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POLYTECHNIC INSTITUTE OF NYU



# abstracts

## SECOND POLYTECHNIC INSTITUTE OF NYU SYMPOSIUM ON UNDERGRADUATE RESEARCH

2008

"Innovation, invention and entrepreneurship (we call it i2e) are clearly the key to success for young people in the 21st century. That's why Polytechnic Institute of NYU has made i2e a core feature of our education and research."

— **Jerry M. Hultin**
**President, Polytechnic Institute of NYU**

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# Preface

The Second Annual Polytechnic Undergraduate Summer Research Program is one of the Institute's major initiatives to introduce intellectually gifted students to the extraordinary research that forms the foundation of the educational experience at Polytechnic. This forward-thinking technology research creates an opportunity for our premier students to work hand-in-hand with some of the Institute's creative and innovative science and engineering faculty. This year, 80 students worked in Polytechnic laboratories as part of a 10-week research immersion program and experienced first-hand the Institute's commitment to educating the technology innovators, inventors and entrepreneurs of this century.

This booklet contains the abstracts of the undergraduate research projects that were performed and will be presented as posters at the 2008 New Student Convocation on Tuesday, August 26. The broad scope of the undergraduate projects ranged from basic knowledge creation and the invention of new materials and processes to the development of new technologies and applications. Specifically, students researched computer game technologies for complex distributed systems, worked on advanced network security issues, engineered nanoscale protein carriers, designed drug delivery carriers for cancer therapeutics and demonstrated the physics of quantum information devices.

The highlight of this year's program was a luncheon on June 18 with Dr. Martin Perl, the 1995 Nobel Prize winner in Physics and a 1948 Polytechnic graduate. Dr. Perl shared stories of his own research experience with the students and encouraged them to be persistent in their pursuit of creating new knowledge and their aspirations to discover, invent, and innovate. The students in the program also took part in weekly seminars with Polytechnic faculty members.

The Undergraduate Summer Research program was initiated in 2007 by the Office of the Provost. Its success in 2007 and 2008 was made possible by the financial support from the Institute's most loyal and generous donors. Additional support came from the Othmer Institute for Interdisciplinary Studies and supplements from the research grants of individual faculty members.

Iraj Kalkhoran
Dean of Undergraduate Academics
Polytechnic Institute of NYU
August 26, 2008

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| *Khorrami, F.* | Electrical and Computer Engineering |
| *Kim, J.* | Chemical and Biological Sciences |
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| *Montclare, J.* | Chemical and Biological Sciences |
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| *Panwar, S.* | Center for Advanced Telecommunications in Technology |
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| *Porfiri, M.* | Mechanical and Aerospace Engineering |
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# Center for Advanced Telecommunications in Technology

## Dynamic-rate Adaptation with Forward-error Correction

*Caleb Li*

**Center for Advanced Telecommunications in Technology**
Polytechnic Institute of New York University, Five MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Shivendra S. Panwar*

Wireless networks bear several characteristics that differ from conventional wired networks. A few challenges arise from error-prone wireless channels, unstable wireless links and other time-varying changes that often contribute to the invalidity or inefficiency of the design and of the implementation methods, which were developed and used for their wired counterparts. Several methods have been proposed to cope with these issues in wireless environments. Two well-known ones are Dynamic Rate Adaptation and Forward-error Correction (FEC). Dynamic Rate Adaptation adjusts transmission rates based on channel conditions. FEC generates and transmits redundant parity packets, which can be put to use by the receiver through block erasure codes, without contacting the transmitter.

In this project, we combine the two mentioned technologies to form a new scheme that would both dynamically adjust the transmission rate as well as apply FEC to optimize the transmission efficiency. In conventional rate adaptation, the transmitter would reduce its transmission rate to a lower level upon losing several consecutive packets. However, in our proposed scheme, instead of dropping the rate after packet loss, we follow a more aggressive approach where FEC is applied appropriately to compensate for the losses while maintaining a higher level of transmission rate. We drop the level of transmission rate only when the FEC is unable to compensate for the losses. The combination of these two mechanisms is efficient due to the ability to transmit the extra parity packets by maintaining a higher transmission rate, resulting in a higher throughput. We further implement the system using open source drivers and socket programming, and run experiments in order to measure the system performance in a real environment.

# Civil Engineering

## Creep in E-Glass

*Shivani Patel*

**Department of Civil Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Magued Iskander*

Today, there are many problems with using conventional materials in certain applications, particularly in piling applications. Current piles are made of steel, concrete, and timber—all materials that do not last very long under the harsh and corrosive environments that the piles are subject to. So, it is proposed that fiber-reinforced plastics be used instead. Unfortunately, there is not much data on the long-term behavior of these plastics, and thus engineers are reluctant to use these materials.

The subject of my research is to find the creep behavior of E-Glass, a common reinforcement used in the plastics. The plastics used for piling are usually HDPE (high-density polyethylene). To estimate the creep of the E-Glass, various stress-strain curves are found at different strain rates. Then, using multiple methods, all based on different initial assumptions, the creep behavior will be extrapolated for an appropriate amount of years, for example, 100 years.

Furthermore, an actual creep test will be performed on the material, and this will be compared to the extrapolated behaviors. This will either validate or invalidate the extrapolated results, and allow us to determine the best method to use to extrapolate creep behavior for this type of material. Additionally, some of the methods used to find creep have been used, and this will determine if it is in fact the best way to determine creep. Hopefully, this research will provide new information to the field of reinforced plastics and, based on the creep data, encourage engineers to use reinforced plastics in various engineering applications.

# Chemical and Biological Engineering

## Incorporation of Non-natural Amino Acids Using the Selenocysteine Biosynthetic Pathway

*Wah Yan, Susheel Kumar Gunasekar, Man Xia Lee and Wendy Hom*

**Department of Chemical and Biological Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Jin K. Montclare*

The established methodologies for the incorporation of non-natural amino acids have proven to be a useful tool for the synthesis of new and novel proteins. However, strategies such as residue-specific incorporation, in which a natural amino acid is replaced globally, and site-specific incorporation, which utilizes misacylated-tRNA synthetase, both have their shortcomings. The former lacks specificity while the latter lacks efficiency. Thus, a new method of incorporation that is both specific and efficient should be developed. To that end, we demonstrate the potential of using the biosynthetic pathway of selenocysteine, a naturally specific and efficient pathway that codes the 21st amino acid selenocysteine into formate dehydrogenase H enzyme (fdhF), as a new method for the incorporation of non-natural amino acids.

## Studies on Transbilayer Transport and Interbilayer Fusion Caused by the Interfaces of pH-controlled Heterogeneities on Model Lipid Membranes

*Gittel T. Gold and Manali Bhaga*

**Department of Chemical and Biological Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Stavroula Sofou*

Targeted therapy of solid tumors necessitates a powerful drug delivery carrier that is rigid while circulating in the blood, but permeable at the site of the tumor—and only there—where it must release its contents. It is essentially a balancing task: to ensure toxicity where toxicity is required, and reduce toxicity at all other sites— to maintain the condition of healthy tissue. Liposomes, which are being engineered here in the Drug Delivery Systems Lab, have the potential to meet the necessary criteria for being the optimal drug delivery carrier. The primary lipid pair that is studied is phosphatidylcholine (PC), which is zwitterionic and phosphatidic acid (PA),

a lipid bearing a negatively charged headgroup. When the pH is decreased, protonation of the PA headgroups allows for hydrogen bonding among the PA headgroups and for potential Van der Waals attractions among the matching length acyl chains of lipids to take place resulting in the formation of lipid heterogeneities. When all lipids are in the gel state, the interfaces of these heterogenities exhibit molecular packing defects rendering the bilayer permeable. With increase in time, and decrease in pH, these interfaces become more 'leaky' causing increased content release. It has been determined [by other members of the lab] that lipid pairs with non-matching tail lengths exhibit more efficient release with respect to pH, and therefore, the primary pair of lipids used is DPPC/DSPA. However, DPPC/DPPA and DSPC/DSPA [matching chain lengths at n = 16 and 18 carbons, respectively] are studied as well, and serve as additional systems for comparison. The effect of the incorporation of both cholesterol and PEG must each be evaluated because PEGylated lipids exhibit longer circulation times in the blood, and cholesterol plays a role in the biological membrane in facilitating rigidity, and their presence will be interdependent on the activity of the liposomes. Many controls are necessary for the various parameters, for example, for each pair of lipids, four sets must be studied: with both cholesterol and PEG, with neither, and with each individually- without the other. The potential therapeutic agent was modeled as a fluorophore (calcein), so that it can be tracked by fluorescence spectroscopy. Because of its property to self-quench at high concentrations [~>10mM], calcein is the fluorophore of choice for this experiment. Calcein-release experiments were conducted to determine the release of contents as a function of pH and time. Further/future studies will monitor the content mixing of the liposome with the endosome in the expectation that once the liposome is internalized by the cell, it will not get to the final endosomal stage, where it will be degraded by the lysosome, but rather—it will mix with the endosomal membrane, thereby emptying its contents into the cytoplasm. The calcein-release experiments are preliminary to the content mixing experiments.

