It is my philosophy that while a deep understanding of scientific principles has intrinsic value, tangible progress is made by applying these principles to large-scale, industrial problems: pharmaceutical companies use stoichiometric quantities of reagents, fermentation processes are run in batch reactors instead of continuous ones, and sensible heat from spent-steam is dissipated by cooling water instead of utilized in energy recovery systems. Because of this ongoing wastefulness, I intend to work on reducing the inefficiency of industrial processes by introducing new methods of chemical conversion and developing alternate pathways to the implementation of existing technologies.

Introduces applicant's values and motivations for conducting research. Clearly states goals.

Before I knew which field I wanted to pursue, I planned my three summer experiences to gain experience in and exposure to three distinct career paths: research in an academic laboratory, a start-up cleantech company, and a large industrial corporation.

Introduces body.

Working with , I examined a possible correlation between the oxidation states of metallic active sites in metalloproteins and certain features of their anomalous scattering factors; the goal was to understand electron transfer in Nitrogenase, so that the lab group could create an artificial enzyme for nitrogen fixation. My work spanned protein expression, purification, crystallization, x-ray diffraction, and computer-aided characterization. During these five months, I produced dozens of crystals that diffracted beyond the 0.95 angstrom detector limit and wrote several programs to automate analysis. I left my postdoctoral mentor with a repository of crystals ready for diffraction and documentation of a new purification and crystallization scheme so my project could be continued.

Describes experience 1 and quantitative results of this work.

After working in an academic setting, I shifted to the opposite end of the spectrum with a three-month internship at , a cleantech company in Iceland, that was the first to .

I worked one-on-one with the CEO on most aspects of the company's operations, personally developing heat, mass, and utility flowsheets and writing business proposals and feasibility studies for potential chemical plants. The highlight of my internship was creating a proposal for an $85M municipal solid waste gasification facility that the CEO immediately pitched to during a crucial investment round. While that investment fell through, I saw how technical creativity could be leveraged to create a business with broad impact; I was inspired to do the same in my career.

Describes experience 2 and how this motivated applicant's careeer goals.

Most recently, I returned to laboratory research with a focus on commercial applicability. Over a period of twelve weeks, I explored a set of compounds for use in acid fracturing fluid for . Because these additives had never been studied in this context, I pioneered new methods of experimentation and means of quantifying their suitability, which were quickly adopted by other employees. Although I frequently updated my managers on my progress, I worked independently during this project. The additive I developed has been slated for pilot-scale testing at two well sites, and the internal legal team is currently reviewing my patent memo. If the technology is approved, per-well oil production will be increased while reducing the raw materials required to stimulate production.

Describes experience 3 and how this makes the applicant a qualified candidate.

These professional experiences strengthened my desire to pursue an advanced research degree and a career in process engineering. Conventional scientific research often has an impact

that is apparent only after progress has been made; process improvement, however, is a goal-driven field, where the project is defined by the application itself. Changing the manner in which chemical technologies are implemented directly benefits the efficiency and sustainability of our industrial practices. Although the private sector may be willing to fund research on cost-minimization, research relevant to environmental protection and social welfare is rarely funded this way; an NSF fellowship would enable me to concentrate on global impact rather than profit.

Concluding paragraph on the significance of experiences and why the applicant deserves the fellowship.

I gained additional perspective towards problem solving through student government. Last March, I was elected to be the VP of and Committee Chair for the student body. I ran for these positions to create a positive, lasting impact at and improve the recently-strained relationship between undergraduates and administrators. In this role, I work closely with trustees, administrators, faculty, and other students to discuss policy changes that affect student life. The committee consists of the undergraduate presidents of the eight residential colleges; my role as Chair requires a nuanced understanding of group dynamics, conflict mediation, and non-academic leadership.

Describes past broader impact experiences related to policy changes, teaching, and curriculum.

Academically, I find myself motivated to achieve the fullest mastery of course material; and I have encouraged that same drive in others through my role as a teaching assistant and tutor. I have taught a total of seven courses, including every chemical engineering course offered to second-year undergraduates. As a member of the Committee, I used this experience to help improve the undergraduate curriculum, including the introduction of a numerical methods course; I am currently working with the professor to design the course layout and curriculum for its debut next term. Last year, I was also asked to jointly lead a TA training session for first-year graduate students, and other teaching assistants continue to consult me for advice. I have discovered both a passion and a propensity for teaching, and will sustain this in graduate school and throughout my career.

While I focused on undergraduate education for the past few years, I intend to expand this outreach to K-12 programs. The ease of positively influencing young students is increasing, partially due to the prevalence of MOOCs and other online resources. Under an NSF fellowship, I would be able to contribute to a broader educational mission: I would have the time and resources to develop online curricula for at-risk youth. For those without internet access, there is tremendous opportunity to adapt short lectures into recordings that are accessible through a voicemail system. Giving back to the scientific community is not only a commitment I value, but also a commitment that I sincerely enjoy fulfilling.

Describes future intended broader impact activities related to past experiences and research.

My growth as a programmer is an example of this reciprocity. I was a complete novice before CS1, Introduction to Computer Science, which I took the first term of my freshman year. Since then, I have found the process of writing code to be both simulating and rewarding, and have learned C, C++, Perl, Python, Fortran, PHP, HTML/CSS, MATLAB, and Mathematica. Because I had such outstanding teachers that inspired my interest in programming, I returned to CS1 as a teaching assistant to inspire the same in others.

Following a Ph.D. program, I intend to find a position in a research and development department with an emphasis on systems improvements. Eventually, I envision myself founding a company to focus on improvements to a particular industrial process by replacing the

antiquated systems that remain the industry standard. After working in the public or private sector for some time, I hope to return to academia and seek a professorship to focus on academic research and continue teaching. Ideally, I would also use this time to develop new industrial-academic research partnerships.

I am committed to making a lasting impact in both academia and industry. With a decreasing pool of global resources, it is becoming increasingly essential to optimize the processes central to modern life. There is significant room for improvement, not only in the discovery of new materials, processes, and technologies, but also in how we apply the knowledge that we currently have. I hope to contribute to the broader scientific community by working on the former and to create new paradigms of engineering and manufacturing by the latter. Under an NSF fellowship, I would have the freedom and flexibility to choose a research group that can prepare me for a productive career, while working on a specific improvement to manufacturing that immediately benefits society.

Concludes narrative by discussing future goals and describes how NSF will benefit applicant's career.