My past research experience covers a variety of fields, from theoretical chemistry to evolutionary biology. For all projects I worked alone under the direct mentorship of the principal investigator of the lab unless noted otherwise. Nevertheless, I learned a lot from discussing different research projects and approaches with other lab members.

My first exposure to scientific research was in high school. During the summer before my senior year of high school, I completed a research internship with the Department of Chemistry and Biochemistry at California State University, Fullerton. Under the mentorship of Dr. Fu-Ming Tao, I conducted an independent computational chemistry project titled, "Contribution of the Phosphodiester Backbone to the DNA Helix Structure." I examined the DNA phosphodiester backbone to determine why the DNA duplex has a constant helix twist by using the Gaussian 98 program to optimize geometries and calculate potential energies. In the lab, I studied the effects of stretching, compression, and twist on a small section of the backbone in the absence of nucleic acid bases. Dr. Tao fostered my interest in research by patiently answering all my questions and encouraging me when I seemed frustrated by failed calculations. Under his guidance, I learned how to carefully document my observations, how to use data interpretations to think of another research direction, and how to learn from failures. Not only did conducting independent research test my patience and thinking skills, but it also allowed me to apply my constant questioning to find innovative approaches to the research problem. Of greater significance, though, was my realization that I enjoyed conducting research. The project I completed that summer earned me recognition as an Intel Science Talent Search Semifinalist.

The summer after my freshman year of college, I was still primarily interested in chemistry and accordingly applied to work in Jeffrey Snyder's lab at the Jet Propulsion Laboratory. I completed a project titled "Thermoelectric Inhomogeneities of Cubic $AgPb_mSbTe_m$." At first, I knew little about materials science and solid state chemistry and physics, but it was fun and interesting to learn about a field I otherwise would have never explored. My project investigated the thermoelectric properties of AgPbSbTe materials, which are believed to have an extremely high efficiency. Thermoelectric materials that generate electricity from heat are currently used in a variety of power generation and cooling applications, and the generation of highly efficient bulk materials could play a key role in making thermoelectric power generation a viable alternative energy solution. The investigation involved fine-tuning the synthesis procedure (a solid state reaction) and using a variety of methods to test the material. X-ray diffraction results and electron microscope scans could not detect any evidence of inhomogeneities. However, by measuring the Seebeck coefficient and resistivity at various points on a sample, I discovered that these materials are actually quite inhomogeneous, which can lead to large errors in estimating the thermoelectric coefficient of merit (a measure of efficiency). The desire for a higher resolution map of the inhomogeneities of the material led us to collaborate with Eckhard Mueller in Germany for use of his new Seebeck microprobe. I also sought to eliminate the inhomogeneities by experimenting with the synthesis reaction, and found that samples prepared with higher temperatures and faster cooling rates are significantly more homogeneous. That summer I also learned how to give scientific presentations and improved my technical writing skills. The paper I wrote was published in *Applied Physics Letters* and later awarded a NASA tech brief award.

Two summers ago I worked in as a summer undergraduate research fellow in a physical organic chemistry lab at the California Institute of Technology. Under the guidance of John D. Roberts, I completed a project entitled "NMR Conformational Analysis of *meso*-Tartaric Acid as a Function of Solvent Polarity and Ionization State." I studied *meso*-tartaric acid to determine the

relative importance of several factors governing conformational preferences, such as steric hindrance, electrostatic effects, hydrogen-bonding, solvent polarity and hyperconjugation. I used NMR spectroscopy to determine conformational preferences of *meso*-tartaric acid and its anionic species in solvents with various polarities and hydrogen-bonding abilities. In addition, I determined the pK_1 and pK_2 of *meso*-tartaric acid in DMSO to figure out the extent of hydrogen bonding in DMSO. To determine the degree to which intramolecular hydrogen bonding between the carboxyl groups influences conformation, I synthesized and analyzed the conformational preferences of dimethyl *meso*-tartrate. My results confirmed that conformational preferences are determined by the interplay of several factors, yet found that the predominant influence was the hyperconjugative specific *gauche* effect. Dr. Roberts provided the initial idea and some good background literature but left most of the experimental design to me. That summer I also learned a great deal from his constant evaluations of my written and oral presentations.

While I enjoyed all three summers of chemistry research, I recently learned that I am more interested in biology. An ornithology class reawakened my childhood dream to become a field biologist, and my growing interest in evolutionary biology led me to join Scott Edwards' lab at Harvard last year. I am now working on my senior thesis on "Genetic Mechanisms Underlying the Evolution of Resistance to *Mycoplasma gallisepticum* in House Finches." In 1994, an epizootic caused by the bacterium *Mycoplasma gallisepticum* (MG) swept through Eastern populations of the house finch, a common North American songbird, causing a significant decline in house finch population numbers in affected areas and the subsequent evolution of enhanced disease resistance. The house finch and MG system is especially interesting as it is a particularly well-documented model for the evolution of host-parasite interactions in the wild. A previous suppression subtractive hybridization study had identified several genes that have been up- or down-regulated in response to MG infection. After reading about the system, I wanted to find the molecular cause for the observed differential gene regulation. If genetic in origin, this differential expression is most likely caused by adaptive mutations in the upstream regulatory regions of these genes. Therefore, I decided to look for adaptive mutations in the regulatory regions of 5 differentially expressed genes by comparing regulatory regions in pre- and post-epizootic populations. I chose to focus on genes involved in the immune system: Hsp90, TIM 1, granzyme A, MHC II Ii, and exon 2 of the MHC class II B gene. I am first obtaining sequences for the regulatory regions by screening the available cosmid library for the genes of interest and then characterizing the regulatory regions of genes on the selected cosmids by subcloning. These sequences will be used to design primers for amplifying the same region in other individuals. With the sequence data, I can use a variety of computer programs to look for variability and selection using several commonly used statistics. The characterization of any changes in the relevant regulatory regions in pre-and post-epizootic birds should provide more insight into the molecular mechanisms underlying host response to parasite infection. I was given a great deal of independence considering that it was my first research project in biology; no one else in the lab has a similar project. This has given me even more chances to practice talking about my research, troubleshooting problems and seeking new methods and technologies to make experiments more efficient.

Publications

Chen, N., Gascoin, F., Muller, E., Karpinski, G., Stiewe, C., Snyder, G.J. Macroscopic thermoelectric inhomogeneities of $AgPb_mSbTe_m$. *Appl. Phys. Lett.* **87**, 171903 (2005).