## Effect of pH on the Critical Micelle Concentration of an Ionic Amphiphile

*Raymond Chen*

**Department of Chemical and Biological Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Stavroula Sofou*

The ability of matter to self assemble is a phenomenon that is a part of life. It is everywhere; from detergents, soaps, liposomes and especially the cell membrane that is the basis of all life. This project focuses on the understanding of those intermolecular forces that affect the critical micelle concentration (CMC) of amphiphilic molecules. CMC is important in understanding why and when these self-assembled structures, such as liposomes, form. Understanding CMC is crucial in our lab, especially when drug delivery systems such as lipid vesicles are being studied. To measure CMC, we used a fluorophore, Nile Red, as an indicator and measured fluorescence intensity. Nile Red fluoresces only when in hydrophobic environments, in this case the inside of the micelle. We prepared a solution of phosphate buffer and Nile Red in a cuvette and gradually added SDS, which is an amphiphilic molecule, in increasing volumes to the cuvette and measured the intensity each time. Our results show strong effect of pH on the measured value of CMC. At decreasing pH, the headgroups of the negatively charged amphiphiles become protonated and electrically neutral, and, thus, experience less repulsion which explains the lower CMC values at lower pH.

## Examination of Aggregation of Amyloid β Peptide by Using GFP

*Mengyue Xiang*

**Department of Chemical and Biological Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Jin Ryoun Kim*

Alzheimer's disease (AD), which is a neurodegenerative disorder, affects 25 million people in the world. There is no effective treatment or diagnosis. Aggregation of the amyloid β (Aβ) peptide is important in the molecular etiology of AD. Examination of aggregation is extremely important for the identification of the molecular processes where toxicity is generated. Monitoring aggregation in living cells is required for this purpose, since aggregation *in vivo* may be different from that of *in vitro* because of the cellular milieu. The objective of the project is to try to examine the *In vivo* aggregation of Aβ under different conditions. To this end, a pre-established genetic screening system where Aβ-green fluorescent protein (GFP) fusion protein is expressed in *Escherichia coli.* will be employed. In this *in vivo* screening system, fluorescence of GFP relies on the aggregation propensity of Aβ. Aggregation of Aβ will reduce the fluorescence of GFP. Our hypothesis is that expression conditions, such as temperatures and expression levels, might have influence of the aggregation of Aβ peptide. A DNA sequence of Aβ-GFP will be cloned into two different plasmids, PdimN2 and PET. The temperatures (25 vs. 37°C) and duration of expression (4 hrs. vs. overnight) were varied and whole cell GFP fluorescence will be measured. Expression levels of Aβ-GFP were monitored by SDS-PAGE of the whole cells following induction of expression.

## Electro-assisted Desorption of Alkanethiol Self-assembled Monolayers

*Michael Hailemariam*

**Department of Chemical and Biological Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Rastislav Levicky*

In biotechnology, the need for producing a diagnostics for analyzing biological molecules is essential. For example, after hybridization of target molecule with the DNA probe, electrochemical methods may offer a method to dehybridize the target without affecting the probe DNA. For DNA-DNA biosensors non-specific adsorption with the substrate can reduce hybridization and limit the efficiency of the sensor. Alkanethiols like 3-Mercapto-1-propanol (MCP) are used to inhibit the interaction between the probe and the gold electrode surface. The desorption of a self-assembled monolayer (SAM) of MCP from a gold surface is investigated under different reduction potentials using an electrochemical method. The kinetics of MCP desorption in a 900mM Phosphate buffer are monitored using a quartz crystal microbalance (QCM), and cyclic voltammetry (CV). Drift from temperature variation and noise from vibration were reduced before testing. The frequency change from the assembly was measured with time, and desorption was determined from the mass change as provided by the Sauerbrey's equation. Also, the dependence of desorption kinetics on potential was investigated.

## Developing Genetic-array Testing: Characterizing the Hybridization of Morpholino and DNA in Solution

*Lonna Gordon and Michael Furman*

**Department of Chemical and Biological Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Rastislav Levicky*

Genetic-array testing is a promising new form of genetic testing in which single strand of a specific sequence of DNA attached to a surface (known as the probe molecule) binds (hybridizes) with the complementary sequence found in solution (known as the target). In order for the test to be accurate, it is essential that the bond between the probe and the target be a strong one. To increase the stability of the hybridized pair, morpholino (MO), a DNA analog, was chosen for the probe because it lacked the charged backbone that creates a repulsive force between DNA strands. Our research used UV spectroscopy to measure and to compare the stability of DNA-DNA hybridized pairs and MO-DNA hybridized pairs in solutions of varied salinity and at different temperatures. We created solutions of the MO probe, DNA probe and DNA target in three concentrations of phosphate buffer separately and in probe-target combinations. From the melting temperature of probe-target duplexes, we found that MO-DNA hybrids are significantly more stable than DNA-DNA pairs, and that its stability was not dependent on the salinity of the solution.

## Cell Uptake of Fluorescently Labeled Liposomes and the Effect of Immunoconjugation

*Michael Hazoglou, Shrirang Karve and Tamara Khaimchayev*

**Department of Chemical and Biological Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Stavroula Sofou*

Current research involving drug delivery systems have liposomes as an integral part due to their non-toxic nature, and ability to encapsulate and release therapeutics triggered by environmental changes. Liposomes have an advantage for cancer treatment because of the EPR effect. The EPR (enhanced permeability and retention) effect is caused by the tumor cells' need for nutrients. To supply this need, the tumor stimulates the production of blood vessels. The structure formed by the endothelial cells that line the vessels is defective and poorly oriented. This leaves wide gaps that are not found in normal vasculature, allowing relatively large particles such as liposomes to extravasate into the tumor. Retention is enhanced by the size of the liposomes which cannot permeate into the lymphatic system as quickly as they are entering. By optimizing the liposomes, we can kill the tumor cells and reduce the toxicity experienced by healthy tissues. By conjugating antibodies onto the PEGylated lipids, the liposomes will predominately target the cancer cells with the corresponding antigen, further enhancing the EPR effect by specific binding to and internalization by the cancer cells that constitute the tumor. Immunoliposomes or liposomes with antibodies are produced through 'click' bioconjugation reactions. Bioconjugation is a series of reactions that bonds the antibodies to the PEG terminus of the lipids. Step 1 involves cleaving the disulfide bond of DSPE-PEG(2000)PDP with DTT. Step 2 introduces maleimide groups onto the antibody Trastuzumab by SMPB. In Step 3, the maleimide group that was introduced to Trastuzumab

becomes conjugated onto liposomes by reacting with activated sulfhydryl groups on lipids. SKOV3 ovarian cancer cells overexpress the HER-2/neu growth factor receptors which bind Trastuzumab readily. The objective of this experiment is to evaluate the effect of immunoconjugation and incubation time on cell binding and internalization of liposomes. Interactions of fluorescently labeled liposomes with cell monolayers were imaged using an inverted optical microscope. Quantitative evaluation of cell binding and internalization was performed on cancer cell suspensions using fluorescence spectroscopy.

## Sufficient Control for Membrane Lytic Peptides

*Hongyuan Lu*

**Department of Chemical and Biological Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Jin Kyoun Kim*

Membrane lytic peptides form pores upon association with the membrane, resulting in its rapid lysis. Lytic activity of these peptides has many potential applications, for example, as anti-microbial agents and drug-delivery carriers. However, the lytic activity is mostly non-specific, limiting such applications. The research presented here aims at the engineering of synthetic membrane-lytic peptides to regulate their lytic activity by specific ligand binding. The ligand binding protein is split into two fragments and each linked to half of a membrane-lytic peptide. We hypothesize that fragments of ligand-binding protein could reunite upon binding to ligands, thereby increasing the proximity of membrane-lytic peptide fragments, which in turn trigger the membrane lytic activity. Evaluation of the ligand-binding protein fragments with the membrane-lytic peptides is currently underway.

