MEDICAL PHYSICS/BASIC SCIENCE OPPORTUNITIES AT NSF

AAPM, WASHINGTON, DC, AUGUST 2, 2016

Bill Olbricht (wolbrich@nsf.gov)
Program Director
Particulate and Multiphase Processes

NSF Mission

- Promote the progress of science
- Advance the national health, prosperity, and welfare
- Secure the national defense; and for other purposes

- Investigator driven
- Receives proposals submitted to standing programs and solicitations

NSF organization: DIRECTORATES – divisions – programs

MATHEMATICS & PHYSICAL SCIENCES
Astronomical Sciences
Chemistry
Materials Research
Mathematical Sciences
Physics

BIOLOGICAL SCIENCES
Molecular & Cellular Biosciences
Integrative Organismal Systems
Biological Infrastructure
Environmental Biology

ENGINEERING
Chemical, Bioengineering, Environmental & Transport Systems
Civil, Mechanical & Manufacturing Innovation
Electrical, Communications & Cyber Systems
Emerging Frontiers & Multidisciplinary Activities
Industrial Innovation and Partnerships

COMPUTER & INFORMATION SCIENCE & ENGINEERING
Advanced Cyberinfrastructure
Computing & Communication Foundations
Computer & Network Systems
Information & Intelligent Systems

ENG/CBET: BIOMEDICAL ENGINEERING

Program Objectives

- develop novel ideas that integrate engineering with life sciences towards solving biomedical problems that serve humanity in the long-term
- to advance both engineering and life sciences with projects that integrate the two disciplines

Areas of Emphasis:

1. Molecular, cellular and tissue approaches for advanced biomanufacturing
2. **Neural engineering and human brain mapping**

Michele Grimm (mgrimm@nsf.gov)

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Quantitative Imaging of Tissue Oxygenation
PI: Vikram Kodibagkar (Arizona State)

- Develop theoretical model for systemic delivery of oxygen imaging probes
- Build MRI-compatible tissue simulating phantom to test model
- Application of model to measure tissue oxygenation using small-molecule MRI agent

Micro- and Nanoengineering Novel MRI Contrast Agents for Biomedical Sensing and Imaging
PI: Xin Zhang (Boston Univ) – ECCS

RUI: Development of Multifunctional Fluorine MRI Contrast Agents Based on Porous Silica Nanoparticles
PI: Jeremy Steinbacher (Canisius)

Extending the Luminescence Lifetime in Breast Cancer Diagnostics
PI: Stefan Bossman (Kansas State) – CBET/Nanobiosensing

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ENG/CBET: BIOPHOTONICS

Program Objective

Apply photonics to the fields of medicine, biology and biotechnology

Areas of Emphasis:

1. Novel technologies such as optogenetics to examine epigenetic changes associated with health and disease
2. Developing molecularly specific sensing, imaging, and monitoring systems with high sensitivity and resolution

Leon Esterowitz (lesterow@nsf.gov)

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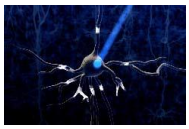
WHERE DISCOVERIES BEGIN

A Neurophotonic Platform for Causal Brain Analysis
PI: Edward Boyden, MIT



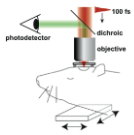
Neuron expressing rhodopsin2 illuminated by blue light fires an action potential

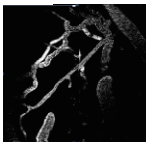
Neural network expressing a light-driven neural silencer is quieted when illuminated with orange light

WHERE DISCOVERIES BEGIN

Imaging Brain Blood Flow
PI: Chris Schaffer (Cornell)

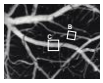
2-photon microscopy provides microscopic "images" deep in the cortex of anesthetized subjects.

