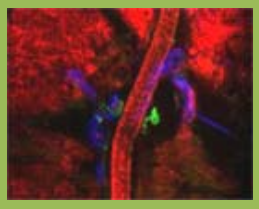
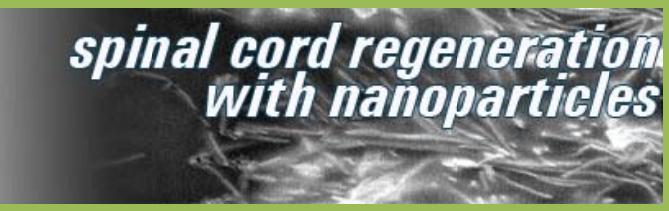
IGERT

NANOMEDICINE

Northeastern University





Northeastern University

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FOREWORD

Nanomedicine, the application of nanotechnology to medicine, has opened up a new, previously unimaginable world in disease diagnosis and therapy. Today new multifunctional nanoplatforms can be constructed that have capabilities for disease targeting using moieties such as antibodies, are endowed with image contrast enhancement capabilities for techniques like MRI and PET, and contain therapeutic payloads that can be released at the disease site. The vision of combining diagnostics and therapeutics, now being referred to as theranostics, was considered futuristic only a few years ago, but is now clearly achievable – the future is almost now! The field is exciting to students and there is worldwide demand for training in this area.

IGERT Nanomedicine Science and Technology is a new integrated doctoral education program at Northeastern University in the emerging field of Nanomedicine, created with support from the National Cancer Institute and the National Science Foundation. The program aims to educate the next generation of scientists and technologists with the requisite skill sets to address scientific and engineering challenges, with the necessary business, ethical and global perspectives that will be needed in the rapidly emerging area of applying nanotechnology to human health.

The Nanomedicine program began was the first of its kind when it was initiated in 2005 with an NSF IGERT grant funded by the National Cancer Institute. The success of the program then led to an NSF funded IGERT renewal grant for the period 2010-2015 with new partners, Tuskegee University, The University of Puerto Rico Mayaguez and collaborators at hospitals affiliated with Harvard Medical School.

The program combines the interdisciplinary expertise of world-renowned faculty members in 11 departments at 3 Universities, collaborating with researchers at teaching hospitals and industry. Students enrolled in a Ph.D. program in Biology, Chemistry, Physics, Chemical Engineering, Mechanical/Industrial Engineering, Electrical/Computer Engineering, or Pharmaceutical Sciences (Northeastern University), Materials Science and Engineering or Integrative Biosciences (Tuskegee University), Applied Chemistry or Chemical Engineering (UPRM) may apply to the IGERT interdisciplinary program. The IGERT fellow will graduate with a Ph.D. degree in their core subject with specialization in Nanomedicine Science and Technology.

The IGERT Nanomedicine program has trainees more than 47 doctoral trainees, established 4 new nanomedicine courses, involved more than 60 faculty from several institutions, led to nearly 100 publications in top journals, and established a vigorous outreach program. This report summarizes the principal achievements and notable highlights of the program. More details can be found at www.igert.neu.edu.

Srinivas Sridhar, Ph.D.
Director, IGERT Nanomedicine Science and Technology
Northeastern University
February 3, 2014

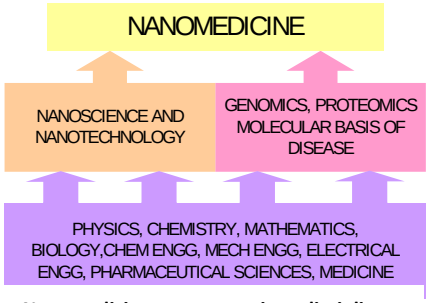
KEY FACTS

Key relevant facts about the NSF IGERT Nanomedicine program are summarized below:

- The NEU Nanomedicine program was the first of its kind and the only IGERT program in Nanomedicine to be renewed by the NSF. Phase I (2005-10) was local, involving NEU only; Phase II (2010-15) expanded the program to a national and global level.
- This interdisciplinary program incorporates students and faculty from 7 departments, including Chemistry, Biology, Pharmaceutical Sciences, Electrical Engineering, Mechanical Engineering, Chemical Apps Engineering, and Physics.
- The program is partnered with 13 partners in industry, hospitals, and government labs; and 22 academic partners including 14 in the U.S. and 8 overseas. 53 external collaborators have participated as student mentors, collaborators, and speakers.
- Over 50 NEU Faculty have participated as Ph.D. advisors, collaborators, and speakers.
- Under this program, 4 new courses in Nanomedicine were developed and taught (166+ students to-date).
    - Introduction to Nanomedicine Science and Technology (3 SH)
    - Nanomedicine Systems Design (2-5 SH)
    - Nanomedicine Product Development: From Concept to Market (3 SH)
    - Nanomedicine Seminar (1 SH)
- 43 Ph.D. students were supported and trained by the program since 2005.
- 390 NEU students & postdocs were trained on Nanocharacterization facility instruments since 2005.
- IGERT Trainees and faculty have published over 100 manuscripts in Nanomedicine since 2005.
- Over 120 talks on Nanomedicine have been organized and held at NEU since 2005. Typically, we host 15-20 talks each year.
- Trainees are co-mentored by internship advisors, leveraging NU's recognized leadership in experiential education (applied here for graduate education).
- Trainees actively participate in a vigorous K-12 outreach program, learning how to teach their newly acquired knowledge in Nanomedicine while inspiring the next generation of potential researchers.
- Overall, IGERT-related work has been mentioned in 63 news items to-date.

NANOMEDICINE – A NEW INTERDISCIPLINARY PARADIGM

Nanomedicine is a new interdisciplinary paradigm emerging from the timely convergence of two parallel recent developments – the decoding of the human genome that is leading to greater understanding of the molecular basis of diseases, and nanotechnology, which offers a powerful means to control molecular interactions (Figure 3). The success of this approach requires the fusion of the creative energies of practitioners of several disciplines, which is already leading to the emergence of nanomedicine as a new inter-disciplinary theme, paralleling similar developments such as neuroscience and bioinformatics.



Nanomedicine – an interdisciplinary paradigm

The central challenges of cancer therapy include: early diagnosis, targeted delivery and non-invasive monitoring of therapeutic treatments. Nanotechnology has opened up new opportunities to meet these challenges. New multifunctional nanoplatforms can be constructed that have capabilities for disease targeting using moieties such as antibodies, which are endowed with image contrast enhancement capabilities, and contain therapeutic payloads that can be released at the disease site. The overall cancer nanomedicine research methodology at the heart of the CaNCURE program is summarized in the accompanying figure (Figure 4).

Some of the specific key challenges that need to be overcome are:

- Development of therapeutic nanoconstructs to treat multi-drug resistant cancers,
- Development of nanoplatforms to facilitate multi-modal imaging using clinical technologies
- Development of new quantitative methods to enable non-invasive monitoring of drug delivery, biodistribution, and pharmacokinetics.

A new cadre of scientific experts and physicians is needed to address these formidable challenges, to sustain the nascent developments in cancer nanomedicine, and to discover future breakthroughs in applying nanotechnology to cancer.

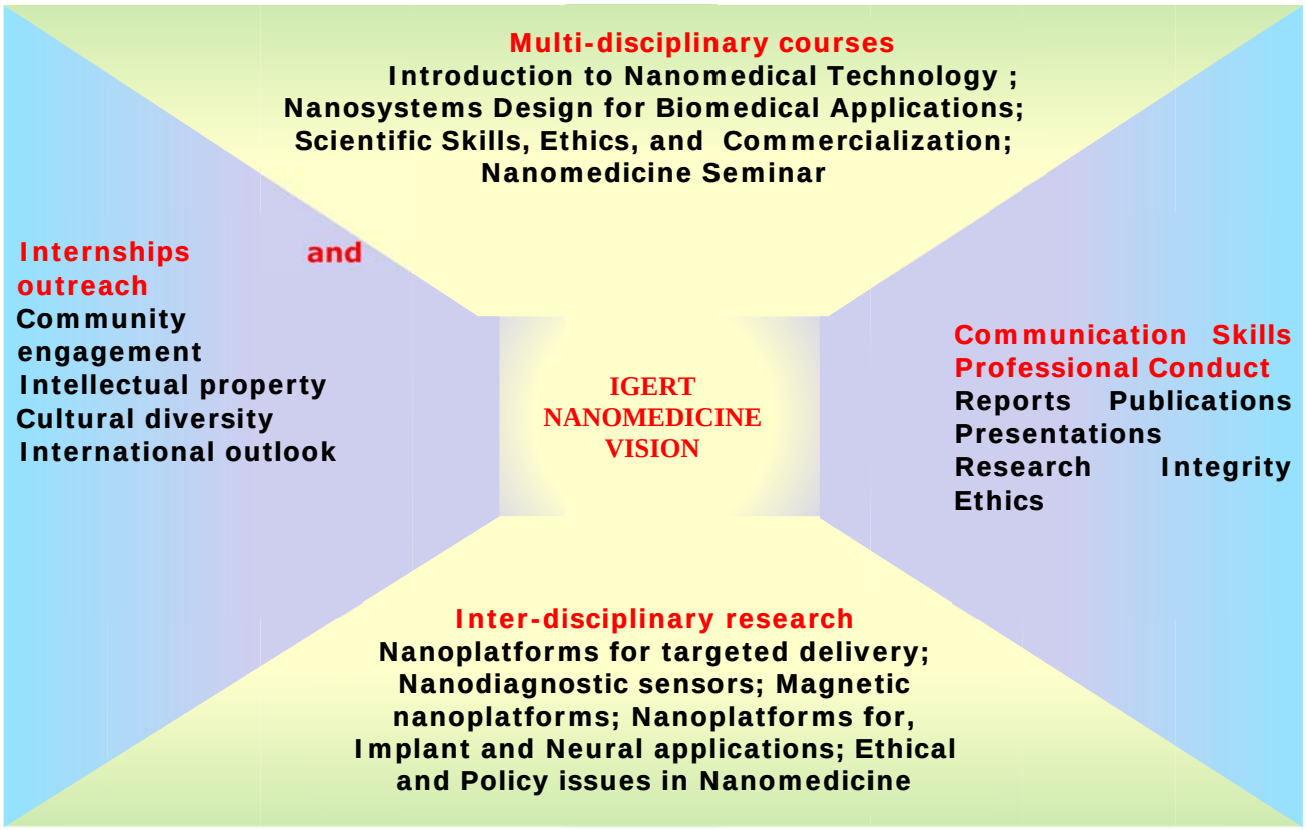
A successful researcher in this field will require a multi-dimensional skill set incorporating:

- The ability to identify key medical challenges and design the appropriate nanotechnology approach;
- The ability to design and fabricate nanoplatforms using principles from chemistry and materials science;
- Familiarity with nanotechnology characterization toolkits including optical microscopy, electron and atomic microscopy, and physicochemical techniques;
- An understanding of human biology and physiology at multiple scales, including tumor biology, drug pharmacokinetics, drug pharmacodynamics, and toxicity;

Because nanomedicine resides at the nexus of several disciplines: biology, chemistry, physics, optics, engineering, pharmaceutical sciences and medicine, a new training program was needed. A successful training program needs to integrate all of these elements at the pedagogical level, and in addition must also ensure that the necessary personal and professional development tools are not forgotten in the training program.

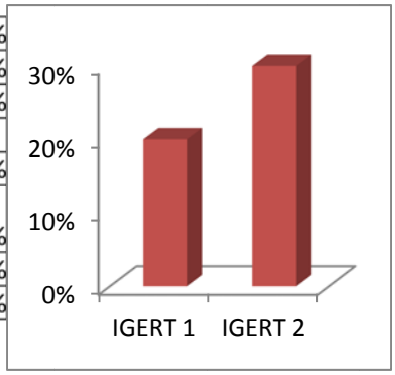
The IGERT Nanomedicine program aims to train the next generation of scientists and technologists who are skilled in research at the interface of nanotechnology, biology and medicine, who are aware of the path to translate fundamental knowledge to marketplace products, who are informed of the ethical and social issues relating to the discipline, and who have a strong sense of community involvement as well as a global perspective.

The IGERT Nanomedicine V ision is summarized in the graphic below.

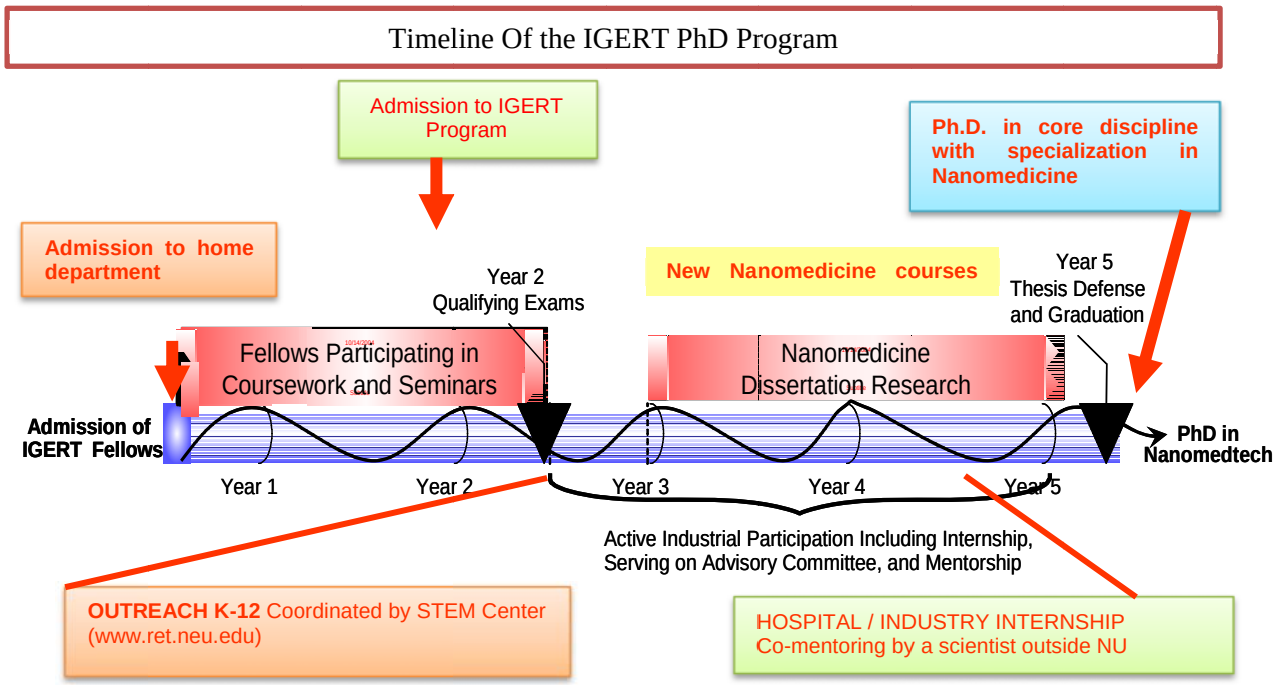


A key feature of the program has been the success in broadening participation by underrepresented populations. The data are summarized below.

Women	52%	Women	60%
Men	48%	Men	40%
Total	100%	Total	100%
Minorities	20%	Minorities	30%
Persons of Color	16%	Persons of Color	0%
Majority	64%	Majority	70%
Total	100%	Total	100%

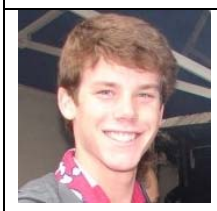


The timeline of academic progression of an IGERT trainee is summarized in the graphic below.



IGERT TRAINEE PROFILES

	Jodi Belz, *Ph.D. candidate* **Department:** Bioengineering, Northeastern University **Advisor:** Sri Sridhar **Implantable Nanoparticles Doped Brachytherapy Spacers for Synergistic Combinatorial Chemo-radiation Therapy in Prostate Cancer** I use a nanoparticle based platforms for a control dual-release localized delivery of therapeutics in conjunction with radiation therapy in prostate cancer. This new approach involves the fabrication of inert spacers doped with nanoparticles encapsulating anti cancer drugs and fluorophores. The use of nanoparticles in fabricating brachytherapy spacers provides a sustained release depot of drug delivering chemotherapeutic drugs at the target site locally, resulting in local radio-sensitization of the prostate with the use of lower radiation doses and thereby leading to less rectal toxicity.
	Codi Gharagouzloo, *Ph.D. candidate* **Department:** Bioengineering, Northeastern University **Advisor:** Sri Sridhar **Quantitative Multi-modal Cancer Imaging**
	Masoud Khabiry, *Ph.D. candidate* **Department:** Bioengineering, Northeastern University **Advisor:** Nader Jalili **High-Throughput Microfluidic Platform for Personalized Nanomedicine** Cancer remains as one of the leading causes of mortality worldwide, affecting over 10 million new patients every year. High-throughput studies of drug-loaded nanoparticles on patient derived cancer cells can be carried out in a novel and simple shear protected microfluidic platform. The goal of this proposal is to develop an integrated microfluidic system containing cell immobilization microchambers which enable the control of fluid flow, generate stable concentration gradients, and regulate cell-nanoparticle interactions in a temporal and spatial manner.

