

Over the past five years, I have participated in a total of four research projects in four different, but related fields. I have done projects in physical chemistry, mathematical biology, mathematics, and biostatistics. Due to this, I have had to learn a wide variety of physical sciences and the mathematics required to operate within them.

I first became involved with chemistry research under Dr. Rudolf Burcl at Marshall University in Huntington, West Virginia, starting in spring 2009, the second semester of my undergraduate career. Under Dr. Burcl, I was introduced to physical chemistry, a highly mathematical field in an applied setting. This project focused on using mathematical principles to model reactions with OH radicals (ab initio calculations). These reactions are highly important in atmospheric sciences, helping form ozone; in exobiological studies, in the search for water on exoplanets; and even in rust formation here on earth.

Starting in the summer of 2009, I received for the NASA Space Grant for Undergraduate Research, helping fund my research under Dr. Burcl for a full year. During both the summer and the academic semesters, 20 hours per week were required for work done on the project. Each week during the summer consisted of at least one full day dedicated to the mathematical theory of the project, such as Heisenberg uncertainty principles, deriving the mathematical formulas (such as Schroedinger's Equation), and learning advanced chemistry beyond my previously limited freshman-level knowledge. Calculations were run on Dr. Burcl's own super-computer cluster, called Titan, requiring me to learn Bash language programming and the MOLPRO software package. Further, at the end of my time working with Dr. Burcl, we received money to expand the computing cluster, which allowed me to learn basic computer hardware assembly as we put together the new machine.

As a recipient of the NASA grant, I was required to present at Marshall University's Sigma Xi, the symposium devoted to undergraduate research. I gave a poster presentation, fielding questions from professors and students from all departments within the College of Science. Further, I gave regular presentations to Dr. Burcl to update him on my progress during the semester. For the academic year of 2010-2011, I did not receive the NASA grant, but continued to work under Dr. Burcl until the end of that academic year, helping prepare a new student for their own Sigma Xi presentation at the 2011 session.

In the Spring of 2011, I enrolled in a special topics course offered called Mathematical Biology. This course was part of a new grant received by the university to help introduce and facilitate mathematical biology research among undergraduate students. During the semester, we discussed various topics such as modelling with the SRI infection model and basic MATLAB programming techniques. At the end of the course we were given the opportunity to apply for the chance to be a part of a new research team which would focus on two different mathematical biology topics, providing the students with a year long stipend to help support the research. I was one of four students chosen from a class of approximately 30 students. The teams were split into groups of two, one mathematics student and one biology student. The project I was assigned to was under Dr. Marcia Harrison, a biology professor, and Dr. Scott Sara, a mathematics professor, working on gravitropism models of pea plants.

For this project our aim was to use time-lapse imaging software and MATLAB to see if we could model and predict the curvature of a pea plant under gravitropism. As with the NASA grant, 20 hours of work per week were required. During the summer semester, I helped set up a dark room to place the pea plants to watch their growth with no affect from light (phototropism). This required setting up a photo-station in an unused room in the university's greenhouse, setting up the camera system, and making sure that there was no outside affect from light sources. Further, because we required the room to be dark, we tested various lights that would allow the camera to see without affecting the plants' growth. Also during the summer, we dedicated many of our hours to reading biological books and papers which would help formulate both the physical and mathematical basis for the project.

As the mathematics student on the team, my job was to focus on using MATLAB to analyze the images captured by the time-lapse camera. To do this, I was in charge of writing a script on MATLAB which would allow the user to direct the selection process of the pea stem by clicking three points, fill in the entire stem to indicate it on the image, and fit the curve using a fourth degree polynomial. Never having had a numerical analysis class up to this point, this required a significant amount of self-study on my part.

We held weekly meetings with the other team to update each other on progress and practice our presentation skills. In spring of 2012, West Virginia's biennial STaR (Science, Technology, and Research) Symposium was held jointly with the annual West Virginia Academy of Science meeting. I presented the research that I had worked on for the past year in a 20 minute oral presentation. A total of 120 students, both undergraduate and graduate, from around the state presented, and I was awarded first place in the Undergraduate Presentation category.