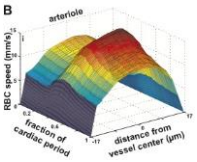


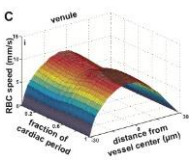


WHERE DISCOVERIES BEGIN

In-vivo imaging gives blood velocity profiles







Positive Contrast MRI for Imaging Small Interventional Devices
PI: Jim Ji Jimji (Texas A&M)

- Address challenges for MRI when interventional devices are involved
- Develop a novel susceptibility mapping technology to achieve rapid contrast MRI of brachytherapy seeds for prostate cancer treatment

ENG/CBET: FLUID DYNAMICS
PARTICULATE & MULTIPHASE PROCESSES

Program Objectives

Both programs support fundamental research in bio-inspired fluid dynamics, particulate systems, and associated transport phenomena

Experimental and theoretical research that spans scales from molecular to macroscopic

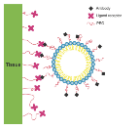
Areas of Emphasis

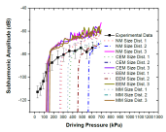
Biomietics, intracellular flows, fluid-structure interactions, hemodynamics, rheology of biological materials, functionalized nanostructures in diagnostics and therapy

Ron Joslin (rjoslin@nsf.gov)
Bill Olbricht (wolbrich@nsf.gov)

Engineering monodisperse lipid-coated microbubbles with distinct scattering spectra for ultrasound molecular imaging applications
PI: Tyrone Porter (Boston U), Kausik Sarkar (GWU)

- Lipid-coated microbubbles with tunable properties by changing lipid chemistry
- Guiding bubbles to targets with biomarkers for disease





Exploring Structure-Function Relationships in the Human Airways through Fluid Mechanics Experiments

PI: Filippo Coletti (Minnesota)

- MRI imaging and PIV velocimetry to characterize the flow experimentally
- 3D printing for fabricating models to study realistic geometries for healthy and diseased human airways
- Explore relations between morphology and mechanical properties of airways and transport of inhaled particles.

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Industrial Innovations and Partnerships

Advancing a Magnetic Resonance Imaging Design Discovery from Physics to the Emerging Imaging Marketplace

PI: Michael Martens (Case)

New magnet designs to reduce helium use, optimization of MRI coil magnets, enhance industrial partnerships

I-Corps: High Risk Patient Monitoring during Magnetic Resonance Imaging

PI: Tsz Ho Tse (Georgia)

New technology for patient monitoring during MRI, including high-risk patients hwo may be excluded from image-guided procedures

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MPS/PoLS: PHYSICS OF LIVING SYSTEMS

Program Objectives

Support theoretical and experimental research exploring the most fundamental physical processes that living systems utilize to perform their functions in dynamic and diverse environments. Focus of research proposals should be on understanding basic physical principles that underlie biological function.

Areas of Emphasis

1. Organization and function of living systems
2. Molecular architecture and dynamics in cells, energy metabolism, gene regulation and intracellular and intercellular communication, collective behavior and evolution of complexity in life forms and living populations

Krastan Blagoev (kblagoev@nsf.gov)

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WHERE DISCOVERIES BEGIN

MPS/PoLS: PHYSICS OF LIVING SYSTEMS

Collaborative Research: Unraveling Cerebral Connectivity with Diffusion MRI, Microscopy and Statistical Physics
PI: Van Weeden (Mass General)

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WHERE DISCOVERIES BEGIN

CISE/CCF: COMMUNICATIONS & INFORMATION FOUNDATIONS

CIF: Low-rank matrix and tensor methods for higher-dimensional MR image reconstruction
PI: Armando Manduca (Mayo Clinic)

CISE/CNF: INFORMATION TECHNOLOGY RESEARCH

A Cyber-Physical Framework for Magnetic Resonance Imaging (MRI) Guided Magnetic NanoParticles
PI: Randall Erb (Northeastern)

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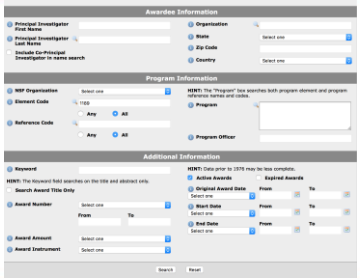
WHERE DISCOVERIES BEGIN

Major Research Instrumentation

Element code = 1189

1/11/17



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Goals of the CAREER Program

- Provide stable support for five years ($500K in ENG) to allow the career development of outstanding new teacher-scholars in the context of the mission of their organization.
- Build a foundation for a lifetime of integrated contributions to research and education.
- Provide incentives to universities to value integration of research and education.
- Increase participation of those traditionally underrepresented in science and engineering

CAREER proposals are still to be submitted separately by the deadline specified in the CAREER solicitation (July, 2017)

CBET Webinar – Spring 2016
http://www.nsf.gov/div/index.jsp?div=CBET (CBET homepage)

Unsolicited proposals to standing programs are submitted during submission windows that vary among programs

Consult specific programs for dates and budgetary information

Computational and Data-Enabled Science and Engineering (CDS&E)

The goal of the program is to promote the creation, development, and utilization of the next generation of theories, algorithms, methods, tools, and cyberinfrastructure in science and engineering applications.

