Personal, Relevant Information and Future Goals Statement: [redacted]

Personal Statement

The history of science has always fascinated me. As I became invested in studying physics in high school and college, I would challenge myself to try to solve scientific conundrums of the past. One time, I attempted to derive the law of conservation of energy that prominent mathematician Emmy Noether proved in 1915. Even though I did not elegantly solve this problem, or many of the others I attempted, conducting these intellectual exercises revealed to me how research uncovers the processes that govern our world, discovers what lies beyond the edge of our current knowledge, and pushes the expanse of that edge a little bit further. After learning about Emmy Noether's work, I learned more about the struggles that women and minorities had to go through to do science back then up through the present. Emmy Noether, who is one of the most important women in mathematics, could not get a paid job in her field for 16 years because universities did not give women academic positions. As an African American male, I too am a member of a group underrepresented in science, yet I am fascinated by the unknown. To contribute to the discovery of the unknown, and at the same time improve the representation of minorities in science, I decided to pursue a Ph.D. in quantitative biology.

Intellectual Merit: synergy in experiments and computation enable scientific discoveries

During the summer after my freshman year as a chemical engineering major at the [redacted], I applied to and received my first opportunity to conduct research at [redacted]. I was awarded the Summer Undergraduate Research Fellowship to work in the material science lab of Dr. [redacted] that studies bulk metallic glass (BMG), a great candidate material for many technological applications due to their tunable mechanical, magnetic, chemical and biological properties. The [redacted] lab uses thin film metallic glass (TFMG) to improve the development of BMG by simultaneously creating many different TFMGs and measuring their properties. However, in their approach, microstructures form on TFMGs that prevent precise measurements of some properties including roughness and conductivity. My project was to determine if annealing the metallic glass near their glass transition temperature can eliminate or reduce these microstructures. During that summer, I created and characterized thin films that I turned in to glass by heating them in a vacuum furnace. I discovered that heating my films above their glass temperature increased the diameter of their structures. Through this experience, I learned about the impact scientific improvements could have on the rate of research progress. The fact the material I made in three days could predict the results of characterizing 1000s of different metal glass amazed me. I learned that I could use data-driven research approaches not just to improve understanding, but also to decide which research directions to pursue further by using high-throughput experimental design and statistical analyses.

The following summer I wanted to continue research and was accepted to the Systems Biology Summer Internship Program at [redacted]. In the program, I performed research with Dr. [redacted] studying how gene expression in *S. cerevisiae* changes at the single-cell level in response to different nutrient conditions. The [redacted] lab had previously found that genetically identical yeast cells have very different responses in their metabolism decisions in response to different concentrations of glucose and galactose. Within my project, I studied how *GAL3*, a gene that encodes a transcriptional regulator, is responsible for the observed population heterogeneity of galactose utilization. Excitingly, I learned through my experiments that genetic variants of *GAL3* cells altered the number of cells that decided to turn "on" the pathway that breaks down galactose rather than the levels of pathway activity in those cells that turned "on". I immediately began to wonder how I could leverage my quantitative background to build a mathematical model that would describe these observations. My attempts to model my results showed me how experiments and accurate model building form a synergistic relationship whereby models can predict key target areas to be probed experimentally, and the results of those experiments can improve the model. As a result, I became **fascinated with the combination of computational modeling and experiments as a means to better understand complex problems in biology**.

Since I did not take any formal computer science classes in college, I wanted to improve my computational modeling skills before applying to graduate school. The summer after my junior year, I pursued and was accepted into a research experience for undergraduates (REU) program at [redacted], where I decided to conduct dry lab research with Dr. [redacted]. Dr. [redacted] lab investigates cardiac arrhythmias using models derived from data captured during single-cell cardiac myocyte electrophysiological experiments. The lab had optimized models using a genetic algorithm. However, when these models were optimized, they did not include data on changes in calcium levels (a key factor regulating heart function). As such, the goal of my project was to improve the algorithm to better represent observed calcium dynamics. I achieved this goal by designing and evaluating better error functions to include calcium dynamics using a high-performance computing cluster to determine which algorithm generated the most accurate models. As a result of my effort to learn different programming languages and write better algorithms, I improved my confidence in my ability to do computational modeling. **It also demonstrated to me that developing and validating computational methodologies adds value to experimental observations.**