# Chemical and Biological Sciences

## Modification of Adhesion Strength of Polyacrylamide Hydrogel with Electric Field

*Ying Chen*

**Department of Chemical and Biological Sciences**
Polytechnic Institute of NYU, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Victor Barinov*

Hydrogel is consists of a network of water-soluble polymer chain with high water content. When hydrogel is applied to the surface of other materials, adhesive bonds may develop between gel and substrate surface due to intermolecular attraction. A total bond may be characterized by adhesion strength, which is equal to the disbonding force divided by the bond area. The strength of these adhesive bonds changes when electric field is applied. The adhesion strength of poly (ethylene oxide) hydrogel can be reduced by direct electric field applied on a gel-aluminum interface. There is a general tendency of decreasing adhesion strength of the hydrogel with increasing magnitude of direct electric field. The effect of direct electric field also varies with molecular mass. The higher the molecular mass, the stronger effect of direct electric field on the gel-substrate interface. The same principle has been used to study the alternating field effect on adhesion strength of polyacrylamide hydrogel. Alternating electric field modified the adhesion strength of polyacrylamide hydrogel. The most effective modification is achieved at the frequency range of 1.0 x$10^3$ Hz.

## Viscosity of Electrorheological Poly(acrylic acid) Solutions

*Guang Shao*

**Department of Chemical and Biological Sciences**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Victor Barinov*

Electrorheological fluids are fluids which can greatly increase their resistance to flow in response to an electric field. The goal was to study the electric field effect on the viscosity of aqueous solutions of poly(acrylic acid). Viscosity is the measure of fluid's resistance to flow. Poly(acrylic acid) is a polymer which contains (-COOH) groups. When dissolved in water, poly(acrylic acid) gives off protons. The electrorheological behavior of poly(acrylic acid) solutions was studied by measuring the viscosity change of various concentrations of polymer solutions in response to the electric field. The viscosity of poly(acrylic acid) solutions was measured by

an Ubbelohde viscometer having its capillary placed in between two metal electrodes. When the electrodes are in electrical communication with a source of electric potential, the electric field is applied to the capillary comprising the flowing fluid. The viscosity of poly(acrylic acid) solutions increases under the electric field effect.

## Search and Destroy: Display of Phosphotriesterase on Cell Surface to Seek Out and Destroy Organophosphates

*Fong Bell, Javi Balroop and Peter J. Baker*

**Department of Chemical and Biological Sciences**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Jin K. Montclare*

Phosphotriesterase (PTE) is an intracellular class of metalloenzyme, which efficiently hydrolyzes a variety of organophosphates (OPs) including nerve agents and agricultural insecticides. OPs are a class of synthetic compounds that inhibit acetylcholinesterase, causing toxic levels of acetylcholine to form in the post-synaptic vessel. We are developing a PTE fusion protein to the outermembrane protein A that will facilitate the expression of PTE on the surface of E. coli. The ultimate goal of this project is to develop an engineered bacteria capable of seeking out and destroying organophosphates.

## New Methods in Drug Delivery: Embedding Enzymes within Polymeric Matrices to Control the Rate of Polymer Matrix Erosion and Release of Biologically Active Compounds

*Carlos Collazo*

**Department of Chemical and Biological Sciences**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisors:** *Professor Richard Gross with Maddy Manoj*

The polymer used in our experiment is referred to as PCL (Poly Capro Lactone), a hydrophobic aliphatic polyester, and therefore it must be broken down via a hydrolysis reaction. An enzyme that catalyzes this reaction is CAL B (Candida Antarctica Lipase B). Our research focuses on embedding CAL B with a UV-active compound into a PCL polymer matrix in order to control the rate at which PCL is broken down. In turn, the rate at which the UV-active compound is released will also be controlled. The model UV-active agents used in this experiment are: P-nitroaniline and Rhodamine B. PCL films with CAL B and the two UV agents mentioned previously were incubated at 37°C and 200rpm in a phosphate buffer in order to mimic the environment inside of the human body. Films were taken out every two hours for eight hours, and one set of films was taken out after 24 hours. The amount of each UV-active agent that was released from the polymer matrix was quantified using UV-VIS spectroscopy. Our goal is determine whether the release profiles of these UV-active agents could be a precursor for drug release experiments. If they are, we will be able to implement this technique, embedding enzymes into polymer matrices to study drug release.

## Synthesis and Characterization of Elastin-based Biomaterials

*Hanna Barra, Carlo Yavienco, Jennifer S. Hagpanah, Susheel K. Gunasekar, Peter James Baker, Wendy Hom and Natalya Volashchuk*

**Department of Chemical and Biological Sciences**
Polytechnic Institute of New York University, Brooklyn, NY, 112011

**Department of Biochemistry**
SUNY Downstate Medical Center, Brooklyn, NY, 112012

**Faculty Advisor:** *Professor Jin K. Montclare*

Advances in molecular biology techniques have been useful in engineering protein-based biomaterials. The work described here is aimed to design novel synthetic biodegradable protein polymer constructs composed of unique motifs via genetic engineering techniques. By combining cartilage oligomeric matrix protein coiled-coil (COMPcc) and elastin-like polypeptide (ELP), we have generated block polymers of different orientation as repeat units. We have synthesized and purified the homopolymers COMPcc and ELP, along with the COMPcc-ELP and ELP- COMPcc di-block co-polymers, as well as the tri-block ELP-COMPcc-ELP. These polymers have been characterized via circular dichroism (CD), biophysical atomic force microscopy (AFM), dynamic light scattering (DLS), and fluorescence.

## Identifying Protein Partners of a Novel Brain Protein

*Yan Mei Chan, Peter James Baker, Robert Agate and Fernando Nottebohm*

**Department of Chemical and Biological Sciences**
Polytechnic Institute of New York University, Brooklyn, NY, 112011

**Field Research Center**
The Rockfeller University, Millbrook, NY 12545

**Department of Biochemistry**
SUNY-Downstate Medical Center, Brooklyn, New York 11203

**Faculty Advisor:** *Professor Jin K. Montclare*

FnTm is a novel transmembrane protein found to be up-regulated in the learning system in birds and other mammals. Identifying FnTm protein partners will allow us to clarify the FnTm signaling pathway in the brain. However, identifying protein pairs is often limited because the weak forces by which proteins interact are not sufficient to preserve the protein-macromolecule complex. To circumvent this limitation, we are working towards introducing a photocross-linkable non-natural analog of para-azidophenylalanine and photoleucine in a residue-specific manner into FnTm. Here we demonstrate the progress of our efforts to discover the protein-protein interactions involved in learning.

## Engineering Artificial Histone Acetyltransferases: A Combined Homology and Biochemical-based Approach

*Wendy Hom, Man Xia Lee, Kinjal Mehta, Susheel Kumar Gunasekar, Zhiqiang Liu, Natalya Voloshchuk, Aye Sandar Moe, Phyllis Frankl and Lisa Hellerstein*

**Department of Chemical and Biological Sciences**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Jin K. Montclare*

In vivo incorporation of non-natural amino acids can be used to improve protein stability. However, there is a trade off; improved stability of the protein may lead to loss in activity. One way to improve function is to employ machine-learning algorithms to identify the variants that improve activity. Our target protein, tetrahymena GCN5 (tGCN5), a member of the histone acetyltransferases (HAT) family, acetylates the lysine residues of histones, enabling transcriptional regulation. Experimental data have shown an increase in stability of the protein against protease degradation, but loss in activity with the incorporation of para-fluorophenylalanine (pFF) into tGCN5 in vivo. Using information from biochemical and structural data, we identified 11 residues to mutate. With the aid of computer guidance, we have designed a set of variants. Here we demonstrate our progress on assembling the tGCN5 mutants and determining their activities.

## Immobilization of Proteases for Preparation of Oligo(lysine)

*Antonio Ho, Kodandaraman Viswanathan and Richard A. Gross*

**Department of Chemical and Biological Sciences**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Richard A. Gross*

Enzymes perform the role of catalyst in many reactions. They are obtained in free form from organisms, wherein they catalyze reactions by lowering the activation energy of a particular reaction. Enzymes in the immobilized form are currently being used in industries to create products such as enantiopure compounds. This paper describes the immobilization of commercially available proteases to prepare water-soluble peptides. Proteases belong to the enzyme class of hydrolases, and their primary function in nature is to cleave peptide bonds. Peptide hydrolysis by a protease is an equilibrium process, therefore, by proper manipulation of reaction conditions, the equilibrium can be reversed to synthesize instead of hydrolyze peptides from amino acids. Numerous examples exist in the literature for synthesis of hydrophobic peptides by protease-catalysis using their corresponding (l) amino acid ester hydrochlorides as monomers. Proteases are also known to self-digest under the reaction conditions normally used during peptide synthesis. Our strategy to immobilize proteases, would not only slow down the self-digestion of the protease, but will provide a method for repeated use of the biocatalyst thereby reducing their cost. Important in this work is the investigation of the efficiency of immobilized protease to synthesize water soluble peptides, especially those formed using the basic amino acid ester hydrochloride substrates. The water-soluble peptides formed can be separated from the immobilized catalyst by simple filtration. With these goals in mind, we foresee this project to provide us with valuable scientific knowledge as well as oligopeptides of importance for biomedical applications.

