My goal is to combine my background in physics and mathematics with experimental neuroscience to build quantitative models of how brains work. Early in college, I fell in love with the uncompromising inquisitiveness of physics and focused my research on the fundamental limits of information processing. A pair of quantum information theory projects in Italy and Canada honed my ability to build and analyze mathematical models and convinced me that I wanted to pursue a career in science. Yet, it struck me that while I and other researchers grappled with the fundamental limits of computation, we still lacked a deep understanding of the very information processor that enabled us to do so – the human brain. Was it possible to understand the human mind just as we understand a magnet or sunset? I spent the next year applying my quantitative background to assist USC Professor Ted Berger's synaptic modeling group, and our work suggested to me that indeed it was.

Since then, I have sought to understand the biophysical mechanisms of neural computation through research in computational neuroscience. During a summer with Kwabena Boahen's group at Stanford, I studied the emergence of synfire chains in biological neural networks through the Stanford Amgen Scholars Program. Above all, this project conveyed to me the importance of collaborations with experimental neuroscientists to build biologically realistic yet mathematically tractable models, an approach that I will continue to emphasize throughout my career. Currently, I am working with USC Professor Bartlett Mel to understand how brains rapidly and robustly encode information presented only once. In particular, we are investigating the optimal dendrite morphology for memory capacity during one-shot learning tasks and studying how the optimal morphology varies with input features such as noise and density of activation. We hypothesize that dendrite morphology is optimized to shift response variability to a regime efficient for memory capacity. Our approach is characteristic of what I believe is a unique and important contribution that physics and mathematics may offer biology – explanations for the functional role of biological mechanisms rooted in arguments for their optimality.

Each of my neuroscience projects has reinforced my desire to pursue a Ph.D. and become a professor to continue my research and share my passion for discovery with eager young minds. In addition to research, I have pursued and excelled in several graduate courses in physics and mathematics and even picked up new analytic tools from other graduate departments, such as information theory and mathematical optimization. Concurrently, I have attained a significant knowledge of modern neuroscience through extracurricular study and research. Thus I am confident in my choice of graduate research and in my preparation for pursuing it.

Furthermore, I am confident that the University of Washington's Physics program would be a great place for me to do so. I am attracted by the large community of faculty and students interested in biophysics and particularly interested in working with Drs. Adrienne Fairhall, Fred Rieke, and Eric Shea-Brown, each of whom I have contacted. As I prefer theoretical work closely coupled with ongoing experiments, I am especially interested in a project co-advised by Dr. Rieke and either Dr. Fairhall or Dr. Shea-Brown. Two interests I might pursue with Drs. Fairhall and Rieke are the roles of prediction and online algorithms in vision. In particular, to what extent does the prediction of common input patterns enable the visual system to increase processing speed and reduce energy expenditure, and how do the temporal demands of a visual task affect the processing of neural signals? Another possibility would be to study the interactions of adaptive mechanisms acting on different timescales, a topic on which I have recently submitted an NSF GRFP research proposal (available upon request). With Drs. Shea-Brown and Rieke, on the other hand, I might seek an understanding of single-neuron response variability, exploring the relative contributions due to input statistics, biological constraints, the exploitation of stochastic resonance, and other potential sources. Another potential focus of our collaboration could be the modulatory effect of persistent network activity on single-neuron responses and the role of this modulation in neural computation. Though the research is my main attraction to UW, I would be remiss if I did not mention that I do my best thinking in the outdoors and welcome the opportunity to spend weekends hiking and mountaineering in the environs of Seattle.