Statement of Purpose

I am interested in using computational and experimental approaches to understand the mechanisms of the brain through the lens of neural population dynamics. By pursuing a Bioengineering PhD at Stanford, I hope to answer the question of **how populations of neurons give rise to the control and learning of motor movements**. I intend to then leverage this knowledge to build more robust brain-computer interfaces (BCI).

My Engineering Science degree at the University of Toronto has exposed me to a wide range of foundational courses from civil engineering to quantum mechanics, and I have found myself intrigued by interdisciplinary subjects where knowledge in one domain can solve problems in another. Having majored in Robotics, I discovered that solutions to robotic problems such as object grasping with robotic arms were intricate and complex from an engineering point of view. Such engineering techniques, however, are more often than not tremendously naive compared to what humans are capable of learning and performing. Thus, I turned my attention to biological systems in the hope that understanding would provide insight into designing artificial systems.

Combining engineering methods with applications in biology began in the summer of second year, when I joined Dr. AAA AAAAA's lab at the University of Toronto working on a bioinformatics project that consisted of combining several existing computational software programs into a pipeline to process data generated by the new CUT&RUN epigenetic technique. Through this project, I learned a great deal about each phase in processing epigenetic data, especially a crucial step called "peak calling", which identifies regions of significant signal in the genome. By carefully examining the standard algorithms used in peak calling, I was able to understand the statistical model used and modify it to take into account a new calibration procedure that utilized spike-ins. Near the end of my summer research, I completed a flexible computation pipeline with much superior performance on our data. This experience provided me with a sense of how computational methods can solve biological problems, and how biological complexities inform the design of algorithms to yield meaningful and interpretable data.

With some experience in bioinformatics, I opted to delve deeper and explore applications of engineering in neuroscience, so I spent six months between 3rd and 4th year working as a research intern at Dr. AAA AAAAA's lab at Imperial College London (ICL). His lab hypothesized that to build more robust BCIs for movement restoration, we need to look beyond the motor cortex and into subcortical areas of the brain. To this end, an experiment was designed where a BCI is used to decode the intended movement direction of mice from electrophysiology recordings in both the motor cortex and the striatum. In preparation for the experiment, I built the complete BCI that interfaces with electrodes (Neuropixels 1.0), processes spiking data, and provides feedback to the animal in the form of audio, all of which operate in real-time. Due to a lag in regulatory approval, I was unable to conduct experiments with mice, and yet I remained fascinated by the field of neural population dynamics and using BCIs as an experimental

paradigm. BCIs provide researchers with the ability to perturb and causally determine the relationships between neural activity and behavior. Combined with the advancement of state-of-the-art electrodes and new computation techniques, it is beyond exciting to imagine what further experiments will reveal about the inner workings of the brain. At ICL, I embraced a taste of what PhD life is like and decided to continue my path in academia following my undergraduate degree.

To enrich my understanding of the lower levels of the brain's computational hierarchy, I am currently completing my undergraduate thesis on mathematical modeling with spiking neural networks (SNN) under the supervision of Dr. AAA AAAAA at the University of Toronto. Neuronal network heterogeneity is hypothesized to play a crucial role in network stability, the lack of which causes epileptic seizure onset. My thesis investigates the role of intrinsic plasticity in shaping neuronal heterogeneity. I incorporated a conductance-based local learning rule into the Hodgkin-Hoxley model and constructed a network of excitatory and inhibitory neurons. By performing tests with various network inputs, I saw neurons beginning to cluster into several groups based on their ion channel conductances, suggesting that the heterogeneity of neuron populations depends on stimulus characteristics. As the work is still in progress, I have experienced the mathematical modeling side of computational neuroscience and recognize how computer simulations can serve as a test bed for generating hypotheses and guiding wet-lab experiments, laying the groundwork for the future design of therapeutic devices.

Stanford has numerous labs that align with my research interest. **Dr. AAA AAAAA**'s work in neural population dynamics and the "computation through dynamics" framework is of particular interest to me. I also find **Dr. AAA AAAAA**'s work on understanding cortical dynamics and building BCIs exceptionally relevant to my past experiences. **Dr. AAA AAAAA**'s research resonates with my interest in neural latent dynamics and motor movements. Finally, I am also interested in working with **Dr. AAA AAAAA** to analyze human motor movement through software modeling and imaging. I plan to conduct my first-year rotations with these labs should I be admitted.

As for my future career plans, whether in academia or industry, I am certain I will continue my path of research in using computational approaches to understand the brain and build more powerful and accessible neuroprosthetic devices. I believe I have acquired a broad but solid foundation in my undergraduate studies, both in terms of research ability and certainty in choosing to pursue a PhD in Bioengineering. Stanford's Bioengineering PhD program provides interdisciplinary collaboration between engineering and biology, which I value as one of my greatest assets having experienced both fields. This program will equip me with the training, resources, and environment to conduct rigorous research, exchange ideas, and understand how the brain effortlessly controls movement. It is my wish to learn how to design technologies that can communicate with the brain.