interdisciplinary research into areas such as global health, drug development, regenerative medicine, Big Data, and much, much more.

Our undergraduate students are a significant part of our research endeavors. In fact, over 500 College of Science students participate in research every year on campus and at institutions around the globe.

Participation in research is the best way to understand the true nature of science and the scientific process. A research experience extends beyond simply working in a laboratory; it also includes communicating the results of that research in presentations and writing. Engaging in research deepens and broadens a student's experience and knowledge in their chosen field and helps prepare them for graduate school, medical school, and careers in industry.

The College of Science offers many opportunities for undergraduate research. The variety of potential topics and depth of scholarly inquiry reflect the resources available and the diversity of faculty research interests within the college. With increased emphasis by the University on scholarly engagement, the opportunities for undergraduate research will continue to increase.


# UNDERGRADUATE RESEARCH

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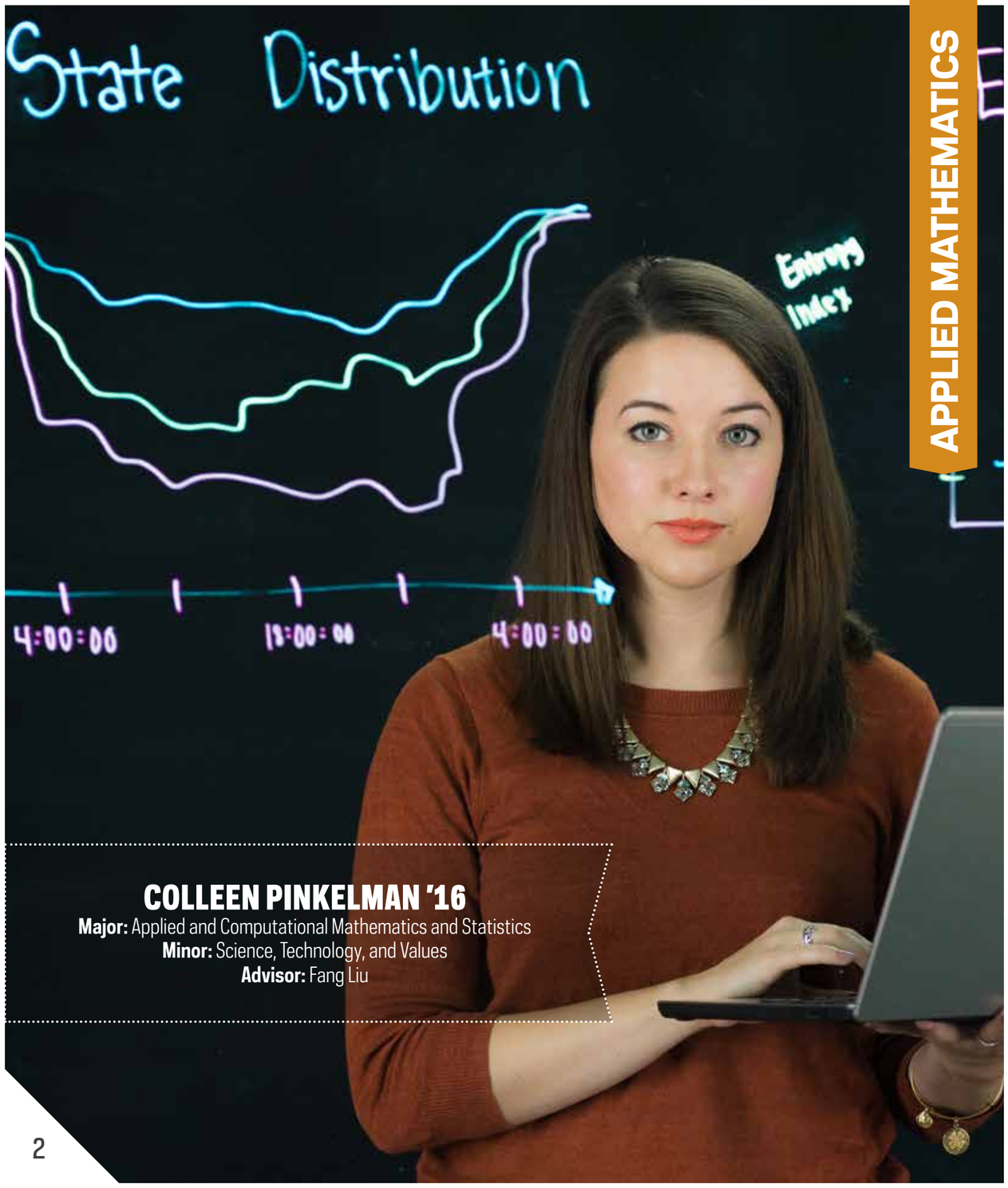



APPLIED MATHEMATICS

**COLLEEN PINKELMAN '16**
**Major:** Applied and Computational Mathematics and Statistics
**Minor:** Science, Technology, and Values
**Advisor:** Fang Liu



# TIME USE RESEARCH

Colleen Pinkelman's inquisitive nature drives her pursuits in and out of the classroom. As an applied and computational mathematics and statistics major, she wanted to find ways to further explore her interest in complex data sets. "My main motivation for pursing research was curiosity. I was eager to see how my classwork would apply to the world, and the concept of working on something entirely new was fascinating," she says.

Colleen's research examines time use research, a new interdisciplinary field that is dedicated to understanding how individuals allocate their time. Using data from the American Heritage Time Use Study database and the programming language R, Colleen explores algorithms for sequence analysis using survey data from 2009-2013. This type of research can influence policymaking for governmental social programs and provide insights in the social sciences.