# Effect of Mutations on Alpha Synuclein's Structure and Aggregation

*Abubakar Mian and Omar Rashid*

**Department of Chemical and Biological Sciences**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Jin Ryoun Kim*

Parkinson disease (PD) is a neurodegenerative disorder characterized by Lewy bodies; cytoplasmic aggregates of a protein. Many studies suggest that the aggregation of alpha synuclein (β-synuclein), a 140 residue pre-synaptic protein, is a critical step in PD's etiology. The aggregation of alpha syncuclein results in β sheet-structured amyloid fibrils. The amyloidogenic aggregation depends on hydrophobic interactions between β strands. As such, a considerable amount of study for control of aggregation has focused on hydrophobic β strand domains. The question that I would like to address is whether one can utilize the linker region connecting β strands for control of aggregation. To this end, mutations were introduced at two linker regions; 65-68 and 83-86 amino acid residue region. The mutations were rationally selected based on propensities to form different turn conformations. The working hypothesis is that the local linker conformation dictated by sequences with high-turn potentials can modulate amyloidogenic aggregation of alpha synuclein. The structure and aggregation of α-synuclein with these mutations will be examined using thioflavin T fluorescence and circular dichroism.

# Computer and Information Science

## Virtualized Gaming as a Pathway to Enhanced Understanding of Complex Networked Systems

*Yan Cheng, Ron Gutierrez, Roman Khmelichek, Kiril Kourtchikov and Matthew Topol*

**Department of Computer and Information Science**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Joel Wein*

The focus of this project is to build essential components of a virtual environment and toolset in order to create a gaming environment for undergraduates to learn complex distributed networks and systems. The goal is to produce graduates who can design, implement, and manage networked distributed systems. Using multi-player, digital game immersion as a vehicle, students will be provided with a real hands-on experience of working with such systems.

The games that students will play in order to learn about complex distributed systems revolve around earning revenue from web services we have built that are akin to Facebook and YouTube. The students will play as teams and try to maximize the up-time of these services in order to get more revenue from the clicks and views of ads from visitors to their sites. We have developed a mechanism for simulating numerous visitors to these sites as well as ways of artificially breaking the complex distributed systems that these teams are trying to administer. These break-case scenarios address various aspects of what we want the students to learn by correcting the mistakes, some of which include errors in the logic of distributed algorithms, misconfiguration of web servers, and errors in the code that can bring down an entire server.

We have also developed a web-based user interface to provide an easy way for teams to monitor the status of their virtualized servers and their game revenue as well as facilitate the purchasing of new servers with the money they earn from advertisements. The user interface also allows an administrator to easily configure the virtualized games that the teams will engage in, as well as to monitor the teams' progress.

This project addresses an important area of national need, the education of future computing practitioners who are able to develop and manage large-scale distributed systems. The outcomes of the project will permit educators to expose their students to realistic platforms, so that students may gain experience with complex, distributed and networked system projects in a globally competitive market.

# Electrical and Computer Engineering

## Steady State Equivalents for Large Radial- and Meshed-distribution Systems

*Yijing Meng*

**Department of Electrical and Computer Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Francisco de Leon*

The study of load-flow and short-circuit for distribution system planning and operation are performed with explicit representation of every section and load. Moreover, the secondary network and each load are also modeled in detail when the information of each section (line, cable and transformer) is available.

However, in daily life, distribution systems often include many thousands of nodes and sections. To address this problem, a new methodology was discovered to obtain equivalent circuits for large distribution system for short-circuit and load-flow studies. By reducing lots of sections to any manageable magnitude of terminals, considerable efficiency gains are obtained when only the external to the equivalent changes.

With the simulation of DEW software, this project implements an efficient method for both small- and large-scaled steady state equivalents for radial and meshed distribution systems. Simulation results demonstrate the reliability and generality of the approach.

## Detection of Tandem Repeats and Palindromes Using High-speed Hardware

*Chao Wang*

**Department of Electrical and Computer Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor H. Jonathan Chao*

A sequence is an ordered list of elements related to each other through logical, mathematical, biological or other relationships. Many bioinformatics applications such as gene finding to the prediction of protein functions and network applications such as network surveillance tools require the comparison of data organized as sequences. Efficient detection of two special types of sequences, tandem repeats and palindromes within DNA sequences

is an important problem. A tandem repeat is a pattern of one or more nucleotides repeated in the DNA sequence and the repetitions are adjacent to each other. A palindrome is a DNA sequence structure that the order of the nucleotides is the same reading from either direction.

Network Intrusion Detection and Prevention Systems (NIDPS) are crucial for network security. The most time-consuming operation for NIDPS is the string matching operation. In NIDPS, string matching is used to compare the network traffic against previously known attacks. The high-traffic volume and the large variety of attacks make string matching for NIDPS a very challenging task. Recent research focuses on improving the speed of string matching for NIDPS using algorithms that can be implemented on hardware to cope up with today's traffic rates of 40 Gbps and beyond.

In our research, we apply knowledge accumulated in the NIDPS research into bioinformatics applications. In particular, we are working towards algorithms for detecting tandem repeats and palindromes in DNA sequences which can also be implemented on high-speed hardware. To demonstrate the effectiveness of our proposal, we implemented our algorithms in C++.

## Scheduling Algorithms for Real-time Disk

***Robert W.H. Fisher and Dmitriy Drusvyatskiy***

**Department of Electrical and Computer Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Joel Wein*

Efficient retrieval of information from static storage has remained an important concept in computer science. However, as capabilities for network bandwidth increase, remote multimedia servers have become very common, and a variety of technical problems have arisen in the context of servicing user-data requests on a central data disk. In order to ensure that the user experience remains optimal, the server must be able to provide guaranteed service quality to each of the users in the system. This means that we must consider the order in which we will be reading data of a primary hard disk to provide the best service possible.

An algorithm, SCAN-EDF, was suggested in 2005 through joint work by IBM, Snap Appliances, and Texas A&M University (1). SCAN-EDF is built to adapt proven techniques of disk scheduling algorithms to the unique challenges of real-time service. In our work, it is shown that if an optimal algorithm is capable of serving n users on a given disk, we cannot be certain that SCAN-EDF will be able to service O (n/k) for any constant k, meaning that SCAN-EDF is not a k-approximation for an optimal algorithm. We suggest an alternative heuristic to improve the performance of SCAN-EDF, and demonstrate the SCAN-EDF is also not a k-approximation to our suggested algorithm, which demonstrates that the improved algorithm is capable of serving many more users in certain circumstances.

## Cable Ampacity

*Rahul Anthony*

**Department of Electrical and Computer Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Francisco De Leon*

Information about the maximum current-carrying capacity (ampacity) which a cable can tolerate throughout its life without risking deterioration or damage is extremely important in power cable engineering and operation. Ampacity values are required for every new cable installation, as well as for cable systems in operation. Because some underground transmission cable circuits are approaching the end of their design life, the development of a systematic method for determining the feasibility of extending cable life and increasing current ratings is of paramount importance. A cable must carry large amounts of current without causing a drop in the voltage. Therefore, it is important to compute the ampacities for the most common cable geometries and installations. Because there are so many possibilities, these calculations are done by a program (C++) that deals with all of the possible cases, which obtains all preliminary information by the user from a file.

## High-speed Router

*Zhuoyuan Zhang*

**Department of Electrical and Computer Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Yang Xu and Professor H. Jonathan Chao*

As more applications are emerging on the Internet, the router is required to be aware of the flows through it, and provide dedicated service to each flow. A prerequisite mechanism of a flow-aware router is packet classification, which has been one of the major challenges in router design since the router needs to process millions of packets per second, matching them against a classifier with thousands of rules.

In this project, we developed a two-stage packet classification architecture, which decomposes the multi-field classification to several single-field classifications, whose results are then combined by a tree structure to get the final decision that which rule is matched. To accelerate the packet classification, we stored each layer of the tree structure into an independent memory, where an optimized hash table has been used to store the transitions, to exploit the pipeline operation.

The efficiency of the two-stage pipelined architecture has been evaluated by simulation written in C++ under realistic classifiers and traffic traces. Simulation result shows that our scheme only requires 2~4 times of memory accesses in average to finish a packet classification operation, which is among the best schemes proposed in literature. Besides the high-speed feature, the architecture has also been well tuned to support incremental updates.

