Braeden Benedict
Graduation Year: Junior
College: Engineering
Major(s): Electrical Engineering
Minors(s): Concentration in Biosystems
Scholar Group Membership: Hesburgh-Yusko, Engineering Scholars Program

Did you received other funding for this project?: Hesburgh-Yusko
Could you have completed this project without CUSE funding? Yes
More details on CUSE funding assistance? Due to the $5000 in funding I received from HYSP, I probably would have still done this project without CUSE funding. However, the total cost of the project was close to $6500 due to the incredibly high cost of living in Geneva. It would have been a financial hardship for me without this CUSE funding, and I would have had to increase the size of my student loans.

Project Title: Research Internship at Blue Brain Project
Project Location: École polytechnique fédérale de Lausanne in Geneva, Switzerland
ND Faculty Mentor: Professor Gregory Timp
Project Type: Internship

Why did you undertake this project/experience? Deepen your knowledge of a topic or issue, Prepare for graduate school (MA or PhD), Career discernment and/or preparation, Internationalize your Notre Dame experience

Did your funded experience help you:
[Deepen your understanding of your coursework or field of study]: Yes
[Discern your interests and post-bac goals]: Yes
[Become confident in your ability to set and achieve your goals]: Very Much
[Gain a more nuanced view of local, national, or global communities]: A Little
[Improve your written and verbal communications skills]:A Little

Tell us about your experience.
This summer, I worked as an intern at the Blue Brain Project (BBP) in Geneva, Switzerland. The project is run by the École Polytechnique Fédérale de Lausanne (EPFL), a highly ranked school for engineering and technology both in Europe and throughout the world. The project's overall goal is to reconstruct and simulate the brain. To do this, the project uses an IBM Blue Gene/Q supercomputer and employs a large team of computational neuroscientists, researchers, and software engineers.

To understand how I ended up at the Blue Brain Project, it's necessary to look back at my experience last summer, working as a volunteer at a medical center for the homeless in Denver. There's not really an obvious connection between these two experiences, so why are they related? While I was living in Denver, I visited the public library and checked out a book called

“Connectome,” which described the theory that it is the millions of connections between the neurons of the brain which hold the information of our memories, personality, and everything that we are. It also described the various efforts to map the connectome and their implications. I greatly enjoyed the book, and it was a major reason I switched from Chemical Engineering to Electrical Engineering at the end of that summer. I liked the idea of working to model the wiring of the brain, and I thought that a background in electrical engineering would allow me to do that.

When I learned of the Blue Brain Project, I was attracted both by the nature and the ambition of the project. Getting a position there for the summer was as simple as a few emails and a Skype interview. Obtaining the required work/business visa was a long and difficult process, due to a combination of complete unresponsiveness from HR at BBP and the Swiss visa rules, which require you to appear in person at the embassy/consulate to turn in paperwork and take fingerprints. I would advise future scholars they should be aware of how difficult the process is, but I think it’s worth the effort.

Once I was offered the position, I knew that much preparation was needed to make sure I would be competent once I arrived. I was mostly concerned about the extent of my programming knowledge, as the project is entirely computationally based. This was one of the reasons I chose to do this particular project this summer. I wanted to improve my programming skills and see if I could see myself doing something like this as a career. I do not know what I want to do with my life, but I hoped that my experience this summer would provide some data to help me make an educated decision.

Thus, I began to prepare myself. I was told that I should be proficient in both MATLAB and Python. I knew MATLAB but had no experience in Python. So, every Tuesday between 11am and noon last semester I went to my room and taught myself the basics of Python using online videos and examples. I put it on my calendar and I stuck to it. It was my favorite class of the week! I ended up doing essentially no work in Python this summer, but I consider that hour each week very well spent. After the semester ended, I dove in completely to the learning that needed to be done. The day after finals, I went to the library and checked out my first ever book: “Ionic Channels of Excitable Membranes.” A real page turner! I also borrowed and read parts of my friend’s neuroscience textbook. I then began the process of learning the two programming languages which make up the NEURON simulation interface by using online tutorials, reading documentation, and playing with examples. My 9 week internship was really more like an 11 week internship if you include the preparation I put into it. I’ll be honest, I did this because I was completely terrified of not knowing what I was doing and looking like a fool. (I studied how to spell my name before my first day of preschool when I was 3 years old. I clearly haven’t changed much!) Once I started work, I was incredibly glad I had done work ahead of time, but I still had so much to learn. One of the unexpected surprises for me was the fact that the computers there used a Linux operating system, which I had never used. So I learned the basics of Linux in addition to everything else.

My supervisor/mentor was Dan Keller, who originally earned a bachelors in electrical

engineering (sound familiar?) before eventually doing a PhD in computational neuroscience. He is an incredibly friendly guy and made me feel welcome. I was definitely the youngest person working there, as most were professional scientists or graduate students. My project was to modify the mechanisms describing current through ionic channels to specify ionic currents (sodium, potassium, calcium, chloride currents) instead of the nonspecific currents which were currently in the mechanism. This would allow us to track intra and extracellular ion accumulation, depletion, and diffusion. It surprised me that their current models did not take this into account, but ion concentrations change so little that concentration changes are often ignored in models. To make these modifications, I had to do a literature review to find out what information was available regarding the permeability of each channel to the various ions, then fit the existing mechanism to that data, while also maintaining the same overall current as before. That was the relatively easy part. I then had to write the mechanisms necessary to track ionic concentrations and to describe the ion pumps which keep the neuron in a steady state. Despite my best efforts, complete success in this last endeavor ultimately eluded me during my time there. I came close, but it's not quite right.

