During the summer following my senior year of high school, I was selected to participate in Argonne National Laboratory’s Pre-College Research Participation Program. This experience revolutionized the way I perceived physics. Working with a theorist in chemical physics, my daily routine consisted of applying centuries-old physical principles to a superficially unrelated field of science and emerging with data that could advance problems in several fields of research. I performed this work simply by designing simulations through computer programming, allowing me to experiment easily and deepen my understanding of the subject I studied. My appreciation for these two aspects of research – interdisciplinary science through physics and theoretical simulations – have motivated many of my educational and leadership experiences and has solidified my desire to pursue a career in research. It is my deepest wish to apply to graduate school and to pursue a faculty position at a leading research institution so that I can continue work in physics toward problems in interdisciplinary science.

My research in computational physical chemistry at Northwestern reinforced my passion for theoretical interdisciplinary science. While studying the use of lasers to control molecular alignment, I have encountered many applications that interface tangibly with issues of global relevance. Reliance on the computational capacity of modern devices has made discovering methods for constructing fast and efficient computers a critical priority. The substitution of molecular machines controlled by optical forces for limited silicon chip technology is an intriguing region of exploration. My own research addresses the alignment of molecular species that possess geometry-dependent electronic properties and are sufficiently responsive to laser control for implementation in molecular junctions. Notably, this area of innovative research exists almost entirely in the theoretical regime, mandating the use of computational techniques for work toward implementing these novel structures.

Having witnessed the importance of computational work toward substantial scientific progress, I was motivated to redesign and teach the curriculum of the Integrated Science Program (ISP) Department’s course on Computing Applications. After taking this class as a freshman, I believed that the goals of this course – to teach programming to students interested in a variety of sciences – were well-founded. Spending two years as a teaching assistant for the class, however, demonstrated that the curriculum was troubled by two fundamental flaws: students who were new to programming had a difficult time assimilating the material quickly enough to be prepared for subsequent lectures, and following the class, it was not immediately obvious to most students how the material learned should be applied to coursework or research. I approached the director of the program to discuss renovating the curriculum to fix these problems, and I was invited to work with another ISP student to renovate the curriculum, and then to teach the class the following year.

The changes made to the course during the following summer were motivated by conversations with faculty members of ISP and professors in computer science. Structural revisions were made: the amount of credit given for the course was increased, the number of hours spent in class each week was doubled, and a special session each week was dedicated to a guided practice of new programming concepts. The other instructor of the course and I decided to introduce a different programming language than previously used to improve the accessibility and relevancy of the course, which required that we design new lectures and create new assignments. The most significant change, however, was the emphasis placed upon the second quarter of the class. Drawing upon my experiences as a student in ISP and an undergraduate researcher, I proposed that we focus the second half of the course upon applying programming specifically to science applications. Thus, after teaching fundamental aspects of programming in the first part of the course, we would demonstrate techniques such as numerical integration, optimization, and time-evolution based simulations. These assignments were placed in the context of themes and topics that students would encounter in future ISP classes. Thus, the applications of programming to such varied subjects as analyzing laboratory data to studying elementary quantum mechanics were made more obvious, enabling students to form insightful conclusions by implementing programming in their future coursework and independent research.

Designing a new curriculum for this class was a fascinating and motivating challenge, and has made teaching the course all the more enjoyable. Equally gratifying, however, is the impact the course has already shown upon the students’ interest in pursuing research. I have already spoken to several interested students about my own experiences with summer research and applying to REU programs, while an increased number of people have approached me regarding advice for pursuing computational research on campus. As the course progresses and students delve more deeply into questions of theory through programming projects, I believe they will find themselves better prepared to successfully compete for and participate in research opportunities both on campus and throughout the many states and nations in which they spend their futures.

The experience I gained through my work with this class also prompted me to design a club to foster undergraduate mentorship of local high school students by engaging them in self-directed research projects. Through this program, I hoped to allow high school students ready access to information regarding research and undergraduate life in the sciences. I worked between two independent science-oriented undergraduate clubs at Northwestern throughout the summer to collaborate with high school administrators and organize a program that would help to introduce high school students to fundamental concepts of research.

The club is designed to match pairs of undergraduates with high school students sharing similar scientific interests. Each small group works together to research and propose a novel experiment. Through this process, undergraduates gain experience in mentorship and collaborative work, while high school students encounter important skills such as how to read a journal article effectively, how to search through literature, and how to question the resources available to prompt open-ended questions that merit further investigation. Each group then works to design a scientific investigation based on the research they have completed. This club is an excellent mechanism for opening dialog between students by permitting access to undergraduates well-suited to answer questions regarding experiences as scientists. It also exposes high school students to the diversity of academic resources available in major research institutions such as Northwestern. In addition to this focus, the project helps high school students learn more about their own science interests, and strengthens their desire to pursue research and science-oriented careers. Individualized mentorship also serves to make this first encounter with research science a more accessible one, and hopefully encourages them to independently seek future internships and research opportunities.

My experiences with research and with designing programs to educate and motivate the deeper investigation of scientific issues have reaffirmed my interest in following a career that will result in a faculty position at a major research institution. The NSF fellowship is an excellent advantage toward pursuing research in a group that will best foster my interests and strengthen my abilities as a scientist. I wish to combine my experiences with these activities with that of my undergraduate research to continue innovation within in the field of science and to share my abilities on an international scale.