

UNIVERSITY OF ILLINOIS
AT URBANA - CHAMPAIGN

Beckman Institute for
Advanced Science and Technology

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FOR IMMEDIATE RELEASE

New Proposals Selected to take the Beckman Institute to the Next Level
Seed proposal competition yields 11 new research awards

URBANA, Ill. – The Beckman Institute for Advanced Science and Technology recently held an open competition for awards to seed new interdisciplinary research directions in engineering and the physical, social, and life sciences. The competition brought many new ideas to the table and the Beckman Institute is pleased to announce that 11 proposals have been selected to receive support.

Pierre Wiltzius, Director for the Beckman Institute, said having the competition and funding these seed proposals is critically important to the Beckman Institute mission of fostering interdisciplinary research.

“This competition continues the self-renewal and reinvention process that is critical to maintaining the vitality of the Beckman Institute,” Wiltzius said. “The expectation is that these selected proposals will lead to externally funded programs within a couple of years and will form the building blocks of a new research initiative at the Beckman Institute.”

The selected proposal titles are as follows (*brief descriptions are included on the following page*):

- *Muscle Imaging and Speech Animation Using MRI Input Data (David Kuehn)*
- *Nanofibrous Scaffolds for Cartilage Engineering (Dominique Griffon)*
- *Multi-modality Molecular Imaging of Breast Cancer (Michael Insana)*
- *Exploring Analogies Between Neural and Social Systems (Thomas J. Anastasio)*
- *Targeted Contrast and Therapeutic Agents for Molecular Biomedical Imaging (Stephen Boppart)*
- *Application of Molecular Motors for Local and High Resolution Characterization of Single DNA Molecules (Alexey Bezryadin)*
- *The Phenotypic Impact of Substrate Dimension and Geometry: Interactions between Articular Chondrocytes and Microfilamentous Scaffolds (Matt Stewart)*
- *Combining Cells and Silicon (Nicholas Carter)*
- *Single Molecule Detection in Living Cells and Tissues Using a New Class of Optical Sensors Based on Single Walled Carbon Nanotubes (Michael S. Strano)*
- *Generating Extreme Speeds and Force from Small, Simple Materials: Biologically Inspired Models from Striking Ability in Trap Jaw Ants (Andrew Suarez)*
- *Developing Novel Methods for Neuroimage Analysis with Applications to Cultural Psychology (Y. Michelle Wang)*

The Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign is an interdisciplinary research institute devoted to basic research in the physical sciences, computation, engineering, and biological, behavioral, and cognitive sciences.

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Beckman Institute for Advanced Science and Technology

Brief Descriptions of the Selected Seed Proposals

Muscle Imaging and Speech Animation Using MRI Input Data

David P. Kuehn, Professor, Department of Speech and Hearing Science

Brad Sutton, Research Scientist, Biomedical Imaging Center

Janet M. Sinn-Hanlon, Biomedical Imaging Specialist, VMIL, Beckman Institute



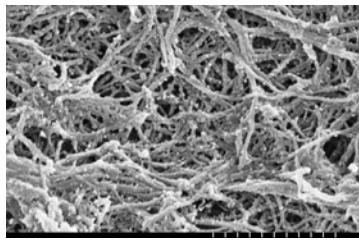
The ability to image the velar (soft palate) region in humans is crucial for a complete understanding of the anatomy of the region and for the best treatment for velar inadequacy, which is a major problem in individuals born with the birth defect of cleft palate. The most commonly used imaging procedures are limited in their ability to image underlying velar and pharyngeal musculature. This proposal will use magnetic resonance imaging (MRI) to substantially overcome current limitations. This new initiative seeks to use MRI to image speech during natural conversational speech to provide animation of critical speech structures within a semitransparent surface rendering of the human head. Such dynamic imaging of the speech production process is very important in diagnosing speech disorders in the clinical population with “occult” submucous cleft palate, which is

difficult to identify with the unaided eye. This approach avoids the necessity of multiple productions and would be a very significant improvement in clinical and research applications.

Nanofibrous Scaffolds for Cartilage Engineering

Dominique Griffon, Department of Veterinary Clinical Medicine, Laboratory for Orthopedic Research on Biomaterials

Brian T. Cunningham, Department of Electrical and Computer Engineering, Micro & Nanotechnology Lab



According to the Center for Disease Control (CDC) one of every three adults in the United States suffers from arthritis or chronic joint pain. Although tissue engineering offers new hope for treatment of damaged cartilage, the ideal matrix for in vitro chondrogenesis remains undetermined. The long term goal of this proposal is to improve the treatment of large articular cartilage defects by engineering osteochondral composites. The objective of this proposal is to optimize the structure of a nanofibrous scaffold in order to promote chondrogenesis. This is innovative because the molding process used to prepare these nanofibers is novel. In addition, adjusting fiber diameter to stimulate chondrocyte functions is a strategy that has not been evaluated.