## PolyLive P2P Live Video Streaming

*Maung Thet Oo*

**Department of Electrical and Computer Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Keith Ross*

To date we have witnessed a fast-growing number of web sites which provide user-generated video streaming services on the Internet, i.e., YouTube, Google Video, and many others. These video services are mainly streaming stored videos. We envision a significant growth in user-generated live streaming over the Internet in a few years. These streaming video are emanated from web cams, digital video cameras, Personal Digital Assistant (PDA) and cellular phones, etc. Using these handheld devices, a user may shoot live events, encode the video streams and share with a potential large number of interested viewers via wireless connections. The distribution of these live video streams to end-users is very challenging due to the huge amount of traffic volume and stringent real-time service requirements. P2P is the most promising driving wheel for large-scale video distribution over the Internet, because the upload capacity of peers can be utilized for video transmission so as to reduce the server load dramatically. The PolyLive system is designed and implemented to address the challenges in providing a cost-effective video distribution service for user-generated live contents using the P2P streaming architecture.

## Noise Reduction in Infrared Image Sequences for Breast Cancer Screening

*Vinay Murthy*

**Department of Electrical and Computer Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Ivan Selesnick*

Synchronization is a well-studied phenomenon that has been observed in many biological systems. It occurs when two systems interact, and is observable in certain measurements made upon the interacting systems. In signals measured from systems that produce oscillating outputs, such as the brain, synchronization manifests as certain relationships between the amplitudes, phases and frequencies of the two signals. In particular, phase synchronization in EEG signals (measurements of voltage signals produced by the brain) is thought to indicate the extent to which different parts of the brain work together to perform cognitive tasks.

The goal of our project is to develop signal-processing algorithms to analyze EEGs and accurately determine the level of phase synchronization present between sets of signals. Analysis of records taken from different parts of the brain during various stages of sleep and alertness should provide further insight into the role of phase synchrony in cognitive functioning. The methods and tools developed for analyzing phase synchrony in healthy patients may be extended to search for precursor events to seizure onset, in effect predicting to some degree when a seizure may occur in epileptic patients.

## Cooperative Control and Planning for Multi-agent Autonomous Systems

*Lamia Iftekhar*

**Department of Electrical and Computer Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Farshad Khorrami*

Controlling the collective behavior of a large population of autonomous agents is an interesting problem that has been investigated by various disciplines with different perspectives. As such, knowledge from different fields has been incorporated to realistically model these dynamic systems, find rules to efficiently and economically control them while addressing challenges such as bandwidth limitation, information sharing constraints, etc. These collaborative control and planning mechanisms can find application in diverse military or civilian areas such as autonomous unmanned vehicles, surveillance, animation and games, robotics, sensor networks, and emergency crowd control. This project aims to facilitate these applications by achieving decentralized control and quasi-optimal planning of multi-agent systems. Analysis and MATLAB-based simulation of existing models have been performed.

# Humanities and Social Sciences

## Philosophy of Technology–China and Europe

*Dai Cui*

**Department of Humanities and Social Sciences**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Harold Sjursen*

The Western question or problem of technology in the tradition of Nietzsche-Heidegger leads to nihilism. Hans Jonas' proposal of a technological ethics for the future ameliorates but does not eliminate this nihilism. The difficulties derive from how Heidegger structured his presentation of fundamental ontology, Western views of science and society, Cartesian arguments about the nature of self (ego), and the limitations of pragmatism.

The hypothesis for is that: If one steps back from the categories of Western metaphysics and reinvestigate the "problem" of technology within the context of neo-Confucian thinking, the nihilistic result is overcome. (Prof. Sjursen)

The Neo-Confucian Metaphysics originated from ancient China with ethics of some Neo-Confucian antecessors such as Chou Tun-i and Zhu Xi. According to Zhu Xi, the theme of Neo-Confucianism is that the Tao of heaven is expressed in principle while sheathed in matter. Nowadays, some philosophers propose to apply the Neo-Confucian thinking to the development of technology. It is a very unique approach, and it might be the balance of eliminating nihilism and limitation of pragmatism.

Through the study of Neo-Confucian thinking in relation with Contemporary technology, our research aims to find the answer to the hypothesis.

## Genetic Privacy Laws in the U.S.

*Jannine Ramlochan*

**Department of Humanities and Social Sciences**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor. Myles W. Jackson*

The completion of the Human Genome Project has raised new concerns of genetic privacy in the United States. Genetic testing can lead to great advancements in science and medicine by determining one's susceptibility to certain diseases. that they may develop. However, if improperly applied, there is potential for discrimination by employers, insurance companies, and other organizations. For this reason, access to genetic information needs to be regulated. Americans want to know: who, how long, and for what purposes will others have access to their genetic information. All of these questions need to be explicitly addressed through legislation.

This project documents the basis for these concerns as well as the chronological responses to them by both the federal and state governments. After several failed attempts at passing applicable laws in Congress, President Bill Clinton issued an executive order prohibiting federal agencies from access to genetic information of employees. Afterward, states took action and implemented genetic privacy laws within their own borders. Some states, such as Oregon and New York, have passed comprehensive laws regarding the use of genetic information. Others have yet to pass any solid legislation. The lack of consistency across all states and the ever-growing importance of this issue led to the passing of the Genetic Information Nondiscrimination Act in May 2008.

## The Tibetan Book of the Dead: Live Theatrical Multimedia Presentation

*May Thazin and Karlen Tam*

**Department of Humanities and Social Sciences (Digital Media)**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Carl Skelton*

The Tibetan Book of the Dead is highly descriptive text of the teachings of the great eighth century Buddhist Master Padmasambhava. The text describes the intricate structure of the ego and the mind and is traditionally read aloud to a dying person. Many artists have attempted to portray these complex and vivid visions and dream states of dying in Thangka paintings. The Tibetan Book of the Dead: Live Theatrical Multimedia Presentation (commissioned by the Asia Society and the Golden Sun Foundation for World Culture) seeks to incorporate traditional Thangka paintings with live music and 3D graphics. The 3D graphics are constructed with the high-end program, AutoDesk Maya, which is used by professionals.

Animation techniques were explored using the 3D models that were created. These include complex character riggings, so that the mesh has a skeletal structure—which is a set of nodes that influence a given set of vertices on the 3D model. The influence these "joints" have over a cluster of vertices can be manipulated by weight painting, which assigns the vertices with a value range from zero to one, which will calculate the transformation of the cluster.

The project also requires the characters to morph from one shape to another. For example, one such character transforms from a human anatomy to a three-headed, six- armed monster. To achieve this effect, blend shape deformers are used, so that the geometry of the character is stored, as well as the target geometry, the monster. In order for the morph to be aesthetically pleasing, each movement of the limbs and other attachments must be choreographed individually, to illustrate the psychedelic and dream-like state of dying. AutoDesk Maya's most powerful tool is the attribute connection editor, which allows one object, a simple curve for instance, to control the attributes of one or more target objects. Maya performs calculations movement and rotation of the components of the objects, based on several user inputs, where the attributes of one object (i.e., scale, rotation and translation) can effect the attributes of a group of other objects. This is a very useful aspect in 3D animations.

# Mathematics

## An Extension of the Cauchy-Davenport Theorem

*Alexey Vugayev*

**Department of Mathematics**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Franziska Berger*

The Cauchy-Davenport Theorem was proved in 1813 by Cauchy and rediscovered by Davenport in 1935. It states that, given two non-empty subsets A and B of the group $Z_p$, i.e., the set {0, 1,..., p-1} with addition and multiplication modulo p, where p is a prime number and assuming that $p \geq |A| + |B| - 1$, the set $A + B = \{a + b : a \in A, b \in B\}$ has at least $|A| + |B| - 1$ elements. As a consequence of this theorem, large subsets of the so-called circulant graphs $G_{p,}$, which are graphs associated to the group $Z_p$, are strongly connected. Recently, the Cauchy-Davenport Theorem was generalized to arbitrary finite groups. In this work, we study extensions of the corollary about circulant graphs to the corresponding Cayley graphs of arbitrary finite groups.

## Flow of Information in a Square Grid

*Yevgeniy Davydov*

**Department of Mathematics**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Franziska Berger*

A piece of gossip spreads on an $n \times n$ grid $G_n$ as follows. At time 0, some of the sites (grid points) are informed, the others are (yet) ignorant. Informed sites remain informed forever, and at every time t, t =1,2,..., every ignorant site with at least two informed neighbors becomes itself informed (a site requires independent confirmation before accepting the piece of gossip).

A set S of initially informed sites is said to percolate on the grid $G_n$ with 2-neighbor information if there is a time $t_0$ such that every site on the grid is informed. This type of problem is also referred to as bootstrap percolation in physics.

It has been shown by Balogh and Pete that, for n large enough, if the sites are initially informed uniformly at random with probability $p(n) \geq \frac{\log^{\circ}(n)^{1+\epsilon}}{\ln(n)}$, the grid will percolate almost surely.

In this project, we study small fixed n and find explicit expressions and bounds for the probability of percolation. We also investigate the expected number of steps until no further sites become informed and the shapes which can occur as end results in a grid which does not percolate.