*"MY MAIN MOTIVATION FOR PURSING RESEARCH WAS CURIOSITY. I WAS EAGER TO SEE HOW MY CLASSWORK WOULD APPLY TO THE WORLD."*

"I was unfamiliar with the nature of research when I first began working with Prof. Fang Liu. She was extremely supportive and guided me through each step of the research process until I was comfortable working on my own."

The benefits of research have been profound on Colleen's work ethic. "The structure of research is completely different than the structure of schoolwork. Being outside of a classroom, without constant deadlines and explicit requirements, has made me more self-motivated and independent."

In addition to her on-campus research, Colleen is an intern at a startup in South Bend called Vennli. Using the programming language R that she learned from her research with Prof. Liu, Colleen helps build data analysis tools that are used for internal research and client requests.

"My goal is to attend graduate school and become a data scientist, which is a career that is inherently research-driven. My undergraduate research experience has been an invaluable introduction to the field of research and has affirmed my desire to work with statistical analysis and computer programming."

**CLAIRE BEDALOV '15**
**Major:** Science-Business
**Minor:** Science, Technology, and Values
**Advisor:** Jenifer Prosperi

BIOLOGICAL SCIENCES

# BREAST CANCER

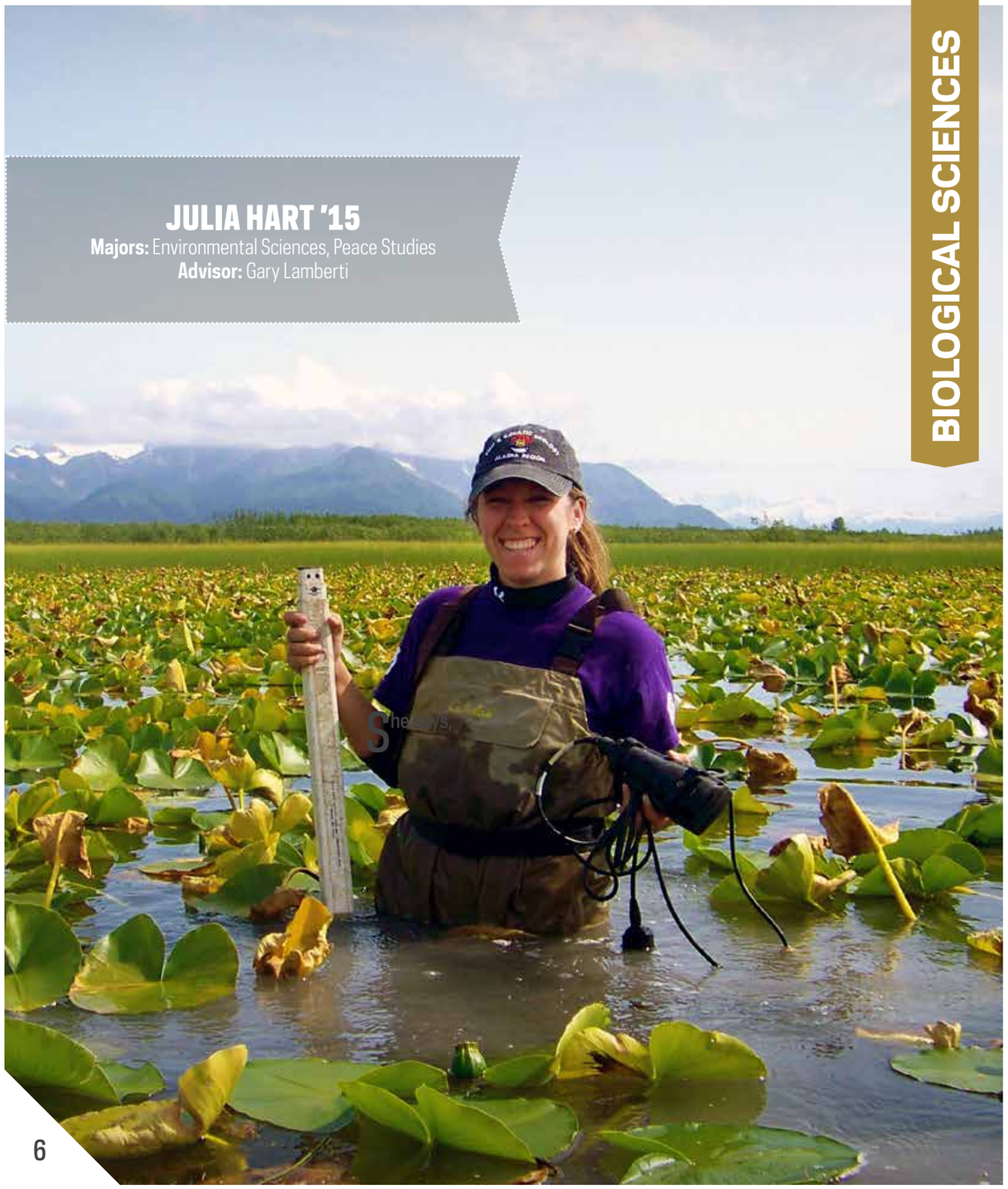
Claire Bedalov wanted her research experience to contribute to a greater cause and chose to find opportunities in labs focused on cancer research. "I wanted to work on cancer research because I've seen so many close friends and family affected by cancer. It's an area where amazing work has been done, but there is still so much to do. I liked the idea of investigating important questions and problems that could potentially improve the lives of others," she says.

