He was my best friend and my bully, my confidant and my rival. My older brother suffered a stroke in his first year of college, paralyzing the left side of his body. Watching him in recovery for 6 months, I knew he would never fully use his left hand again. Yet this injury that would typically have hindered his engineering studies was instead overcome through the application of years of artificial intelligence research; namely, a speech-to-text app. Today, my brother is a medical student finishing his dissertation. Seeing how new natural language processing technologies alleviated aspects of his physical ailments was awe-inspiring, and I embraced my acceptance to the engineering program at the Ohio State University in hopes of researching and one day building new technologies that would help others like my brother. Over the past four years, I have had the pleasure of undertaking interesting projects and working in both a mathematical immunology and computer systems lab. These experiences were eye-opening and fulfilling, and have reinforced my passion for research and my commitment to pursuing a PhD in machine learning.

My journey into open-ended problems began in freshman year with the Honors Engineering Robotics competition. Despite minimal prior experience in hardware and software design, my team was tasked with building a robot to precisely navigate an obstacle course and complete complex motor tasks. In the process, I learned to write bills of materials, plan design schedules, and embrace the software challenges of programming a robot. While the technical knowledge I gained was valuable, I was surprised to find the social aspects of the work just as meaningful. Learning to collaborate effectively with my peers taught me the importance of communication and flexibility when working as a team. To balance everyone's outside time commitments and rigorous coursework meant building flexible schedules that still met deadlines, and addressing the technical needs of the project while being sensitive to everyone's personal needs required compassion and tact in managing group messages and communication. Through this process, I realized that it was not only the technical skills of each individual on our team that drove our progress, but also and perhaps more importantly, our collaboration. Though the final Robotics competition was canceled due to the onset of the Covid-19 pandemic, I still finished the work with a deep sense of fulfillment: We fully constructed and programmed our robot to complete the obstacle course and accomplish all bonus objectives, meaning I got to both challenge myself and tackle open-ended problems with teammates who became friends.

With this newfound drive, I started my first research experience in Dr. Jayajit Das' lab within the Battelle Center for Mathematical Medicine. One method for understanding biological systems is building mechanistic models of cellular processes through systems of differential equations that contain any number of unknown parameters. During my time in Dr. Das' lab, I developed parameter estimation software for single-cell models. Parameter estimation of single-cell data is a challenging problem as data is often noisy and protein abundances can vary on many orders of magnitude. Initially, we started analyzing simulated noisy time snapshot data using a set of known parameters but later applied our method to immunological systems, specifically single-cell CD8+ T cell data. Through optimizing a cost function derived from the generalized method of moments with particle swarm optimization, we reproduced tight and unbiased confidence intervals around model parameters embedded in differential equations fitting the means and variances of experimental data. Based on this work, we submitted a manuscript that is currently under review in PLOS Computational Biology, and a software paper to BMC Bioinformatics. In the process, I furthered my understanding of various statistical and computational techniques, especially ones related to optimization. Working with biophysicists every day has shown me that computational research is valuable not only for augmenting the lives of others through its applications but also can explain biological processes that may one day provide insights on how to better treat diseases that affect those like my brother.

For my ongoing honors senior thesis, I am exploring the idea of a model-data commons with Dr. Christopher Stewart's ReRout lab. Working with another undergraduate student, we benchmarked vision models and optimization heuristics such as Particle Swarm Optimization against multiple datasets, showing that relative model performance can be heavily data dependent. Thus far, we have submitted two research papers, one on arXiv, which aims to justify the need for metadata on model performance, and one recently accepted by the AAAI-23 conference, exploring the relationship between conventional benchmarking datasets and digital agriculture. We hope to continue exploring many other machine learning-related questions during my last year at Ohio State, especially ones related to cancer modeling.

My time in Dr. Das' cancer research lab and Dr. Stewart's ReRout lab has furthered my interest in machine learning model interpretability and robustness, especially around its interdisciplinary application to the physical sciences. As datasets drastically increase in dimension, as seen with the recent development of Image Mass Cytometry datasets, conventional mechanistic modeling techniques may not fully discern the complex relationships embedded within them. On the other hand, machine learning techniques are well-suited for discovering high dimensional patterns within datasets, but can often fail under difficult or complex data situations. The Computer Science doctoral program at the University of Wisconsin-Madison would allow me to pursue this interest at the highest level. Specifically, Dr. Sharon Yixuan Li and her work in model robustness with out-of-distribution detection is extremely interesting. I would also be honored to work with Dr. David Page, and his work in data mining, especially in building models to predict the most harmful breast cancers. In a more general sense, I am very excited about the interdisciplinary applications of machine learning.

In addition to my research interests, my experiences as a teaching assistant and an undergraduate ambassador for high school STEM outreach efforts have instilled a desire to pursue further opportunities in mentorship. As the famous physicist Richard Feynman shared, "If you cannot explain something in simple terms, you don't understand it." Breaking down complex coding concepts into digestible chunks for first-time coders was not only emotionally fulfilling but also refined my basic coding skills. Similarly, presenting the amazing applications of machine learning research in front of high schoolers and seeing their eyes light up has reinforced my desire to pursue a PhD. After graduate school, I hope to one day mentor others while pursuing research in an academic setting toward professorship.