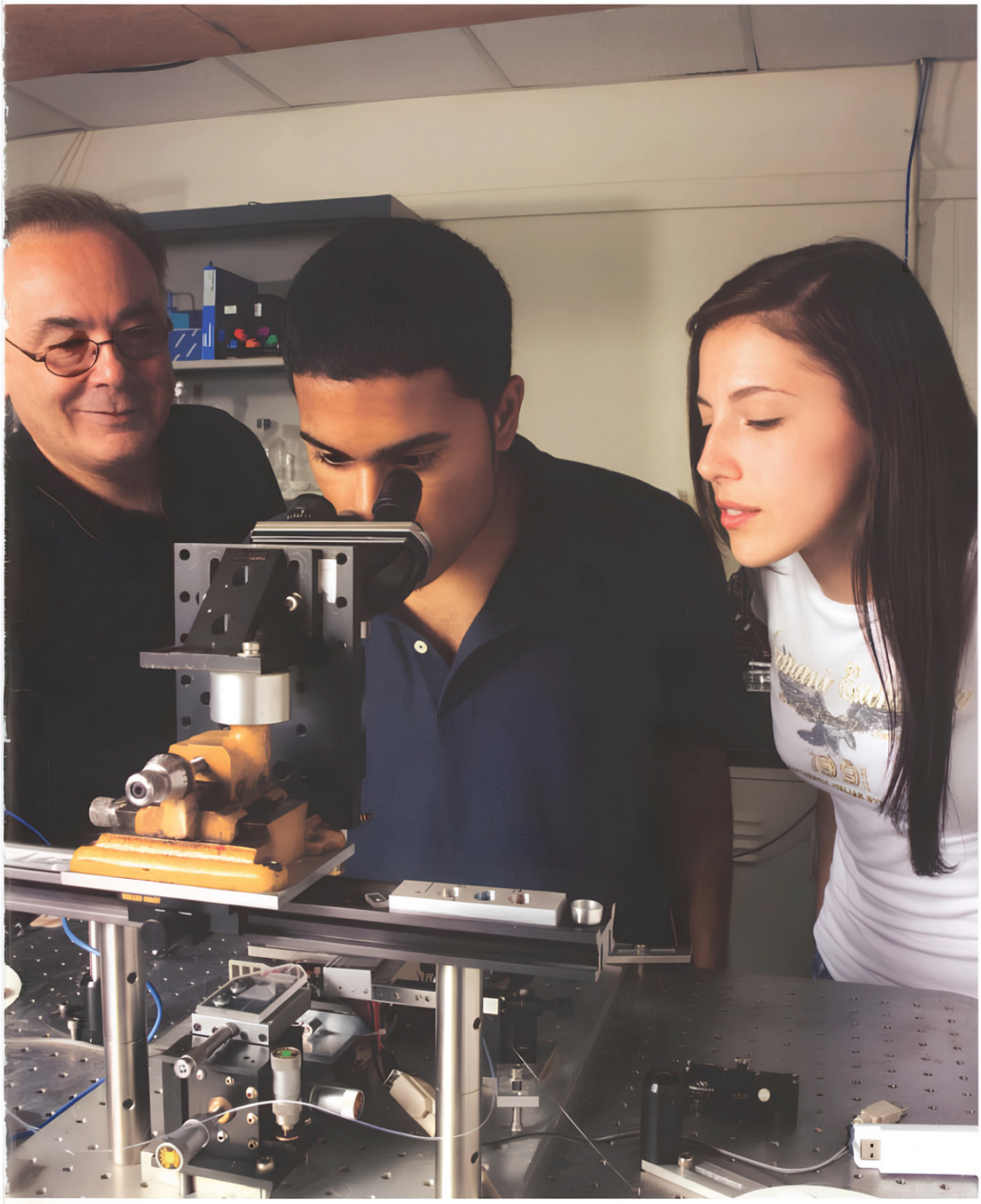
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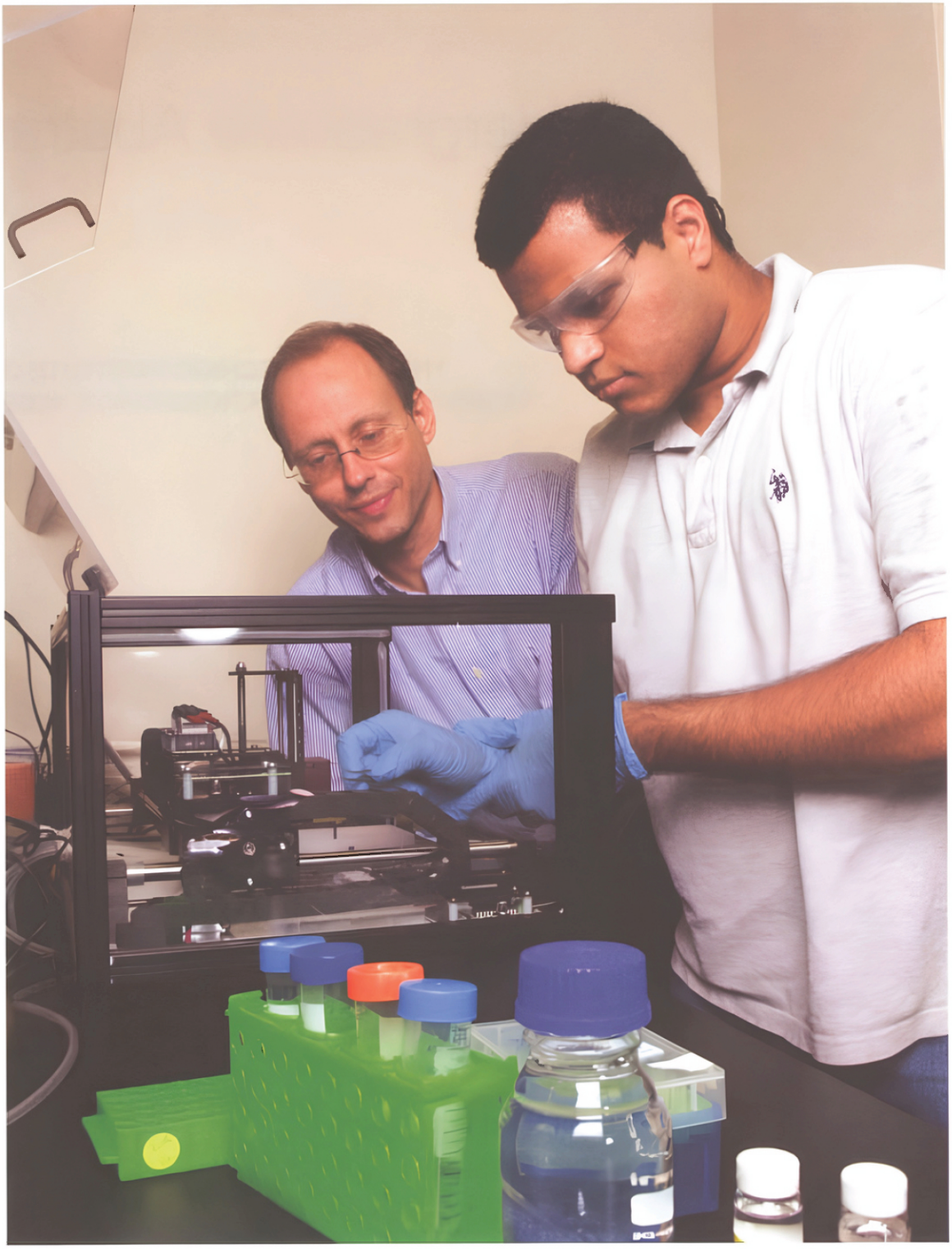
UNDERGRADUATE ABSTRACTS