	Robert Abbott, *Ph.D. candidate* **Department:** Biology, Northeastern University **Advisor:** Michail Sitkovsky **Lymph node nanoparticle delivery of A2aR antagonists to boost vaccine responses , Lymph node targeting using nanoparticle delivery system for HIV vaccine**
	Daniel Hickey, *Ph.D. candidate* **Department:** Chemical Engineering, Northeastern University **Advisor:** Thomas Webster **Nanostructured Magnesium as a Novel Material for Orthopedic Tissue Engineering**
	James Teh, *Ph.D. candidate* **Department:** Chemistry, Northeastern University **Advisor:** Robert Hanson **Design and Characterization of Multimeric RGD Peptidomimetic Gold Nanoparticles for Tumor Diagnostics and Enhanced X-ray Radiotherapy** Gold nanoparticles (AuNPs) have unique physical and chemical properties appropriate for diagnostic and therapeutic applications in cancer. A novel approach is the use of AuNPs for radiotherapy, which upon exposure to low-energy X-ray radiation produces Auger electrons ultimately causing cellular apoptosis. Thus, a radio-sensitization effect of AuNPs can be achieved by making them more selective towards the target tumor cells. AuNPs can be engineered to conjugate with targeting ligands designed to bind specifically to receptors on tumor cell for molecular-specific imaging and detection. Over-expression of αvβ3 integrin receptors on the surface of tumor cells plays a critical role in regulating tumor invasion and metastasis. Therefore, targeting ligands containing the RGD sequence have been developed to have high specific binding affinity toward αvβ3 integrin receptors. Monovalent ligands may interact too weakly for adequate tumor targeting, and therefore we proposed a new approach in which AuNPs that display multivalent ligands may overcome this problem. Thus, the goal of this proposal is to functionalize the surface of AuNPs with linkers that incorporate multivalency. RGD peptidomimetics will be designed for coupling via “click” chemistry to trivalent dendrons which are themselves designed to bind to AuNPs. Furthermore, surface-enhanced Raman scattering (SERS) tags are covalently bound to the surface of AuNPs to produce significant Raman signals that will be employed for bioimaging. Investigations conducted on this approach will be employed in vitro and in vivo using human cancer cells expressing αvβ3 integrin receptors.

Jennifer Woodring, *Ph.D. candidate*
Department: Chemistry, Northeastern University
Advisor: Michael Pollastri

Site-Specific delivery of anti-infective therapies in neglected tropical diseases using nano-sized formulations

Human African trypanosomiasis, or African sleeping sickness, is a NTD disease that affects 36 countries in sub-Saharan Africa. It has a 100% fatality rate if not treated. There are only 4 drugs available for HAT: pentamidine, suramin, melarsoprol, and eflornithine. All 4 are expensive, not orally bioavailable, have severe adverse effects, require patient hospitalization, and are starting to show signs of resistance. Furthermore, melarsoprol has a 5% mortality rate due to its extreme toxicity. There is a dire need for new therapeutics, as well as better delivery systems for widespread distribution and patient compliance of these chemotherapeutics. A recent study showed that when melarsoprol is complexed with cyclodextrin, not only was it orally bioavailable, but it was just as potent and less toxic to the animal models compared to regular melarsoprol dosing. By encapsulating drugs into oil-in-water nanoemulsions or liposomes, we hope to increase the bioavailability of these current commercial drugs as well as our own NEU synthesized compounds. These nanoformulations could also have the potential to show less toxicity and better blood brain barrier penetration.

Stacey Markovic, *Ph.D. candidate*
Department: Electrical and Computer Engineering, Northeastern University
Advisor: Mark Niedre

Enumerating Rare Cells Labeled with Fluorescent Nanoparticles, Nanoparticle Diffusion in PC3 Prostate Tumors In Vivo

Raquel Feliciano, *Ph.D. candidate*
Department: Materials Science and Engineering, University of Puerto Rico, Mayaguez
Advisor: Oscar Perales-Perez

Aqueous Processing Of Semiconductor Quantum Dots For Potential Bio-Medical Applications

Nanoparticles (NP) and quantum dots (QDs) exhibit unique optical properties that make them promising candidates for nanomedicine applications, e.g. bioimaging, pathogen detection and photodynamic therapy (PDT). The optical properties of CdSe nanoparticles are desirable in bio-imaging and cell sorting applications because of their tunable photoluminescence at the visible range. Previous studies have already demonstrated that CdSe could be utilized for pathogen detection, but given the potential cytotoxicity of CdSe for biomedical applications, the use of inorganic oxides with known biocompatibility with humans, such as ZnO, has also been considered.

	Although the synthesis of ZnO as antimicrobial agents has been reported elsewhere, the used of ZnO NPs for pathogens detection limit are scarce or preliminary. Our scope is not only confirms the antimicrobial activity, but developed a coupling with the ZnO NPs to enhance the detection limit that is already report in the literature. Based on the above considerations, the present research will assess the applicability of fluorescent Zn-based nanocrystals as probes for detection of pathogens with the aim of achieving extremely low detection limits. Cd-based quantum dots will be used to establish the proof-of-concept and will also be evaluated for comparison purposes only. The first part of the research will address the optimum functionalization of the QDs with ligand species specific to pathogens' outer membrane. *E. Coli* will be used as a first case-study. The conditions leading to the optimum QD-bacteria coupling will also be determined. Finally, the protocols for the highly-sensitive detection of pathogens using coupled QD-bacteria will be established.
	Julaunica Tigner, Tuskegee U, *Ph.D. candidate* **Department:** Materials Science and Engineering, Tuskegee University **Advisor:** Tamara Floyd-Smith **A Carbon NanoFiber Sensor with Integrated Microfluidics for Detection of Glucose and Interleukin 6** A carbon nanofiber array (CNF) sensor with electrochemical detection is proposed for the detection of both glucose and Interleukin 6 (IL-6), an important biomarker in immune response. The CNFs are vertically aligned with a range in diameter from 25 to 100 nm and a range in height from hundreds of nanometers to one micrometer. These CNFs are grown by plasma enhanced chemical vapor deposition (PECVD). The CNFs have a bamboo-like structure with active sites at the open ends of the CNFs and along the shaft of the CNFs. Biological agents such enzymes and antibodies can be attached to these active sites using surface chemistry. For detection of glucose, the enzyme, glucose oxidase, is proposed to catalyze the oxidation of glucose to produce hydrogen peroxide which can be detected using electrochemistry. For the detection of IL-6, antibody-antigen binding followed by electrochemical transduction is proposed. By the completion of this project, we anticipate developing (1) a glucose sensor that can be used as a tool to deploy nanomedicine to K-12 classrooms and (2) an optimized IL-6 sensor with potential commercial applications
	Matt Dubach, Ph.D. (2012) **Department:** Bioengineering, Northeastern University **Advisor:** Heather Clark **Sodium concentration reporting fluorescent nanosensors for biological applications** My research focuses on developing novel fluorescent nanoparticles to use as tools for measurement of chemical concentrations in biological samples. With these

	nanoparticles, we have measured sodium dynamics in excitable cells and sodium concentrations in the skin of mice, which correlate to blood concentrations. I am currently creating nanoparticle sensors that will function as a long-term sensing tattoo in the skin and developing novel imaging devices to measure the sensor response. This research has enabled me to establish a company, Ionu Biosystems, with the goal of making our nanoparticle sensing technology a medical product for human use. In 2012, we received an SBIR grant from NASA to develop a smart phone Chem8 blood test. As the principal investigator on this grant I plan to utilize the skills and knowledge I obtained in the Igert nanomedicine program to advance our product towards human use. http://www.ionubiosystems.com/ www.linkedin.com/in/jmdubach https://www.researchgate.net/researcher/38672802_J_Matthew_Dubach/
	Mary Kate Balaconis, Ph.D. (2013) **Monitoring** **Department:** Bioengineering, Northeastern University **Advisor:** Heather Clark **The Development of Fluorescent Glucose Nanosensors For In Vivo Glucose** My project is the development and in vivo testing of fluorescent nanosensors for glucose monitoring. These nanosensors will provide a minimally-invasive method for monitoring glucose levels in diabetes. In our proposed system, the sensors will be injected minimally-invasive into the upper layers of the skin. Their fluorescence intensity will be measured and correlated to glucose levels using a handheld device. www.linkedin.com/pub/mary-kate-balaconis/79/803/425 https://www.researchgate.net/researcher/35816657_Mary_K_Balaconis/
	Anthony D'Onofrio, Ph.D. (2009) **Department:** Biology, Northeastern University **Advisor:** Kim Lewis **Nanoparticle Antimicrobial Development** The unique properties of iron oxide nanoparticles hold exciting potential as an antimicrobial. Magnetic iron oxide nanoparticles are capable of producing heat when exposed to an external oscillating magnetic field. When targeted specifically to bacterial cells, this property could be exploited to induce bacterial death by hyperthermia. This strategy has exciting implications since bacterial infections are known to be notoriously recalcitrant. Biofilm infections in particular are difficult to sterilize due to a small subpopulation of persister cells, which are tolerant to antibiotics. These cells are phenotypic variants in a state of dormancy, which affords them tolerance to high doses as well as combinations of antibiotics. Thermal disruption by nanoparticles is

	particularly exciting because the strategy aims to disrupt bacterial cells regardless of their metabolic state. The technique has the potential of sterilizing infections by killing not only the bulk of the population but the tolerant persister fraction. The project is being carried out as a collaboration between the Northeastern IGERT Nanomedicine Program and the Northeastern Antimicrobial Drug Discovery Center. www.linkedin.com/in/anthonydonofrio http://www.northeastern.edu/insolution/technology/2012/03/sample-america/
	Sucharita Saha, *Ph.D. Candidate* **Department:** Biology, Northeastern University **Advisor:** Donald O'Malley **Collaborators:** Mansoor Amiji, Latika Menon **Visualization and Enhancement of Spinal Cord Regeneration using Nanoparticles** The goal of this project is to employ functionalized nanoparticles to evaluate the feasibility of delivering DNA- or RNA-functionalized nanoparticles to brainstem neurons damaged in spinal cord injury. We will visualize the expression of exogenous neural repair genes in identified brainstem neurons and determine the effects of such expression on axonal regeneration and functional recovery. This project will establish an important technical paradigm since the retrograde transport of functionalized nanoparticles, has not previously been documented. Using this system, we will be able to test the effects of candidate repair genes in a system in which both the regenerating descending neurons and the target spinal neurons can be individually identified and visualized inside the intact, regenerating animal. **Application of Nanoarray Technologies to Spinal Stimulation and Regeneration: the Nano-BMI (brain-machine interface)** The purpose of this project is to design a nanowire interface to study the electrical properties of biological cells and tissues. The long term goal in fabricating this device, will be to evaluate the use of nanowire arrays to stimulate spinal regeneration and elicit locomotor movements in spinal-injured larval zebrafish. Prior to testing nanowire implants in zebrafish, we will perform validation experiments on cultured cell lines that will establish effective nanowire, and nanowire array, dimensions for both the recording and stimulation of neural activity.This work will allow us to directly test the efficacy of nanoscale brain-machine interfaces inside a vertebrate animal where we can visualize both the array and the surrounding neural networks with high-resolution. Testing the performance characteristics of such in vivo arrays, for both recording and stimulation, is an essential first step towards the use of nano-BMIs in the repair of the damaged central nervous system.

Paula Lampton, Ph.D. (2008)
Department: Biology, Northeastern University
Advisor: Carol Warner

Using Nanoparticles to Analyze Key Immune System Molecules in Embryonic Stem Cells
The goal of my IGERT thesis project is to characterize the expression and localization of MHC class I molecules in embryonic stem cells. Embryonic stem cells are pluripotent cells capable of unlimited self renewal as well as differentiation into all the cell types of the body. The major histocompatibility complex plays a major role in the success of transplantation therapy and is therefore an important area of research for ES cells and their differentiated derivatives. Semiconductor nanoparticles, quantum dots, will be utilized for specific imaging and localization of MHC class I proteins in embryonic stem cells and for live cell tracking of different stem cell populations.

Imaging of Embryonic Stem Cells using Multiphoton Luminescence of Gold Nanoparticles
Using the Keck 3D Fusion Microscope (located at Northeastern University), we were able to detect gold nanoparticles via multiphoton photoluminescence in mouse embryonic stem cells. The embryonic stem cells were able to grow for several passages in the presence of the non-toxic gold nanoparticles and cellular uptake of the nanoparticles was demonstrated by multi-photon imaging. The use of multi-photon luminescence using gold nanoparticles may be useful for in vitro stem cell tracking and monitoring.
www.linkedin.com/pub/paula-lampton/4/5b4/951
https://www.researchgate.net/researcher/14706082_Paula_W_Lampton/

Savidra Lucatero, Ph.D. (2011)
Department: Chemical Engineering, Northeastern University
Advisor: Elizabeth Podiaha-Murphy

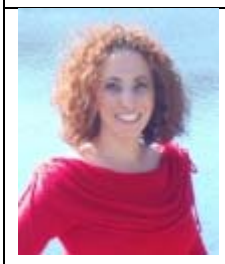
Photocatalytic activity of AuFe/TiO2 composites
My research project focuses on characterizing the photocatalytic performance of FeAu/TiO2 composites for the degradation of chlorinated contaminants and hydrogen generation. This system is designed to prevent catalyst aging or deactivation effects observed in Au/TiO2 through cathodic protection by galvanic contact to a less noble metal, Fe. An improved photoactivity of this novel catalyst is expected under UV irradiation by noble metal incorporation and enhanced surface area available by its nanoporous structure. In addition, this enhanced activity is expected to last longer than Au/TiO2 counterparts by means of Fe incorporation. The catalytic performance of the fabricated composite is being investigated under monochromatic UV light and characterized by means of cyclic voltammetry, a step in the illumination and

	impedance modulated photocurrent spectroscopy. www.linkedin.com/pub/savidra-lucatero/1a/a58/855 http://iris.lib.neu.edu/chemical_eng_diss/11/
	Brian Plouffe, Ph.D. (2011) **Department:** Chemical Engineering, Northeastern University **Advisor:** Shashi Murthy **Microfluidic Cell Separation Using Functionalized Magnetic Nanoparticles** Metastases are a significant problem in cancer research, since metastasis from the primary tumor to distant organs causes 90% of cancer-related deaths, i.e. half-a-million people in the US. Detection of (CTCs) in whole blood demonstrates that there is a connection between the primary tumor and metastases. I plan to develop a point-of-care, disposable microfluidic device capable of efficient and rapid isolation of rare circulating tumor cells (CTCs). My approach hopes to provide a unique platform technology to detect cancer and capture circulating tumor cells. Moreover, this new microfluidic tool to capture CTCs could lead to the discovery of targets for further basic and clinical research. I propose to integrate nanotechnology, biology and microfluidics to isolate CTCs from whole blood focusing, specifically, on breast cancer cells. In order to achieve this objective, I hope to (1) develop a method to enable selective selection of CTCs by nanoparticle labelling and then (2) develop a point-of-care, high-throughput microfluidic CTC capture technology utilizing the now magnetically label cells. www.linkedin.com/in/bdplouffe http://www.northeastern.edu/news/2012/02/plouffe/ Part-time faculty at northeastern, Chemical Engineering Thermodynamics II http://quadtechnologies.com/about/
	Vanessa Ayala Rivera, Ph.D. **Department:** Chemical Engineering, University of Puerto Rico Mayaguez **Advisor:** Madeline Torres-Lugo **Collaborators:** Carlos Rinaldi **Effect of molecular weight of grafting polymer on colloidal stability, cell-nanoparticle interactions and in vivo biodistribution**
	J. Adam Hendricks, Ph.D. (2009) **Department:** Chemistry, Northeastern University **Advisor:** Robert Hanson **Synthesis of Spin Labeled Nanosensors for the Estrogen Receptor** Since the term "nanotechnology" was introduced in 1986 by Eric Drexler, it has grown to include a variety of disciplines; such as medicine. The goal of my research is to apply

	nanotechnology to the field of medicinal organic chemistry through the development of novel nanosensors for the estrogen receptor. This research project will begin with the synthesis of a spin labeled 17-α-substituted estradiol using a Stille coupling. Concurrently with the preparation of the spin labeled estradiols will be the synthesis of nanoparticle linkers. Electron paramagnetic resonance (EPR) studies of the new compounds will further characterize the estrogen receptor in more physiological conditions allowing for the determination of any conformational changes that occur upon binding of a ligand. With these results a second generation of spin labeled estradiols will be prepared and immobilized to gold nanoparticles that were being prepared throughout. The immediate application of these sensors will be as a new diagnostic material that can be used for drug design. It is the long term goal of this project is to use these compounds not only as nanosensors but as "nanomachines" in drug delivery and possible as therapeutics themselves. http://iris.lib.neu.edu/chemistry_diss/15/ www.linkedin.com/pub/j-adam-hendricks/a/835/767 https://www.researchgate.net/researcher/71456534_J_Adam_Hendricks/
	Heather Brodkin, Ph.D. (2009) **Department:** Chemistry, Northeastern University **Advisor:** Mary Jo Ondrechen **Computationally Guided Protein-Specific Labeling with Nanoparticles** We propose a new approach to the labeling of human biomarker proteins with nanoparticles. We have predicted binding sites on biomarker proteins using electrostatics methods developed by us. Small molecule ligands with high, specific affinity for these sites will be attached to the biomarkers. Linker groups on the small molecules will be coupled to nanoparticles. In order to express human biomarker proteins, we had to develop new techniques for expression in bacterial systems. Using computationally guided experimental design, we hope to provide a fast, cost effective means for the labeling of proteins with nanoparticles using highly specific coupler ligands for biomedical research. www.linkedin.com/pub/heather-brodkin/3a/405/203 https://www.researchgate.net/researcher/57832732_Heather_R_Brodkin/
	Tatyana Chernenko, Ph.D. (2010) **Department:** Chemistry, Northeastern University **Advisor:** Max Diem **Novel Approach to Imaging of Nano-Drug-Delivery Carriers Based on Raman Microscopy** Cell targeting has been the growing field of interest in gene therapy and anticancer treatments. Of particular interest are pharmaceutical drug delivery systems, such as