*"I LIKED THE IDEA OF INVESTIGATING IMPORTANT QUESTIONS AND PROBLEMS THAT COULD POTENTIALLY IMPROVE THE LIVES OF OTHERS."*

Claire works with Prof. Jenifer Prosperi at the Indiana University School of Medicine-South Bend (IUSM-SB). Prof. Prosperi is a member of the Harper Cancer Research Institute, a research partnership with Notre Dame and IUSM-SB, and studies the protein *Adenomatous Polyposis Coli* (APC) and its role in breast cancer. Using techniques such as cell culture, immunofluorescence, and PCR (polymerase chain reaction), Claire's work examines how mutations in APC affect cell signaling pathways and chemotherapeutic resistance. This research could one day lead to novel targeted therapies for breast cancer caused by APC mutations.

In addition to her breast cancer research, Claire researches public health with a Notre Dame faculty member who specializes in environmental justice. "A professor I took a class with invited me to be her research assistant. I search for articles related to her current projects and prepare papers for publication. I encourage students to take classes in interesting areas outside of the sciences, as it could lead to opportunities that are unique and different. Research does not necessarily need to be bench research."

Claire has valued her time researching breast cancer, especially since she plans to attend medical school. "My research experience has been a significant part of the process of applying to medical schools. Prof. Prosperi has been such a great mentor and it's a great topic to discuss during interviews."



## JULIA HART '15

**Majors:** Environmental Sciences, Peace Studies
**Advisor:** Gary Lamberti

She says,



# ENVIRONMENTAL CHANGE

Julia Hart loves the outdoors and realized she could do research outside after taking an aquatic ecology class during her sophomore year.

"The lab component of the class involved working around lakes or streams every week, and I loved spending that time outside, especially on the water. The following summer I participated in the University of Notre Dame Environmental Research Center (UNDERC) program in the Upper Peninsula of Michigan, where I learned how to conduct fieldwork and design my own independent research project. After a summer of lakes, trees, boats, and bugs, I was hooked," she says.

*"I HAVE BEEN VERY FORTUNATE TO HAVE AWESOME RESEARCH MENTORS AND PROFESSORS. UNDERGRADUATE RESEARCH SUCCEEDS BECAUSE OF THEM."*

Working with Prof. Gary Lamberti, Julia's current research project focuses on the relationship between methane production and decomposition in ponds on the Copper River Delta in Alaska. She spent the summer before her senior year in Alaska studying the methane production in nine ponds on the delta. Using incubation bottles, she created pond microcosms with sediment, water, and floating lily plants and collected gas samples weekly to measure the methane concentrations.

"Methane is an extremely potent greenhouse gas that is estimated to be over twenty times more effective at trapping heat in our atmosphere than carbon dioxide. It is projected that the effects of climate change will be manifested most prominently in northern latitudes, so understanding the factors that drive methane production is valuable on the Copper River Delta."

Julia credits her love of fieldwork to the people who have helped her along the way. "I have been very fortunate to have awesome research mentors and professors. Everybody I have worked with is so passionate about what they do, and it is completely contagious. Professors are excited to talk about their research, and research mentors are a constant source for new ideas. Undergraduate research succeeds because of them."

BIOLOGICAL SCIENCES

**JONATHAN JOU '15**
**Major:** Biological Sciences
**Advisor:** Rebecca Wingert

# KIDNEY REGENERATION

Jonathan Jou got his first taste of scientific research as a junior in high school while studying abroad for a summer in the Canary Islands of Spain. During the week, he worked in a lab creating phylogenetic trees to reveal the loss of a sodium channel in the brain of vertebrates. On the weekends, he would surf.

A surfing experience that summer influenced his research interests at Notre Dame. After receiving a large superficial wound from a surfing accident, which left a distinctive scar on his right hand, Jonathan became fascinated with the wound healing processes of the body. He decided to find a lab to explore the mechanisms of regeneration.

*"BE BOLD IN YOUR THINKING. YOU DON'T ALWAYS HAVE TO BE RIGHT, YOU JUST HAVE TO BE CURIOUS."*

Jonathan successfully found a research position in Prof. Rebecca Wingert's lab, studying kidney regeneration. Using the zebrafish as a model, his research focuses on characterizing the fibroblast growth factor pathway in kidney regeneration. Using an antibiotic with known nephrotoxic effects to stimulate acute kidney injury, he measures the changes in gene expression as the kidney repairs itself. Understanding which genes are activated or used during regeneration can lead to therapeutics for patients suffering from kidney disease or injury.

The relationships Jonathan has formed during his time in Prof. Wingert's lab have been extremely influential. "Finding the right mentor, someone with whom you get along with in and out of lab and someone you can trust with your scientific, academic, and sometimes personal burdens, is a must. Having the right bench-side mentor, either a post-doctoral researcher or graduate student, is also imperative to success," he says.

Jonathan has learned that thinking creatively and facing challenges head-on is one of the best ways to learn and achieve the desired results in research. "Be bold in your thinking, try to go beyond the textbook and apply what you have learned. We learn both in success and failure, and some would argue we learn more when we do not succeed. Science is unique in this aspect; you don't always have to be right, you just have to be curious."

**FORREST WEGHORST '16**
**Major:** Neuroscience and Behavior
**Minor:** Anthropology
**Advisor:** Joseph O'Tousa

# NEURODEGENERATIVE DISEASES

Growing up, Forrest Weghorst had dreams of attending medical school to become a physician. Noticing Forrest's interest in biology, his high school biology teacher suggested he look for research opportunities at Notre Dame.

"As I began to immerse myself in more advanced biology courses, I found that the thrill of discovery and asking questions really piqued my interest in research and motivated me to find a lab that interested me," he says.

