TEACHING PROPOSAL

Each applicant is expected to propose a teaching plan that has promise to improve science education. Although this is an opportunity to share the philosophy and principles that guide you as a teacher-scholar, you must include concrete examples of what you have done and, most importantly, what you plan to do. Your plan needs to be substantive and must demonstrate a long-term commitment to your role as a teacher. Research Corporation program officers screen teaching proposals initially, and only those that pass this screening are submitted to peer review of the teaching and research, giving equal weight to both.

STATEMENT OF THE PROBLEM, SIGNIFICANCE OF THE PROBLEM, AND PLAN OF PROCEDURE (State clearly the problems or issues you wish to address and how they relate to any ongoing work. Carefully outline the importance of your plan and the impact it may have on your students, especially undergraduates. A viable approach should be given, including examples from your own experience and/or from the literature. Indicate ways in which the completion of this work has a broader impact.)

Statement of the Problem and its Significance

As a scientist and educator, my foremost goals are to ensure mentoring and professional development for students at all levels, and to provide students with high quality research experiences, even in traditional lecture-laboratory classes. Northeastern University's focus on practice-oriented education, as evidenced by our nationally-recognized cooperative (co-op) education model, complements my commitment to discovery-based learning and professional development. Thus, I bring a set of key attributes integrated with and beyond my research goals to contribute to and grow the Department of Chemistry and Chemical Biology.

There are several major needs that have been identified for modern students in the physical and life sciences (Godwin 2005): the need for interdisciplinary education and integrated coursework; the need for inquiry-based approaches in laboratories; and the need for high quality undergraduate research experiences. These needs are particularly acute for Northeastern University students as interdisciplinary coursework and undergraduate research experience greatly expands the range of co-op opportunities available to them. Greater depth in chemical biology coursework will increase the potential impact students have in their co-op positions. Moreover, having a solid background in interdisciplinary fields helps the students integrate their coursework with their co-op experiences.

Plan of Procedure

<u>I am developing a new course, "Principles of Chemical Biology" for Chemistry majors.</u> There is a profound need for such a course to address this emerging area of Chemistry (Godwin 2005). Principles of Chemical Biology will be an introduction to the principles and major findings in Biochemistry and Molecular Biology and will focus on using chemical and biophysical tools to address biological questions. For example, the discussion of nucleic acids will include not only the structure, function, and biosynthesis of nucleic acids, but also common chemical reactions of nucleic acids, solid phase synthetic methods, combinatorial libraries, and *in vitro* selection (SELEX) techniques. My classes are dynamic environments in which, even in primarily lecture situations, there is a dialogue among students and with me. Students take more initiative when participation is not just rewarded, but expected. I will pose questions that range from basic concepts to quickly assess comprehension, to more complicated questions that ask students to suggest an experimental method to address a problem or to interpret experimental results. Students will be expected to present summaries of papers from the primary research literature several times throughout the semester. Particularly noteworthy papers will be discussed in depth. Thus, students will gain experience in reading the primary literature and will have an opportunity to improve their communication skills.

The laboratory component of "Principles of Chemical Biology" will include discovery-based laboratory exercises and projects. These projects will often be related to work in my research laboratory or those of other faculty in the department. In the first week, students will be introduced to sterile technique and then will conduct a phenotypic screen, a typical first step when attempting to characterize a gene of unknown function. The students will be given a bacterial strain in which a gene of interest has been deleted, and which will be compared to the wild-type strain. In this case the gene that is deleted encodes a protein of unknown function that was found to interact with (**) in a proteomics experiment carried out by one of my students. Students will be allowed to choose agents and conditions of interest with which to treat the strains in order to begin to infer the function of this gene. A substantial number of "hits" from the

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proteomics experiment are genes of unknown or poorly characterized function, and we have knockouts of non-essential genes (Baba 2006), as well as expression clones (Kitagawa 2005) of interest. Subsequent semesters of this class will characterize other genes. Promising results will be followed up either in my research laboratory or as independent research projects as part of the Chemical Biology laboratory, with the students involved receiving co-authorship. The latter part of the semester will consist of a multi-week experiment in which students will choose residues of alkaline phosphatase (PhoA) to mutate in order to test their contributions to catalytic efficiency. Students will use the molecular visualization software VMD (Humphrey 1996) to examine the positions and effects of known mutations on PhoA catalytic efficiency (Kim 1991) and design additional mutations, based partly on predictions from the THEMATICS program (Ondrechen 2001) developed here at Northeastern. The students will then construct the mutations in an expression plasmid (Chaidaroglou 1988). The students will perform kinetics assays to determine the catalytic efficiency of wild-type PhoA and purified variants. In the future, the site-directed mutagenesis experiment will be expanded to other systems. Additionally, in future semesters there will be an opportunity for independent research projects. *With funding from the Cottrell Scholar program, an undergraduate student would be hired to develop other research-based laboratory experiments.*

The effectiveness of the course and the laboratory will be assessed with formal teaching and course evaluations, mid-term evaluations, peer evaluation of teaching by classroom observation, and discussions with students and teaching assistants. I have consistently used mid-term evaluations to gauge teaching effectiveness and the learning environment, and will continue to do so. Since this is a new course that is not required for graduation, sustained enrollment in the course will also indicate its effectiveness.