	micelles and liposomes. In order to monitor their uptake, intracellular fate and determine their sites of action, fluorescence microscopy has been widely used in the biological field as an imaging technique. However, this method provides a number of limitations which include low contrast or photo-bleaching of the sample as well as the need for introduction of extrinsic dyes or stains into the system. Although they have been extensively used, fluorescing labels, introduced intracellularly, may potentially alter the biochemical properties of the molecule of interest. We thus employ Raman micro-spectroscopic techniques, which are based on vibrational spectroscopy coupled with optical microscopy to provide a non-invasive and non-destructive method for cellular imaging. This technique provides a novel method to spectroscopically map the biochemical components of an individual cell. Spectra can be recorded from different organelles or locations within the cell and spectral differences identified that characterize biochemical components. We propose to utilize this technique to identify the presence of liposomes within a cell and map their concentration and distribution therein. In addition, the sensitivity of liposome detection can be substantially increased by fabricating them entirely from deuterated phospholipids, which provide very strong Raman signals. Liposomal research is still underway and their sub-cellular targets still under scrutiny. Hence the dire need for the ease of chemical characterization of the liposomes themselves as well as their docking sites is still one of the top priorities. We thus offer a novel approach to monitoring liposomal targeting, which can ultimately be applied to in vivo studies. www.linkedin.com/pub/tatyana-chernenko/4/a20/12 https://www.researchgate.net/profile/Tatyana_Chernenko/
	Agnes Rafalko, Ph.D. (2011) **Department:** Chemistry, Northeastern University **Advisor:** William Hancock **Use of nanotechnology for imaging of cell surface oligosaccharides for early diagnosis of cancer** Glycosylation is one of the most common post-translational modifications for human and other eukaryotic proteins and is required for many proteins to fold to the correct 3-dimensional structure and thus achieve full biological activity. It has been established that cell surface oligosaccharides are major determinants of altered glycosylation pattern in cancer cells. Profiling of glycans in cells and biological fluids for elucidating their function with respect to human disease has been accomplished by affinity capture with lectins. In order to visualize changes in glycosylation in cells and tissues we propose to functionalize the surface of gold nanoparticles (40 nm) with lectins that will be delivered to specific glycan types via selective binding of lectins to different glycan

	motifs. Once incorporated into the glycans, this nanosystem will be applied to non-invasive imaging of glycan types and changes in their structure using 2-photon confocal laser scanning microscopy. Imaging of glycosylation changes presents a significant opportunity for early non-invasive, sensitive, and specific detection of unique "biochemical signatures" that differentiate and characterize tissues beyond and before their gross anatomical features become obvious. www.linkedin.com/pub/agnes-rafalko/18/a08/2b8 https://www.researchgate.net/profile/Agnes_Rafalko/
	Joslynn S. Lee, *Ph.D. candidate* **Department:** Chemistry, Northeastern University **Advisor:** Mary Jo Ondrechen **Computationally Guided Ligand Design for the Human Adenosine A2A Receptor for Nanoparticle Imaging of Hypoxic Tumors** www.linkedin.com/in/joslynnlee https://www.researchgate.net/researcher/55385395_Joslynn_S_Lee/
	Jennifer (Monahan) Fore, Ph.D. (2013) **Department:** Chemistry, Northeastern University **Advisor:** Max Diem **Raman-active gold nanoparticles as beacons in breast cancer cells** Nanoparticles can be utilized to overcome the undesired side effects that occur with current chemotherapeutic treatments by delivering the drug directly to the tumor site. Raman-active gold nanoparticles (RA-AuNPs) can be used as biotags to deliver and track the nanosystem throughout cervical cancer cells by exploiting surface-enhanced Raman spectroscopic (SERS) effects. We propose a nanosystem design containing a gold nanosphere core along with a SERS reporter (2-cyano-2-hexanoic acid). This SERS reporter was chosen due to its cyano functional group, which can be used to track these particles. The location of the peak in the Raman spectrum is devoid of any other cellular information allowing for the use as a beacon. This inner core will be encapsulated by a hydrophobic pocket to allow for incorporation of hydrophobic drugs. The hydrophobic pocket will be surrounded by a hydrophillic outer layer, which will include targeting peptides for the HER2/neu receptor of breast cancer cells. The SERS reporter will behave as a beacon by enhancing the Raman signal while the targeting peptides will specifically target breast cancer cells. The use of Raman microspectroscopy allows for mapping of cancerous cells. When coupled with vertex component analysis contained in an in-house written MATLAB routine, namely ViChe, allows the production of pseudo color maps based on spectral dissimilarities. This process will allow us to detect and monitor RA-AuNPs capable of delivering

	chemotherapeutic agents. www.linkedin.com/pub/jennifer-fore/30/822/8a0 https://www.researchgate.net/profile/Jennifer_Fore/
	Michael Cuccarese, *Ph.D. candidate* **Department:** Chemistry, Northeastern University **Advisor:** George O'Doherty **Synthesis of Nanoencapsulated Aminoglycosides as Small-Molecule Gene Therapeutics** Aminoglycosides are a class of broad-spectrum antibiotics. Neomycin is the active ingredient in the topical antibiotic Neosporin and other aminoglycosides, such as Kanamycin and Gentamicin, are regularly used to treat life-threatening bacterial infections. The bad news is that aminoglycosides cause harm to the kidneys and ears, in many cases causing hearing loss. Also, aminoglycosides can only be administered intravenously, which is a significant disadvantage hurdle in patient compliance. The plan to address these issues is twofold: The first is to encapsulate existing aminoglycosides into nanoparticles. This will help shield the positive charge on the aminoglycoside and help it escape from the bloodstream and diffuse into cells. This should also skirt the tendency of kidneys to aggressively pump in the drug because it will be hidden inside the nanoparticle. The second is to make new aminoglycosides. Using de novo palladium-catalyzed glycosylation, aminoglycosides with a similar framework but different characteristics will be synthesized in hopes of finding a better analogue. www.linkedin.com/pub/michael-cuccarese/33/373/a73 https://www.researchgate.net/researcher/2033983424_Michael_F_Cuccarese/
	Ramonita Díaz Ayala, Ph.D. **Department:** Chemistry, University of Puerto Rico Mayaguez **Advisor:** Juan López Garriga **Collaborators:** Carlos Rinaldi pr.linkedin.com/pub/ramonita-diaz-ayala/22/3b4/475 https://www.researchgate.net/researcher/35275454_Ramonita_Diaz-Ayala/
	Yogesh G Patel, *Ph.D. candidate* **Department:** Electrical and Computer Engineering, Northeastern University **Advisor:** Charles Di Marzio **Understanding optical properties of nanoparticles towards application with biospecific markers for pre-cancer detection**

	Among skin malignancies, basal cell carcinoma (BCC) is the most common, occurring at an estimated rate of 800,000 cases in the United States every year costing $500 million/year. BCCs are tumors most commonly occurring on sun-exposed areas of the body such as the face or head, and often on or near the nose, eyes, ears or mouth. Because of this occurrence in high-risk anatomical areas, BCCs require precise excision with minimal loss of the surrounding normal tissue, and are effectively treated with Mohs micrographic surgery. Optical imaging methods are being developed that may enable rapid detection of BCCs directly and non-invasively in surgical skin excisions, minimize the need for frozen pathology and may expedite Mohs surgery. The optical methods include optical quadrature microscopy, confocal reflectance microscopy, optical coherence tomography, Raman spectroscopy, and fluorescence microscopy. Many of these non-invasive optical imaging modalities being developed for ex vivo BCC detection (with potential in vivo application) require a contrast agent to enhance and/or label BCCs. Optical imaging methods with a specific contrast agent will allow for increased detection of the varying types of BCCs that are difficult to diagnosis under standard light microscopy. The application of nanoparticles labeled with molecular biomarkers associated with BCCs may potentially be applicable in lieu of a contrast agent for non-invasive optical imaging in vivo. The goals of this project are to define the optical properties of nanoparticles for application in detection of BCCs in skin, ex vivo and potentially in vivo, and to understand the optical properties of normal and cancerous skin, and their impact on optical imaging using optical quadrature microscopy. The clinical application of a molecular contrast agent and non-invasive optical imaging modality will greatly increase detection of BCCs and ultimately improve cure rates for all types of BCCs.
	Myisha Roberson Moore, *Ph.D. candidate* **Department:** Materials Science and Engineering, Tuskegee Institute, Alabama **Advisor:** Vijaya Rangari **Profiling and Characterization of Silver, Zinc Oxide and Silver/ Zinc Oxide Hybrid Nanoparticles for Antimicrobial Properties** Design and characterization of silver, zinc oxide and hybrid silver zinc oxide nanoparticles designed to be used as antimicrobial agents against common skin pathogens. www.linkedin.com/pub/myisha-roberson-moore/6a/b83/2ab

Robert Camp, Ph.D. (2011)
Department: Mechanical & Industrial Engineering, Northeastern University
Advisor: Jeffrey Ruberti

The Mechanosensitivity of Type I Collagen to MMP Cleavage

In general, the goal will be to quantify collagen's mechanosensitivity to enzymatic cleavage by MMPs. Data such as the time to cleavage as a function of mechanical load, enzyme bonding, and cleavage force kinetics will be recorded. Using this data, a spring constant curve for collagen will be developed. This understanding can be applied to other potential Mechanomes.

To study collagen's mechanosensitivity to enzymatic attack, it will be necessary to develop a means to fix a single collagen monomer such that a measurable force may be applied to it. Firstly, the collagen will have to be prepared so that it can be "grabbed". By using antibodies at either end of a procollagen molecule and covalent functionalization, we will attach a 1.0 µm diameter paramagnetic particle to one end and 2.0 µm diameter nonmagnetic polystyrene bead to the other. This will give two "handles" that can be used to manipulate the procollagen monomer.

I will construct a magnetic trap based on a design by Yan, Skoko, and Marko of the University of Illinois at Chicago.1 This device will be used to manipulate the procollagen. This design uses 3 1.0 mm micropipettes and a 200 µm diameter magnet mounted at the end of a tapered glass rod operating in a 500 µl well that is mounted to a inverted microscope. The first micropipette is the "bead-catching" pipette, has an inside diameter of 2 µm, and is mounted to a micromanipulator. The glass rod with the magnet is also attached to a micromanipulator. The second micropipette is the "loading" pipette and has an inner diameter of 20 µm and is mounted to a manual three-axis manipulator. The final micropipette is the "force-measuring" pipette. It has an inside tip diameter of 2 µm and it is mounted on the microscope at a fixed position. Using this setup we can inject the double bead attached collagen to the test fixture using the loading pipette. Once in the well, the bead-catching pipette can be used to capture the nonmagnetic bead of the collagen pair using suction. The procollagen bead pair then can be transferred to the force-measuring pipette where it is also held in place with suction. Once it is attached, the pipette containing the magnet can be used to stretch the procollagen monomer and apply a load.

Dr. Ruberti estimates that the nominal force on a single collagen monomer varies widely in the body; this varies from roughly 3.5 pN in the cornea to upwards of 250 to 300 pN in an Achilles tendon. This near-field magnetic tweezer can possibly achieve the forces necessary to simulate these conditions.

In previous studies done by Sun, et al2 it has been shown by using optical tweezers that a collagen molecule can be fully stretched with a force of around 3 pN. To ensure that we will be stretching the monomer only axially, the stage containing the magnet will be translated to pull the monomer to maximum length while applying only nominal loads (less than 10 pN). Now that the procollagen monomer is held perpendicularly

between the two pipettes, forces can now be applied in a uniform manner. Forces of 10, 20, 50, 100, 150, 200, 250, and 300 pN will be applied in successive experiments. While the procollagen monomer is being stretched, the MMP solution will be introduced. For each loading condition the cleavage time will be recorded. For each force loading, there will be at least four successful runs, for a total of at least 32 experimental data points.

It is expected that this experiment will demonstrate the relationship between mechanical load and cleavage time. If this experiment demonstrates the cleavage rate is affected by the mechanical load applied to the collagen, Dr. Jeffrey Ruberti's hypothesis on collagen mechanical properties will be strongly supported. Even if the null hypothesis is shown, this experiment will still supply important data on MMP binding kinetics, MMP binding forces, and MMP cleavage rates on a single collagen molecule.

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http://www.maritime.edu/index.cfm?pg=directory&empid=3216

Brendan Flynn, Ph.D. (2012)
Department: Mechanical & Industrial Engineering, Northeastern University
Advisor: Jeffrey Ruberti

Determination of the sensitivity of collagen fibril formation to static and oscillatory strains

It has been hypothesized that collagen is mechanosensitive material, with strain slowing enzymatic degradation and potentially increasing fibril formation. These theories are based on a number of findings where tension inhibited degradation or increased thermal stability. To study the dependence of fibril formation on strain, a system must be designed in which small strains can be applied to newly forming fibrils while fibril formation is monitored quantitatively. Collagen solutions will be reconstituted in delta-T dishes (Bioptics) while micropipettes controlled by micromanipulators (Eppendorf Transferman NK2) will induce small strain on the solution. Fibril kinetics will be monitored via DIC microscopy. Brendan is attempting to construct a mathematical model that accurately describes the formation and enzymatic degradation of loaded collagen matrices by bacterial collagenase.

Collagen Single Fibril Mechanochemistry

Mechanical strain has been show to effect the enzymatic degradation of collagen. Single collagen fibrils are the fundamental units of connective tissue in mammals, and have yet to be probed mechanochemically. I am attaching individual collagen fibrils to a micromechanical testing system inside a microbioreactor, then adding enzyme and probing the effect of various loading regimes.

www.linkedin.com/pub/brendan-flynn/18/67a/841

Samira Faegh, Ph.D. (2013)
Department: Mechanical & Industrial Engineering, Northeastern University
Advisor: Nader Jalili

Piezoactive Bio-NanoMechanical Cantilever Force Sensor for Disease Diagnosis
Detection of multiple analytes for the purpose of disease diagnosis requires sensitive biosensing tools capable of transducing molecular interactions into some physical quantity. For this, a microdiagnostic platform based on arrays of microcantilevers with self-sensing capability is proposed for disease diagnosis. Microcantilever-based detection technique equipped with piezoactive read-out device enables transduction of molecular recognition into a nanomechanical motion. The proposed mechanism offers a variety of advantages over other detection techniques such as low cost, simplicity, high sensitivity, low sample consumption, and non-sample preparation requirement. Specific aims of this study would be applying the proposed mechanism as biosensor for detection of glucose concentration in blood, detection of specific markers of acute myocardial infarction for continuous monitoring of the level of these marker proteins in blood, and finally increasing the sensitivity and selectivity of the proposed diagnostic kit. Detection of proteins is the main requirement in disease diagnosis. Microcantilever-based biosensors are capable of transducing the bio-interaction into a nanomechanical motion which enables diagnosis through detection of a great number of analyte at the same time in just one step. The proposed NMCS offers a unique laser-less, compact, cheap, and portable platform for detection of marker proteins relative to specific diseases and enables label-free biological detection at the nanoscale. It also enables easy integration for multiple arrays. Functionalizing piezoresistive microcantilever with antibodies, or any receptor for analyte, specific binding takes place while submerging the NMCS in the solution. The change of surface stress and thus cantilever deflection as a result of this binding can be obtained through the change of resistivity of the piezoresistive layer.
www.linkedin.com/pub/samira-faegh/11/b03/3b8
http://iris.lib.neu.edu/mech_eng_diss/52/

Lara Milane, Ph.D. (2010)
Department: Pharmaceutical Sciences, Northeastern University
Advisor: Mansoor Amiji

Tumor Hypoxia, the Warburg Effect, and Multidrug Resistance: Modulation of Hypoxia Induced MDR Using EGFR Targeted Polymer Blend Nanocarriers for Combination Paclitaxel/Lonidamine Therapy
The clinical focus of Lara's work is Multi-Drug Resistant (MDR) cancer. MDR cancer is most often implicated in cases of recurrent, non-responsive disease and is a significant obstacle in the treatment of cancer. Common treatment regimens accompanied by the

non-specific character of traditional chemotherapeutics inadvertently foster the development of acquired MDR. As such, current treatment options do not adequately address the treatment of MDR cancer.

The biological focus of Lara's work is to explore the relationship between the hypoxic microenvironment of a tumor, the development of MDR, and the energetic profile characteristic of the Warburg effect (aerobic glycolysis). The therapeutic aim of Lara's research is to develop an actively targeted nanocarrier system for combination (paclitaxel/lonidamine) therapy for the treatment of MDR cancer. Lara is conducting a complete pre-clinical evaluation of this drug delivery system including in vivo studies evaluating the therapeutic efficacy, safety, biodistribution, and pharmacokinetic parameters in an orthotopic model of triple negative breast cancer.

In addition to her primary research, Lara is involved in many interdisciplinary collaborations. Lara is also an advocate for K-12 and community outreach; she developed the IGERT "Introduction to the Nanoworld" platform and is perpetually involved in the education of local youth.

Targeted Delivery of a Mitochondriotropic Apoptosis Modulator Using Multifunctional Polymeric Nanoparticles for the Treatment of Drug Resistant Tumors

Mitochondria are well recognized as the central organelles of energy production and the apoptotic pathway. Mitochondrial dysfunction contributes to the pathogenesis of a multitude of conditions including neurodegeneration, obesity, diabetes, and cancer. The significance of mitochondria in maintaining cellular homeostasis is exemplified in the disease state of cancer which is the uncontrolled proliferation of cells - cells which fail to undergo apoptosis. The successful treatment of cancer is often obstructed by the development of multidrug resistance (MDR); current clinical therapies are ineffective at treating MDR cancer as MDR cancer cells evade the arsenal of common chemotherapeutic agents.