## Matchstick Graphs

*Irina Igel*

**Department of Mathematics**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Franziska Berger*

A matchstick graph is a graph obtained by constructing a connected figure out of matches which meet at most at common ends (i.e. the matches aren't allowed to cross). The vertices of the graph are placed at the ends of the matchsticks and the edges correspond to the matches themselves. Mathematically, such graphs are planar rectilinear graphs in which every edge has unit length.

It is a long-standing open problem to find a smallest matchstick graph which is r-regular for $r = 4,5$, i.e., in which every vertex has exactly r neighbors. The cases $r = 2,3$ are easy to solve, $r \geq 6$ is easily shown to be impossible.

If the graph is not planar, then any r is possible, but explicit graphs are only known for small values of r. In the project, we consider several relaxations of the above problem. Thus, we construct minimal (r,s)-matchstick graphs of degree s on the outer face and degree r in the interior. We also consider graphs in which several edge-lengths are permitted. Gröbner bases are used to give explicit coordinates for the vertices whenever possible.

## The Mathematics of Soap Films

*Ruobing Han*

**Department of Electrical and Computer Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Franziska Berger*

Have you observed what happens if you form a circle out of wire, dip it into soap solution and lift it up carefully? You will see a soap surface that forms between the wire and the soap solution. The particular shape is called a catenoid. Its base is a circle of the same radius as that of the wire. Surfaces formed by soap solution have the property that their mean curvature H is zero, as a consequence of the Laplace-Young equation. In this work, we explain why in our experiment, a catenoid is formed rather than, say, a cylinder, and determine its properties, including the phenomenon that occurs when you continue lifting the wire: the radius of the base circle decreases, and when it is 0, connection with the soap solution is lost, and the soap surface bursts.

## Studying the Growth of the Radii of Highly Ordered Ga Nanodroplets on a GaAs Surface Formed by a Focused-Ion Beam with Respect to Time

*Nafis Rahman*

**Department of Electrical and Computer Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Yinong Yang*

The emerging field of nanofluidics aims to design new technologies to control the flow of minute quantities of liquid. By interacting with such small amounts of liquid (nanodrops) we can eventually place a small computer chip in a biological system that can replicate the testing and diagnosis abilities of a full-sized medical laboratory. Understanding the behavior of these nanodrops may help us advance several developing nanotechnologies. Recently, scientists have discovered that when a GaAs (Gallium Arsenic) surface is induced by an FIB (Focused Ion Beam), Ga nanodroplets self-assemble into a highly ordered and mechanically strong hexagonal pattern. Self-assembly is normally induced at temperatures below the melting point resulting in their being mechanically weak and thermally and chemically unstable. By studying a particular differential equation, we can understand the the rate of change of the droplet radius with respect to time.

# Mechanical and Aerospace Engineering

## Fabrication and Test of IPMCs

*Weiyang Lin*

**Department of Mechanical and Aerospace Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Maurizio Porfiri*

An Ionic Polymer Metal Composite (IPMC) consists of an ionic polymer membrane, sandwiched between two conductive metal electrodes. By applying a low voltage across the electrodes, a mechanical bending of the IPMC can be obtained; versa, a mechanical deformation generates an electric voltage across the electrodes. Therefore, electro-active polymers can be used as novel sensors and actuators and can be especially useful for underwater applications.

The Dynamical Systems Laboratory is using IPMCs for developing novel underwater propulsion systems. IPMCs are currently being attached to the fins of a robotic fish to mimic the swimming of real carangiform fish. A thorough procedure has been established in the laboratory to fabricate segmented IPMCs with tailored properties. The core of the fabrication process is chemical reduction. Tape is used in the fabrication process to obtain multiple electrodes that can be independently controlled and yield complex bending scenarios. Actuation and sensing performance of IPMCs is strongly influenced by the electric capacitance. Therefore, the capacitance and resistance of the IPMCs have been experimentally studied by applying different input voltages at various frequencies and measuring the current flowing through the transducer. The set-up of the test is composed of a voltage generator, an IPMC strip clamped between metal (gold/copper), an auxiliary resistor, and a digital acquisition card. LabVIEW has been used to process the data.

## Towards a Wall-shear Stress Sensor for Arbitrary Wall Geometries

*Karl Abdelnour*

**Department of Mechanical and Aerospace Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisors:** *Professor Sean D. Peterson and Professor Maurizio Porfiri*

Due to the complex wall geometries of the human vasculature, wall shear stress measurement in physiologically relevant models is not presently feasible. Currently, researchers rely heavily upon numerical simulations with little experimental validation to extract wall shear stress for correlation with cellular response data. To validate numerical simulations, wall shear stress needs accurate measurement in physiologically relevant geometries. Typical experimental arterial models are constructed using rapid prototyping from a CT scan of a patient's vasculature. The goal of the present study is to develop a wall shear stress sensor that can be built directly into a rapid prototyped arterial model capable of measuring stresses in a physiological Reynolds numbers range (Re=500-4000).

A floating element head wall shear stress sensor was designed in SolidWorks 2007 for measuring the wall shear stress in a fully developed pipe flow. The sensor uses the whispering gallery mode optical resonance principle (Arnold et al.) of a microsphere to measure the forces on the floating element. For a silica microsphere, the relative hardness of the sphere is considerably higher than that of rapid prototyping plastics and resins. Therefore, numerical simulations were performed in the ANSYS workbench module to determine the order of magnitude of the sphere deflection under the desired flow conditions. It was found that a silica microsphere with diameter ~1mm would deflect on the order of tens of nanometers assuming a sensor constructed out of ABS plastic. Given a laminar flow regime, a solid silica microsphere was found to not deflect sufficiently to obtain desired stress resolutions. Microspheres manufactured out of the polymer polymethylmethacrylate (PMMA) would deflect sufficiently in both the laminar and turbulent cases.

Experiments are currently underway to test a physical device constructed of ABS plastic using a 3D printer. The experimental set up consists of one half inch diameter glass tubes with sufficient entrance length to be fully developed for both laminar and turbulent water flow. Steady flow is produced via constant head tanks. Results of the experiments are forthcoming. Future work includes designing and testing a sensor into a 3D reconstruction of a patient specific artery.

## Mechanics-based Design and Control of Robotic Fish

*Jared Alan Frank*

**Department of Mechanical and Aerospace Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Maurizio Porfiri*

Conducting research on newly-discovered advanced materials often leads to design realizations for exciting engineering applications. Electro-Active Polymers (EAPs) called Ionic Polymer Metal Composites (IPMCs) are an emerging smart material that can potentially serve as both sensors and actuators. IPMCs immersed in a liquid solution not only bend when a voltage is applied across their electrodes, but also reversibly produce a voltage when deformed. Therefore, this smart material is being tested in underwater applications as both a sensor and an actuator. As an actuator, IPMCs have been developed for use as artificial muscles. The Dynamical Systems Laboratory is using IPMC actuators controlled by PIC microcontrollers to function as propulsion systems for robotic fish applications. The robotic fish use an IPMC attached to a caudal (back) fin made of an elastic polymer to mimic the real swimming behavior of carangiform and subcarangiform species of fish. The goal is to develop a sustainable and programmably flexible underwater robotic fish with IPMC propulsors. Two robotic fish are being built—a small, simpler prototype helps observe the IPMC material's thrust capabilities. Then a larger, more complex prototype will utilize XBee hardware for wireless control and navigation. Each prototype

consists of 3 major subsystems: the outer shell, the inside components—circuit/electrical and electronic hardware/batteries—and the IPMC/fin combination. Our design builds on rigorous mathematical modeling of fish propulsion systems using continuum mechanics. Computational Fluid Dynamics (CFD) software has been used to simulate the flow around the fish and to calculate the drag and lift forces for the range of velocities at which the robotic fish will be maneuvered. Experimental measurement apparatuses have been designed and assembled to accurately determine the drag and the thrust on the fish from the water and the IPMC, respectively. Several outer shell and fin geometries have been considered, and their optimal dimensions—in order to minimize drag and to maximize both thrust and stability—were obtained following appropriate research and virtual flow tests. Several actuating systems are being investigated and experimentally compared to build a lightweight, maneuverable, and fast robotic fish. The project makes use of practical, hands-on skills like machining and metalworking, waterproofing, circuit etching and rapid prototyping while taking into consideration mechanical, electrical, and control systems fundamentals as well as solid and fluid mechanics theory.

