I have pursued neuroscience and physics research in parallel - neuroscience for the questions that drive me and physics to hone my ability to build and analyze mathematical models. My training in physics has focused on quantum information theory (QIT), a subfield of physics seeking to build a quantum computer. I felt that QIT's focus on the physical limits of computation might shed light on how to study information processing in the brain. During the summer of 2009, I worked with USC Professor Paolo Zanardi and his QIT group at the Institute for Scientific Interchange (ISI) in Torino, Italy supported by a USC Provost Summer Research Fellowship. Through calculations and computer simulations, we sought to define and justify an appropriate concept of thermal equilibrium in quantum mechanics. Working closely with Zanardi's collaborator Lorenzo Campos Venuti, I learned many mathematical tricks beyond my coursework. I learned how to milk mathematical models and computer simulations for physical results, an essential skill for my proposed research. My summer in Torino also opened my eyes to scientific research done outside the US and has ensured that I never allow national borders to limit my readings and collaborations. Most importantly, the excitement of constructing a theory where none existed before convinced me that science was indeed the career for me.

Seeking to further my understanding of the physical limits of computation, I spent part of this past summer at the Institute for Quantum Computing (IQC) in Waterloo, Ontario working with Professor Andrew Childs on the proof of a mathematical theorem that we felt might lead to new algorithms for quantum computers. While a quantum computer possesses unique capabilities beyond a classical computer, algorithms designed to exploit those capabilities are essential to making quantum computers useful to society. Over six weeks, Childs and I iterated between provisional theorems and test cases generated by a computer program that I had written. In a series of efforts culminating in a five-hour whiteboard session, Childs and I found our proof. The following week I had the honor of giving a colloquium to a roomful of physicists, mathematicians, and computer scientists,[1] providing valuable practice in giving a talk accessible outside of my own field. Throughout this project, I also experimented with non-technical progress reports on my blog,[2] an outreach effort I intend to continue and expand upon during graduate school.[3] Childs and I have continued our collaboration to this day and are currently working on a generalization of our result for publication. Maintaining an international collaboration has given me valuable experience in a skill I will continue to exercise throughout my career. My QIT research has even influenced my neuroscience by giving me a visceral understanding of the play between theory, simulation, and experiment. It has taught me how to propose an idea based on my intuitions, iterate between simulations and further refinements, and mathematically (or, depending on the context, experimentally) verify my hypothesis.

Concurrent with my physics research, I have also pursued research in computational and mathematical neuroscience. During my junior year, I borrowed techniques from computational physics to help USC Professor Ted Berger's neuroscience group speed up their simulations of chemical diffusion at neural synapses. Their numerical integration algorithm was having trouble with the multiple timescales present in biological dynamics, and I discovered the source of this difficulty and proposed an adaptive algorithm to significantly speed up simulations. I found this project especially exciting because the group's models were used primarily for designing novel drugs, and my algorithm contributed directly to this effort. In addition to my main project, I also assisted a graduate student in building compartmental models of neurons to aid in the development of a hippocampal implant. The familiarity with compartmental modeling and

---

[1] DJ Strouse, *A Levinson's Theorem for Scattering on Graphs*, IQC Colloquium, June 2010.
[2] www.djstrouse.com

simulations of chemical signaling that I gained that year will prove invaluable in my proposed research.[5] The successful application of my training in physics and mathematics to a problem in neuroscience also reinforced my confidence that a quantitative background is a useful resource in biology. Moreover, the rapidity with which I and the biologists learned from one another stressed to me the importance of interdisciplinary work, which I am actively promoting.[3] Through my encouragement, our collaboration has since led to a series of joint projects between the Berger group and the computational condensed matter group from USC's physics department, an unprecedented link between USC's neuroscience and physics communities.

Seeking to gain additional experience in computational neuroscience outside of my own university, I spent the majority of this past summer working with Professor Kwabena Boahen's group at Stanford through the sponsorship of the Amgen Scholars Program. My project was to investigate suitable conditions for the existence of a neural network substructure called a "synfire chain" that has been theoretically predicted to increase the reliability of spatiotemporal pattern generation. While many theoretical studies have considered the computational advantages of synfire chains, experimental searches for them have proven difficult and inconclusive. To narrow the search, I analyzed a series of neural network models for the likelihood and most probable shape of synfire chains using both computer simulations and analytic calculations. I chose my network models for their biologically plausibility based on consultations with one of Boahen's experimental neuroscience students. My main discovery suggested that the learning rules and past activity in a network play a crucial role in the development of computationally useful synfire chains. At the end of the summer, I presented my research at the Stanford Amgen Scholars Symposium,[4] providing valuable experience in communicating mathematical methods and results to an audience of non-mathematicians. Throughout the summer, I also blogged on the many lessons I learned about doing neuroscience,[2] which I will continue to do in the future.[3] I found my project especially exciting because I was given a great deal of freedom in formulating and investigating the problem, an experience which has motivated my interest in seeking academic freedom through an NSF fellowship. My work at Stanford also taught me how to collaborate with experimental neuroscientists to build biologically realistic yet mathematically tractable models, an approach that I will continue to emphasize throughout my PhD research.

Currently, I am investigating how neurons select their presynaptic partners with USC Professor Bartlett Mel. We hypothesize that immature (or "silent") synapses may serve as trial connections to help a neuron identify appropriate connections.[5]

I have pursued a diversity of research projects in two seemingly unrelated fields. This strategy has provided me with unique insights into my neuroscience research, increased certainty about the research I wish to pursue in my career, and the ability to engage in successful interdisciplinary collaborations. I have worked alone as well as one-on-one with professors, postdocs, and grad students, accommodating me to a range of research team dynamics. I have engaged in international collaborations and worked in both universities and research institutes, exposing me to a wide range of environments in which science is done. Furthermore, I have strived to deliver widely accessible presentations on my research, both through seminars and writings on my blog. Each of my projects has not only reinforced my desire to pursue a career in science, but has provided me with the confidence that I am capable of succeeding in doing so.

---

[3] See "Personal Statement" for further discussion.
[4] DJ Strouse, *Reliable Brains from Unreliable Neurons: The Search for Synfire Chains in the Brain,* Stanford Amgen Scholars Symposium, Aug 2010, http://ssrp.stanford.edu/ssrp_experiences/projects2010.html
[5] See "Proposed Plan of Research" for further details.