*"I'VE FOUND THAT RESEARCH REQUIRES THE UTMOST CREATIVITY AND INGENUITY TO DESIGN EXPERIMENTS CAPABLE OF ANSWERING OUR QUESTIONS ABOUT THE UNIVERSE."*

Forrest received a College of Science Summer Undergraduate Research Fellowship and began working in Prof. Joseph O'Tousa's lab during the summer after his sophomore year. The O'Tousa lab specializes in the genetics and signal transduction that leads to the degeneration of nerve fibers, known as axons, in the neurons found in retinal cells of the fruit fly *Drosophila melanogaster*. Forrest specifically studies the protein Wallenda and its impact on axonal degeneration in *Drosophila*'s visual system. Although potential medical applications of this research may be decades in development, using *Drosophila* to understand the neuronal degeneration process will provide a framework for an approach to human neurodegenerative diseases such as Alzheimer's, Parkinson's, and other debilitating conditions that result from spinal cord injuries or diabetic neuropathy.

"Research has become an important part of my undergraduate experience, just like going to football games or participating in clubs outside of academics. I've found that research requires the utmost creativity and ingenuity to design experiments capable of answering our questions about the universe. A summer of research in the O'Tousa lab made it clear that I wanted to work research into my long-term goals."

Forrest is now planning to pursue a Ph.D. in cell biology after graduation. "I remember being in the lab one day and thinking, 'I can see myself doing this for the rest of my life.' Research has profoundly influenced my educational and career goals."

**ORRIN BELDEN '15**
**Major:** Science Preprofessional Studies
**Minors:** Latino Studies and International Development Studies
**Advisor:** Brian Baker


# CANCER IMMUNOLOGY

Orrin Belden knew he wanted to find a research opportunity to make a difference in the medical field. "My interest in research initially began when my grandfather passed away in elementary school. At a young age, I realized that despite all of medicine's advancements, it still had many shortcomings. Coming to Notre Dame, I knew I wanted to contribute my time towards advancing scientific knowledge in an effort to improve medical treatment," he says.

*"COMING TO NOTRE DAME, I KNEW I WANTED TO CONTRIBUTE MY TIME TOWARDS ADVANCING SCIENTIFIC KNOWLEDGE IN AN EFFORT TO IMPROVE MEDICAL TREATMENTS."*

Orrin works in Prof. Brian Baker's lab on cancer immunology and immunotherapy research, a field dedicated to finding ways to employ a person's immune system to detect and eliminate cancer in the body. Studying the cytotoxic T-cell and its receptors, Orrin is trying to determine if an engineered T-cell can kill melanoma cells more effectively than regular T-cells. His work is focused on understanding the properties and interactions of engineered T-cells, including the biological ramifications of the engineered cells for both healthy and malignant tissue in the tumor microenvironment.

"If we are able to use a person's own immune system to kill melanoma in the body, this will be especially valuable for melanoma that has metastasized and spread. If successful in the lab, this research has the potential to become a cancer treatment one day."

In addition to his lab work, Orrin has worked on the staff of *Scientia* since his freshman year. *Scientia* is the student-run undergraduate journal of scientific research at Notre Dame, and Orrin currently serves as co-editor and chief. *Scientia* students host monthly seminars featuring undergraduate and faculty research and publish the journal every spring. "My involvement with *Scientia* has been very important to my Notre Dame experience. I've been exposed to research outside of my major and have helped build a platform to highlight undergraduate research throughout the academic year."

**BRYCE JONES '15**
**Major:** Chemistry
**Advisor:** Marvin Miller



# DRUG DEVELOPMENT

Bryce Jones discovered his passion for organic chemistry through his classes at Notre Dame. "I originally came to Notre Dame planning to study pre-medicine, but quickly changed my major to chemistry after taking Prof. Marvin Miller's freshman organic chemistry class. During lecture, he would discuss aspects of his research and relate them to the topics we were learning. I was really interested in his work and asked if I could volunteer in his laboratory over the summer. I've been researching with him ever since," he says.

*"MY ANTICANCER RESEARCH IS APPLICABLE BEYOND THE LABORATORY—IT CAN BE EXTENDED ALL THE WAY TO HOSPITAL BEDSIDES."*

Prof. Miller's research is focused on the synthesis and study of biologically important compounds, including small molecule drugs. Bryce's project in the lab specifically centers on the discovery and optimization of novel anticancer drugs. By utilizing laboratory techniques such as extraction, distillation, column chromatography, mass spectrometry, and nuclear magnetic resonance (NMR), Bryce synthesizes compounds and tests various cancer cell lines *in vitro* to determine if the compounds exhibit anticancer activity.

"My anticancer research is applicable beyond the laboratory—it can be extended all the way to hospital bedsides. The Miller research group is currently working to license several of our compounds which have shown excellent activity and selectivity for breast cancer. "

Undergraduate research has taught Bryce some very important skills that will stay with him for the rest of his life. "Researching with Prof. Miller has helped me learn the importance of perseverance. Research progresses slowly at times, but hard work eventually pays off."

After graduation, Bryce plans to attend graduate school and pursue an M.D./Ph.D. "Working with Prof. Miller has significantly impacted my career goals and I plan to work in academic medicine. I'm particularly interested in using enzyme replacement therapy to treat rare and neglected diseases."

**TOBY TURNEY '16**
**Major:** Biochemistry
**Advisors:** Darryl Pappin, Cold Spring Harbor Laboratory
Anthony Serianni, Notre Dame



# PROTEOMICS

Toby Turney has been fascinated with structural biology since high school when he discovered a public video game that was designed for players to contribute to protein folding research. "I loved the idea that simple problem-solving skills could be applied to solve important scientific questions," he says.