The objective of this project is the development of a targeted delivery system for the co-administration of a mitochondriotropic apoptosis modulator and a common chemotherapeutic agent for the treatment of MDR cancer. The apoptosis modulator will be used to reduce the apoptotic threshold of MDR cancer cells rendering the tumor vulnerable to the chemotherapeutic. The overexpression of EGFR will be exploited to achieve cancer-cell specific targeting of the multifunctional nanoparticles.

www.linkedin.com/pub/lara-milane-phd/2a/12b/46

Luis Brito, Ph.D. (2008)
Department: Pharmaceutical Sciences, Northeastern University
Advisor: Mansoor Amiji

Targeted eNOS Gene Delivery with Lipopolyplexes for the Treatment of Coronary Restenosis

	The main thrust of this research is to develop gene therapy strategy using safe and effective non-viral vectors for local production of endothelial nitric oxide synthase (eNOS) on arterial wall. Local eNOS production has shown to regulate many biological functions, including regeneration of arterial endothelium after coronary angioplasty and prevention of restenosis. www.linkedin.com/pub/luis-brito/7/506/462 US Head of Formulation Science at Novartis Vaccines
	Lilian van Vlerken, Ph.D. (2008) **Department:** Pharmaceutical Sciences, Northeastern University **Advisor:** Mansoor Amiji **Development of a Polymeric Nanoparticle Formulation to Overcome Multidrug Resistance of Cancer via a Multifunctional Therapy** Nanotechnology is a very useful tool in the design of drug delivery systems to combat many diseases, where these nano-platforms can aide in target specific localization, controlled release, and multifunctionalization of the therapy. The use of nanoparticles, colloidal carriers of submicronic (<1 ï¿m) size is particularly of use in the delivery of therapeutics to tumors. Resulting from the rapid growth of a tumor mass, many tumors present with fenestrated vasculature and poor lymphatic drainage, resulting in an enhanced permeability and retention (EPR) effect. Long circulating nanoparticles can extravasate through these fenestrations to accumulate, and deposit their drug load, specifically at the tumor site. A great challenge to cancer therapy is the development of cross-resistance to a multitude of chemotherapeutic agents, termed multidrug resistance (MDR). It is believed that the development of MDR in a small subset of cancer cells is the reason for tumor survival despite invasive chemotherapy, a phenomenon that is particularly taxing in the treatment of breast and ovarian cancer, where MDR develops in half of the clinical cases. Although MDR is known to arise through alterations of several cellular processes in the cancer cell, recent research suggests the importance of alterations in apoptotic (programmed cell death) signaling, rendering the MDR cell impervious to cell death resulting from chemotherapy. This project is aimed at overcoming MDR through a therapeutic strategy that uses polymeric nanoparticles to carry and co-administer an MDR modulator, involved in mending the alterations in apoptotic signaling, with a classical chemotherapeutic to re-sensitize MDR cancers to chemotherapy. Objective: The development of multidrug resistance (MDR) in many tumor types is a major barrier to successful anti-cancer therapy. One of the mechanisms that leads to such chemoresistance is inhibition of apoptotic signaling in MDR cancer cells through glycosylation of the apoptotic mediator ceramide. The purpose of this study was to investigate whether MDR could be reverted by co-administering exogenous C6-

	ceramide with a chemotherapeutic (paclitaxel), co-encapsulated in polymeric nanoparticles to produce a multifunctional anticancer therapy. Experimental Methods: The experimental approach involved testing efficacy of the therapeutic strategy by quantifiying % cell death of drug sensitive vs. multidrug resistant cancer cells in response to the nanoparticle treatment compared to conventional treatments. Next, apoptotic activity in response to paclitaxel/ceramide co-therapy was quantified using a commercially available apoptosis assay. Lastly, intracellular nanoparticle accumulation and localization was observed by fluorescent microscopy. Results: Results indicate that nanoparticle delivery of the co-therapy reduces chemoresistance of the MDR cells to paclitaxel 100-fold, to produce a chemosensitivity profile in the MDR cells that is similar to their drug-sensitive counterpart cell-line. Co-therapy of ceramide with paclitaxel appeared to increase apoptotic activity 2 fold in the MDR cells, suggesting that delivery of exogenous ceramide reinstates the apoptotic signal to resensitize MDR cells to chemotherapy. Conclusions: Altogether, co-administering paclitaxel with ceramide, delivered in polymeric nanoparticles appears to greatly re-sensitize drug resistant ovarian tumor cells to chemotherapy. The results demonstrate the great potential for clinical use of this therapeutic strategy to overcome MDR. https://search.knodeinc.com/viewProfile.action?profile.profileId=A3035927#.UqZALo2zkT4
	Mattia Migliore, Ph.D. (2008) **Department:** Pharmaceutical Sciences, Northeastern University **Advisor:** Barbara Waszczak **Intranasal Delivery of GDNF for the Treatment of Parkinson's Disease** Glial cell line-derived neurotrophic factor (GDNF) exerts a neuroprotective and a neuroregenerative effect on midbrain dopamine neurons and has been promoted as possible treatment for Parkinson's disease (PD). However, GDNF does not cross the blood-brain barrier. Therefore, administration of GDNF is limited to direct intracerebral infusions, which require invasive surgical procedures. My project will utilize nanotechnology to develop a cationic liposomal drug-delivery system to encapsulate, and deliver GDNF to the brain non-invasively. The liposomal GDNF will be administered intranasally in order to bypass the blood-brain barrier, and to avoid systemic absorption and possible peripheral side effects. Parkinson's disease (PD) is a progressive neurodegenerative disease resulting from the destruction of dopaminergic neurons of the A9 nigrostriatal pathway in the midbrain. Glial Derived Neurotrophic Factor (GDNF) is a potent neurotrophic factor which has been shown, both in vivo and in vitro, to both protect and restore dopaminergic neurons.

	GDNF does not readily cross the blood-brain barrier, and therefore cannot reach its site of action. This limits its use as a therapeutic treatment and potential cure for PD. Intranasal administration, together with nanoparticle technology, can greatly improve GDNF CNS penetration making this therapeutic potential treatment a reality. http://www.linkedin.com/pub/mattia-migliore-rph-ph-d/1a/4b0/68a http://www.mcphs.edu/about%20mcphs/directory%20listing/Bio?id=0044611
	Padmaja Magadala, M.S. (2008) **Department:** Pharmaceutical Sciences, Northeastern University **Advisor:** Mansoor Amiji **Pancreatic Cancer Gene Therapy with EGFR-Targeted Gelatin-Based Nanoparticle Systems** Over the last few decades, the incidence of pancreatic cancer has risen to become the fourth leading cause of cancer deaths, in both males and females, in the western world. The vague manifestation of its symptoms, in addition to the lack of specific and early diagnostic procedures, further complicate the approaches to successful therapy of pancreatic ductal adenocarcinoma (PDAC). At the molecular level, while mutations in p53 cause over 50% of solid tumors in humans, over-expression of the epidermal growth factor receptor (EGFR) has been implicated in the poor prognosis and clinical outcome in pancreatic cancer. Novel approaches to increase safety and therapeutic efficiency of non-viral gene delivery agents for cancer therapy have gained wide-spread attention in recent years. Current efforts in this direction are focused on using biocompatible materials, which can be efficiently directed to accumulate in the tissue and/or cell of interest with the use of targeting ligands. The main objective of this project is to develop and characterize a novel EGFR-targeted gelatin-based engineered nanoparticulate system for safe and efficient in vitro and in vivo therapeutic plasmid DNA delivery in pancreatic cancer. EGFR-targeting peptide is conjugated to the surface of gelatin nanoparticles via a PEG-spacer to accomplish longer circulation time and cell-specific targeting of nanoparticles for in vivo applications. Plasmid DNA expressing wild-type p53 tumor suppressor protein will be encapsulated and the therapeutic effect will be evaluated in an orthotopic Panc-1 pancreatic cancer xenograft model. www.linkedin.com/in/padmajamagadala https://www.researchgate.net/profile/Padmaja_Magadala/

Christopher Kakidas
Department: Pharmaceutical Sciences, Northeastern University
Advisor: Heather Clark

Continuous Monitoring Redox Nanosensors: The Next Step in Understanding Cancer
The American public has been bombarded by commercials touting the positive effects of antioxidants and negative effects of oxidative free radicals of which the interplay is controlled by the reduction/oxidation (redox) state of the cell. A cell's redox state has been historically difficult to determine due to a lack of analytical tools capable of operating in real time without altering the cell. We propose to develop an array of nanosensors capable of selectively and quantitatively responding to reactive oxygen species in real time finally shedding light on the cell's true redox state. We will then use these nanosensors to investigate an important biological problem: cancer cell metabolism.
It is the hypothesis of our collaborators at the Beth Israel Deaconess Medical Center that the chemical fluctuations in cancer cells display a lower degree of mathematical complexity than do normal cells. The redox nanosensors developed will be tested to determine if it is possible to use a mathematical nonlinear complexity "read-out" technique to detect differences between "cancerous" and "normal" cells. If successful, this approach can be developed as a novel diagnostic tool to discriminate between tumorigenic and non-tumorigenic cells potentially leading to new screening tools for cancer therapy agents in development.
http://www.linkedin.com/pub/christopher-kakidas/7/4b0/399

Brendan Harmon, Ph.D. (2013)
Department: Pharmaceutical Sciences, Northeastern University
Advisor: Barbara Waszczak

Intranasal Delivery of GDNF-expressing Nanoparticles to the Brain: Toward a Gene Therapy Approach for Parkinsons Disease
Parkinson's disease (PD) is a progressive neurodegenerative disorder that primarily destroys the A9 tract of dopamine neurons that project from the substantia nigra pars compacta (SNc) to the corpus striatum (made up of the caudate and putamen in humans). For dopamine neurons specifically, glial cell-derived neurotrophic factor (GDNF) has been shown to promote their survival and proliferation both in culture and in vivo. GDNF has even been shown to be neuroprotective and restorative in various animal models of PD and some human clinical trials. However, its delivery is far from clinically practical since its use involves invasive surgical routes directly to the brain. The purpose of the proposed research is to advance non-viral gene delivery systems to the CNS using a rarely-utilized route of administration, the intranasal pathway. Intranasal administration circumvents the blood-brain barrier (BBB), providing a non-

	invasive means of targeting large molecular weight substances to the brain. Focusing on a treatment for PD, we hope to combine the therapeutic potential of GDNF gene transfection with the non-invasive approach of intranasal delivery to the brain. Expression plasmids containing the reporter genes for enhanced green fluorescent protein (EGFP) and luciferase will be evaluated using lipoplex and poly-lysine nanoparticle formulations. The formulation found superior for brain transfection will be carried forward and used for pGDNF delivery; the efficacy of which will be evaluated in a 6-hydroxydopamine (6-OHDA)-lesioned rat, a common animal model for PD. www.linkedin.com/in/brendanharmon
	Thomas Barchet, *Ph.D. Candidate* **Department:** Pharmaceutical Sciences, Northeastern University **Advisor:** Mansoor Amiji **Role of Polyunsaturated Fatty Acid-Containing Nanoemulsions in Drug Delivery and Neuroprotection in Alzheimer's Disease** http://www.linkedin.com/pub/thomas-barchet/19/352/695
	Bobby Riehle, Ph.D. (2013) **Department:** Pharmaceutical Sciences, Northeastern University **Advisor:** Vladimir Torchilin **Combination Anticancer Nanopreparations of Novel Proapoptotic Drugs, TRAIL Ligand and siRNA** Cancer cells are known to use multiple pathways and mechanisms to promote survival and proliferation. In addition, some tumors are able to acquire resistance to various drugs over the course of treatment. As such, combination therapies targeting different dysregulated pathways have emerged as a powerful approach to treat cancer and multidrug resistant (MDR) tumors. PEG-PE micelles have been used to increase the solubility of a variety of poorly soluble drugs. In addition to advantages of increased solublization and stability, the surface of these nanoparticles can be decorated with a variety of moieties to create multifunctional delivery vehicles. This project aims to deliver novel pro-apoptotic drugs targeting the PI3-kinase pathway, in PEG-PE micelles surface modified with TNF-related Apoptosis Inducing Ligand (TRAIL) as a combined nanoformulation. These poorly soluble drugs are effectively loaded into PEG-PE micelles (~70% loading efficiency). TRAIL is efficiently conjugated (~85%) to the surface of micelles by reaction with pNP-PEG-PE included in the micelle preparation. Combined preparations of drug-loaded and TRAIL-modified micelles were shown to have a synergistic effect against a variety of cell lines including A2780, U87-MG, DU-145 and the Taxol resistant SKOV-3 TR when compared to individual treatments. These results indicate the potential

benefits of micellar proapoptotic drug combined with surface modified with TRAIL.

Development of Dual-Targeted Liposomes for Delivery of Nucleic Acid

A novel cationic lipid based system for potential improved delivery of siRNA and DNA has been designed. Liposomes are modified with the cell surface targeting moieties Folic acid (FA) and Transferrin (TF). Many human cancers over-express FA and TF receptors and are therefore good targets for drug delivery. The cellular association of these co-targeted liposomes to human cancer cells is drastically increased as compared to plain liposomes, due to what appears to be a synergistic effect of the two moieties.

Liposomal Loading and Delivery of Proapoptotic BH3 Peptides

This project aims to incorporate small peptides into liposomes with the purpose of increasing cellular delivery. These small peptides have been engineered to bind to BH3 domains on a variety of pro-apoptotic proteins (BID, BIM, BAD). These peptides must reach their targets in the cytosol of the cell. Based on the physicochemical properties of the peptides, namely larger size and increased polarity, they are unable to cross the cellular membrane. However, encapsulation into liposomes will allow for increased intracellular delivery.

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Michael J. Johnson, *Ph.D. candidate*
Department: Pharmaceutical Sciences, Northeastern University
Advisor: Alex Makriyannis

Development of a Selective, Theranostic Nanoplatform to Inhibit Human Monoacylglycerol Lipase

My research, the development of a highly selective, theranostic nanoplatform-based inhibitor of, and imaging modality for, human monoacylglycerol lipase (MGL) has driven me to research and develop new technologies and strategies for treating metastatic disease. Epidemiological data, from a 2010 meta-analysis, forecast that more than 12% of female newborns in the United States will be diagnosed with breast cancer within their lifetime. Those with aggressive forms of the disease will have less than a 25% chance of surviving 5 years after diagnosis. Without pharmacological intervention, breast cancer will remain a significant, global health problem for the foreseeable future. Currently, the limiting step in the breast cancer drug discovery initiative is the identification of highly selective imaging and therapeutic agents for the early diagnosis and treatment of the disease. The discovery, design, and characterization of a novel, multimodal, theranostic nanoplatform, which has the unique ability to diagnose disease states while showing real-time, traceable therapeutic efficacy, is the focus of my efforts. In addition to being a novel therapeutic tool, I argue that this platform will increase the efficiency of translation of new, medically relevant discoveries from the lab bench to the clinic.

MGL is a serine hydrolase that regulates endocannabinoid signaling. It has a typical

	serine-histidine-aspartate catalytic triad, belongs to the α/β hydrolase family, and is the major enzyme responsible for the hydrolysis of 2-arachidonoylglycerol (2-AG); an endocannabinoid that is synthesized and localized in the membrane bilayer. Increased levels of 2-AG are considered antinociceptive, antiallodynic, anti-inflammatory and therapeutic for neurodegenerative disorders. Overexpression of MGL, and the resultant over-hydrolysis of 2-AG, elevates the level of protumorigenic signaling lipids in cancer cells. As such, MGL regulates a fatty acid network that promotes cancer pathogenesis. MGL inhibition has been shown to attenuate the growth, migration and invasion of aggressive/metastatic, prostate and breast cancer cells. The development of a highly selective imaging modality for examining functional MGL will be a key step in our understanding of the complete metabolic role this potential biomarker plays. MGL transiently associates with cell membranes. To completely understand the mechanism of action of this enzyme, it is vital that we first unravel the structural dynamics of the MGL-membrane interaction and also MGL's intracellular localization. MGL, like most lipases, exhibits interfacial activation and undergoes a transition from a "solution," to a "membrane-associated" conformation; a process that involves attachment of part of its lid domain to the phospholipid bilayer. As a prerequisite for developing small molecule drugs that target MGL, it is essential to unravel how these conformational and spatial dynamics come about. I propose to achieve this by addressing three Specific Aims: (1) the development of a silica-coated, super-paramagnetic, iron oxide core/gold shell, theranostic nanoplatform (fLPA-SPIO@AuNS) -- functionalized with a novel MGL inhibitor, (2) determination of the kinetics of MGL hydrolysis in a nanodisc biological membrane mimetic; with further characterization the nanodisc model using high resolution imaging techniques, and (3) the use a novel, "Michael probe" system to specifically label and image active human MGL
	Kathy Chaurasiya, *Ph.D. candidate* **Department:** Physics, Northeastern University **Advisor:** Mark Williams **Investigating quantum dot toxicity by quantifying DNA polymerase activity with single molecule force spectroscopy** Quantum dots (QDs) have widespread, revolutionary applications in medicine, but the toxicity of these nanoparticles is multifaceted and not well understood. Cytotoxicity due to QD interference in vital cellular processes will be investigated by examining the effect of cadmium telluride (CdTe) QDs on DNA polymerase III (DNAp III), the replicative polymerase in Escherichia coli (E. coli). Single-molecule force spectroscopy will be used to investigate the structure and functional mechanisms of this bacterial replicase. The difference in the elasticity of single- and double-stranded DNA will be utilized to measure the catalytic rate of α DNAp III as a function of the tension on the DNA template strand. This technique will provide a quantitative description of its catalytic activity and active site size, which is essential to a fundamental understanding

	of both bacterial and eukaryotic replicative polymerases. The activity of α DNAp III will then be measured in the presence of CdTe QDs to elucidate the effect of the nanoparticles on the catalytic rate and active site of the replicative polymerase, thus determining the extent and mechanism of QD cytotoxicity due to interference with DNA replication.
	Francisco J. Reynoso, M.S. (2010) **Department:** Physics, Northeastern University **Advisor:** Sri Sridhar **Multifunctional Nanostructures for Theranostics** The role nanotechnology plays in medicine is increasingly important due in large part to the numerous medical uses of nanostructures in both diagnostic and therapeutic capacities. The small size, relatively large surface area, and in-vivo kinetics of nanoparticles makes them uniquely suited for biomedical applications. Different forms of nanoparticles are currently being employed as diagnostic and therapeutic tools independently, mainly due to their size specific pharmacokinetic and magnetic properties. Diagnostic capacities are widely used in the form of imaging contrast agents that increase sensitivity and/or specificity of MR images. The therapeutic capabilities of nanoparticles are also used in a clinical capacity as various forms of drug carriers, particularly liposomal forms of cancer drugs. These nanoparticle-based systems can be combined to form novel image-guided drug delivery techniques that aim towards targeted diagnosis and treatment of disease. Treatments that can provide diagnostic and therapeutic benefits are now referred to as theranostic agents. The ability of such systems to both treat and diagnose diseases is an emerging concept that allows for increased functionality and effectiveness of current treatments. The purpose of my proposed research is to study nanostructures in which the concept of theranostics is explored. http://www.linkedin.com/pub/francisco-j-reynoso/18/363/255

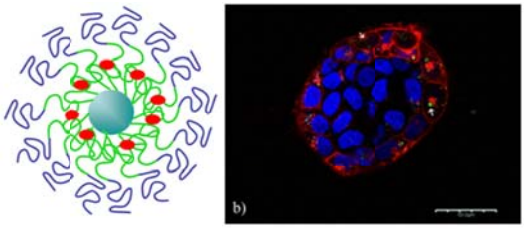
RESEARCH PROJECTS

Nanomedicine seeks to exploit a timely convergence of two parallel recent developments toward the diagnosis and therapy of disease - the decoding of the human genome that has led to greater understanding of the molecular basis of diseases, and nanotechnology, which offers the means to control single molecular interactions. The Nanomedicine Science and Technology program was formed to establish nanomedicine as a new paradigm for diagnosis and therapy of cancer, infectious and cardiovascular diseases from bench to bedside. Based at Northeastern University, the program collaborates with outstanding medical institutions such as Massachusetts General Hospital, Beth Israel and Deaconness Medical Center and Dana Farber Cancer Center, and industrial organizations including Genzyme and Boston Scientific.

