NJIT

Tomorrow's University:

CULTIVATING SYNERGY BETWEEN LIFE SCIENCES AND ENGINEERING

Over the past two decades, cascading breakthroughs and advances, particularly in information technology and the life sciences, have created a new interdependence among engineering, the physical sciences, computer science and math, and the biomedical sciences. This convergence of the life and healthcare sciences with the STEM disciplines is one of the major strategic themes for NJIT.

The Biology Connection

Associate Professor of Biological Sciences **Eric Fortune** *(above right)* studies the mechanisms of animal behavior, how their brains work, and what can be learned from them about how creatures, including humans, cooperate. He studies the Andean plain-tailed wren and other species with the goal of better understanding how human brains control their own behavior. With an NSF grant, he is studying the neural mechanisms for cooperative behavior, primarily the specific neural mechanisms and computations that are used in the coordination of vocal behavior between individual wrens. He also studies the interaction of social behavior and locomotor control in the central nervous system of weakly electric fish. He examines the cellular and circuit-level mechanisms by which fish cooperate through the control of their electric field and their locations relative to others of the same species nearby.

Advancing Neural and Tissue Engineering

Professor **Treena Livingston Arinzeh** *(left in photo above)* has earned national recognition for her pioneering adult stem cell research to find ways to use biomaterials to re-engineer tissues, especially using electrospinning, a technique in which an electrical charge draws nanoscale fibers from a liquid. She and Research Professor **George Collins** are currently developing a biologically-inspired material for cartilage tissue repair using a novel, semi-synthetic derivative of cellulose. Her work is supported by grants from the NSF and the Musculoskeletal Transplant Foundation. A paper by Arinzeh and her former student **Tonye Briggs'11** *(right in photo above)* published in the *Journal of Biomedical Materials Research*, examined the formulation of emulsion electrospinning as a method to prepare fibrous materials for growth factor delivery and provided an improved method for achieving controlled release of bioactive proteins from electrospun materials.

Associate Professor **Mesut Sahin** *(below)* is studying development of neural prostheses – devices and technologies for interfacing with the central nervous system. He is developing an interface between a patient's brain and a computer so that the paralyzed individual can control his own wheelchair and other equipment without help from a caregiver. A recent study published in the *Journal of Neuroengineering and Rehabilitation* in collaboration with his former doctoral student **Abhishek Prasad '10**, now on the faculty of the University of Miami, demonstrated that forelimb kinetics could be reconstructed by utilizing descending voluntary command signals in the dorsolateral spinal cord tracts above the point of injury as an alternative to brain-computer interfacing.

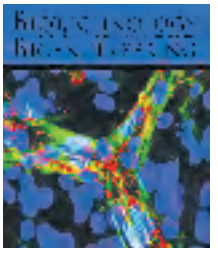
Professor **Farzan Nadim**'s *(below left)* research focus is to understand how synaptic dynamics, such as short-term depression and facilitation contribute to the generation and control of oscillatory neuronal activity. With grant support from the NIH, he is working to understand the structure and function of neuronal circuits essential for developing treatments for mental disorders. He is developing experimental measurements in the context of a novel mathematical framework to understand how synaptic and neuronal dynamics contribute to circuit function in oscillatory networks in the highly accessible crustacean pyloric network. The methods and characterizations developed can be generalized to more complex networks of the human brain to describe the emergence of biological oscillations and their disorders as observed in injury or pathological conditions resulting from demyelinating diseases, disorders of the striatum such as Parkinson's disease, schizophrenia and autism spectrum disorders.

Jorge Golowasch *(below)*, professor and chair of biological sciences, studies the relationship between biological rhythms and neuroactive substances such as neuromodulators, hormones and neurotransmitters. With NIH grant support, he is looking into the mechanisms by which neuromodulators and the neuronal networks' own activity regulate rhythmic pattern generation to understand the normal function of the nervous system. The capacity to recover stable neuronal output following disease or trauma may be of enormous therapeutic relevance and lead to the design of effective treatments for trauma, memory and sleep disorders.

Assistant Professor **Simon Garnier** *(below)* recently launched a new interdisciplinary research group called the Swarm Lab to study the mechanisms underlying the coordination of large animal groups, such as ant colonies or human crowds, and their applications to complex problems such as the organization of pedestrian traffic. He recently collaborated with researchers from the Research Center on Animal Cognition in Toulouse, France, in a study reported in *PLoS Computational Biology* that successfully replicated the behavior of a colony of ants on the move using miniature robots. The goal was to discover how individual ants when part of a moving colony, orient themselves in the labyrinth-like pathways that stretch from their nest to various food sources.