During his sophomore year, Toby was able to find a lab position that matched his interests and now works with Prof. Anthony Serianni. Toby's work focuses on structural studies of sugars using x-ray crystallography and molecular modeling strategies.

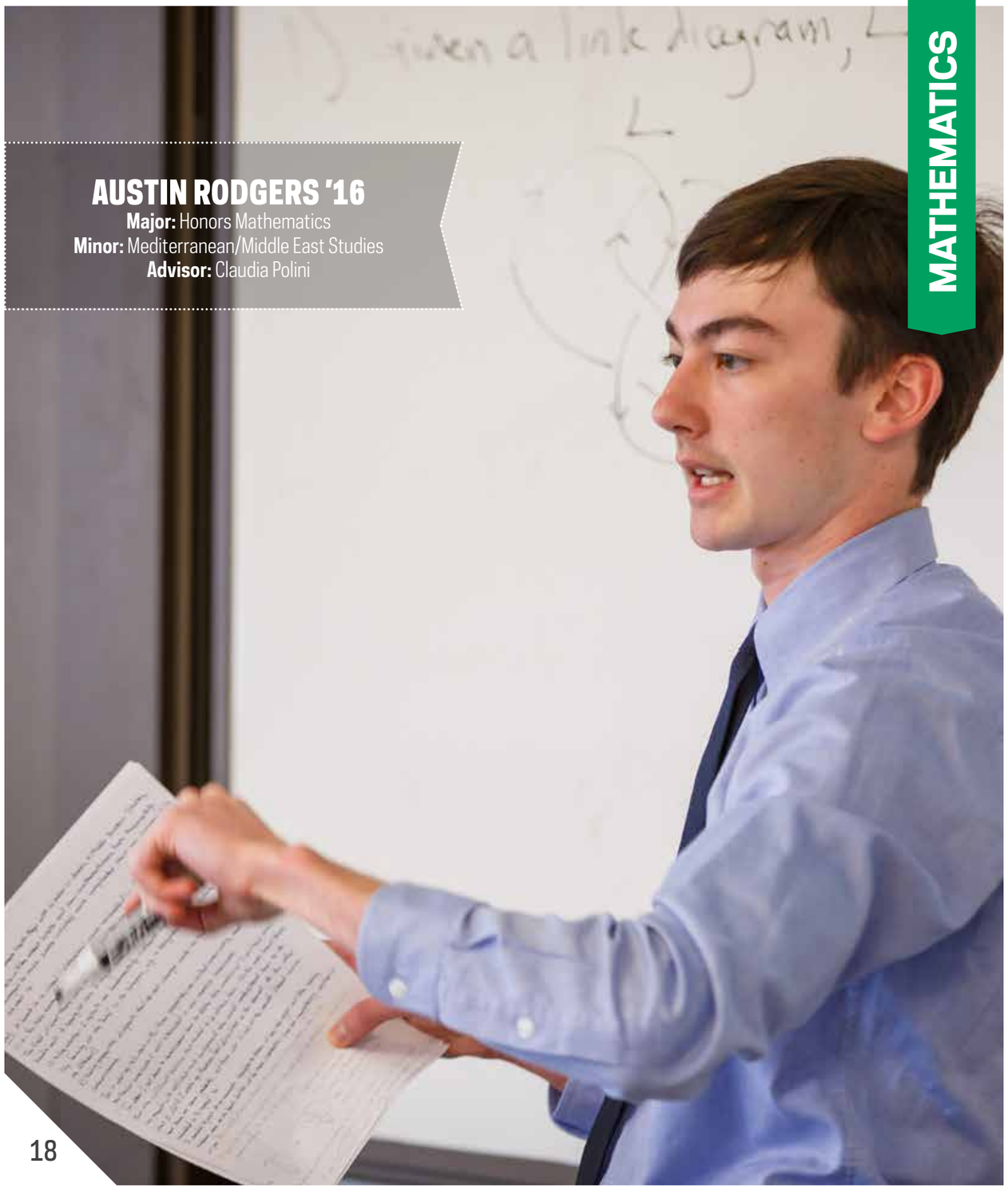
"I'm really interested in molecular structures and my work in Prof. Serianni's lab has fallen along those lines. I also really enjoy the teaching aspect of structural biology. If you have a picture of a molecule, it can be surprisingly easy to explain science to someone who isn't a scientist."

Toby's research experience and academic record helped him earn a spot in the very prestigious Cold Spring Harbor Laboratory (CSHL) summer undergraduate research program. Located in Long Island, New York, CSHL is a research and educational institution that specializes in molecular biology and genetics.

