Essay #25: "Where Drive and Talent Can Take you – Biomedical Engineering"

Molecular Biophysics Essay

Ever since I was young, I have wanted to understand not just how the body solved complex engineering problems, but also how these mechanisms worked at a fundamental level. In particular, I am interested in applying computer and experimental techniques to biological problems (and vice versa). Of particular interest is the use of computational tools in analyzing issues relating to sequence analysis/protein engineering, protein folding (and the reverse problem).

I think this is why I find the pursuit of a Ph.D. almost a necessity, given my need to satiate my mind's curiosity for seeking deeper knowledge in this area. In fact, I think this methodology has been reflected throughout my life, as I have always strived to challenge myself to find answers and overcome various obstacles. When I arrived in the United States, I knew only one work in English (the word "no"). Yet, I was determined to work hard in order to catch up. Graduating valedictorian of my class in high school and serving as co-president of Science Olympiad proved that it could be done.

I went on to Carnegie Mellow University, not just because of the merit-based scholarship, but also because I wanted to gain deeper understanding of computer techniques and then applications in biology/medicine. While I majored in electrical and computer engineering with a minor in biomedical engineering, I took as many relevant biology and chemistry courses as I could within the curriculum, including advanced courses like 03-510 (Computational Biology) and 42-680 (Bioinstrumentation). This spring, I am scheduled to take biochemistry and second organic chemistry class. I expect to have the necessary prerequisites for advanced biochemistry study by graduation.

I am confident that I will succeed in advanced courses given my background. I also feel that I have some rather unique advantages as a non-biology major. Having a heterogeneous entering class composed not only of biology/biochemistry majors allows for more diversity in thought processes. Having undergone a similar curriculum with similar experiences, biology majors will likely have similar perspectives when encouraging a novel problem. In contrast, an individual like myself may have a unique, novel contribution. Many of the breakthroughs in the past have come from interdisciplinary study resulting in a link between two previously unknow areas which went on to serve as the basis for an invention (and a new area for research). Tow recent examples include the invention of DNA-based computers and biochips. In each case, a biologist or an electrical/computer engineer working alone could not have carried the project to fruition.

I have always strived to complement my education/experiences in computational approaches with fundamental biology. I have gained experience with biology both at the molecular level and at the systems level which allows me to see the big picture. When chosen by the Ohio governor to represent the state, I went to the Lawrence Berkeley Laboratory for a program on "Life Sciences and Biotechnology." Here, I attended both lectures and did lab work involving biotechnology. Professors included Dr. Marian Diamond, Nobel Prize winner Dr. Glenn Seaborg, Dr. Sylvia Spenger (on the Human Genome Project). Dr. Mina Bissell, and Dr. Jeff O'Neil (Calgene). At a summer course at Case Western Reserve University entitled "Biotechnology and Genetic Engineering," I gained additional knowledge in experimental techniques.

Name your advisors.

From the aforementioned programs, I have gained experience with such biological techniques as electrophoresis, Southern blots, transformations, recombinant DNA techniques, PCR, chromatography, and sequence analysis. Through

Make a laundry list of laboratory skills.

class/lab work and various programs, I have become knowledgeable in computer techniques used in biology such as coding region identification (via base composition, codon bias/preference, etc.), BLAST/FASTA algorithms for sequence match scoring methods, multiple sequence alignment, general similarity and homology methods (e.g., dynamic programming, dot-metrix methods, usage of hashing), secondary structure prediction (methods like Chou-Fasman, Garnier-Osguthorpe-Robson, SOPMA, etc.), and hydrophobicity analysis.

Don't assume your reader will know what you can do.

In terms of bioinstrumentation, I have learned about NMR, IR, and techniques for novel instrumentation design. This past summer, I worked on a signal processing project in the Tachycardia Research group of St. Jude Medical's Pacesetter (a company formally owned by Siemens), I designed and built a stimulus waveform generator. Then, I initiated a research study with the group's manager involving pain thresholds (in over 30 individuals) and co-authored "Sural Nerve Sensory Thresholds of Defibrillation Waveforms" which has been submitted and accepted. It will be presented at the next American College of Cardiology Scientific Session and published in the organization's peer-reviewed *Journal of the American College of Cardiology.*

Trace the history of your interest. This applicant is able to trace this particular idea back to freshman year.

One example where I applied computational/engineering techniques to biology (as I hope to do in my career) goes back to the first semester of my freshman year. I independently wrote my own grant proposal based on an idea I thought of while at the Lawrence Berkeley Lab which involved application of neural networks to the classification of DNA fingerprints. When my proposal won a SURG grant, I carried out the project independently under mentor Prof. Jose Moura, editor-in-chief of *IEEE Transactions on Signal Processing.* This endeavor, combined with academic achievements, resulted in my recognition via honorable mention as part of the all-USA College Academic Team competition (published in *USA Today)*. Only one Carnegie Mellon student is known to have ever been recognized in this competition. Since it involved novel code techniques deployed on a PC and supercomputing environment, the work also led to an article (which I wrote) in the "Cross Platform Strategies" section in five magazines in 82 countries.

For the past several semesters, I have been working on a research project on the "system level" at the University of Pittsburgh Medical Center. It involves analysis of EEG signals from brain waves and design of a barbiturate drug infusion system with Dr. Marc Bloom, the director of neuroanesthesia at the University of Pittsburgh's medical center. The results of my project are rather exciting. The control system was tested on a live rhesus monkey and later revised. We are currently discovering and classifying relations between various patient variables and the sedative state and already have some interesting correlations. As we approach the next phase, this information will be combined "to establish an entirely new approach to patient modelling and the use of control in bioengineering systems" (as originally stated in the NSF grant from a group of three professors which I helped to form last semester).

I believe I can make a significant contribution to the current literature during graduate school and eventually lead efforts in innovation upon graduating from the University of Pennsylvania. I think the result from my experience at Motorola's Speech Technology Laboratory is an example of such an endeavor. Not only did I put

forth a new idea, I also implemented it in a prototype and wrote the first draft of the patent (which I presented to the other co-investors for input). The patent was submitted to the patent office in July after approval by the Motorola review committee.

I also have experience in writing, a skill which is obviously imperative for researchers who wish to communicate their findings with others. As a writer for several newspapers, I have had the chance to interview people such as Ohio's governor, a U.S. Congressman, a CEO (FORE Systems), three current and past presidents of Carnegie Mellon, and a managing editor for *U.S. News & World Report.*

I have found several faculty that share my interest at the University of Pennsylvania. In Prof. Lewis's lab, I am interested in the work going on related to computational methods used for studying protein-nucleic acid complexes. Papers from Prof. Sharp's research in structure of protein at the molecular level (using computational techniques as an option) also piqued my interest. I see a possible match with Prof. Wrobelski's work involving image processing and protein structure. I am open to working in other labs involving a combination of computational and experimental techniques in biochemistry as well.

Address the question, "Why here?" This candidate wrote different and successful applications to Caltech, Stanford, MIT, Berkley, and others. Customize, customize, customize. Of course, it helps to be as accomplished as this *scholar.*