Multi-Modality Molecular Imaging of Breast Cancer

Michael F. Insana, Department of Bioengineering

Thomas Huang, Department of Electrical and Computing Engineering

Zhi-Pei Liang, Department of Electrical and Computing Engineering

Stephen Boppart, Department of Electrical and Computing Engineering, Colleges of Engineering and Medicine

Rohit Bhargava, Department of Bioengineering

These investigators and their collaborators are actively developing molecular imaging technologies for cancer imaging. Uniting and focusing their efforts — as this proposal outlines — will provide an opportunity to explore the vast potential of multi-modality molecular imaging, draw in clinical collaborators, and thus address cancer imaging more comprehensively. The investigators envision that molecular approaches will enable noninvasive imaging of key anatomical and functional features of breast tissues that indicate molecular pathways unique to specific disease states, and thereby improve the sensitivity and specificity. To reach this goal, this group will work to identify the most promising imaging feature space for diagnosis and then optimally combine those features for lesion discrimination.

Exploring Analogies Between Neural and Societal Systems

Thomas J. Anastasio, Department of Molecular and Integrative Physiology

Lillian Hoddeson, Department of History

This proposal will explore how studying social systems might open new perspectives for understanding neural systems. The work will focus on two case studies. One will compare the organization and function of hierarchical social systems, such as scientific institutions, with hierarchical processing in brains. The other case study will compare the effects of trauma on memory loss in brains with the effects on cultural memory of “social traumas” such as war or other crises. The long-term goal is to grow the project from the case studies to a new interdisciplinary program in which ideas flow between the neural and social sciences in both directions, yielding new insights that would not only deepen knowledge, but also provide inspiration for novel technological applications.

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Targeted Contrast and Therapeutic Agents for Molecular Biomedical Imaging

Stephen Boppart, Department of Electrical and Computing Engineering, Colleges of Engineering and Medicine

William O'Brien, Department of Electrical and Computing Engineering, Colleges of Engineering and Medicine

Kevin Kim, Department of Electrical and Computing Engineering

Hyungsoo Choi, Department of Electrical and Computing Engineering

Michael Oelze, Department of Electrical and Computing Engineering

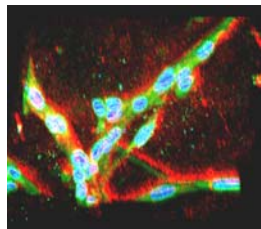
Kenneth Suslick, Department of Chemistry

John Katzenellenbogen, Department of Chemistry

Michael Strano, Department of Chemical and Biomolecular Engineering

Daniel Pack, Department of Chemical and Biomolecular Engineering

Kenneth Watkin, Department of Speech and Hearing Science



The development and application of molecularly-targeted contrast and therapeutic agents, across all clinical modalities, is in its infancy. Their development will contribute widely to the fields of medicine and biomedical imaging. The technical goals of this research initiative are as follows: 1) develop a set of contrast agents that may also have therapeutic capabilities; 2) develop a set of corresponding targeting protocols based on known cellular and molecular targets in cancer and heart disease; and 3) evaluate the efficacy of these targeted agents in tissue phantoms, cell cultures, and animal models. The intellectual merits of this proposal span multiple disciplines and directly address the need for translational research between the basic sciences, engineering and clinical medicine.

Application of Molecular Motors for Local and High-Resolution Characterization of Single DNA Molecules

Alexey Bezryadin, Department of Physics

Taekjip Ha, Department of Physics

Lawrence B. Shook, Department of Animal Sciences

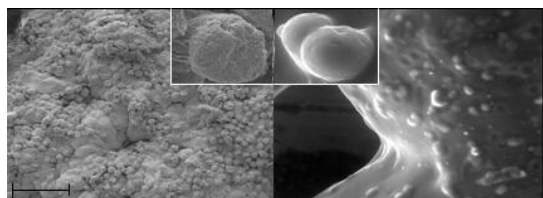
Gregory L. Timp, Department of Electrical and Computer Engineering

This proposal addresses the question as to if biological machines can be used to achieve high-resolution, high-rate imaging on the molecular level. Several proof-of-principal studies have reported interfaced molecular motors with nanoscale man-made objects, but the dream of using Nature's own nanomachines for practical applications has yet to be realized. Thus, molecular motors remain interesting structures that stir the imagination, but have not been used to create practically important functional devices. This project will make this important step by combining nanofabrication, kinesin-mediated microtubule transport, microfluidics and optical single-molecule detection. While each component of the project have been demonstrated previously, it is the unique combination proposed that makes this approach highly exploratory with very attractive future possibilities. Generally speaking, applications of molecular motors could provide elegant solutions to many practical problems including assembling multi-dimensional DNA structures.