## Impact Properties of Syntactic Foams

*Dennis John and Makisim Koshur*

**Department of Mechanical and Aerospace Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Nikhil Gupta*

Hollow particle-filled composites, called syntactic foams, are known as highly damage-tolerant lightweight composites. Epoxy and aluminum matrix syntactic foams containing glass hollow particles are used in marine and aerospace structures, sports equipment and insulation applications. The present study is focused on synthesis and characterization of vinyl ester matrix syntactic foams. Vinyl ester resins are widely used in marine applications because of their suitable mechanical properties and low moisture absorption coefficient. Impact tests are performed on the specimens using an instrumented Dynatup POE 2000 impact tester. The tests are conducted on notched and un-notched specimens in accordance to ASTM D256-02, D4812-99 standards, respectively. Load-displacement and time-energy graphs are obtained in the study, which are analyzed to study the damage mechanisms in these materials under impact loading conditions. Sixteen compositions of syntactic foams are tested to obtain an understanding of various parameters such as particle volume fraction and porosity on the impact properties of the composites. The results show that in notched specimens the crack initiation stage does not consume significant amount of energy and controls the specimen fracture characteristics. Compared to the neat vinyl ester resin the composites showed lower energy absorption, but higher specific fracture strength.

## Compressive Properties of Functionally Graded Syntactic Foam

*Ryan Caeti*

**Department of Mechanical and Aerospace Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Nikhil Gupta*

Syntactic foams are composed of hollow particles (microballoons) dispersed within a matrix material. Primarily, syntactic foams are used in buoyancy, thermal insulation and structural application such as the hulls of boats as well as for parts in the aerospace industry. In these applications, the need arises for materials with both a low density and a high compressive strength. Therefore, new tailored materials are required for these applications.

In previous research, syntactic foams were created by randomly/homogeneously distributing the microballoons within structure matrix material. While these materials were suitable for certain applications, further improvement of the materials is required to meet the ever increasing performance requirements. This in turn led to the creation of functionally graded syntactic foams (FGSFs) in which the materials were composed of a layered structure either based on the volume fraction or wall thickness of microballoons. Previous studies on these FGSFs had their gradient created by gluing layers of plain syntactic foams of desired compositions with an epoxy resin binder. However, layered material structures suffer from disadvantages when subjected to shear stresses. In this study, new techniques were employed to create a single monolithic structure comprised of the gradient layers. This was achieved by pouring the mixtures of different compositions into molds according to their densities, thereby, creating natural layers within the specimen as per the desired FGSF configuration. By utilizing this technique, it was found that the compressive properties of the FGSFs were able to be tailored to very precise needs. While retaining their high compressive strength to density ratio, it was found that volume fraction (VF) based FGSFs exhibited a sharp drop in stress of 30% to 50% upon entering the plastic region. This attribute was not present in wall thickness (WT) based FGSFs where the stress drop is only 20% to 40% upon entering the plastic region. Furthermore, it was found that wall thickness based FGSFs are more capable of retaining a high compressive strength up to at least 50% strain (the point at which testing was halted) within the plastic region, resulting in a high energy absorption.

## Development of an Apparatus and Control System for Stretching Optical Fibers

*Kwok Mak*

**Department of Mechanical and Aerospace Engineering**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Nikhil Gupta*

A regular optical fiber is made of a glass core surrounded by a layer of cladding, also made of glass. Optical fibers guide light by utilizing a phenomenon called total internal reflection. When a beam of light is in a medium, surrounded by another medium with a smaller index of refraction past a certain critical angle, all the incident light gets reflected back into the denser medium and none of it leaves the medium. In optical fibers, the cladding has a smaller index of refraction then the core, which makes incident light stay in the core. The diameter of the core with cladding in the optical fibers obtained from the manufacturers is 125 microns. However in certain applications, we need to reduce the diameter of the fibers to the range of 10 microns. These modified optical fibers can be used as sensors for stress, temperature, humidity, and strain. The goal of the research was to design and build an apparatus and associated control system that is capable of stretching the optical fibers according to the given specifications. The design process required you to understand which heating method is more effective and what minimal temperature is needed to stretch the fiber. You also need to know how the stretching rate and stretch time will affect the diameter of the fiber. The critical values for the parameters must also be known to prevent fracture on the fibers. The apparatus was built with the above-mentioned parameters in mind and the result was system with a three step procedure. First a micro torch is put near the fiber to heat it up, then the fiber will be stretched, and finally the torch will be taken away from the fiber to let the fiber cool down. A LabVIEW-

based program is developed to control and implement the procedure, because the apparatus must be controlled very precisely to get the desired diameter. The speed which the fiber is stretched is controlled using pulse-width modulation (PWM). PWM is a powerful technique for controlling analog circuits with a digital output from tho computer. The apparatus and associated control system developed in the project has been successfully used for stretching the optical fiber to 10 microns.

# Physics

## Variations in Information Redundancy in a Qutrit System Surrounded by Thermal Environment of Qubits with Temperature

*Srinivasa Chemudupati*

**Department of Physics**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Vladimir Tsifrinovich*

Since the advent of quantum information science, the theory has made tremendous progress. However, decoherence is still a major challenge for the construction and operation of a quantum computer (QC). In order to study decoherence and the consequent loss of information from a QC to the environment, seminal works in the recent past have treated the problem by studying information redundancy using Partial Information Plots (PIP's). PIP's plot the mutual information (of the system under consideration (QC) and the sub-environment), against the number of sub-environments into which the information has "leaked". These plots have been shown to be of importance in studying the transition between the quantum and the classical realms via information redundancy. It becomes imperative that a parameter that governs this transition be found. In all of the previous treatments of the subject, the assumption has been made that the universe exists in a pure state and certain symmetry theorems for the PIP's have been shown to exist. If, however, one does not make such an assumption and treats the environment as being in a state that belongs to an ensemble of states (thermal environment), with a probability governed by the temperature, then, such symmetry theorems do not hold anymore. This work aims in showing precisely that using a quantum ternary information unit (qutrit) system that is coupled with a thermal environment comprising of quantum binary information units (qubits). The research project also sets out to find the value of the aforementioned transition temperature.

## Magnetic-resonance Force Microscopy with Spin-one Particles and Crystal Fields

*Thomas Fan*

**Department of Physics**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

**Faculty Advisor:** *Professor Vladimir Tsifrinovich*

Magnetic-resonance force microscopy (MRFM) is a method to detect particles below the surface of a non-transparent solid. The oscillating cantilever-driven adiabatic reversal (OSCAR) is the technique in MRFM being analyzed. This technique involves a ferromagnetic particle attached to a cantilever tip which experiences a magnetic force produced from a spin-one particle. This force will cause a frequency shift, which is measured accurately in laboratories. This allows for the detection of the particle. The frequency shift is calculated on spin-one particles with the effects of crystal fields. These calculations allow for the frequency shifts to be interpreted into useful data such as the state of the spin-one particle.

## Optimization of Surface-enhanced Raman Scattering in Rhodamine 6G-Silver Colloid Solutions

*Bernard H. Everson*

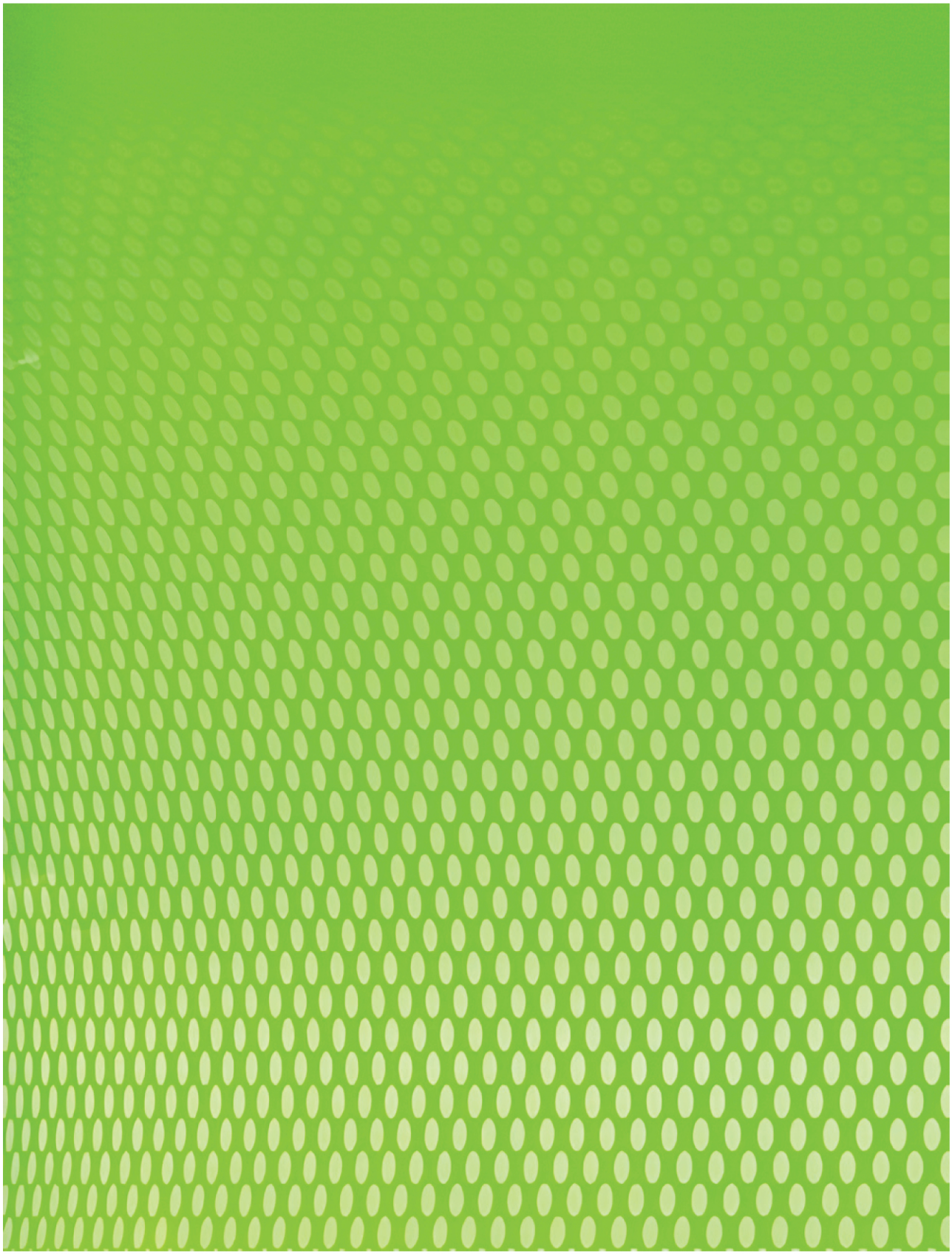
**Department of Physics**
Polytechnic Institute of New York University, Six MetroTech Center, Brooklyn, NY 11201

