DEFINING & PITCHING YOUR RESEARCH

Please prepare a 1-page executive summary for a research idea that answers the following questions. A format is proposed in the sample summaries included in this assignment. Be prepared to share your writeup/pitch your idea to be critiqued and discussed during the interactive session during Day 2 of the Faculty Boot Camp series.

- **Overview:**
  - What is your research idea, overall goal?
  - Why is it important, unique, different than others? What will it add/transform?
  - What is the methodology?
  - What objectives must be met in order to accomplish your goal?

- **Intellectual Merit:**
  - What will come out of the research? Why/how will it advance knowledge base of science or engineering?
  - Why are you uniquely qualified to conduct the research?

- **Broader Impact:**
  - What broader impact will your work have? What is the potential to benefit society and contribute to the achievement of specific, desired societal outcomes? (e.g., economic, environment, education, underrepresented populations)

- **Agencies:** What funding sources will you target?
PROJECT SUMMARY

Overview:
This Accelerating Innovation Technology Translation project focuses on development of a microfluidic platform for therapeutic removal of blood constituents. The ability to safely and efficiently remove selected constituents from blood would enable treatment of a variety of medical conditions, ranging from autoimmune diseases to high cholesterol. However, it is not possible to achieve adequate removal of target entities without damaging blood cells using existing blood processing technologies. The proposed concept is based on highly parallelized microfluidic channels - allowing operation at clinically relevant flow rates - with a microscale geometry optimized for harnessing red blood cell (RBC) migration to enhance adsorption at the device surface. To ensure biocompatibility and selective adsorption, the internal surface of the device will be coated with a nonfouling polyethylene oxide (PEO) brush layer, and selected bioactive agents will be immobilized to the PEO chain ends. As an initial proof-of-concept, this proposal focuses on treatment of sepsis as a high-impact application for such a technology, using a surface coating containing a novel antimicrobial peptide that shows high affinity for adhesion of susceptible bacteria and endotoxin. Funding from the NSF PFI program will allow completion of the critical next steps towards commercialization of this technology, and ultimately enable the design of a working prototype.

Keywords: microfluidics, adsorption, surface coatings, bioconjugation, sepsis, blood

Intellectual Merit:
The proposed work will focus on demonstration of two innovative concepts: (1) harnessing RBC migration to enhance adsorption within high flow rate microfluidic devices and (2) advanced surface coatings to prevent nonspecific adsorption and prominently present adhesion ligands to flowing blood. Together, these concepts are expected to allow vastly superior biocompatibility and adsorption efficiency compared with the current state of the art, enabling a new paradigm in blood processing with applications ranging from treatment of high cholesterol to autoimmune diseases. The proposed microfluidic adsorption platform follows from NSF-funded research under grants awarded to Drs. Higgins, Sharp and McGuire. Dr. Higgins is currently supported by an NSF CAREER grant that focuses on development of high flow rate microfluidic devices for processing of cryopreserved blood cells, and Dr. Sharp was supported by a CAREER grant from 2004-2010 that focused on experimental and computational investigation of particle trajectories in microfluidic devices. The microfluidic concept proposed here follows directly from this previous NSF-funded research. In addition, the proposed approach for coating the device surface follows from NSF-funded research directed by Dr. McGuire from 2006-2009, which demonstrated that PEO-containing triblock copolymers can be immobilized at interfaces, with bioactive agents tethered to the PEO chain ends in a fashion preserving their molecular mobility and solvent accessibility as well as nonfouling character of the layer itself.

Broader Impacts:
Sepsis is a blood infection that affects 750,000 people per year in the US and accounts for nearly $17 billion in treatment costs. There is no cure for sepsis; approximately 1 in 3 people who develop sepsis will die. Thus, clinical translation of the proposed technology will have important ramifications for both patient health and treatment costs. To move the technology toward the clinic, the research team will work with Dr. Turner and the OSU Venture Accelerator to develop a commercialization plan. Through these interactions, the PIs and graduate students will gain first-hand experience with the research translation process. In addition, the students and PIs will participate in an innovation workshop called "Lens of the Market" which provides training for researchers in market analysis and translation of fundamental research into commercial products. The graduate students will also participate in a 9-month interdisciplinary project with MBA students to develop a detailed business plan for the microfluidic adsorption technology. Together, these activities will empower the PIs and graduate students with the knowledge and mindset to be entrepreneurs and innovators.
Designing failure-tolerant complex engineering systems (NSF CMMI-1562027; Tumer & Dong)

The goal of this research is to understand the failure tolerance of complex engineering systems based on a complex networks perspective by producing new modeling, analysis, and simulation formalisms. Of principal concern is that, as systems scale in size, the failure behavior of the system becomes increasingly dependent upon the pattern of connections between components, and the variables and parameters governing the physics-based behaviors of those components. While many researchers have introduced network models of complex engineering systems to address this property, the fundamental limitation in their approach is the reliance on physical and functional dependencies between components alone. This may in turn inadvertently produce systems having behavioral coupling leading to emergent global failure behaviors. The new methodological approach will: 1) explicitly address both physical architecture and behavioral, physics-based relations as contributing to the system's tolerance to failure; 2) incorporate a mesoscale property of complex networks and modularity, to understand how the architecture of components and their physics-based relations contribute to creating stability and failure tolerance. Our research objective are to: produce a methodology to model the behavioral and architectural morphology of complex engineering systems based on a synthesis of inter-genre network of networks and multi-domain design structure matrices; introduce new ways to model system failure modes as forms of faults in complex networks; derive a suite of metrics from mathematics of graph spectra, network robustness, and diffusion properties on networks to characterize the robustness of complex engineering systems; and, investigate new ways to design more robust complex engineering systems by re-architecting them at behavioral and architectural levels.