Professor of Biomedical Engineering **Tara Alvarez** *(above)* is continuing her research on the vergence system, which controls the inward and outward turning of the eye and supports viewing in depth and relates to everything from traumatic brain injury to the ability to wear progressive eyeglass lenses. With NSF support, she is currently developing an integrated portable neurovisual assessment system that will enable basic and clinical research scientists to assess neurovisual functions in normal and impaired populations. The two primary applications of this project will be to evaluate biomarkers to aid in the diagnosis of mild traumatic brain injury and develop new therapies for children who suffer from binocular dysfunctions. She has an international patent application for a technique to predict which individuals cannot adapt to wearing progressive lenses (bifocals without the line) with funding from Essilor International, Paris, France.

Research in the laboratory of Assistant Professor **Cheul Cho** *(below left)*, Department of Biomedical Engineering, has significant implications for cardiac health, tissue engineering and drug testing. Carried out in collaboration with Research Professor **George Collins** *(below top row, right)* and **Ali Hussain '11** *(below bottom row, left)* and doctoral student **Derek Yip** *(not pictured)*, the results of this work were reported in an article featured on the cover of *Biotechnology and Bioengineering*. The researchers co-authored "Functional 3-D Cardiac Co-culture Model Using Bioactive Chitosan Nanofiber Scaffolds," which describes an approach to the design and improvement of engineered tissues for the repair of myocardial infarcts and other healthcare applications.



Bryan Pfister *(above)*, associate professor of biomedical engineering, is leading a research team investigating physiologicial dysfunction from repetitive mild head injury with funding from Rutgers Medical School; New Jersey Commission on Brain Injury Research. While mild traumatic brain injury does not cause damage that can be revealed by neurological imaging, unknown changes may be inflicted on the brain, particularly when repetitive head injuries occur as may happen in sports or in active military duty. The study, in collaboration with faculty at New Jersey Medical School, is analyzing changes in neuronal signaling and behavior due to single and repetitive mild head injuries. The team is developing several methods for measuring changes in neurons and neural circuits and linking them to behavioral impairments in learning, memory and motor function.

Developing Diagnostic Technologies

Professor and Chair of Biomedical Engineering **Bharat Biswal** *(below standing)* focuses his research on mapping the brain's activity using non-invasive functional Magnetic Resonance Imaging (fMRI) to study how different regions of the brain communicate while the brain is at rest and not performing any active task. He and research associates *(below)* **Suril Gohel** *(center)* and **Rui Yan** *(right)* are currently working to determine the biophysical aspects of aging using fMRI in a project funded by the NIH through New Jersey Medical School. They are testing and quantifying the neural and hemodynamic components to identify neural and vascular mechanisms that cause older subjects to have altered brain activation in comparison to young subjects.

Research Assistant Professor **Alokik Kanwel** *(above left)* and **Reginald Farrow** *(above right)*, research professor of physics, lead a research team of physicists and chemists developing a prototype lab-on-a-chip that would someday enable a physician to detect disease or virus from just one drop of liquid, including blood. A paper describing their carbon nanotube-based device to noninvasively and quickly detect mobile single cells was published in *Biosensors and Bioelectronics*.

Syamala Pillai '13 *(below)* took first place in the International Society of Engineering Graduate Poster Contest for her poster describing a new, non-invasive technique for diagnosing fungal infections, a serious health threat for immune-compromised patients. Her team synthesized highly fluorescent derivatives of antifungal drugs that bind themselves to fungal cells, rendering them fluorescent and allowing diagnostic imaging.

Creating Pharmaceutical Technologies

Doctoral student **Afolawemi Afolabi** *(above)* won third place at the technical research exhibit of the National Society of Black Engineers for his presentation, "Batch and Continuous Production of Stable Dense Nanoparticle Suspensions via Wet Stirred Media Milling." Based on his PhD thesis research and supported by the NSF Engineering Research Center for Structured Organic Compounds, the study focuses on the formation and stabilization of drug nanoparticle suspensions. Assistant Professor **Ecevit Bilgili** is his advisor.