<u>As a postdoctoral scholar at MIT, I designed and taught a seminar-style course for advanced undergraduates based on the primary literature, demonstrating my commitment to undergraduate education.</u> The course, “The Role of DNA Repair in the Prevention of Human Disease,” featured in-depth discussions of DNA replication and the different classes of DNA repair, and enrolled Chemistry, Biology, and Humanities majors. Reports from the primary literature were chosen to represent a broad range of techniques, approaches, and systems. I emphasized critical reading of the primary literature and creative thinking about interpreting the literature in the broader context of the field. For example, students were asked to consider the application of techniques that we had previously discussed to the topic at hand, and to predict possible experimental outcomes and limitations. I encouraged the students to consider their own experiences in research laboratories and how they might apply those experiences to the papers we discussed, and vice versa, to help them integrate their classroom learning with research experiences. Whenever possible, papers were chosen that expanded upon or contradicted papers that were discussed in prior weeks, to provide examples of the development of a given subfield. The student evaluation comments indicated that they appreciated the opportunity to “learn about a subject in a more in-depth manner”, that it helped them consider experimental design and the importance of controls, and that “it was cohesive.”

<u>I will continue to provide high quality mentoring to undergraduate and graduate students and trainees in my laboratory.</u> The research pursued in my laboratory encompasses disciplines including biophysics, biochemistry, biotechnology, chemical engineering, microbiology, and genetics. Thus, students in my research laboratory receive broad-based interdisciplinary training consistent with modern needs for researchers with cross-disciplinary training. Moreover, the adage that ‘science is international’ is manifest in my research group, as the group currently hosts students from China, South Korea, Germany, Eastern Europe, and the Caribbean. Students gain valuable skills in communicating with others with different scientific perspectives as well as different cultural backgrounds. I encourage group discussions and collaborative problem solving in weekly group meetings, biweekly subgroup meetings, journal clubs and informal interactions, leading to a stimulating, supportive, and cooperative atmosphere in the laboratory. I encourage students to attend local and national scientific conferences. Several undergraduates working in my lab have applied for and received independent funding, gaining experience writing research proposals.

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Undergraduates in my laboratory have presented their work at American Chemical Society and Experimental Biology national meetings.

I have taught the required "Chemistry and Chemical Biology at Northeastern" class to incoming Chemistry majors. This is a class intended to acculturate first-year students to the University and the Department, as well as to build community among students. In this class, I emphasized to students the benefits of gaining research experience early in their undergraduate careers. Recent findings suggest that early research experiences are crucial for encouraging undergraduates to pursue research careers (Seymour 2004; Russell 2007). This work indicates that undergraduates should be encouraged to begin laboratory research projects as early as possible. The students in the class interview faculty and other researchers to learn what motivated these individuals to pursue research careers and what continues to excite them. As a result of this encouragement, two first-year students began working in my research laboratory in the spring term, and continued full-time in the summer. *I have continuously had between three and seven undergraduate researchers in my laboratory, and plan to continue this trend. Funding from the Cottrell Scholar program will enable me to support undergraduate researchers, including a co-op student, in my laboratory.*

My commitment to mentoring led me to teach "Research Skills and Ethics", which is a required course for graduate students in Chemistry and Chemical Biology. The course has also attracted other students since I began teaching it. I revised and updated the course, and placed a greater emphasis on writing assignments, including a research proposal. I provided detailed feedback on the writing assignments and included a peer review exercise (Patterson 2007). I also adopted in-depth discussion of case studies to develop moral reasoning (Macrina 2005) and discussion of "interest-based" conflict resolution (Fisher 1981; Ury 1991; Klomparens 1997). I encourage all graduate students and postdoctoral scholars to attend class sessions of interest for their own professional development.

I have a record of accomplishment in enhancing the recruitment and retention of women in science (Beuning 1999). I am currently the President of Graduate Women in Science-Boston (www.gwisboston.org), a professional society of over 200 professionals, students, and trainees. As such, I have planned seminars and workshops that address issues of diversity in science. Additionally, I have organized myriad professional development workshops targeted to the needs of women, but open to everyone, on topics such as: negotiation skills, project management, getting effective mentoring, and many others. I chaired a conference (GWIS National Conference, "Building Bridges", June 2004) focusing on the professional development and retention of women at all stages in science. I coordinated a presentation on the status of female and underrepresented minority faculty in Ivy League universities. I continue to be a sought-after speaker at career workshops for graduate students and postdoctoral scholars. Finally, because of my record in improving professional development opportunities for scientific trainees and researchers at all levels, I have been interviewed and sought out for insights on the status of women in science (Durant 2004) and of postdoctoral researchers (Whitlock 2003), as well as funding issues for young faculty (Shipley Hiles 2006) by the popular scientific press and mainstream media.

As the first person in my family to earn a Bachelor's degree, I have a deep appreciation for the transformative power of higher education, as well as the critical importance of quality mentoring. My life was literally turned around by the influence of gifted and dedicated teachers, the beauty of science, and the opportunity to join a community of scholars. Like me, most students entering college will not have had this acculturation. I valued the close relationships between faculty and students in my undergraduate experience at Macalester, a small liberal arts college. This spirit is entrenched at Northeastern, even though it is a much larger campus. The process of student acculturation into the learning community is institutionalized in, for example, the "Chemistry and Chemical Biology at Northeastern" and "Research Skills and Ethics" formal courses. In addition to teaching the subject matter, I believe that we as educators, mentors, and researchers must also introduce students to the culture and norms of higher education and the scientific community in order to prepare them to enter the profession and the professional community.

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(**) information deleted