

Personal Statement

My early desire to be a biomedical engineer led to the choice of dual undergraduate majors in chemistry and chemical engineering. Upon completion of both a B.A. degree from Smith College, a private institution, and a B.S. degree from the University of Massachusetts, I continued my education by completing a Ph.D. in polymer science and engineering. My unique multidisciplinary training leaves me poised to become a significant contributor to the emerging regenerative medicine and molecular engineering fields both nationally and internationally.

Working on my dissertation under the direction of David A. Tirrell, Chair of the Division of Chemistry and Chemical Engineering at California Institute of Technology, I became proficient in recombinant DNA techniques, including gene design and manipulation, protein expression, and protein purification. These tools have been quite useful for synthesizing biointeractive protein materials. Following completion of my Ph.D., I became a postdoctoral researcher in the laboratory of Jeffrey A. Hubbell, (Currently the Director of the Laboratory of Regenerative Medicine and Pharmacobiology at the EPFL, Switzerland) in the Institute for Biomedical Engineering at the ETH in Zurich, where I learned much of the polyethylene glycol (PEG) hydrogel technology developed in this laboratory.

My laboratory seeks to learn from protein-derived bioactive signals and to manipulate these signals to develop next generation biomaterials for regenerative medicine and protein derived pharmaceuticals. Specific examples are provided in the next section (Research Goals).

Research Goals

The overall goal of my research is to translate what I learned from complex biological systems to new engineering approaches aimed toward the development of novel, bio-molecular-based biomaterials used in the design of smarter and more effective therapeutics and diagnostic devices. More specifically, I train students and postdoctoral researchers in my laboratory to characterize and optimize biologically active motifs of proteins for strategically relevant bioengineering applications, i.e. molecular engineering and regenerative medicine.

My laboratory seeks to learn from protein-derived bioactive signals and to manipulate these signals to develop next generation biomaterials for regenerative medicine and protein derived pharmaceuticals. Specific examples of already published research areas include (i) controlled release of therapeutics (Seal and Panitch, *Biomacromolecules* 4(6) 2003), (ii) for self-assembly of synthetic hydrogels (Seal and Panitch, *Biomacromolecules* 4(6) 2003 and Seal and Panitch *Mat. Res. Soc. Symp. Proc. N.3.2.1* 2002), and (iii) for development of peptide-based therapeutics (Tessier, et al. *Journal of Vascular Surgery*, 40(1), 2004). Also within the field of regenerative medicine it is widely known that proteins contain motifs that are necessary for cell adhesion, cell proliferation, cell differentiation, proteolytic degradation, and growth factor storage and delivery. Many investigators including my laboratory group are working toward development of bioactive and biomimetic materials that can coax the body to regenerate tissue and organs (Seal, Otero and Panitch, *Materials Science and Engineering R: Reports: A Review Journal*. 43(4-5)).

Recent Research Accomplishments

During my tenure as an Assistant Professor I have focused on combining the techniques learned during my Ph.D. and postdoctoral studies to engineer novel biomaterials, such as artificial proteins and hybrid natural/synthetic hydrogels. While I have continued to take advantage of the specificity of protein synthesis using genetic engineering methods and combined this with PEG hydrogel technology, I have also expanded into systems composed of shorter protein sequences, synthesized synthetically, combined with polysaccharides and PEG. These techniques provide tools for the engineering of biointeractive materials including sites for controlled growth factor and trophic factor release, crosslinking, cell adhesion, and degradation. Specifically, I have enhanced the synthesis toolbox by including peptide synthesis. My laboratory recently demonstrated that peptides could be conjugated to multifunctional polymers and used to construct an artificial extracellular matrix based purely upon physical assembly by controlling interactions between peptides and polysaccharides. The matrix resembles the native matrix in its ability to coordinate peptides and polysaccharides and to release and sequester bioactive molecules based upon the affinity of the molecule for the polysaccharide component of the matrix. This work was published in *Biomacromolecules* (2003), a top journal ranked number 3 for impact factor in polymer science.

Despite the intrinsically time consuming nature of artificial protein research, I have shown that I am able to control both mechanical properties and degradation rates with these novel nano-biomaterials. I am in the process of preparing two full manuscripts on this work; these manuscripts will be submitted by December 2004.

My contribution to a large multidisciplinary project in nerve regeneration, sponsored through the Bio/Micro/Info contract from DARPA has led to a collaboration on spinal cord regeneration with Mark Preul, M.D at Barrow Neurological Institute. We have submitted an NIH RO1 proposal based on preliminary data we have obtained. This proposal is currently pending NIH study section review. We plan to continue to develop materials for nerve regeneration and to evaluate the *in vivo* effectiveness of the materials in collaboration with Dr. Preul.