The tightly-integrated interdisciplinary team of medical researchers, pharmaceutical scientists, physicists, chemists, and chemical engineers, has an extensive range of expertise to facilitate research on nanomedicine:

- Development of nanomedical technologies using polymeric nanoparticles, lipid nanoparticles, metal nanoparticles, and self-assembling nanosystems,
- Synthetic chemistry required to design and optimize new strategies for nanoparticle preparation and functionalization,
- Science and technologies for cancer diagnostic and imaging techniques using nanoparticles as reporter platforms and contrast enhancing agents,
- Therapeutic targeted and intracellular drug and gene delivery using nanocarriers,
- Preparation of nanoparticles susceptible to external factors, such as electromagnetic fields from radio-frequency to infrared radiation, and hyper/hypothermia, that they can transfer to surrounding cells and tissues (tumor),
- Theoretical modeling of nanoparticle processes in biological and medical environments, and of drug and gene delivery,
- Clinical diagnosis and therapy of prostate, breast, and liver cancer.

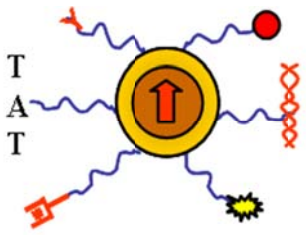
Phd Projects

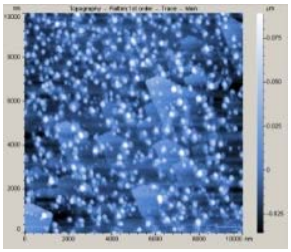


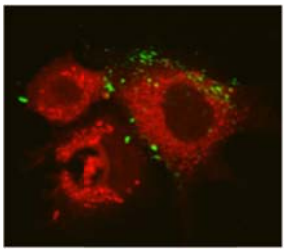
Multifunctional nanoparticles consisting of magnetic core, block copolymer coating with thermoresponsive (green) and hydrophilic (blue) blocks, and drug/siRNA payload (red). Visualization of green fluorescent iron oxide nanoparticles coated with carboxy-methyl dextran and epidermal growth factor (IO-CMDx-EGF) in CaCo-2 cells. Cell nucleus (blue) and cell membrane (red).

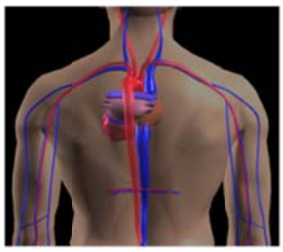
- Application of Nanoarray Technologies to Spinal Stimulation and Regeneration: the Nano-BMI (brain-machine interface)
- Collagen Single Fibril Mechanochemistry
- Combination Anticancer Nanopreparations of Novel Proapoptotic Drugs, TRAIL Ligand and siRNA
- Computationally Guided Ligand Design for the Human Adenosine A2A Receptor for Nanoparticle Imaging of Hypoxic Tumors
- Computationally Guided Protein-Specific Labeling with Nanoparticles
- Continuous Monitoring Redox Nanosensors: The Next Step in Understanding Cancer
- Design and Characterization of Multimeric RGD Peptidomimetics Conjugated Gold Nanoparticles for Tumor Diagnostic and Enhanced X-ray Radiotherapy
- Determination of the sensitivity of collagen fibril formation to static and oscillatory strains
- Development of a Polymeric Nanoparticle Formulation to Overcome Multidrug Resistance of Cancer via a Multifunctional Therapy
- Development of a Selective, Theranostic Nanoplatform to Inhibit Human Monoacylglycerol Lipase
- Development of Dual-Targeted Liposomes for Delivery of Nucleic Acid

Overview of CaNCURE Cancer Nanomedicine Research Methodology



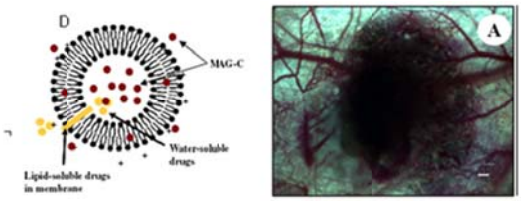






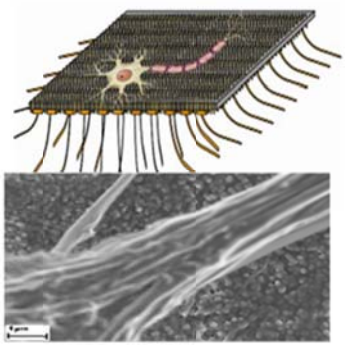
Nanoplatforms	Characterization toolkit	Cellular and Phyiological Mechanisms	Diagnosis and therapy
• Polymers, lipids, organelles, self-assembling ampiphiles, • Magnetic nanoparticles • Metallic nanoparticles • Quantum dots • Nanoporous coatings on implants	• Nanoscale Microscopies: SEM, TEM, AFM, STM, NSOM, • Fluorescence confocal and optical microscopy • Spectroscopies: Femtosecond optical spectroscopy, XAFS, • Zeta Potential, SQUID, Coulter	• Apoptosis • Delivery to nucleus, mitochondria or ribosome • Endocytosis, Cellular uptake • Gene Silencing • Organ biodistribution and pharmacokinetics	• Nanoplatforms for multimodal imaging • Targeted Delivery of drugs, DNA, siRNA... • Photodynamic Therapies • Image guided drug delivery • Localized energy delivery • Prostate, Breast, Ovarian, Lung, ...

- Enumerating Rare Cells Labeled with Fluorescent Nanoparticles
- High-Throughput Microfluidic Platform for Personalized Nanomedicine
- Imaging of Embryonic Stem Cells using Multiphoton Luminescence of Gold Nanoparticles
- Implantable Nanoparticles Doped Brachytherapy Spacers for Synergistic Combinatorial Chemo-radiation Therapy in Prostate Cancer
- Intranasal Delivery of GDNF-expressing Nanoparticles to the Brain: Toward a Gene Therapy Approach for Parkinsons Disease
- Investigating quantum dot toxicity by quantifying DNA polymerase activity with single molecule force spectroscopy
- Liposomal Loading and Delivery of Proapoptotic BH3 Peptides
- Lymph node nanoparticle delivery of A2aR antagonists to boost vaccine responses
- Lymph node targeting using nanoparticle delivery system for HIV vaccine



(Left) Schematic of magnetic liposome. (Right) Magnetic liposomes accumulated using magnetic targeting in mouse tumor.

- Microfluidic Cell Separation Using Functionalized Magnetic Nanoparticles
- Multifunctional Nanostructures for Theranostics
- Nanoparticle Antimicrobial Development
- Nanostructured Magnesium as a Novel Material for Orthopedic Tissue Engineering
- Novel Approach to Imaging of Nano-Drug-Delivery Carriers Based on Raman Microscopy
- of Nanoparticle Diffusion in PC3 Prostate Tumors In Vivo
- Pancreatic Cancer Gene Therapy with EGFR-Targeted Gelatin-Based Nanoparticle Systems
- Photocatalytic activity of AuFe/TiO2 composites
- Piezoactive Bio-NanoMechanical Cantilever Force Sensor for Disease Diagnosis
- Raman-active gold nanoparticles as beacons in breast cancer cells
- Role of Polyunsaturated Fatty Acid-Containing Nanoemulsions in Drug Delivery and Neuroprotection in Alzheimer's Disease
- Site-Specific delivery of anti-infective therapies in neglected tropical diseases using nano-sized formulations
- Sodium concentration reporting fluorescent nanosensors for biological applications
- Synthesis of Nanoencapsulated Aminoglycosides as Small-Molecule Gene Therapeutics
- Synthesis of Spin Labeled Nanosensors for the Estrogen Receptor
- Targeted Delivery of a Mitochondriotropic Apoptosis Modulator Using Multifunctional Polymeric Nanoparticles for the Treatment of Drug Resistant Tumors
- Targeted eNOS Gene Delivery with Lipopolyplexes for the Treatment of Coronary Restenosis
- Targeted Nanocarriers
- The Development of Fluorescent Glucose Nanosensors For In Vivo Glucose Monitoring
- The Mechanosensitivity of Type I Collagen to MMP Cleavage



(Top) Schematic of and (Bottom) neurons grown on a nanowire neural interface.

- Tumor Hypoxia, the Warburg Effect, and Multidrug Resistance: Modulation of Hypoxia Induced MDR Using EGFR Targeted Polymer Blend Nanocarriers for Combination Paclitaxel/Lonidamine Therapy
- Understanding optical properties of nanoparticles towards application with biospecific markers for pre-cancer detection
- Use of nanotechnology for imaging of cell surface oligosaccharides for early diagnosis of cancer
- Using Nanoparticles to Analyze Key Immune System Molecules in Embryonic Stem Cells
- Visualization and Enhancement of Spinal Cord Regeneration using Nanoparticles

Associate Projects

- Alumina Templates
- An Analysis of the Effect of PEG on Physical Properties of Cationic Liposomes Intended for Gene Therapy
- Au Nanowire Arrays for Stimulating and Detecting Electrical Activity in Neuronal Cells
- Biomolecular Sequence Quantification Using Magnetic Nanoparticles With a Giant Magnetoresistive (GMR) Sensor
- Collagen Nanoloom
- Drug-Eluting Titanium Oxide Nanotube Arrays
- Electrical Release of Magnetic Nanoparticles from Liposomes
- Fluorescent Tagging Of Cells Via Conjugation With CdTe Quantum Dot -
- TiO2 Nanotube Composite Nanostructures
- Intranasal Gene Delivery Using Cationic Liposomes: A Novel Treatment Strategy for Parkinson's Disease
- Magnetically Induced Hyperthermia
- Magnetically Induced Hyperthermia and Drug Delivery with Liposomes
- Microbial Corsortia
- Molecular Modeling of the C-terminal End of Human Intestinal Mucin (MUC2)
- Nanoparticulate carriers for Mitochondrial Gene Therapy: Optimization of Non-radioactive DNA probe labeling and detection kit analysis of Mitochondrial Transcription by Northern blotting
- Nanowire arrays for neuron recordings
- Optical Properties of TiO2 nanotubes
- Polymeric Nanofilms as Biopassive and Bioactive Neuroprosthetic Implant Coatings
- Star-Shape Gold Nanoparticle Synthesis
- Surface Modification Techniques for Iron Oxide Nanoparticles
- Synthesis and Surface Modification of Iron Oxide Nanoparticles
- Synthesis of Cobalt Iron Oxide Nanoparticles
- The Culturing of Rat Intestinal Stem Cells

PUBLICATIONS

More than 91 nanomedicine related publications by students and faculty

Publications and Presentations through 2013 by IGERT Fellows

Cohort	No. of Students	Publications	Publications other (non-Refereed, conference, books, book chapters)	Presentations
2006	9	1	5	7
2007	5	7	3	22
2008	3	11	3	29
2009	4	19	13	17
2010	5	17	8	28
2011	7	25	5	16
2012	6	10	1	10
2013	5	1	1	15
Total	44	91	39	144

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Program Coordinator

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A = Advisor, **B** = Facility User, **C** = Collaborator/Co-Author, **S** = Speaker

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Phyliss Strauss, PhD (C)
Rebeca Rosengaus, PhD (B)
Misha Sitkovsky, PhD (A)
Erin Cram, PhD (S)

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Tomas Rejtar, PhD (C)

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Jennie B. Leach: University of Maryland
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Sangeeta Bhatia: MIT
Jennifer West: Rice University
Gerard D'Souza: West Virginia University

NANOMEDICINE COURSES AND TRAINING

4 new nanomedicine courses established – more than 100 students have taken these course

- 115 students + 28 postdocs trained on Nanofacility instruments

NNMD 5470: NANOTECHNOLOGY AND NANOMEDICINE PRODUCT DEVELOPMENT: FROM CONCEPT TO MARKET (New Course!! Beginning Spring 2013)

Course Description:
This course offers a comprehensive overview of key elements involved in commercialization of nanotechnology-based R&D from concept to market. Guest speakers will include venture capitalists, entrepreneurs, and regulatory officials. Fundamental concepts around various business models, protection of intellectual property (IP), capital and financing, mathematical modeling of business valuation and transactions will be discussed. This course also covers regulatory process for technical and clinical validation of nano-based products, including nanodiagnostics and nanomedicine, as well as mechanisms for raising capital to support product development. Each student is required to complete two projects: (1) an individual project, (2) and a team project. These projects are selected from ongoing research activities in Northeastern University and other leading research centers and are designed to apply concepts learned throughout the course.
Course Credits:
3 Semester Hours
Course Instructors:
Prof. Srinivas Sridhar
Dr. Mostafa Analoui, Head of Healthcare and Life Sciences at Livingston Securities.
Textbooks and References: There are no specific textbooks for the course; assigned readings will be announced weekly based on topics being covered and recommendations by invited speakers.
Pre-requisite: Graduate and Senior Undergraduate students from Colleges of Science, Business, Engineering and Bouve Health Sciences are eligible to enroll directly. Students from other colleges and non-Northeastern students are also welcome and are eligible to enroll as special students.
The course will utilize some mathematical and accounting techniques, and additional support will be provided for students who may need help in these areas. Explicit technical background in nanosciences is not required and extra reading materials will provided to those who may want to expand their technical knowledge.

NNMD 7270: INTRODUCTION TO NANOMEDICINE SCIENCE AND TECHNOLOGY (Every Fall Semester)
The purpose of this introductory course is to provide an overview of the distinctive features of nanotechnology and their application to bio-medical problems. The course contrasts macro/micro/nano to bring out the unique properties of nanotechnology in nanomedicine. Cutting-edge nanomedical technologies for sensing and imaging, drug delivery, and therapeutic applications will be addressed. The course is taught by NEU faculty and also by guest speakers from local area hospitals and research establishments.

Representative topics covered:

- Synthesis, characterization and functionalization of nanoparticles
- Overview of nanotechnology from Physics perceptive

- Magnetic nanoparticles and energy delivery for therapy
- Polymeric nanoparticles and their applications in nanomedicine
- Applications of nanotechnology in microfluidics
- Design and synthesis of functionalized nanoparticles
- Nanotechnology and highly organized tissues
- Environmental and social impact of nanotechnology
- Bio-Nano-Robotics
- Mitochondrial gene therapy and nanomedicine
- Liposomes and micelles in nanomedicine

Course Credits: 3 Semester Hours

Course Requirements:

1. Class attendance is mandatory. Students are also encouraged to actively participate in this course by engaging instructors in discussion of issues, asking questions in class, and generally being involved with the course.
2. Students can opt for either a satisfactory/unsatisfactory or a letter grade.
3. Students will be evaluated on the basis of term paper on a nanotechnology application topic, presentation, and cumulative take home final exam. The topic for presentation will be based on student's research background and theme of the course.

NNMD 7370: NANOSYSTEMS DESIGN FOR BIOLOGY AND MEDICINE (Every Spring Semester)

This course aims at providing an introduction into theory with simultaneous laboratory experience for instrumentation in nano-medicine. Through this course students will be exposed to a very wide gamut of techniques; the expectation is that this will widen awareness from the narrow confines of individual laboratory to the wider university level community. This is one of the principal goals of the IGERT program. In keeping with the interdisciplinary goal of the IGERT program this course will require the students to give a presentation on a topic related to a new emerging advanced instrumentation method or technique related to their research. The grades will be based on the conventional written lab reports, a comprehensive term paper, and the presentations.

Course Credits: 2 Semester Hours, 1 hour for lecture and 2 hours for laboratory

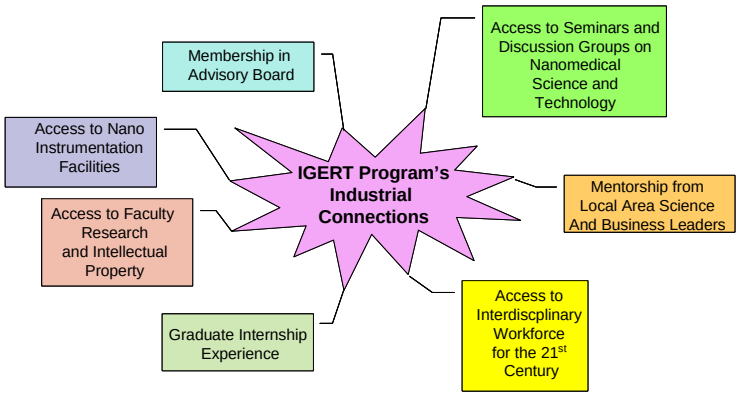
NNMD 7272: NANOMEDICINE SEMINAR (Every Fall and Spring Semester)

Seminars will be presented by world-renowned distinguished scientists in the field of Nanomedicine.