The Phenotypic Impact of Substrate Dimension and Geometry: Interactions between Articular and Microfilamentous Scaffolds

Matt Stewart, Veterinary Clinical Medicine

Paul Kenis, Chemical & Biomolecular Engineering



Articular cartilage is a highly specialized connective tissue that lines the surfaces of high-motion joints. It equally distributes load across joint surfaces, resists compression and most importantly, provides frictionless, pain-free motion. Articular cartilage degeneration affects approximately 30% of adult Americans and over 50% of the elderly. It has little — if any — inherent reparative capacity. This proposal focuses on cartilage tissue regeneration. The major challenge of tissue engineering approaches to biological repair is to recapitulate the critical cell: matrix interactions that define and enable tissue function. Central to this issue is an understanding of how matrices impact cell phenotype and associated cellular activities. The complexities inherent to tissue engineering objectives far exceed the simplistic “cells on plastic” models used in most conventional biology studies. This study will focus on the dimensions and geometries of supporting 3D scaffolds which profoundly influence the phenotype and activities of articular chondrocytes, the cells responsible for cartilage synthesis. The goal of this proposal is to determine how the intrinsic dimensions and geometries of synthetic matrices influence the articular chondrocytic phenotype.

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Combining Cells and Silicon

Nicholas Carter, Department of Electrical and Computing Engineering

Geoffrey Dahl, Department of Animal Sciences, Environmental Physiology and Management,

Gregory Timp, Department of Electrical and Computing Engineering

Matthew Wheeler, Director, Transgenic Animal Facility at the UIUC Biotechnology Center

From drug design to environment monitoring, many of the critical challenges facing the research community lie at the boundaries between the traditional disciplines of biology and engineering. To overcome these challenges, new techniques must be developed that allow biological processes to be observed, analyzed and manipulated at the cellular level. In this proposal a program of research is outlined that will develop systems that combine nanoscale integrated circuits and living cells to directly interact with biological phenomena, leading to a revolution in biological and chemical sensing, new experimental platforms that allow fine-grained control of cellular development and implantable monitoring devices that protect food supplies from chemical contamination and disease.

Single Molecule Detection in Living Cells and Tissues Using a New Class of Optical Sensors Based on Single Walled Carbon Nanotubes

Michael S. Strano, Department of Chemical and Biomolecular Engineering

Taekjip Ha, Department of Physics

Thomas Eurell, Department of Veterinary Sciences

Klaus J. Schulten, Departments of Physics & Chemistry

Ilesanmi Adesida, Department of Electrical and Computing Engineering

Bibiana Onoa, Dupont Research

The focus of this proposed research program is to develop the scientific and engineering basis necessary to realize robust, single molecule detection in living cells in real time. To accomplish this, researchers will try to accomplish the following: understand and control transport and localization of nanotube sensors inside a murine myoblast stem cell model; investigate and utilize optical transduction mechanisms at the single nanotube level; develop and design rules for macromolecular assembly onto single walled carbon molecules by calculating intermolecular potential functions and simulating optical properties; and fabricate multifunctional, single nanotube sensors and demonstration of extended, real time detection of target analytes in a living cell system. The outcome could lead to technologies that transform science and medicine by creating probes as small as a single molecule that could communicate information about the sub-cellular environment remotely using near infrared light. This would have immediate applications to single cell physiometry, metabolic pathway engineering, disease diagnostics and biomarker identification, cell signaling and tracking trace analytes.

Generating Extreme Speeds and Force from Small, Simple Materials: Biologically Inspired Models from Striking Ability in Trap-jaw Ants

Andrew Suarez, Department of Animal Biology

Fred Delcomyn, Department of Entomology

Xudong Zhang, Mechanical and Industrial Engineering

Sheila Patek, Integrative Biology, University of California at Berkeley



The trap-jaw ant has an extreme striking ability and is among the fastest biological movements ever recorded. Advances in measurement and video-graphic technologies allows these movements to be characterized with improved precision which results in the characterization of novel mechanisms for energy storage, amplification and release (Patek et al. 2004). This proposal uses trap-jaw ants to identify general design principles for generating, storing and releasing large amounts of force using small, simple materials. In addition to direct measurements, this proposal will develop biomechanical models to characterize these movements. Ultimate goals of this research include the development of biological principles to inspire the design of robots, artificial limbs and muscles, and microtechnology.

Developing Novel Methods for Neuroimage Analysis with Applications to Cultural Psychology

Y. Michelle Wang, Departments of Statistics, Psychology and Bioengineering

Denise C. Park, Department of Psychology

Bradley P. Sutton, Department of Bioengineering, Biomedical Imaging Center

Increasingly, scientists collaborate across sites in brain imaging research. Thus, there is an increasing need for the development of improved analyses for interpretation of fMRI and sMRI data collected from different classes of subjects or patients and across different magnets or sites. This proposal seeks to develop novel, integrated methods for analyzing sMRI and fMRI data across sites, utilizing data collected from a project on the aging brain conducted jointly by scientists at UIUC and Singapore General Hospital. The project will develop novel analysis techniques as well as procedures for assessing comparability of neural signal across different research sites. The techniques developed will be available for applications in cross-cultural MRI data analysis as well as other applications more generally. This new project will not only advance research on the cognitive neuroscience of culture and aging, but also contribute to bioengineering research in medical imaging and biosignal analysis.