I was somewhat surprised that, on the first day, I showed up and was basically given my project for the next two months. While I talked to Dan every couple of days about what I was working on, it was very much self-guided. I had expected more specific, smaller tasks and deadlines. In retrospect, I should have known that's not how scientists operate. While I certainly enjoyed the independence that I know I would never have in a corporate environment, struggling endlessly on the same problem for days at a time can become tedious and frustrating. When there's no deadline, a task can last forever if it's not completed perfectly. I do expect to find myself in an academic setting like this again, and I think it would be useful to set deadlines for myself in the future to force me to move on even if it's not perfect.

Another realization that came from my experience this summer is that there's a big difference between the computational model and what is actually happening in the real world. We try to match the biological neuron as closely as is possible/practical, but ultimately there is so much we don't know at this time and so much missing that it's hard to say that it models a real neuron. And of course, the model is only as good as the data you put into it. This is applicable not just to models of neurons, but any computational models of systems. I think that models can be useful, but I think I'm more interested in knowing what's actually happening rather than observing what's happening in a model which might somewhat resemble something in the real world. As an academic pursuit, I think it's very interesting, but I don't know that I would want to dedicate my life to it.

While English was the primary language of the workplace, there were individuals working there from many different countries. I worked with people from Switzerland, Germany, France, Italy, Greece, Spain, Portugal, India, the UK, the US, and the Middle East (not sure which country). I enjoyed learning about some of these countries from lunchtime conversations. Even with this diversity, the workplace environment was certainly the most familiar due to the presence of English. I studied Spanish in school and told my sister she would never use French when she

decided to study it. She had the last laugh as I fumbled through my extremely limited French all summer. The most interesting cultural difference in my opinion is that the city completely shuts down on Sunday. Almost all stores including grocery stores are closed, a nontrivial inconvenience. I did however really enjoy the fantastic public transportation throughout the city.

Probably the most important thing I learned from this experience is that I think I would be happy programming as a career. The reason I did not study computer science is that I did not want to be sitting in front of a computer staring at code all day. Well, I did that for 9 weeks and it wasn't as bad as I expected. While aspects of the modeling were frustrating when they didn't work, I greatly enjoy writing and debugging code.

My favorite part of this experience was getting to work on such a huge project on such a large team. I am hopeful that the mechanisms I modified or created will eventually be used in the full model. In that case, I would hopefully be included as a coauthor on a publication. I scattered my name around in the comments of every file I worked with, so hopefully they remember me! My least favorite part is that I am not satisfied with the final results of my work. While Dan understood the difficulties I had and said he was impressed with the work I did, I hate to fail. I wish I could find a way to finish the work I started this summer, but I doubt I will have the time during the year. I would certainly recommend this experience to future students and would be happy to share my thoughts with anyone who might be interested.

Describe the impact this project had, both on you as a student-scholar and on the people you worked with.

Through this project, I was able to greatly improve my programming skills. I am now confident that I can pick up any new languages I need in the future after learning several for this summer. My view has changed somewhat on the idea of a career in software development, as I now realize that I would find the work interesting and challenging. Despite that, I think that I am now less interested in modeling, as I have seen its shortcomings firsthand. I think that basic research and technology development is of much more use to society. I am still fascinated by the brain, but I think that I would like to work closer to the real thing.

I have been told that I was a productive member of the team this summer and thanked for my contributions to the project. I hope that my models will be used in future work at the BBP, and I have done my best to fully document my work. I am hopeful that I may be included as a coauthor on a future publication.

Describe how this experience is connected to your plans as a student or future professional.

Since Notre Dame does not offer an undergraduate degree in bioengineering, I am studying electrical engineering with a concentration in Biosystems. The work I did this summer is part of my efforts to swing my studies in the direction of bioengineering. I think this will likely help me in

my applications to graduate schools in bioengineering. As I have discussed, it has also provided some insight to my career discernment process. If I am able to fix some of the problems I was unable to solve before the end of my internship, it would also make for a good poster presentation. Finally, if I am included on a publication, this would be a major bonus when applying to graduate schools and national fellowships.

What advice would you give other students who are planning to pursue similar projects?
As I mentioned previously, I would advise students to be aware of how difficult the Swiss visa process is. It requires you to appear in person at a consulate or embassy, and there is not one located in Chicago. I had to go to the San Francisco consulate. Fortunately I was able to do so on the way home from my home in California, but this only worked because I was totally on top of what needed to be done.

I acknowledge that this form has been filled out truthfully and to the best of my ability. I understand that this information will be shared with many different CUSE constituencies. As such, I have provided as much useful information as I was able. I understand that CUSE will not complete my award disbursement until this form is successfully completed. If I have any questions or concerns, I will contact CUSE before submitting this form. To illustrate that you understand all of these points, please enter your Notre Dame email in the box below.
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