High performance and emerging computational tools in advancing mathematical modeling, simulation and analysis to describe and analyze with greater fidelity, complexity and scale, engineering processes in chemical, biochemical and biotechnology systems, bioengineering and living systems, sustainable energy and environmental systems, and transport and thermal-fluids systems.

Due: October 2016

NSF's Proposal Submission and Evaluation Processes

- **Pre-submission**: Consult with program directors to find appropriate program; the preferred method is to submit a 1-page summary of your idea via email
- **Submission**: Follow the Grant Proposal Guide (submit by 5:00 PM local time)
- **Post-submission**: Wait a few months – most proposals are evaluated in topical panels

Evaluation criteria are **Intellectual Merit** and **Broader Impacts**

NSF Evaluation Criteria

- ***Intellectual Merit – the potential to advance knowledge***
  - Advancement and contribution of knowledge in its own field or across disciplines
  - Creative, original, and potentially transformative concepts
  - Well-conceived and organized research plan
  - Qualifications of the PIs
  - Access to sufficient resources

NSF Evaluation Criteria

- ***Broader Impacts – the potential to benefit society and contribute to the achievement of specific, desired societal outcomes***
  - May be accomplished through the research itself, through activities directly related to the research, or through activities supported by, but complementary to, the project.
  - Develops a diverse, globally competitive STEM workforce
  - Improves STEM education and educators at any level
  - Increases participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)
  - Enhances research/education infrastructure, such as facilities, instrumentation, networks, and partnerships
  - Increases public scientific literacy and engagement

NSF's Proposal Submission and Evaluation Processes

- Proposals must have a separate section titled "Broader Impacts"
- Proposals must have a section "Results from Prior NSF Support" for all Senior Personnel with NSF support in last 5 years, including descriptions of Intellectual Merit and Broader Impacts of the results
- A proposal can be designated as a renewal, but it will be treated as a new proposal
- A resubmission must be substantially revised and will be treated as a new proposal

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Questions ?

Contact: Bill Olbricht (wolbrich@nsf.gov)
703-292-2563

Thank You !

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WHERE DISCOVERIES BEGIN

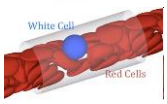
ENG/CMMI: BIOMECHANICS & MECHANOBIOLOGY

Program Objectives
Support fundamental research on multiscale mechanics approaches that integrate across molecular, cell, tissue and organ domains. Influences of mechanical forces on cell and matrix biology in the histomorphogensis, maintenance, regeneration and aging of tissues.

Areas of Emphasis:
1. Relationships between mechanical behavior and extracellular matrix composition and organization
2. Living tissues as smart materials that are self-designing

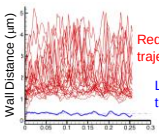
David Fyhrie (dfyhrie@nsf.gov)

WHERE DISCOVERIES BEGIN



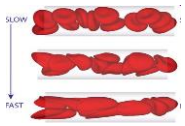
Dynamics of Blood Flow
PI: Jonathan Freund, Illinois

- An overactive inflammatory response starts with leukocyte adhesion to the endothelium.
- Fluid mechanical interactions between white and red cells influence onset of inflammation.



Red cell trajectories

Leukocyte trajectory



WHERE DISCOVERIES BEGIN

Designing Materials to Revolutionize and Engineer our Future (DMREF)

NSF and the Materials Genome Initiative

NSF is interested in activities that accelerate materials discovery and development by building the fundamental knowledge base needed to design and make materials with specific and desired functions or properties from first principles.

The DMREF goal is to control material properties through design by understanding interrelationships of composition, processing, structure, properties, performance, and process control.

- Proposals from multidisciplinary teams

  Chemistry Computer Science Materials Science
  Physics Engineering Mathematics

- Covers all material classes
  - Electronic
  - Photonic
  - Molecular
  - Biomaterials
  - Polymers
  - Magnetic
  - Ceramic
  - Metals
  - Alloys
  - Catalytic
  - Energy
  - Composites
  - Nano