Course Credits: 1 Semester Hours

PARTNERS

13 partners: industry, hospitals, government labs; 22 academic partners: 14 US, 8 foreign



Hospitals and Laboratories

Massachusetts General Hospital

Beth Israel Deaconess Medical Center

Partners Healthcare

Dana Farber Cancer Institute

Forsyth Institute

Wellman Center for Photomedicine

Harvard-MIT Division of Health Sciences and Technology

Boston University

Harvard Medical School

A novel feature of the IGERT program is the creation of a unique national partnership between Northeastern University, two minority-serving institutions, the University of Puerto Rico and Tuskegee University, and 6 research hospitals in Harvard Medical School. This partnership will bring the educational outcomes and research capabilities developed at Northeastern University and Harvard Medical School to minority institutions that have nascent research programs in nanomedicine, but do not have the critical mass at present to develop their own IGERT programs.

The partnership is enhanced by industry groups (e.g. TIE-Boston, Mass Biotech Council) representing the life sciences and entrepreneurship industries whose members further enrich mentored experiences of IGERT Fellows.

INDUSTRY	MEDICAL RESEARCH	GOVERNMENT
Genzyme Corp, Boston Scientific, Novartis, Astra Zeneca, Lexigen, Amgen, Bristol-Myers Squibb, Merck, Pfizer, United Therapeutics, Nanobiosym, Minerva Biotech…	Mass General Hosp, Dana Farber Cancer Center, Beth Israel Deaconness Medical Center, Sloan Kettering Cancer Center, Childrens Hospital, Brigham Womens Hospital…	National Cancer Institute, Brookhaven Natnl Labs, Los Alamos Natnl Labs, Air Force Res Labs, Sandia Nat Labs, Natick Army Labs, Naval Research Labs…

NANOMEDICINE EVENTS

More than 140 talks on Nanomedicine organized. Typically we have 15-20 talks each year.

2013

November

- 15 Friday
  - **Nanodrugs in the Post-Blockbuster World – Critical FDA Regulatory and Patent Issues**
    Speaker: Dr. Raj Bawa, President and Patent Agent, Bawa Biotech LLC
- 12 Tuesday
  - **Biomimetic Nanomaterials for Drug Delivery and Regenerative Medicine**
    Speaker: Dr. Ennio Tasciotti, Director, Spine Advanced Technology Lab, The Methodist Hospital Research Institute
- 08 Friday
  - **Drug Delivery from Macro to Nano**
    Speaker: Daniel Kohane, M.D., Ph.D. , Department of Anaesthesia, Harvard Medical School Pediatric Critical Care, Boston Children's Hospital

October

- 25 Friday
  - **Pegylated POD DNA Nanoparticles Attenuate Retinal Degeneration**
    Speaker: Dr. Rajendra Kumar-Singh, Associate Professor of Ophthalmology, Tufts University School of Medicine
- 11 Friday
  - **Theranostic Nanoprobes for Cancer Imaging and Therapy**
    Speaker: Anna Moore, PhD, Associate Professor in Radiology at Harvard Medical School
- 04 Friday
  - **Nanoparticles for Cardiovascular Molecular Imaging**
    Speaker: Matthias Nahrendorf, MD, PhD, Center for Systems Biology, MGH/Harvard Medical School

September

- 27 Friday
  - **Enhancing the Effect of Cytotoxic and Targeted Therapies Through the Use of Multifunctional Nanoparticles**
    Speaker: Daniela Dinulescu, PhD, Brigham and Womens Hospital, Harvard Medical School
- 20 Friday
  - **Critical issues in Risk Assessment of Engineered Nanomaterials: Current evidence and remaining challenges**
    Speaker: Philip Demokritou, PhD, Associate Professor & Director, Center for Nanotechnology and Nanotoxicology, Harvard School of Public Health

April

- 03 Wednesday
  - **IGERT Nano-Bio Innovation Seminar with Dr. Paul Galvin**
    Speaker: Dr. Paul Galvin , Life Sciences Interface Group, Tyndall National Institute, Cork, Ireland
  - **IGERT Nano-Bio Innovation Seminar with Adnan Nasir, MD, PhD**
    Speaker: Adnan Nasir, MD, PhD, Clinical Professor of Dermatology, UNC Chapel Hill

March

- 27 Wednesday
  - **IGERT Nano-Bio Innovation Seminar with Prof. Thomas Webster**
    Speaker: Prof. Thomas Webster, Chairman and Professor, Chemical Engineering Dept., Northeastern University
- 20 Wednesday
  - **IGERT Nano-Bio Innovation Seminar with Marie Dlorio**
    Speaker: Dr. Marie Dlorio, Executive Director, NRC, National Institute For Nanotechnology
  - **IGERT Nano-Bio Innovation Seminar with Job Elders**
    Speaker: Job Elders, PhD, Director, Zinnergy innovation fund

February

- 27 Wednesday
  - **IGERT Nano-Bio Innovation Seminar with Jonathan Fleming**
    Speaker: Jonathan Fleming , Managing Partner, Oxford Biosciences Partners
- 20 Wednesday
  - **IGERT Nano-Bio Innovation Seminar with Douglas W. Jamison**
    Speaker: Douglas W. Jamison, Chairman of the Board, Chief Executive Officer & Managing Director, Harris & Harris VC
- 13 Wednesday
  - **21st Century Innovation/Technology**
    Speaker: Dr. Nicholas Donofrio, Former Vice Chairman of IBM
  - **The PDS Biotechnology Story**
    Speaker: Dr. Frank Bedu-Addo, President and CEO, PDS Biotechnology Corporation
- 06 Wednesday
  - **Translating Cancer Nanomedicines from Lab to Clinic: The NCI Cancer Nanotechnology Initiative**
    Speaker: Dr. Piotr Grodzinski , Director, NCI Alliance for Nanotechnology in Cancer

January

- 30 Wednesday
  - **IGERT Nanotechnology and Nanomedicine Innovation Seminar with Dr. Lindy Fishburne**
    Speaker: Dr. Lindy Fishburne, Executive Director, Breakout Labs
- 23 Wednesday
  - **Web Seminar: Funding your Venture with Federal SBIR and STTR grants**
    Speaker: Dr. Ben Schrag, NSF Program Director
- 16 Wednesday

- **Commercializing Nanotechnology: The NanoTerra approach**
  Speaker: Myer Berlow, Chairman/Founder Nano-Terra Inc.
-

2012

November

- 09 Friday
  - **Nanomechanics of Native and Engineered Musculoskeletal Tissues: Towards a fundamental, quantitative mechanistic understanding of tissue function, quality, and pathology**
    Speaker: Dr. Christine Ortiz, Professor of Materials Science and Engineering, Massachusetts Institute of Technology

October

- 19 Friday
  - **Nano-Devices for Next Generation Stem Cell Therapeutics, Medical Adhesives, and Drug Delivery Systems**
    Speaker: Prof. Jeffrey Karp, Professor in Medicine, Brigham and Womens/Harvard Medical School
- 12 Friday
  - **NanoMedicine: Current State of Global R&D, Investment, and Future Outlook**
    Speaker: Dr. Mostafa Analoui, Head of Healthcare and Life Sciences, The Livingston Group, New York
- 05 Friday
  - **Nanoparticles for Biomedical Imaging and Image-Guided Surgery**
    Speaker: Hak Soo Choi, Ph.D., Assistant Professor of Medicine, Center for Molecular Imaging, Beth Israel Deaconess Medical Center

September

- 14 Friday
  - **Integration of Nanodiagnostics and Nanotherapeutics: Prospects and Challenges**
    Speaker: Dr. Ratnesh Lal, Professor, Mechanical and Aerospace Engineering, Bioengineering, UC San Diego

April

- 11 Wednesday
  - **Gold Nanoparticles as Vascular Disruptive Agents During Radiotherapy**
    Speaker: Ross I. Berbeco, Ph.D., Department of Radiation Oncology, Division of Medical Physics and Biophysics, Brigham and Womens Hospital Dana-Farber Cancer Institute and Harvard Medical School

March

- 28 Wednesday
  - **MR guided focused ultrasound of the brain and targeted delivery of therapeutics**
    Speaker: Rivka R. Colen, M.D., Brigham and Women's Hospital, Dept. of Radiology
- 14 Wednesday

- **Nanoparticles for delivery of imaging probes through the blood-brain-barrier in vivo in Alzheimers disease model mice**
  Speaker: Tara L. Spires-Jones, DPhil, Instructor in Neurology, Harvard Medical School, Assistant in Neuroscience, MGH

February

- 29 Wednesday
  - **Molecular Imaging with MRI**
    Speaker: Dr. Ravi Teja Seethamraju, MR R&D, Siemens Medical Solutions USA, Inc.
- 15 Wednesday
  - **Application of Magnetic Nanoparticles in Microfluidic Cell Separation**
    Speaker: Brian Plouffe, Ph.D., MIT
- 08 Wednesday
  - **Nanomedicine Seminar**
    Speaker: Shifalika Tangutoori, Ph.D., MGH, Wellman Center for Photomedicine
  -

2011

December

- 02 Friday
  - **IGERT Nanomedicine Seminar Series**
    Speaker: Dr. Philip Demokritou, Assistant Professor of Aerosol Physics, Department of Environmental Health, Harvard School of Public Health

November

- 18 Friday
  - **IGERT Nanomedicine Seminar Series**
    Speaker: Dr. Lajos Balogh, Adjunct Professor of Pharmaceutical Sciences at NEU and Editor-in-Chief of Nanomedicine: Nanotechnology, Biology and Medicine
- 15 Tuesday
  - **IGERT Nanomedicine E-Lecture**
    Speaker: Amit Joshi, Ph.D., Assistant Professor of Radiology, Baylor College of Medicine
- 04 Friday
  - **IGERT Nanomedicine Seminar Series**
    Speaker: Dr. Tyrone Porter, Assistant Professor, Departments of Mechanical Engineering and Biomedical Engineering and Associate Director, Center for Nanoscience and Nanobiotechnology, Boston University
- 01 Tuesday
  - **IGERT Nanomedicine E-Lecture**
    Speaker: Dr. Rajesh R. Naik, Air Force Research Laboratory, Materials and Manufacturing Directorate

October

- 21 Friday

- **IGERT Nanomedicine Seminar Series**
  Speaker: Dr. Rohit Karnik, D'Arbeloff Assistant Professor, Department of Mechanical Engineering, MIT
- 04 Tuesday
  - **IGERT Nanomedicine E-Lecture**
    Speaker: Dr. Anu Puri, CCR Nanobiology Program, NCI-Frederick, NIH, Frederick, MD

September

- 30 Friday
  - **IGERT Nanomedicine Seminar Series**
    Speaker: Dr. Mukesh Harisinghani, Associate Professor, Harvard Medical School & Director Abdominal MRI, Massachusetts General Hospital

April

- 22 Friday
  - **Designer Nanoparticles for Drug Delivery: Physical Answers to Biological Questions**
    Speaker: Dr. Samir Mitragotri, Professor, Chemical Engineering, University of California
- 08 Friday
  - **Nanotechnology for Medical Applications**
    Speaker: Dr, Anuj Bellare, Director, Orthopedic Nanotechnology Laboratory, Brigham & Womens Hospital and Assistant Professor of Orthopedic Surgery, Harvard Medical School

February

- 04 Friday
  - **Flame synthesis of functional nanoparticles: Non-toxic nanosilver for biosensors**
    Speaker: Dr. Sotiris E. Pratsinis, Professor, ETH Zurich, Switzerland
  -

2010

November

- 19 Friday
  - **Self-assembly of DNA into Nanoscale Three-Dimensional Shapes**
    Speaker: William M. Shih, Ph.D., Associate Professor of Biological Chemistry and Molecular Pharmacology, Harvard Medical School, Department of Cancer Biology, Dana Farber Cancer Institute
- 08 Monday
  - **Control of Magnetic Drug Delivery: from magnets that push, to simulations that predict in-vivo behavior, to autopsy studies**
    Speaker: Dr. Benjamin Shapiro, Associate Professor, Fischell Department of Bioengineering, Institute for Systems Research

October

- 22 Friday
  - **Nanomedicine and Cardiovascular Disease**
    Speaker: Jason R. McCarthy, Ph.D., Center for Molecular Imaging Research and The Center for Systems Biology, MGH and Instructor in Radiology, Harvard Medical School

February

- 11 Thursday
  - **Synthesis and Characterization of Nanodevices for Targeting Tumor Microvasculature**
    Speaker: Wojciech Lesniak, Ph.D. , Instructor of Oncology, Roswell Park Cancer Institute, Department of Radiation Medicine, NanoBiotechnology Center
  -

2009

November

- 06 Friday
  - **IGERT Nanomedicine Distinguished Lecture**
    Speaker: Dr. Omid Farokhzad, Laboratory of Nanomedicine and Biomaterials, Department of Anesthesiology

October

- 30 Friday
  - **IGERT Nanomedicine Distinguished Lecture**
    Speaker: Dr. Mukesh Harisinghani, Director Abdominal MRI, Massachusetts General Hospital

2008

December

- 15 Monday
  - **Triggered Release of Doxorubicin from Nanoparticles**
    Speaker: Erin Pritchard, IGERT Undergarduate Phsyics Assocaite
- 05 Friday
  - **IGERT Nanomedicine Distinguished Lecture**
    Speaker: Dr. Anita Goel, Harvard/MIT, Founder Nanobiosym, Inc

November

- 05 Wednesday
  - **Luis Brito Dissertation Defense**
    Speaker: Luis Brito, Ph.D Candidate, Department of Pharmaceutical Sciences and IGERT Nanomedicine Fellow

October

- 24 Friday
  - **IGERT Nanomedicine Distinguished Lecture**
    Speaker: Lee Josephson, Ph.D, Associate Professor, Massachusetts General Hospital/Harvard Medical School

September

- 26 Friday
  - **IGERT Nanomedicine Distinguished Lecture**
    Speaker: Lev Perelman, Ph.D, Professor, Department of Physics and of Electrical and Computer Engineering
- 19 Friday

        - **Polymeric Nanoparticles for Targeted Drug and Gene Delivery**
          Speaker: Luis Brito, IGERT Nanomedicine Trainee and PhD Candidate, Dept of Pharmaceutical Sciences
    - 16 Tuesday
        - **Introduction to Nanomedicine**
          Speaker: Dr. Mansoor Amiji , Associate Professor, Dept of Pharmaceutical Sciences

August

- 11 Monday
    - **Nanomed Discussion with Yogesh Patel**
      Speaker: Yogesh Patel, PhD Candidate, ECE Department, and IGERT Nanomedicine Trainee

July

- 21 Monday
    - **Nanomed Discussion with Sucharita Saha**
      Speaker: Sucharita Saha, PhD Candidate, Department of Biology, and IGERT Nanomedicine Trainee

June

- 16 Monday
    - **Nanomed Discussion with Luis Brito**
      Speaker: Luis Brito, PhD Candidate, Department of Pharmaceutical Sciences, and IGERT Nanomedicine Trainee

May

- 12 Monday
    - **Nanomed Discussion with Lara Milane**
      Speaker: Lara Milane, PhD Candidate, Department of Pharmaceutical Sciences, and IGERT Nanomedicine Trainee
- 01 Thursday
    - **Application of Aptamer Technology in Protein Domain-Specific Targeting and Nanomedicine**
      Speaker: Wei Duan, Ph.D, Deakin University, Victoria, Australia

April

- 18 Friday
    - **IGERT Nanomedicine Distinguished Lecture**
      Speaker: Cynthia Bamdad, Founder & C.S.O. Minerva Biotechnologies
- 07 Monday
    - **Nanomedicine Discussion with Mattia Migliore**
      Speaker: Mattia Migliore, PhD Candidate of Pharmaceutical Sciences, and former IGERT Nanomedicine Fellow

March

- 24 Monday
    - **Nanomedicine Discussion with Paula Lampton**
      Speaker: Paula Lampton, PhD candidate of Biology, and former IGERT Nanomedicine Fellow
- 10 Monday

- **Nanomedicine Discussion with Lara Jabr Milane**
  Speaker: Lara Jabr Milane, PhD candidate of Pharmaceutical Sciences, and IGERT Nanomedicine Fellow

February

- 25 Monday
  - **Nanomedicine Discussion with Christian Matthaeus**
    Speaker: Postdoc, Diem Lab

2007

December

- 12 Wednesday
  - **Quartz Crystal Microbalance with Dissipation Workshop**
- 07 Friday
  - **Nanoparticle-based Antimicrobial Photochemotherapy in Biofilms**
    Speaker: Dr. Nikos Soukos, Director, Applied Molecular Photomedicine Laboratory, Forsyth Institute

November

- 27 Tuesday
  - **Engineering of Highly-Organized Tissue**
    Speaker: Dr. Jeffrey Ruberti, Associate Professor, Department of Mechanical and Industrial Engineering, Northeastern University
- 20 Tuesday
  - **Transport Phenomenon in Drug Delivery Systems**
    Speaker: Dr. Rebecca Carrier, Assistant Professor, Department of Chemical Engineering, Northeastern University
- 09 Friday
  - **Early detection, prognosis and customized therapy for breast cancer using quartz crystal nanobalance technology**
    Speaker: Dr. Susan Braunhut, Professor, Department of Biological Sciences, UMass Lowell
- 02 Friday
  - **Nanomedicine and Drug Delivery Symposium**
    Speaker: Dr. Robert Langer of MIT