*"I LOVED THE IDEA THAT SIMPLE PROBLEM-SOLVING SKILLS COULD BE APPLIED TO SOLVE IMPORTANT SCIENTIFIC QUESTIONS."*

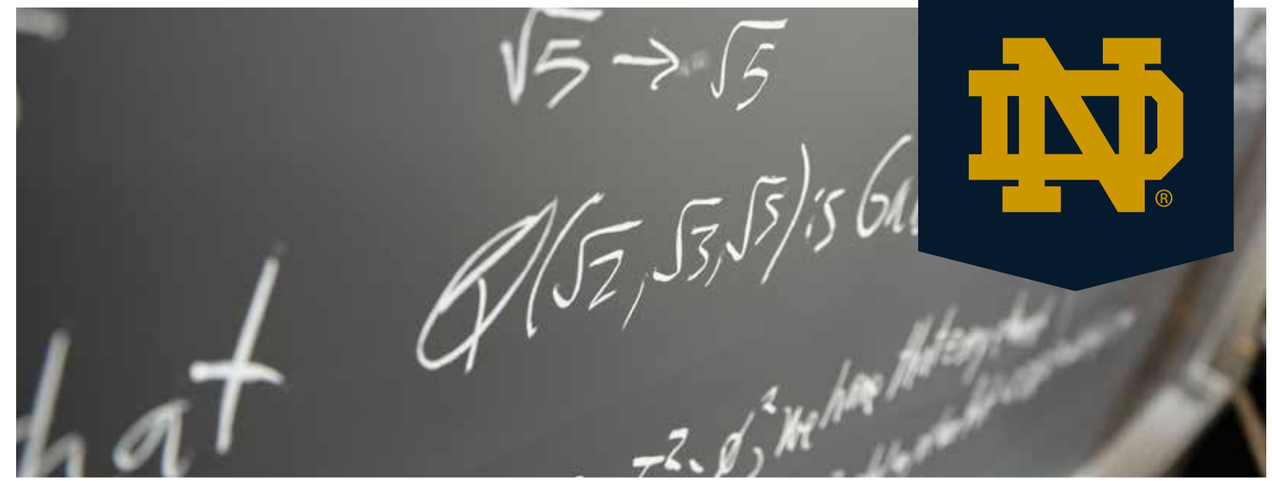
During his ten weeks at CSHL, Toby worked with Prof. Darryl Pappin on proteomics research using mass spectrometry, a technique widely used to identify cancer biomarkers and vaccine targets. Prof. Pappin's lab discovered a unique protease that is of particular interest to researchers for its ability to improve the efficiency of mass spectrometry experiments. Toby's project focused on purifying the protease so that other researchers would have access to this protease.

Toby credits much of his research success to his lab mentors. "There are definitely things which you can learn in class that can help you with your research, but having someone get you acquainted with the instruments you will be working with and help you set up your first experiment is really priceless."



MATHEMATICS

**AUSTIN RODGERS '16**
**Major:** Honors Mathematics
**Minor:** Mediterranean/Middle East Studies
**Advisor:** Claudia Polini



# ALGEBRAIC GEOMETRY

Austin Rodgers enjoys immersing himself in the learning process and knew research would be a great way to do this.

"I wanted to get involved in undergraduate research because the concept of creating knowledge through original work was attractive to me. My honors mathematics professors have stressed the importance of research and encouraged me to seek out topics that I wouldn't have too much exposure to as an undergraduate," he says.

*"MY HONORS MATHEMATICS PROFESSORS HAVE STRESSED THE IMPORTANCE OF RESEARCH AND ENCOURAGED ME TO SEEK OUT TOPICS THAT I WOULDN'T HAVE TOO MUCH EXPOSURE TO AS AN UNDERGRADUATE."*

Austin works with Prof. Claudia Polini who studies the interplay between commutative algebra and geometry. Algebraic geometry is a developing field that has been applied to code-breaking, biochemistry, and robotics. Austin's current research examines projective plane sextics. He is trying to determine if other classes of singular plane curves can be distinguished geometrically when traditional approaches fail to give distinct invariants.

Through research, Austin has significantly strengthened his critical thinking and problem solving skills. "Knowing a lot about the subject matter you research is only the first step in actually accomplishing something with that knowledge. For example, you can quote theorems and memorize proofs for those theorems, but until you understand the method of the proof, you won't be able to use those theorems effectively. This critical thinking and intuition applies to all disciplines, not just math."

Austin credits much of his development as a mathematician to his faculty mentor. "Prof. Polini has been a very influential part of my research experience. Her command of the subject matter helps me gain intuition for the material and helps me see the end goal through the muddy details."

As he begins to think about his plans after graduation, Austin knows he will follow his passion for research. "I'd like to study algebraic geometry in graduate school. I think it's the most beautiful area of math because of the relationships we can find between algebraic structures and geometric objects."

**TAYLOR CORPUZ '16**
**Major:** Physics
**Advisor:** Justin Crepp

# ASTROPHYSICS

Taylor Corpuz's life-long passion for science influenced her decision to choose a major in physics. "I'm interested in astrophysics and it is so fascinating because there's literally an infinite space to explore that we are just barely learning about. In the past hundred years alone we've gone from not even knowing what a galaxy was to landing on the moon, almost leaving the solar system, and discovering new, far off planets. I really wanted to get involved in research as soon as possible so I could experience how we learn about the universe," she says.

*"I REALLY WANTED TO GET INVOLVED IN RESEARCH AS SOON AS I COULD SO I COULD EXPERIENCE HOW WE LEARN ABOUT THE UNIVERSE."*