My immediate goals are to further develop the emerging area of nano-biomaterials engineering, specifically targeted for cardiovascular and neurological medical needs, e.g. enhancing the endothelialization of the lumen of vascular grafts, and in enhancing angiogenesis in biomaterials and in neural tissue regeneration where I am developing materials to improve the interface between neural recording electrodes and the brain and materials to enhance nerve regeneration in the spinal cord.

Establishment of a multidisciplinary research collaboration with Colleen Brophy, M.D., a vascular surgeon and research professor, and Lokesh Joshi, Ph.D., a plant biochemist: Our laboratory has been involved in synthesis and delivery of a therapeutic peptide, which was discovered in the laboratory of Dr. Brophy. This peptide, a critical link in vasorelaxation, has been shown to disrupt stress fibers in the actin cytoskeleton and thereby induce vasorelaxation. This area of research is funded by an NIH Career Development grant on which I am the principal investigator; this proposal was chosen by the NIH to be posted on their website as an exemplar proposal to serve as a model for others preparing applications. It has also led to a research partnership with Prolexys Pharmaceuticals, Inc. in Salt Lake City, Utah to search for small molecule mimetics of our peptide-based pharmaceuticals. This collaboration has led to a start up venture, AzERx, Inc., with its mission focused on therapeutics for disease states resulting from impaired vasorelaxation. This venture has helped to increase my patent application portfolio which contains four full patent applications and several provisional applications. These applications seek coverage for composition of our peptide therapeutic and methods of use and delivery of the therapeutic. This new area has also led me to explore one of the thrust areas of the Ira A. Fulton School of Engineering and The Biodesign Institute at Arizona State University through entrepreneurial research and corporate spinouts.

In addition, my laboratory has been able to develop delivery systems for the peptide therapeutics being developed by AzERx, Inc. One delivery system is based off technology that was published in biomacromolecules (Seal and Panitch, Biomacromolecules 4(6) 2003). The second technology is a transdermal delivery system, which carries the therapeutic across the skin.

Accomplishments to date include:

- Twelve published archival journal papers
- One published national conference paper
- Two published book chapters
- Two published encyclopedia chapters
- 39 published national conference presentations
- Nine patent applications
- Nineteen invited presentations at national and international conferences and research institutions;
- Establishment of a research program in biomaterials and regenerative medicine, which has been funded since 1999 with 14 grants including both single investigator and multi-investigator grants. Granting institutions include the Culpeper Foundation, DARPA, NIH, NSF, AHA, and Arizona Disease Control Research Commission and six internal grants;
- NSF CAREER award
- NIH career development award
- Proposal selected by NIH to post on their website and serve as an exemplar proposal
- \$1,388,000 in individual grant money from external agencies (6 individual grants)
- Over \$8,000,000 in multi-investigator grant money from external agencies

wards for my students: include first (D. Almazon), second (B. Seal) and third (B. Seal) place finishes for best prior design poster/projects at ASU BME day, which includes research on artificial protein design and biologically-base drug delivery systems; a travel award (B. Seal) for best poster presentation entitled, "Biologically-Based Self-Assembling Hydrogels for Drug Delivery" at a Gordon Research Conference; two Silver Medal awards (B. Seal) for graduate research on "Biologically-Based Self-Assembling Hydrogels" and "Self-Assembling physical polymer matrices based on affinity interactions between peptides and polysaccharides" from the Materials Research Society; one BMES national award (A. Conovaloff) for undergraduate research entitled, "A biomimetic peptide-based anticoagulant"; and recently recognition of research (B. Seal) resulting in an oral presentation on "Physical Polymer Matrices Based on Biological Affinity Interactions" at the "Signal Transduction in Engineered Artificial Matrices" Gordon conference at Bates College.

Overall Educational Goals

My philosophy, which is pervasive in both teaching and research, is that a strong biological background is required if we are to succeed in our attempts to regenerate tissue and organs and to create pharmaceuticals with improved efficacy and reduced side effects. I also believe that a firm foundation in engineering principles is crucial. To this end, I have developed four new courses, discussed below, that teach at the interface of engineering and biology and I attempt to instill in my students the need to embrace both engineering principles and biology.