These experiences also highlighted the value of single-cell science performed in a high-throughput manner. This led me to pursue further study at the PhD level where I was accepted into the [redacted] Biology Program at Vanderbilt University and **was awarded [redacted] for highly qualified underrepresented minority students**. The program enabled me to apply my knowledge of math and chemistry to help solve problems in the biological sciences. As a part of the program, I rotated in four different research labs doing a combination of mathematical modeling and experimental analysis. At the end of my first year, I joined the lab of [redacted], which studies gene regulation at the single-cell level. This lab aligns with my interest in studying cellular heterogeneity and model-based experimental design. I was also **awarded the competitive [redacted] Training Grant** and entered the [redacted] program. The quantitative training I have obtained so far will enable me to study epigenetic regulation of gene expression through a combination of mathematical and experimental methodologies.

Broader Impacts:

Throughout my life, I was presented with many STEM opportunities that most individuals from my background do not get. Knowing how these opportunities influenced my professional trajectory, and that there is a large disparity in these opportunities between individuals, motivates me to help other African American students have similar experiences. That way they can be well informed to make decisions on whether to pursue STEM education. To provide such opportunities to others, **I volunteered during 3 years of college to get elementary schoolers and middle schoolers interested in STEM fields**. I did this through First Lego League (FLL) for the [redacted]. The First Lego League is an international competition where kids learn to build and program Lego-based robots to perform specific tasks themed around specific real-world problems. Engaging in hands-on STEM experiences like these helps kids learn program solving, programming, and engineering skills, as well as connect STEM concepts to real-world problems. Once I got involved with FLL and learned about its mission to inspire young people to be scientific leaders and innovators in technology, I was hooked and stayed heavily involved through my junior year. During my time with FLL, I supervised the practice area where teams prepare for the competition, assisted in the judging of teams on the project aspect of the competition, and kept score during the robot obstacle part of the competition. Through all of these duties, I enjoyed giving back and seeing the excitement children can have on building robots while learning about science. Working with the children at First Lego League has shown me that it is possible to get young people to do science without having to ignore the complications of the societal problems that science attempts to address.

My experience with First Lego League (FLL) allowed me to see that diversity leads to better science. As an undergraduate student, I was also a part of the Meyerhoff Scholars Program at the [redacted]. The goal of the Meyerhoff Program is to increase the representation of underrepresented groups in STEM at the Ph.D. and MD/Ph.D. levels. The program helped me see that when people of different backgrounds and diverse perspectives come together, better science gets done. The program's support and vision are a foundation that helps underrepresented minority students navigate the academic pipeline for pursuing STEM careers. However, many students who are initially interested in pursuing STEM education become disheartened and exit the path, due to systemic roadblocks and a lack of seeing people like them in STEM fields. To fix this, I plan to intervene early encouraging more underrepresented elementary and middle schoolers to be interested in science, and to give those already interested in science the ability to conduct scientific research. **I will be volunteering weekly to help facilitate science outreach in a local elementary school classroom in Nashville, through FUSE.** FUSE is a program that brings science into elementary schools to get more students interested in STEM disciplines, improving how students learn about science in school. Each week I will help underrepresented students tackle different science challenges they want to work on. I have also connected with the Vanderbilt Student Volunteers for Science to provide hands-on based science lessons to kids in middle school. **In the future, I plan to start a volunteering initiative specifically geared towards children who are traditionally unrepresented in science**, which will help them see that they too can do science. This initiative would encourage students through the same lens I was encouraged to do research: showing children the historical perspective of science. I will demonstrate that unsolved questions about life can be answered by scientists from diverse backgrounds to get more children interested in science.

Future Goals:

My professional goal after obtaining a Ph.D. is to do biomedical research in an academic or industry setting that utilizes mathematical modeling and model-guided genetic engineering to address problems in environmental sustainability. Along with this, I aim to continue encouraging underrepresented minorities to get involved in science. I want to show disadvantaged children that science is not just reserved for the elite, but that science is something anyone can get involved in. The support of the NSF Graduate Research Fellowship will enable me to utilize the NSF Extreme Science and Engineering Discovery Environment (XSEDE) computing cluster resources to improve the modeling and simulations I will need for my proposed thesis work. The funding received from this fellowship will give me the financial and educational resources to improve our understanding of basic gene regulation processes and inspire the next generation of scientists.