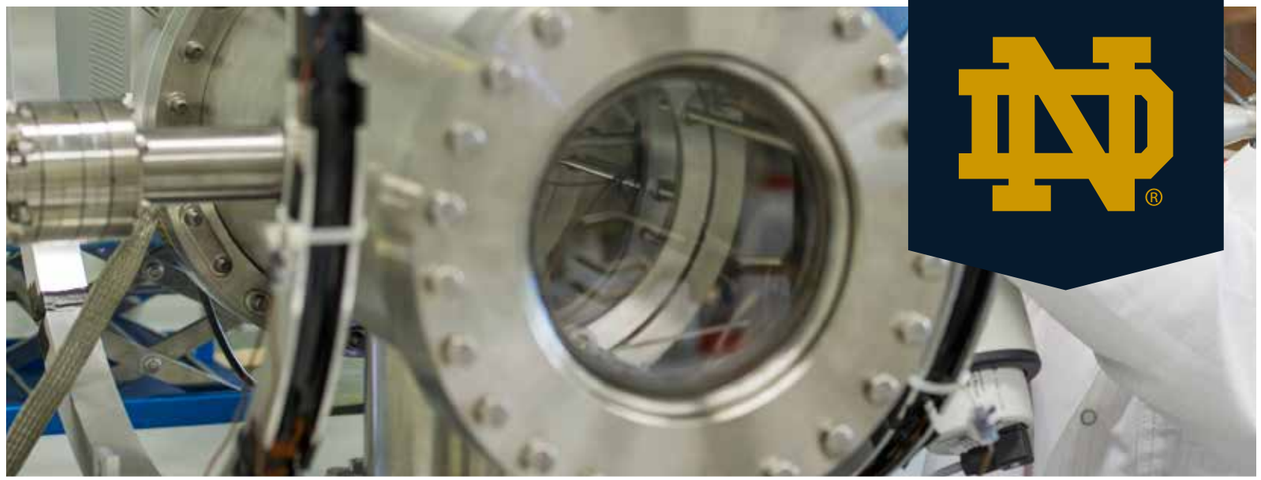
Taylor works on the iLocater project in Prof. Justin Crepp's lab. iLocater, or Infrared Large Binocular Telescope Exoplanet Recovery, will be an ultra-precise, near-infrared spectrometer used at the Large Binocular Telescope in Arizona, one of the world's most advanced optical telescopes, to search for extrasolar planets. The telescope is still in development and anticipated to be completed by 2017. Taylor's role in the project includes developing MATLAB data reduction techniques and exploring potential future experiments for the instrument.

Taylor has learned that, although research can be challenging, the experience is very rewarding. "Research is different than other things I've done because there really isn't a point when I can say I'm finished, like I do when completing a band performance or a final. Some weeks it feels like I am getting absolutely nowhere, but if I work consistently, I eventually make significant progress. Research has taught me how to stay motivated and excited about what I'm doing, even when it is difficult."

Undergraduate research has also cultivated a new passion for Taylor that may influence her future career plans. "I've learned that I really like coding and am very interested in the film special effects industry. I spoke with someone in the industry who told me that with a physics and computer science background I could work on developing physics engines for computer special effects, which would be amazing."

## JOANNA KABUYE '15

**Major:** Science Preprofessional Studies
**Advisor:** Sylwia Ptasinska



# BIOPHYSICS

Joanna Kabuye's passion for research was inspired by a high school biology project. Her project explored the medicinal properties of Enguu leaves, which are used by the Luhya tribe in her hometown in Kenya. She prepared agar plates to test the effects of the leaves on three types of bacteria and found that the leaves provided no antibacterial effect.

"Although I was disappointed in destroying over 100 plates of research, this experience unquestionably fueled my desire to pursue research opportunities at Notre Dame. I was fascinated with the idea of being at the forefront of scientific discovery and fell in love with the experimental aspect of research," she says.

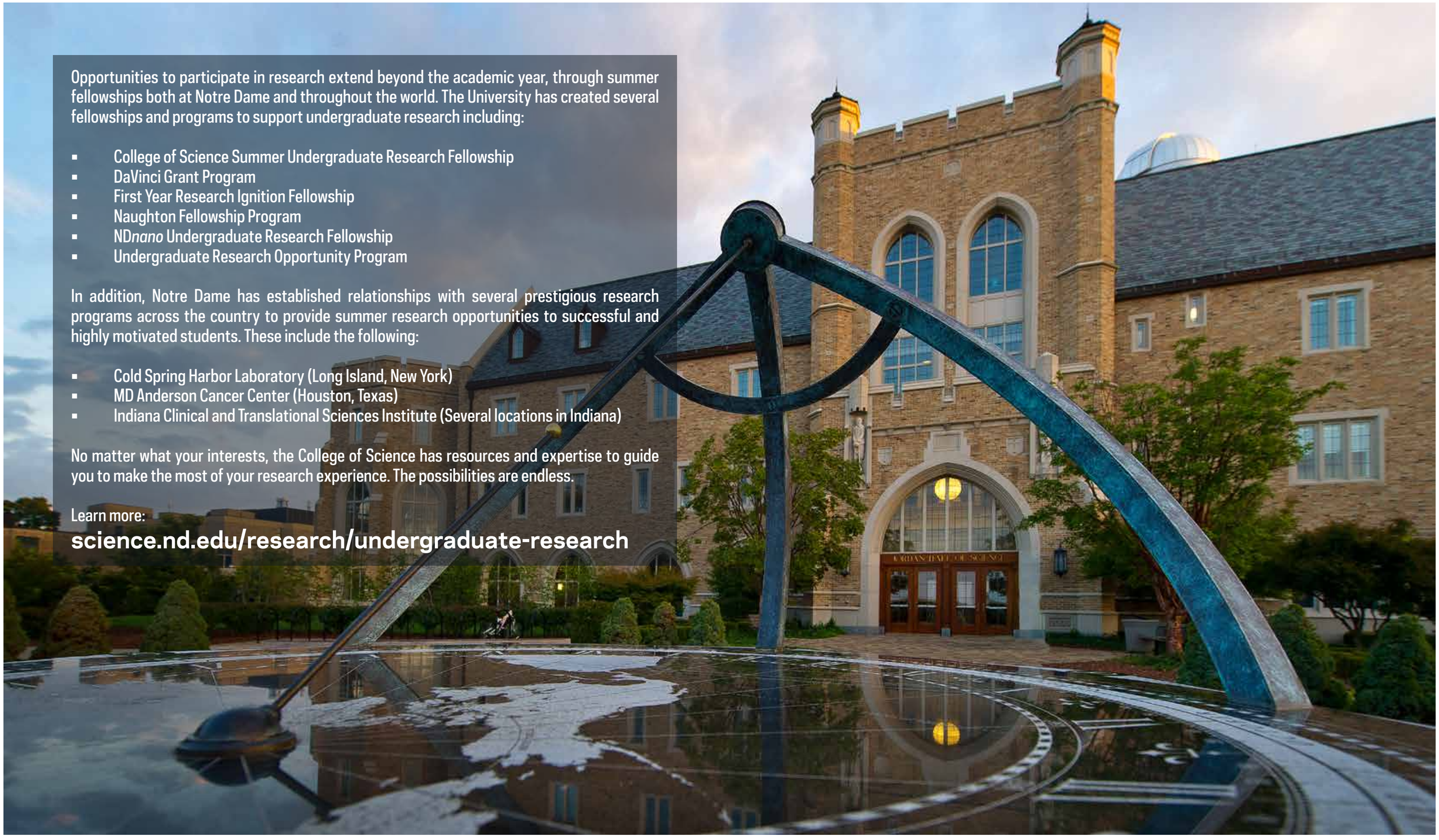
*"BY ENGAGING IN MEDICAL RESEARCH, I AM BUILDING THE FUTURE OF MEDICINE BY ADVANCING MEDICAL KNOWLEDGE."*