I have developed an educational track at ASU for training Ph.D. and MS students in my area of expertise. This involves formal classroom and laboratory training, as well as independent research. Classroom training includes a course on Molecular, Cellular and Tissue Engineering encompassing cell-material interactions, device design, biomaterial surface modification, control of geometries, as well as issues such as molecular recognition. A second course is Biotechnology Techniques, which provides practical and lecture experience with a variety of biotechnology techniques involved in genetic engineering to both biology and bioengineering undergraduate and graduate students. The third course is Advanced Biomaterials, which includes information on material interactions with the body and current efforts to design lasting biomaterials and materials that serves as temporary scaffolding for tissue engineering, as well as using biology to create advanced materials for sensors and semiconductor applications. The fourth course, Advanced Molecular and Cellular Biology for Engineers, includes lectures ranging from DNA, RNA and proteins to cellular function and communication and the extracellular matrix; the course also includes a discussion section to review current literature embracing engineering and biology.

I have also been active in undergraduate education. I have taught BME 201, Introduction to Bioengineering several times. Within the course I developed modules on biomaterials and biotechnology, which contain in class exercises, panel presentations and a short laboratory experience. I have also mentored a minimum of two senior design students annually and often have undergraduate students in the laboratory participating in research.

Educational outreach includes K-16 activities. I have worked with the WISE program to develop short labs for junior and high school students. I have also partnered with professors Patty Ashby and Suzanne Kelly at Scottsdale Community College to run a seminar course for the community college students; the course introduces students to topics, research and faculty in Bioengineering at ASU. I have presented twice to the community through the President's community outreach program.

Accomplishments to date include:

- One Ph.D. student graduated (Tinna Otero, December of 2003)
- Two Ph.D. students set to defend in October and December of 2004
- Currently mentoring 6 Ph.D. students including one Whitaker Fellow two M.S. students and one postdoctoral scientist;
- Designed and delivered four new 500 level BME courses: Introduction to Molecular, Cellular and Tissue Engineering, Biotechnology Techniques - A Laboratory Class, Advanced Biomaterials, and Advanced Molecular and Cellular Biology for Engineers.
- Taught and designed biomaterials and biotechnology modules for BME 201

Panitch 4

- Active in both undergraduate and graduate education.

Service

My service activities to date span all levels of the University as well as national and include:

Department

- Chair of the Graduate Committee for 2 years and co-chair for 1 additional year. I have increased the ratio of PhD:MS students from less than 50% to greater than 60%. The quality of the applying and enrolled graduate students continues to rise. I have successfully worked with the faculty to create a strong set of graduate core courses and comprehensive exam.
- Member of Undergraduate Curriculum Committee
- Chair of Department Space Committee
- Former Chair of the Diversity Committee
- Member of 4 faculty search committees
- Established the Bioengineering Core Cell Culture Facility

College

- Member of the Undergraduate Curriculum Committee
- Member of the Quality of Instruction Committee
- Chair of the ECE 384/386 (Numerical Methods) Committee
- Member of the search committee for Associate Dean (Paul Johnson appointed)

National

- Chairing sessions and reviewing abstracts for the Society for Biomaterials and the Biomedical Engineering Society
- Reviewing for several journals in my field: Biomacromolecules, Biomaterials, Journal of Biomaterials Science, Polymer Edition, IEEE transaction in Biomedical Engineering, Journal of Controlled Release, Acta Materialia
- Reviewing proposals for NASA- biomaterials panel (2002), the NIH special emphasis panel on biomaterials for tissue engineering (2003) and NSF CAREER panel in Bioengineering (2003) and STTR/SBIR panel in Bioengineering (2004)
- I was a judge for the graduate student awards for the Materials Research Society and I am now a member of the Awards committee and the Graduate Awards subcommittee.

Other

- Member of the Microbiology Faculty Search Committee, 1999-2000
- Member of the Chemical Engineering Search Committee, 2001-2002

Future Outlook

As our knowledge in biology and medicine continues to grow exponentially, the opportunities for biodesign will expand equally as rapidly. I plan to continue to develop novel ways in which to deliver bioactive fragments of proteins and other biologically relevant molecules intracellularly for improved targeting and reduced side effects. I will also continue to develop synthetic polymers and artificial proteins that act as synthetic extracellular matrices for regenerative medicine. My laboratory has begun to make inroads into how to best present polysaccharides for storage and release of growth factors, how to use biological functional groups to control mechanical properties of hydrogels and to manipulate peptide sequences to control degradation of hydrogels. We are beginning to integrate this information to develop next generation materials for regenerative medicine. In summary, I confidently envision that my research and teaching will continue to embrace and adapt new knowledge in order to ensure that I am both helping to educate a new generation of students who can navigate life sciences and engineering in a transdisciplinary manner, as well as, move the frontiers of knowledge forward in a productive and impactful manner and effectively communicate my results across the greater biomedical community.