October

- 23 Tuesday
  - **Nanotechnology and Societal Impact**
    Speaker: Dr. Chris Bosso, Professor and Associate Dean, Department of Political Science, Northeastern University
- 19 Friday

- **Microengineering the Cellular Environment for Tissue Engineering**
  Speaker: Dr. Ali Khademhosseini, Division of Health Sciences and Technology (HST), Harvard-MIT
- 16 Tuesday
  - **Biophysics of DNA Interactions**
    Speaker: Dr. Mark Williams, Associate Professor, Department of Physics, Northeastern University
- 12 Friday
  - **Entrepreneurship in Nanotechnology**
    Speaker: Dr. Paul Zavracky, Dean, School of Technological Entrepreneurship, Northeastern University
- 09 Tuesday
  - **Nanoparticles and Optics in Imaging**
    Speaker: Dr. Charles DiMarzio, Associate Professor, Electrical and Computer Engineering, Northeastern University
- 05 Friday
  - **Nanomedicinal Chemistry**
    Speaker: Dr. Robert Hanson, Professor, Department of Chemistry, Northeastern University
- 02 Tuesday
  - **fMRI and Neural Network Imaging**
    Speaker: Dr. Marcelo Febo, Assistant Professor, Department of Psychology, Northeastern University

September

- 21 Friday
  - **Nanomedicine for Treating Organ Failure**
    Speaker: Dr. Thomas Webster, Divisions of Engineering and Orthopedics, Brown University
  -

August

- 29 Wednesday
  - **Amphiphilic Core-Shell Nanoparticles with Poly(ethylenimine) Shells as Potential Gene and Drug Delivery Carriers**
    Speaker: Dr. Pauline Pei Li, Department of Applied Biology and Chemical Technology, The Hong Kong Polytechnic University, Hong Kong
- 22 Wednesday
  - **New Technologies for Directing and Analyzing Cell Response to Engineered 3D Environments**
    Speaker: Jennie B. Leach, University of Maryland, Baltimore City
- 02 Thursday
  - **Endothelial Nitric Oxide Synthase (eNOS) Gene Therapy with lipid / polymer based nanovectors**
    Speaker: Luis Brito, Ph.D. Candidate, Department of Pharmaceutical Sciences, IGERT Nanomedicine Fellow

July

- 17 Tuesday
  - **IGERT Nanomedicine Science and Technology Distinguished Lecture**
    Speaker: Dr. Ravi Kumar, Nanotechnology-Drug Delivery Group, INDIA, Department of Pharmaceutics & Center for Pharmaceutical Nanotechnology, National Institute of Pharmaceutical Education and Research (NIPER)

June

- 28 Thursday
  - **Application of Nanotemplates and Nanoparticles in Nanomedicine**
    Speaker: Evin Gultepe, PhD Candidate, Physics Department, Northeastern University
- 14 Thursday
  - **HER2/neu Receptor-Targeted Gelatin-Based Nanovectors for Pancreatic Cancer Gene Therapy**
    Speaker: Padmaja Magadala, IGERT Nanomedicine Fellow

May

- 27 Sunday
  - **The Mechanosensitivity of Type I Collagen to MMP Cleavage**
    Speaker: Robert Camp, IGERT Nanomedicine Fellow
- 11 Friday
  - **Molecular Response and Imaging-Based Combination Strategies for Optimal PDT**
    Speaker: Dr. Tayyaba Hasan, Professor, Dermatology, Mass General Hospital/Harvard Medical School

April

- 13 Friday
  - **Commercializing Nanotechnology for Biopharma Applications**
    Speaker: Dr. Michael Helmus, Sr. VP Biopharma, Advance Nanotech, Inc.
- 02 Monday
  - **Barry A. Berkowitz Symposium on Biotechnology**
    Speaker: Dr. Judah Folkman, "Angiogenesis in Biology and Medicine"

March

- 16 Friday
  - **Hybrid Nanoparticles in Cancer Therapy**
    Speaker: Dr. Shiladitya Sengupta, Assistant Professor, Brigham and Women's Hospital and Harvard-MIT Division of Heath Sciences and Technology

February

- 23 Friday
  - **Graduate Materials Links Symposium on Interdisciplinary Graduate Research**
- 16 Friday
  - **Biodendrimers for Medical Applications**
    Speaker: Dr. Mark Grinstaff, Professor, Departments of Biomedical Engineering and Chemistry, Boston University

2006

December

- 08 Friday
  - **Combination Thermal Medicine and Drug Delivery in Cancer**
    Speaker: Dr. Nahum Goldberg, Associate Professor of Radiology, Harvard Medical School
- 01 Friday
  - **Liposomes and Micelles**
    Speaker: Dr. Vladimir Torchilin, Professor and Chair, Director of the Center for Pharmaceutical Biotechnology and Nanomedicine, Northeastern University

November

- 21 Tuesday
  - **Mitochondrial Nanomedicine**
    Speaker: Dr. Volkmar Weissig, Assistant Professor, Pharmaceutical Sciences, Northeastern University
- 17 Friday
  - **The Nano-Photomedicine Initiative in Oral Disease**
    Speaker: Dr. Nikos Soukos, Director, Applied Molecular Photomedicine Laboratory
- 07 Tuesday
  - **Bio-Nano-Robotics**
    Speaker: Dr. Constantinos Mavroidis, Professor, Department of Mechanical and Industrial Engineering, Northeastern University
- 03 Friday
  - **Aptamers and Cancer Nanotechnology**
    Speaker: Dr. Omid Farokhzad, M.D., Assistant Professor, Harvard Medical School, Brigham and Women's Hospital

October

- 20 Friday
  - **Dr. Lee Josephson**
    Speaker: Dr. Lee Josephson, Associate Professor, Center for Molecular Imaging Research, Massachusetts General Hospital Associate Professor, Department of Radiology, Harvard Medical School
- 17 Tuesday
  - **"Tissue Engineering and Nanotechnology"**
    Speaker: Dr. Jeffrey Ruberti, Associate Professor, Mechanical & Industrial Engineering Department, Northeastern University
- 13 Friday
  - **"Precision-Guided Nanoparticles: Design and Synthesis"**
    Speaker: Dr. Robert Hanson, CAS Distinguished Professor, Department of Chemistry and Chemical Biology, Norheastern University
- 06 Friday
  - **"Microfluidics"**
    Speaker: Dr. Shashi Murthy, Assistant Professor, Department of Chemical Engineering, Northeastern University

- 03 Tuesday
  - **"Polymeric Nanoparticles"**
    Speaker: Dr. Mansoor Amiji, Professor of Pharmaceutical Sciences, Northeastern University

September

- 29 Friday
  - **Seminar**
    Speaker: Dr. Mansoor Amiji, Professor of Pharmaceutical Sciences, Northeastern University
- 26 Tuesday
  - **"Magnetic Nanoparticles and Energy Delivery for Therapy"**
    Speaker: Dr. Sri Sridhar, Vice Provost for Research, CAS Distinguished Professor of Physics, Director IGERT Nanomedicine Science and Technology, Northeastern University
- 22 Friday
  - **"Overview of Nanotechnology II: Imaging"**
    Speaker: Dr. Latika Menon, Assistant Professor, Physics Department, Northeastern University
- 19 Tuesday
  - **Overview of Nanotechnology I : Nanofabrication**
    Speaker: Dr. Latika Menon, Assistant Professor, Physics Department, Northeastern University

August

- 16 Wednesday
  - **Seminar**
    Speaker: Dr. Mary Jo Ondrechen, Professor, Department of Chemistry and Chemical Biology, Northeastern University
- 02 Wednesday
  - **Convergent Synthesis of Precision Guided Bifunctional Nanoparticles**
    Speaker: Adam Hendricks, IGERT PhD fellow

July

- 19 Wednesday
  - **Roles of Two Processivity Clamps in Resistance to DNA Damage and DNA Replication Stress**
    Speaker: Dr. Penny Beuning, Assistant Professor, Department of Chemistry and Chemical Biology, Northeastern University

June

- 07 Wednesday
  - **Alumina and Titania Nanotemplates in Nanomanufacturing and Nanomedicine**
    Speaker: Evin Gultepe, Ph.D. Candidate, Department of Physics, Northeastern University

May

- 26 Friday
  - **IGERT seminar: open discussions**
- 19 Friday
  - **Department of Pharmaceutical Science Research Showcase: "Emerging Therapeutics**

- 12 Friday
  - **Biomedical Applications of Microfluidics and Nanoscale Surface Engineering**
    Speaker: Dr. Shashi Murthi, Assistant Professor, Dept of Chemical Engineering, Northeastern University
- 05 Friday
  - **Adherent Leukocytes Capture Sickle Erythrocytes in an In Vitro Flow Model of Vaso-occlusion in Sickle Cell Disease**
    Speaker: Eileen Finnegan, Ph.D Candidate, Department of Chemical Engineering, Northeastern University

April

- 28 Friday
  - **IGERT seminar: open discussions**
- 21 Friday
  - **Karl Weiss Symposium on Membranes and Membrane Systems**
- 14 Friday
  - **Seminar**
    Speaker: Dr. Mary Shann, Professor, Department of Administration, Training, and Policy, Boston Univeristy
- 07 Friday
  - **Approaches to Novel Bivalent Linkers for Functionalized Nanoparticles**
    Speaker: Dr. Robert Hanson, Professor of Bioorganic and Medicinal Chemistry, Northeastern University

March

- 30 Thursday
  - **Application of Micro- and Nanotechnology Tools to Tissue Dysfunction**
    Speaker: Dr. Sangeeta Bhatia, Associate Professor, Health Sciences & Technology/Electrical Engineering & Computer Science, MIT
  - **Seminar**
    Speaker: Dr. Jennifer West, Isabel C. Cameron Professor of Bioengineering, Rice University
- 24 Friday
  - **Keck 3D Fusion Microscpe Facility for Nanomedicine Research**
    Speaker: Dr Gary Laevsky, Keck Facility Manager, CenSSIS, Northeastern University
- 03 Friday
  - **Nanoparticulate Carriers for Mitochondrial Gene Therapy**
    Speaker: Carol Kycia, IGERT undergraduate Fellow
  - **Seminar**
    Speaker: Dr. Volkmar Weissig, Professor of Pharmaceutical Science, Northeastern University
  - **Seminar**
    Speaker: Dr. Gerard D'Souza, rofessor of Agricultural and Resource Economics, West Virginia University

February

- 24 Friday

- **Intranasal delivery of GDNF for the treatment of Parkinson's disease**
  Speaker: Mattia Migliore, IGERT PhD fellow
- **Using Nanoparticles to Analyze Key Immune System Molecules in Embryonic Stem Cells**
  Speaker: Paula Lampton, IGERT PhD fellow

o 17 Friday
- **Computationally Guided Protein-Specific Labeling with Nanoparticles**
  Speaker: Heather Brodkin, IGERT PhD fellow
- **Magnetic Bacterial NanoProbes**
  Speaker: Anthony D'Onofrio, IGERT PhD fellow

o 10 Friday
- **IGERT Outreach**
  Speaker: Claire Duggan, Outreach Coordinator, Northeastern University

o 03 Friday
- **Development of a Polymeric Nanoparticle Formulation to Overcome Multidrug Resistance of Cancer via a Multifunctional Therapy**
  Speaker: Lilian van Vlerken, IGERT PhD fellow
- **Seminar**
  Speaker: Dr. Sri Sridhar, Director, IGERT Nanomedicine Science and Technology

NANOMEDICINE IGERT IN THE PRESS

- **63 news items mentioning EMRI/IGERT related work.**

2012

December

- 19 Wednesday
  - **Nanomedicine Course at University of Puerto Rico**

November

- 20 Tuesday
  - **IGERT Nanomedicine Trainee, Chris Kakidas, shows off his "Nano-Tattoos" at MoS Outreach Event**

June

- 19 Tuesday
  - **IGERT Director, Sri Sridhar, on broadening participation at IGERT PI Meeting 2012**

March

- 27 Tuesday
  - **Paper by IGERT trainee, Brian Plouffe, is among the Hottest Research Articles of 2011 in J Magnetism and Magnetic Materials**

February

- 24 Friday
  - **IGERT Trainee, Brian Plouffe, designs miniature device to detect late-stage cancer**
- 02 Thursday
  - **NU on IGERT trainee, Samira Faegh, and her micro-cantilever approach to cancer diagnostics**

January

- 20 Friday
  - **IGERT Trainee, Brian Plouffe, gets coverage for his IGERT research in Chemical and Engineering News**
  -

2011

July

- 26 Tuesday
  - **IGERT Trainees, Matt Dubach and Kate Balaconis "digital tatoo" work featured in Wired**

- 20 Wednesday
  - IGERT trainee, Matt Dubach, featured in MITs Technology Review

June

- 10 Friday
  - NU IGERT Nanomedicine trainees on YouTube!

May

- 06 Friday
  - IGERT trainees, Kate Balaconis and Samira Faegh, contestants in IGERT's 1st Online Poster Competition

April

- 22 Friday
  - IGERT Nanomedicine Reception
- 06 Wednesday
  - IGERT Trainees Brian Plouffe and Matt Dubach "Outstanding" presenters at 2011 NU Research Expo

February

- 22 Tuesday
  - IGERT Trainees, Kate Balconis and Matt Dubach make CIMIT Top 10
- 02 Wednesday
  - IGERT Trainee Brendan Harmon Receives ASPET Graduate Student Travel Award

January

- 21 Friday
  - IGERT Nanomedicine Program Recognized on IGERT.org

2010

December

- 03 Friday
  - IGERT Undergrad, Mathew Chamberlain, aka 'Veteran of the Research Lab'

October

- 07 Thursday
  - IGERT Nanomedicine Program mentioned in President Aoun's 'Our Research Enterprise'

September

- 25 Saturday

- IGERT Recruits at GEM Grad Lab

July

- 14 Wednesday
  - "Intro to Nanoworld" Series Carries on!
- 01 Thursday
  - NSF RENEWS IGERT NANOMEDICINE PHD PROGRAM! 2010-2015

April

- 19 Monday
  - IGERT Trainees Attend, and Win, at UT Austin IGERT Workshop!

March

- 24 Wednesday
  - IGERT Nanomedicine Trainees and Associates show up big at 2010 NU Research Expo

February

- 17 Wednesday
- Breakthrough technology for testing Alzheimer's and Parkinson's drugs

2009

December

- 21 Monday
- Nanotechnology collaboration aimed at curing cancers with "smart implants"

May

- 19 Tuesday
  - IGERT Trainee, Yogesh Patel, wins IGERT PI meeting poster competition
- 08 Friday
  - IGERT Trainee, Lara Jabr, wins ISPE poster competition

2008

April

- 25 Friday
  - IGERT Nanomedicine Fellow, Padmaja Magadala, wins second place for research presented at the AAPS-NERDG Academic Research Award poster competition
- 07 Monday
  - Sridhar gives talk at Northeast Bioengineering Conference at Brown
- 02 Wednesday
  - IGERT Fellow, Padmaja Magadala, wins ISPE poster competition

- 01 Tuesday
  - NIH National Graduate Student Research Festival

February

- 29 Friday
  - IGERT Fellow, Mattia Migliore, selected for Phi Kappa Phi Honor Society
- 05 Tuesday
  - IGERT Director, Sri Sridhar, quoted in Discovery News Online article on Nanowires

January

- 18 Friday
  - IGERT sponsored research leads to MJFF grant

2007

November

- 29 Thursday
  - IGERT Research Coordinator Dattatri Nagesha quoted in Express Pharma Online
- 26 Monday
  - 2008 Undergraduate Summer and Graduate Program Opportunities

October

- 16 Tuesday
  - Sucharita Saha and Paula Lampton attend 2007 NCI Alliance Investigators Meeting

August

- 07 Tuesday
  - IGERT Nanomedicine Outreach: Introduction to the Nanoworld

July

- 20 Friday
  - Indian nanomedicine leader tells doctoral students: Future is bright
- 03 Tuesday
  - Fall Internship Opportunities at Pfizer

June

- 22 Friday
  - IGERT Student Research Symposium 2007
- 21 Thursday
  - Fellowship Opportunities

- 14 Thursday
  - IGERT Nanomedicine Fellow, Lilian van Vlerken, published in Cancer Research
- 01 Friday
  - IGERT CO-Director Mansoor Amiji interviews with Nanopharmaceuticals Online

May

- 29 Tuesday
  - IGERT Nanomedicine Program Recruits Padmaja Magadala, Participant of the Minority Training Program in Cancer Control Research, MTPCCR, UCS
  -

2006

November

- 20 Monday
  - 2007 Undergraduate and Graduate Summer Opportunties

March

- 29 Wednesday
  - IGERT Fellow, Lilian van Vlerken, Wins ISPE Competition

January

- 01 Sunday
  - Northeastern Announces IGERT Program For Nanomedicine Technology
  -

2005

September

- 21 Wednesday
  - National Cancer Institute And National Science Foundation Award Training Grants For Nano-Biotechnology
  - National Cancer Institute And National Science Foundation Launch Collaboration
  - NU Receives $3.3 Million Grant From National Cancer Institute

K-12 OUTREACH

- Vigorous K-12 outreach program – more than 40 outreach projects by trainees.

IGERT Outreach provides education and leadership to young people from surrounding elementary, middle, and high schools in the Boston area. IGERT PhD's participate in various outreach activities, some of which include the following:

Young Scholars Program

The Young Scholars Program offers future scientists and engineers an opportunity for hands-on experience while still in high school. The program is open to Boston area applicants who have completed either their sophomore or junior year in high school. IGERT Trainees spend several weeks mentoring one or two students from this program and describe it as a very rewarding experience.