Intellectual Merit
We envision two broad scientific outcomes from this research. The first is a new conceptualization of robust design based upon the relational stability between design elements (physical components of a system and the variables and parameters that govern their behavior.) This would represent an important conceptual shift in thinking about robust design, moving away from component reliability alone towards consideration of the pattern of connectivity of elements. This will in addition expand upon the important principle of modularity in the engineering of complex systems due to their important function of control and stability within the system. The second is a network-based methodology and simulation environment capable of calculating indicative metrics of the robustness of a complex engineering system. We will introduce a set of measures which holistically capture the failure behavior of the complex engineering system not just at phase transition between nominal behavior and failure but before and after that as well. The aim is to produce a set of indicators to assist engineers in quantifying the failure tolerance of complex engineering systems without going through the expense of a complete system simulation, which in some cases may be neither feasible nor practical.

Broader Impacts
This project will use a simulation environment to calculate metrics of robustness for a complex engineering system that will be compatible with Modelica. As such, our simulation environment will be immediately available to the existing community of users. Users will be able to produce architectural and behavioral network models from their existing models, and then simulate robustness with their choice of metrics. The two GRAs will have the opportunity to visit each other over summer terms, consistent with NSF's East Asia and Pacific Summer Institutes for U.S. Graduate Students (EAPSI) program; and will help the students initiate professional relationships to enable future collaborations with foreign counterparts. The GRAs will also work with collaborators at NASA Ames Research Center during summers to understand the NASA complex network platform and the required design characteristics, and to obtain experience and exposure in a NASA setting. Undergraduate research for women and under-represented minorities will be an integral part of this project through programs at OSU (PNW-LSAMP and WEOP) and REU supplements. Thesis students will be co-mentored by the PIs as well as the GRAs, providing valuable mentoring experience for our GRAs. Finally, in addition to dissemination through conferences, the methods and insights from this research will be infused into existing undergraduate and graduate classes as Oregon State University.
Project Summary

CAREER: Advancing Grid Integration of Diverse Renewable Energy Sources

The objective of this proposal is to perform the fundamental research necessary to advance the grid integration of diverse variable renewable energy sources. The state of Oregon, along with many other states, has mandated a goal of 25 percent renewables by 2025. This proposal will research, investigate, and determine a concrete set of recommendations, supported by extensive research, analysis, and data, to approach 50 percent integration.

One of the most significant obstacles to the large-scale integration of renewable energy sources (e.g., wind, wave, solar) is the fundamentally variable nature of the output. Integrating variable sources to the regulated grid in large amounts is a significant technical challenge. Different renewable sources have different variability characteristics. It is hypothesized that wind, wave, and solar energy sources connected to the grid simultaneously will have a natural tendency to smooth variability in the aggregate generation, allowing more total renewable energy to be connected to the grid.

The proposed research will advance the state-of-the-art in three tasks. The first task is building the tools to describe and analyze variable renewable sources. The second task is using those tools to model how variable renewable sources interact with the grid and discover barriers to high penetration. The third task is to take the knowledge gained from the previous tasks and research real-world effective means of removing barriers to high grid-penetration of variable renewable sources.

Intellectual Merit

Engineers must rise to the challenge of matching a well-established, dispatchable-source, fossil-fuel paradigm to a new, flexible, variable renewable generation paradigm. The proposed research is on the very cutting edge of this challenge. The challenges and solutions to integrating large amounts of variable sources to the grid are not well understood. This proposal performs the fundamental research necessary to understand these limitations and also explores and creates novel, effective methods for removing these limitations.

Broader Impact

The proposed research will impact the energy systems field by discovering the advantages and challenges that lie within large-scale diversified renewable energy generation. The broader impacts also extend to the larger society, as increasing renewable energy generation will allow the eventual displacement of fossil fuel based generation. This will reap large benefits in terms of environmental impact and energy independence. The engine of this proposal work will be the graduate and undergraduate students, who through this process, will gain a keen understanding of the importance of renewables. In particular, the proposed research will provide an opportunity to several female graduate students who are studying with the PI in the area of renewable energy control. Involving these students in the research, outreach, and dissemination will assist in attracting additional underrepresented students to the program. The education and outreach components of this proposal will disseminate information directly to leading educators through faculty workshops. The public will be served through a series of free short courses and lectures on energy issues through a local community college.