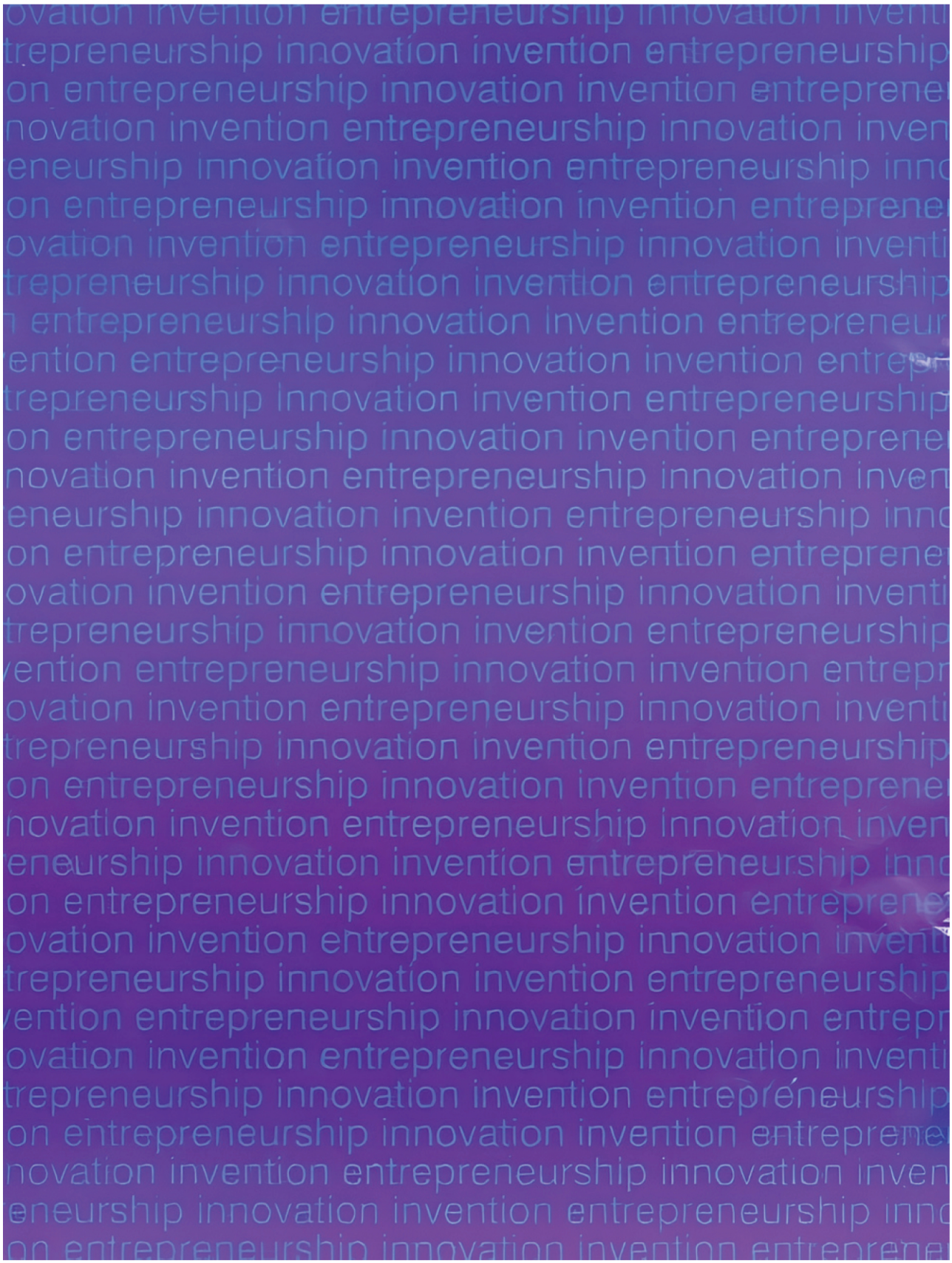
**Faculty Advisor:** *Professor David Mugglin*

Many techniques have been developed to identify and examine the structure of molecules. Among these is Raman Scattering, in which a molecule is excited by a photon to a virtual energy state. The excited molecule then decays to a vibrational state different than that of the molecule prior to excitation. The emitted photon is shifted in energy from the incident photon, and the resulting shift gives detailed information on the structure of the molecule. There is a drawback, however, in that Raman scattering cross sections are many orders of magnitude smaller than those related to other scattering phenomena. To remedy this, a technique known as Surface-enhanced Raman Scattering (SERS) is employed, in which surface plasmons in metal nanoparticles play a role in local field enhancement, increasing the Raman scattering cross section. In this project, we observe the SERS effect in a Rhodamine 6G-silver colloid solution. A characterization is made of the silver colloid solutions that provide the optimal Raman signal enhancement. A He-Ne Laser is used as a source of incident light. The scattered light is analyzed using an OceanOptics USB2000 fiber optic spectrometer, and the absorbance spectrum of the colloids is analyzed using an OceanOptics USB4000 fiber optic spectrometer.

# The 2008 Undergraduate Summer Research Program Seminar Series

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| 6/26/2008 | **Erich Kunhardt, Provost**<br>Polytechnic Institute of NYU<br>"Undergraduate Education Rooted in I2E" |
| 7/2/2008 | **Rastislav Levicky, Donald F Othmer Assistant Professor,**<br>Department of Chemical and Biological Engineering, Polytechnic Institute of NYU<br>"DNA Dynamics" |
| 7/9/2008 | **Keith Ross, Leonard J. Shustek Distinguished Professor**<br>Department of Computer and Information Science, Polytechnic Institute of NYU<br>"P2P Technologies" |
| 7/16/2008 | **Magued Iskander, Associate Professor**<br>Department of Civil Engineering, Polytechnic Institute of NYU<br>"Rebuilding New York Water Front Using Plastic Piles" |
| 7/23/2008 | **Kurt Becker Associate Provost, Research and Technology Initiatives and Professor**<br>Department of Physics, Polytechnic Institute of NYU<br>"Cold Microplasmas: Science and Applications" |
| 7/30/2008 | **Myles Jackson, The Dibner Family Professor of the History and Philosophy of Science and Technology Senior Fellow of the Othmer Institute for Interdisciplinary Studies and Chair of the Department of Humanities and Social Sciences,** Polytechnic Institute of NYU<br>"Why on Earth Do I Need to Take Humanities Courses at Poly? Biotech and Biocthics: A Case in Point" |
| 8/6/2008 | **Nasir Memon, Professor**<br>Department of Computer and Information Science, Polytechnic Institute of NYU<br>"File Carving" |
| 8/13/2008 | **Nikhil Gupta, Assistant Professor**<br>Department of Mechanical and Aerospace Engineering, Polytechnic Institute of NYU<br>"Advanced Composite Materials Research: Role of Undergraduate Students at Polytechnic" |




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