At the same time, I was finishing my undergraduate degree and was enrolled in the Capstone course required of senior students at Marshall. We are required to conduct research in our field and present the research, along with submitting a paper, at the end of the semester. I used my research with Dr. Harrison

as the basis for my capstone, writing a 25 page paper to summarize my work.

I applied to Missouri S&T with the anticipation of completing my master's degree in mathematics. In my second semester, spring 2013, I became involved in a mathematics research project under Drs. David Grow and Matt Insall. I became interested in the project after discussing my physical sciences background with Dr. Grow during my first semester. For the entirety of my masters degree, I participated in weekly meetings with Drs. Grow and Insall, though did not seek a thesis for my masters.

The complete iterative inversion method (CIIM) is the first project I have been involved in which is truly mathematical. However, like all projects I have worked on, there is still significant application. With the CIIM, we seek to give a mathematical basis to a method used by physical chemists to determine energy potentials of systems. In reality, I was revisiting the ideas I first learned under Dr. Burel as a freshman undergraduate, but now from a mathematician's point of view. I have greatly enjoyed seeing the other side of a very similar problem.

Up to this point, I have never applied for or received any kind of funding for my work on the CIIM, choosing to do it purely out of interest and intrigue. For four semesters I focused on using MATLAB techniques to program the method outlined in the three mathematical papers published concerning the CIIM, with a goal to expand the theoretical to a working application. For the past semester, spring 2015, I have instead shifted focus away from the application to a much more theoretical goal, attempting to answer one of the many open problems posed by CIIM. My work has been entirely self-paced and self-motivated, and I have learned invaluable skills in both balancing of research and classes, along with a much stronger ability to self-educate. I once again find myself in a project requiring significant numerical analysis techniques, but have yet to take a formal class in the subject. In programming, we have had to learn function definition, integration techniques, spline techniques, and approximation error techniques.

Also on the team are, at any given moment, one to three undergraduate students who are interested in expanding their research experience. Up to this point, I continue to be the only mathematics student working on the project. As the only graduate student, it was often my job to help explain the concepts covered in papers to undergraduates, give them tasks to help further research, and direct their efforts. I present my work every week in meetings, whether it is progress in programming or in theory, and give a typed summary of advances from each meeting to send to the group.

I finished my master's from S&T in the spring of 2014. That summer, I decided to try another project, this time under Dr. Gayla Olbricht, a statistician at S&T. I was given a stipend to study epigenomics, a fastly growing field in biostatistics. The topic was focused on how genetic mutations affect auxin regulation, a key hormone in plant growth. Coupled with a biology group at University of Missouri St. Louis, we analyzed large datasets of mutated pea plants to determine statistically significant genetic changes. This project was similar in biological principle as the pea project I wrote my capstone on, thus completing my undergraduate degree.

For the biostatistics project, I was required to learn the code that Dr. Olbricht has been using to analyze data and then learn and recode a different method of my own choosing. To do this, I researched both the statistical and biological history of epigenomics; read papers which reviewed different methods for determining significant genes; compared methods to determine which I thought were the most interesting; and programmed a script to run the analysis. The team consisted of myself and two other graduate students, both statistics PhD students in the Mathematics Department. Each week we discussed theory of the project to help each other understand it best, presenting one paper each to the group. Afterwards, we spent three weeks working on our own chosen method and presented our results at the end of the summer both to each other and to the biology group at UMSL.

The epigenomics project was the first project in which I used the statistical package known as R. Further, having never had a statistical analysis class beyond Experimental Design, I was required to learn some of the more advanced myself. This was a great opportunity to do something very much out of my comfort zone and experience up to this point.

I have always had a huge interest in the physical sciences, as evidence by my varied research experience. In my undergraduate career, I took every introductory physical science course offered by my university (Chemistry I and II, Physics I and II, Biology I and II) and have a very wide knowledge of many fields for this reason. I am always interested in how I can apply mathematics to a problem to help further the fields of biology, chemistry, and physics. My goal is to use my interest in physical principles and my strengths in mathematics to merge the two fields together, rigorously whenever possible, elevating physical sciences to an even higher level of exactness and logic. It is my hope that I am able to show every scientist the usefulness and ease with which mathematics can be incorporated to their field.