Laurent Simon *(below)*, associate professor of chemical, biological and pharmaceutical engineering, focuses on research that assists pharmaceutical companies in the development of innovative drug-delivery technologies. One recent study involved the distribution of timolol, a beta-blocker, in the

skin layers. He created a virtual environment to help predict patch performances, at early design stages, and determine the time elapsed before reaching a desired delivery rate. Another project identified chemicals that improve skin permeability to facilitate transdermal delivery of large drug molecules.

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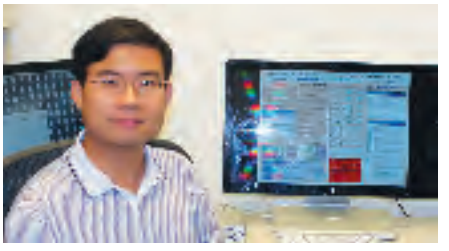
Healthcare Connections

Associate Professor of History **Stephen Pemberton** received a very positive review of his book, *The Bleeding Disease: Hemophilia and the Unintended Consequences of Medical Progress*, in the prestigious *American Historical Review*. He is currently working on a research project exploring how genetics was understood, appropriated, and advanced by 20th-century physicians engaged in preclinical and clinical research involving blood and diseases of the blood; from the use of biochemistry and animal models to the incorporation of the techniques of molecular biology into blood work, hematologists played a significant role in the formation of genetic medicine in the 20th century.

New Jersey Health Information Technology Extension Center (NJ-HITEC) and **NJIT** successfully partnered to bring Health Information Technology (Health IT) to students by assisting them in creating individual electronic Personal Health Records (PHRs) at the Campus Atrium in Newark. More than 500 students kicked off getting "Health IT Connected" by participating in this event through entering their medical information through Medicat, the Electronic Health Record (EHR) system selected by **NJIT**. New Jersey Commissioner of Health **Mary O'Dowd** *(left standing)*, looks on as a student inputs her medical information. Established by at **NJIT** and directed by **William O'Byrne**, NJ-HITEC is the leading Regional Extension Center in the nation with more than 7,900 member physicians, and more than 6,600 live on an EHR system. **Donald H. Sebastian**, **NJIT**'s senior vice president for research and development, is principal investigator.

Songhua Xu *(below)*, assistant professor of information systems, uses advanced computer techniques to build human-centered applications in information retrieval and management, web search, and data mining for biomedical applications. He is currently collaborating with researchers



at Oak Ridge National Laboratory on an NIH-funded project to data mine the web in the environmental cancer risk domain. The team will develop dedicated cyber-informatics algorithms and tools to automatically search online sources for retrieving and integrating contents related to individuals' cancer history and spatiotemporal environmental exposure profiles. The system will synthesize this information to accelerate knowledge discovery on environmental cancer risk change due to an individual's migration activities.

Doctoral student **Maxx Capece** earned a first-place prize in a competition sponsored by the Catalent Institute for a paper reviewing applications of dry-polymer control release drug delivery technologies on the particulate scale. His entry showcased insights on enabling a broader range of controlled-release application to dose forms such as film strips, solid oral dispersible tablets and liquid oral suspensions. **Rajesh Dave**, distinguished professor of chemical engineering, is his advisor.

Technologies designed to produce better medicines and improve the ways in which drugs are manufactured are the work of the NSF-supported Engineering Research Center for Structured Organic Particulate Systems (C-SOPS), a collaboration among **NJIT**, Rutgers University, Purdue University and the University of Puerto Rico, Mayaguez. **Rajesh Dave** *(below)*, distinguished professor of chemical engineering, lead investigator at **NJIT**, heads a team developing engineered

organic particulate materials with unique properties suitable for drug product formulations and drug delivery. He recently led a team of NJIT graduate students that developed a technology designed to mask the most challenging, unpleasant and bitter-tasting pharmaceutical active ingredients. The technology has been exclusively licensed by Catalent Pharma Solutions.

Cristiano Dias, assistant professor of physics, *(right)* with graduate student **Chitra Narayanan**, specializes in theoretical and computational biophysics. Using physical models and high performance computing to understand emergent phenomena in molecular biology, he seeks to decipher microscopic mechanisms accounting for protein stability and for the formation of secondary structure in peptides, to understand the role of water in the energetics and conformations of proteins, and to unravel how proteins interact with each other. The ultimate goal is the rational design of drugs for medical purposes. A recent study published in *Physical Review Letters* highlighted a unifying microscopic mechanism for pressure and cold denaturations.