Through a friend, Joanna found a research position in the Radiation Laboratory with Prof. Sylwia Ptasinska to study DNA damage caused by radiation. Humans are exposed to radiation on a daily basis, and although seemingly harmless in small quantities, accumulated DNA damage can have severe effects on normal cellular processes and can lead to cancer.

Joanna's work focuses on irradiating amides that help us understand the radiation effects of electrons on proteins. Using a specialized experimental high vacuum chamber, Joanna irradiates the molecules and analyzes the results using a quadrupole mass spectrometer.

"Prof. Ptasinska's group is very collaborative and working with them has taught me the importance of teamwork. We have regular meetings where we each present our data to the rest of the group for critique and constructive feedback."

After graduation, Joanna will take time off to do service and then plans to apply to medical school. "Research has stimulated not only my critical reasoning and analytical skills, but also my patience and resilience, which I believe will be crucial in accurately treating my future patients. By engaging in biophysics research, I am building the future of medicine by advancing medical knowledge. It has been an honor to be part of this work."



Opportunities to participate in research extend beyond the academic year, through summer fellowships both at Notre Dame and throughout the world. The University has created several fellowships and programs to support undergraduate research including:

- College of Science Summer Undergraduate Research Fellowship
- DaVinci Grant Program
- First Year Research Ignition Fellowship
- Naughton Fellowship Program
- ND*nano* Undergraduate Research Fellowship
- Undergraduate Research Opportunity Program

In addition, Notre Dame has established relationships with several prestigious research programs across the country to provide summer research opportunities to successful and highly motivated students. These include the following:

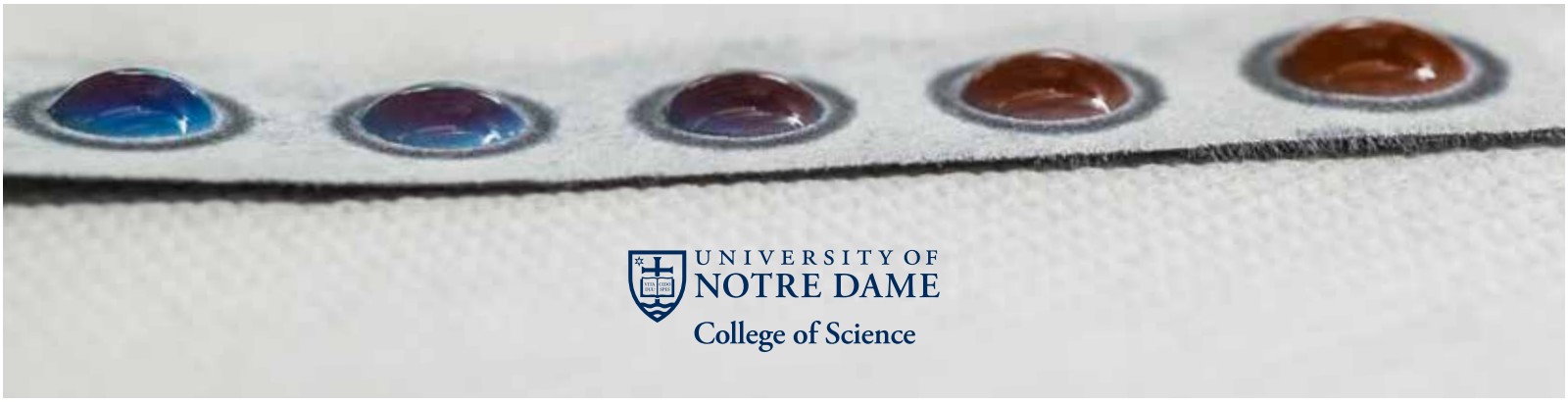
- Cold Spring Harbor Laboratory (Long Island, New York)
- MD Anderson Cancer Center (Houston, Texas)
- Indiana Clinical and Translational Sciences Institute (Several locations in Indiana)

No matter what your interests, the College of Science has resources and expertise to guide you to make the most of your research experience. The possibilities are endless.

Learn more:

**science.nd.edu/research/undergraduate-research**


# LIVE OUT YOUR LOVE OF SCIENCE



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