Experiences for Teachers, "RET"

The RET program provides Middle and High School teachers the opportunity to participate in a six week summer research experience and supporting professional development. IGERT Trainees train and mentor high school teachers in the area of Nanomedicine. The intent is to familiarize them in a new field to bring back to their classrooms.

Lesson Development

Some IGERT Trainees work solely on preparing lessons for high school teachers, enabling them to bring new topics such as Nanomedicine to the classroom.

Field Trips/Presentations

IGERT Trainees plan and host several field trips per year for middle and high school students from Greater Boston Area schools. Students are given tours of Northeastern University research labs, are presented with new research concepts, and at times, take part in mini lab experiments.

Science Fair Mentoring and Support

Both IGERT Trainees and Undergraduate Associates assist regularly in mentoring Boston Public School students at a variety of Science Fairs. Northeastern University also holds its own Annual Science Fair for the purpose of supporting local public school students interested in the sciences.

OUTREACH HIGHLIGHTS

Title: Adam Hendricks - Outreach
Media Outlet/Organization: O'Bryant High School
Activity Date: 06/01/2006
Description: Adam Hendricks made a "What is Nano?" presentation for O'bryant high School student field trips to Northeastern University on 6/5/06 and 6/8/06.

Title: Anthony D'Onofrio - Outreach
Media Outlet/Organization: NSF RET program for Wellesley High and Medford High teachers
Activity Date: 06/01/2006
Description: Anthony D'Onofrio took part in a a 6 week Research Experience for Teachers summer program. He was responsible for developing and training teachers on a research project they can then bring back to their classrooms.

Title: Heather Brodkin - Outreach
Media Outlet/Organization: Organizer for O'bryant High School student Field Trip
Activity Date: 06/01/2006
Description: Heather Brodkin organized a very large visit of O'bryant High School Students to visit several Northeastern University labs on 6/5/06 and 6/8/06.

Title: Heather Brodkin - Outreach
Media Outlet/Organization: Dover-Sherborn High School
Activity Date: 06/01/2006
Description: Heather hosted a field trip for high school students from Dover-Sherborn High. She did demonstrations on each piece of equipment in her lab and explained clearly to students their uses.

Title: Lilian van Vlerken - Outreach
Media Outlet/Organization: Young Scholars Program, Northeastern University
Activity Date: 06/01/2006
Description: Lilian van Vlerken hosted two Boston area high school students in the Young Scholars Program for a summer research internship. The project exposed the students to nanoparticle engineering and use.

Title: Mattia Migliore - Outreach
Media Outlet/Organization: Brigham and Women's Hospital Anticoagulation Service
Activity Date: 07/01/2006
Description: Mattia Migliore has been regularly mentoring high School Students through the Brigham and Women's Hospital Anticoagulation Service.

Title: Mattia Migliore - Outreach
Media Outlet/Organization: Health Careers Academy's Science Fair
Activity Date: 02/01/2007
Description: On 2/1/07 and 3/10/07 Mattia Migliore was a judge for the Health Careers Academy's Science Fair.

Title: Paula Lampton - Outreach
Media Outlet/Organization: Codman Academy, Dorchester MA
Activity Date: 09/01/2006
Description: Fall 2006 semester Paula Lampton served as a teaching aide for a high school chemistry class at Codman Academy. Paula's role was primarily lesson development.

Title: "Introduction to the Nanoworld" Presentation Series (1)
Media Outlet/Organization: Quincy High School
Activity Date: 02/11/2009
Description: The Nanoworld presentation and its accompanying experiments challenge students to probe the journey of medicinal nanotechnology, and to consider future implications and current obstacles. Brain Plouffe, led this workshop.

Title: "Introduction to the Nanoworld" Presentation Series (2)
Media Outlet/Organization: Exxon Mobil Bernard Harris Summer Camp
Activity Date: 07/07/2008
Description: IGERT Trainees, Brian Plouffe, Agnes Rafalko and Tatyana Chernenko, gave

the Introduction to the Nanoworld Presentation Series for the annual Exxon Mobil Bernard Harris Summer Camp to 40 inner city middle school students.

Title: Community College Lecture
Media Outlet/Organization: MassBay Community College
Activity Date: 04/03/2009
Description: Tatyana Chernenko was invited by the Chemistry department at MassBay Community College to give a lecture on her work with nano-particles. She also explained research options if they are to apply to a full time accredited university.

Title: Nanomedicine Presentation/Field Trip
Media Outlet/Organization: MassBay Community College, Newbury College, Bunker Hill Community College
Activity Date: 04/03/2009
Description: IGERT Nanomedicine Trainees, Dennis Szymanski, Agnes Rafalko and Robert Camp gave a nanomedicine presentation and a tour of their research laboratories to community college students looking to transfer to Northeastern.

Title: Research Science Institute Mentoring
Media Outlet/Organization: Research Science Institute (in collaboration w/ MIT)
Activity Date: 07/01/2008
Description: IGERT Trainee, Padmaja Magadala, hosted her annual Research Science Institute student in summer 2008.

Media Outlet/Organization: NU Step-Up program
08/06/2009
IGERT trainees, Agnes Rafalko and Dennis Szymanski, gave a presentation on nanotechnology to students enrolled in community colleges with goals of recruiting and retaining under-represented students in stem fields.

Media Outlet/Organization: MCC Women in Science
03/02/2010
IGERT trainees, Agnes Rafalko and Kathy Chaurasiya, were panelists of the 5th Annual Women in Stem Panel to advise STEM community college students on how to achieve their research goals at 4-year institutions and beyond.

Media Outlet/Organization: Exxon Mobile
07/09/2009
IGERT Trainees, Agnes Rafalko and Dennis Szymanski, helped host the ExxonMobil Bernard Harris Summer Science Camp at NU. The goal is to enable youth to achieve their full potential through support of social, recreational and STEM education prog's.

Media Outlet/Organization: Young Scholars Program
07/22/2009
IGERT trainee, Dennis Szymanski, presented the "Introduction to the Nanoworld" to students from the Young Scholars Program. The "Nanoworld" presentation series was developed by our NU Nanomed trainees in 2006 and has been used since.

Media Outlet/Organization: Boston Public Regional Science Fair
03/06/2010
IGERT Trainees, Kathy Chaurasiya and Dennis Szymanski, judged the Northeastern University science fair for K-12 students of Boston Public Schools.

Media Outlet/Organization: Young Scholars Program
06/01/2009
IGERT trainees, Brian Plouffe, Thomas Barchet and Yogesh Patel, each mentored two high school students for the summer from the Young Scholars Program in their laboratories. Students are given small research projects to work on.

Media Outlet/Organization: Massachusetts State Science and Engineering Fair
03/06/2010
IGERT trainee, Kathy Chaurasiya, was a judge of the Massachusetts State Science and Engineering Fair.

Media Outlet/Organization: Harvard Musuem of Natural History
01/01/2010
IGERT trainee, Joslynn Lee, spent one Wednesday a month volunteering at the Harvard Musuem of Natural History for various family-focused science events.

Media Outlet/Organization: Science Club for Girls
01/01/2010
IGERT trainee, Joslynn Lee, does volunteer teaching at various Boston area schools through the Science Club for Girls which targets educating female students from grades K-7 in science. She also mentors one eighth grade student through this program.

Media Outlet/Organization: Museum of Science
05/01/2010
IGERT trainee, Kathy Chaurasiya, participated in the Museum of Science 'Inspiring Minds: Meeting Women in Science'. The program aims to bring women from all fields of science together to learn from, to collaborate with and to inspire and motivate.

Media Outlet/Organization: PRISM
07/14/2010

IGERT trainees, Joslynn Lee, Bredan Flynn and Kathy Chaurasiya hosted 25 freshmen STEM and Science-Undeclared students with tours of their various labs and a nanomedicine presentation. The overall goal is to encourage them to pursue STEM careers.

Media Outlet/Organization: Massachusetts State Science and Engineering Fair
04/30/2010
IGERT trainee, Kathy Chaurasiya, was a judge of the the Massachusetts State Science and Engineering Fair.

Media Outlet/Organization: Young Scholars Program
06/01/2010
IGERT trainee, Thomas Barchet, mentored a young visiting scholar Gary Lee (from Singapore) for an entire summer in his laboratory at NU. His project was on evaluating the e?cacy of oil-in-water nanoemulsion systems as vectors for plasmid delivery.

Media Outlet/Organization: Exxon Mobile Summer Camp
07/14/2010
Each year our IGERT trainees gather as a group and give a presentation titled "Introduction to the Nanoworld" to Jr High student who stay at NU for the Exxon Mobile summer camp. The presentation series includes a small 'nano' experiment.

Media Outlet/Organization: Edward M. Kennedy Academy for Health Careers
04/12/2011
IGERT trainee, Brendan Harmon, was a judge at the Edward M. Kennedy Academy for Health Careers Fair for high school students.

Media Outlet/Organization: Smithsonian
04/02/2011
IGERT Trainees, Matt Dubach and Katie Balaconis, were invited as guests to speak about Nanomedicine at "Nanodays" at the Smithsonian. They spoke and did demonstrations for grade school students.

Media Outlet/Organization: Edward M. Kennedy Academy for Health Careers
03/01/2011
IGERT trainee, Katie Balaconis, spoke with students from the Edward M. Kennedy Academy for Health Careers about her experience working in a nanolab. The event was planned to recruit two high school students for summer mentoring.

Media Outlet/Organization: Massachusetts State Science and Engineering Fair Judge
05/06/2011
IGERT trainee, Kathy Chaurasiya, is scheduled to be a judge for the 5/6/11 Massachusetts State Science and Engineering Fair.

Media Outlet/Organization: Michael J. Perkins Elementary School

Date of activity:
09/20/2011
Type of activity: K-12
IGERT trainee, Katie Balaconis gave a demo at the Michael J. Perkins Elementary School in South Boston fortheir Annual Science Night!

Media Outlet/Organization: American Chemical Society
07/01/2011
Type of activity: K-12
IGERT Trainees, Katie Balaconis and Matt Dubach, mentored two high school students in their lab from the Edward M. Kennedy Acadamy for Health Careers. The students worked over the summer and each completed their own research project.

Media Outlet/Organization: Exxon Mobile Summer Camp
07/14/2011
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Type of activity: K-12
Each year our IGERT trainees gather as a group and give a presentation titled "Introduction to the Nanoworld" to Jr. High students who stay at NU for the Exxon Mobile Summer Camp. The presentation series includes a small 'nanomedicine' experiment.

Media Outlet/Organization: Northeastern PRISM program
10/15/2011
Type of activity: Undergraduate
IGERT trainee, Bobby Riehle, volunteered with first year STEM program students at Northeastern University. He educated them on Nanomedicine and the advantages of STEM degrees.

Media Outlet/Organization: Massachusetts State Science & Engineering Science Fair
05/04/2012
Type of activity: K-12
IGERT trainee, Bobby Riehle was a judge at the Massachusetts State Science & Engineering Science Fair. He represented the field of nanomedicine and the Northeastern IGERT Nanomedicine Program in particular.

Media Outlet/Organization: Rho Chi Pharmacy Honor Society
09/01/2011
Type of activity: Informal Science
IGERT trainee, Brendan Harmon, is a member of the Rho Chi Pharmacy Honor Society, Beta Tau Chapter at Northeastern University where he volunteers as a science tutor as needed.

Media Outlet/Organization: Tuskegee University's Research Experience for High School and Undergraduates Program (REH/REU)
06/16/2011

Type of activity: K-12
TU IGERT Trainee, Myisha Roberson (TU), mentored 1 high school student in (REH/REU) program in STEM experiments, and prepared her for the SAT and ACT.

Media Outlet/Organization: Northeastern University PRISM
08/20/2011
Type of activity: Undergraduate
NU IGERT Trainees Jennifer Monahan and Michael Cuccarese volunteered with PRISM's 'Summer Preview' to introduce incoming freshmen to nanotechnology, guide laboratory tours, and answer questions regarding graduate school and general research.

Media Outlet/Organization: Girl Scouts of Eastern Massachusetts
05/01/2012
Type of activity: Informal Science
In May 2012, NU IGERT Trainee, Jennifer Monahan became an official Girl Scout of Eastern Massachusetts Volunteer. She will aid a local troop and assist the girls in earning science badges. Her goal is to motivate them about careers in science.

Media Outlet/Organization: Name of media outlet or organization for which outreach was done:
University of Puerto Rico Mayaguez
06/01/2011
Type of activity: K-12
UPRM IGERT Trainee, Ramonita Ayala, trained a high school science teacher for six weeks under the Research Experience for Teachers (RET) summer program sponsored by Wisconsin-Puerto Rico Partnership for Research and Education in Materials [Wi(PR)2EM)]

Media Outlet/Organization: Northeastern University PRISM
06/15/2011
Type of activity: Informal Science
NU IGERT Trainee, Michael Johnson, revised and prepared "Introduction to the Nanoworld" PowerPoint presentation for future IGERT Nanomedicine outreach tours. The presentation has already been used for PRISM students.

Media Outlet/Organization: UPRM STEP-UP
07/01/2011
Type of activity: K-12
UPIGERT Trainee, Ramonita Ayala, mentored a high school student for 8 weeks in STEP-UP. Student was involved with hands on research as well as oral and poster sessions.

Media Outlet/Organization: UPRM Center for Research Excellence in Science and Technology (CREST)
09/01/2011
Type of activity: K-12

UPRM IGERT Trainee, Vanessa Rivera, took part in a CREST high school visit, where volunteers interacted with high school students by performing various activities related to polymers properties, applications and their use in nanotechnology.

Media Outlet/Organization: Northeastern University PRISM
08/23/2012
Type of activity: Other: high school and undergraduate
Michael Johnson participated in the planning and execution of a short lecture series on nanotechnology followed by three laboratory demonstration sessions for Northeastern University PRISM students. Michael has been working with PRISM for three years

Media Outlet/Organization: Roxbury Community College
01/07/2013
Type of activity: Undergraduate
IGERT Trainee, Samira Faegh, is leading group of Roxbury Community College undergraduates in building and testing high quality resonating circuits. This project is a two semester project and will extend into the coming summer.

Media Outlet/Organization: Northeastern University's STEM Education "College Days"
06/03/2012
Type of activity: K-12
IGERT Trainees, Jennifer Monahan, Jennifer Woodring and Stacey Markovic participated in Northeastern University's STEM Education "College Days" which was an event for eighth graders from Boston local schools to learn about college level sciences.

Media Outlet/Organization: Girl Scouts of Eastern Massachusetts
06/01/2012
Type of activity: Government
IGERT Trainee, Jennifer Monahan's involvement with the Girl Scouts has been ongoing. This past year Jennifer has participated in two science workshops with the Girl Scouts to get third grade female students excited about science.

Media Outlet/Organization: Young Scholar's Program
09/01/2012
Type of activity: K-12
IGERT trainee, Jennifer Monahan, spent a semester volunteering with Northeastern's Young Scholar's Program. Jennifer hosted two Boston high school students several days a week and led them in a project on Melanoma.

Media Outlet/Organization: Northeastern University STEM
11/23/2012
Type of activity: Undergraduate

Over the Thanksgiving break, IGERT trainee, Michael Cuccarese, created and gave a presentation on drug discovery/development and led accompanying lab tours to Northeastern University freshmen interested in sciences.

Media Outlet/Organization: Northeastern University PRISM
08/23/2012
Type of activity: Other: high school and undergraduate
IGERT Trainee, Michael Cuccarese, participated in the planning and execution of a short lecture series on Nanotechnology followed by three laboratory demonstration sessions and a panel discussion to Northeastern University freshman PRISM students.

Media Outlet/Organization: Northeastern University PRISM
06/28/2012
Type of activity: Undergraduate
IGERT trainee, Christopher Kakidas, participated in the planning and execution of a short lecture series on nanotechnology followed by three laboratory demonstration sessions and a panel discussion to Northeastern University PRISM students.

Media Outlet/Organization: Museum of Science
11/21/2012
Type of activity: Museum
IGERT Trainee, Christopher Kakidas, volunteered at the Museum of Science annual event for ACS National Chemistry Week. Chris presented his research on glucose sensors to K-12 students and set up a mini experiment for the students to participate in.

Media Outlet/Organization: Cambridge Science Festival
04/12/2013
Type of activity: Informal Science
IGERT trainee, Christopher Kakidas, volunteered at the Cambridge Science Festival, a ten day event hosted by MIT, Harvard, WGBH, MOS & City of Cambridge. It is the first of its kind in the United States.

Media Outlet/Organization: Boston Regional Science Fair, Northeastern University
03/02/2013
Type of activity: K-12
IGERT trainees, James Teh Stacey Markovic and Robert Abbott, all served as Science Fair Judges to K-12 students at Northeastern 's annual Boston Regional Science Fair.

Media Outlet/Organization: Northeastern University PRISM
08/23/2012
Type of activity: Undergraduate
IGERT Trainee, Jennifer Woodring, participated in the planning and execution of a short lecture series on

Nanotechnology followed by three laboratory demonstration sessions and a panel discussion to Northeastern University freshman PRISM students.

Media Outlet/Organization: Greater Boston South Shore Science Partnership
06/04/2012
Type of activity: K-12
IGERT Trainee, James Teh, trained K-12 teachers from the Greater Boston South Shore Science Partnership in his current chemistry lab activities. The teachers then modified these experiments to their classroom levels.

Media Outlet/Organization: Society for Women Engineers
09/20/2012
Type of activity: Undergraduate
IGERT trainee, Stacey Markovic, was part of a panel of Northeastern University female graduate students in the sciences at who answered questions to incoming freshmen about increased amounts of women in engineering fields.

Media Outlet/Organization: Tuskegee Institute Middle School, Tuskegee, AL
10/10/2012
Type of activity: K-12
Trainee, Julaunica Tigner has been involved in outreach targeting local middle school students. Middle school Students participating had a significant increase in their knowledge of biosensors (outreach topic) as well as their interest in STEM Careers