NEW YORK UNIVERSITY

Undergraduate Abstracts

THIRD POLYTECHNIC INSTITUTE OF NYU
SYMPOSIUM ON UNDERGRADUATE RESEARCH

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Introduction

NYU-Poly's Summer Undergraduate Research Program provides a unique opportunity for students to get involved in research during the summer. This program offers students far more than the traditional classroom experience by allowing them to work alongside faculty mentors on cutting-edge research projects. Close interaction with faculty and research staff provides students with an educational experience that promotes the i^2e model of invention, innovation and entrepreneurship. Undergraduate students are afforded the opportunity to conduct research as paid interns during a 10-week summer period. The program aims to enhance and broaden students' knowledge base by applying classroom learning to solve practical and contemporary problems and to better prepare them for life-long learning.

Summer 2009 marked the third annual NYU-Poly Undergraduate Summer Research Program with 28 faculty members and 38 students participating. In addition to their work in the labs, students attended weekly seminars in which faculty members presented and discussed their research with students enrolled in the program.

NYU-Poly's faculty participation in this program was essential, as was the financial support from many faculty mentors as well as Polytechnic Institute of NYU's Board of Trustees. The program is an initiative of Institute Professor Erich Kunhardt and Associate Provost Kurt Becker who have played a vital role in making the program possible since its inception. Dean of Student Affairs Michael Hutmaker's efforts in organizing NYU-Poly's 2009 convocation event were vital in making the Undergraduate Summer Research poster presentations possible.

The abstracts published in this volume are representative of the poster presentations given at the symposium celebrating the accomplishments of the undergraduate researchers during Undergraduate Student Convocation.

I congratulate all of the the student researchers who participated in the 2009 Summer Research Program and look forward to future summers of intellectual and scholarly activities.

Iraj Kalkhoran
Dean of Undergraduate Academics

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Center for Faculty Innovations in Teaching and Learning

Database Creation for Center for Faculty Innovations in Teaching and Learning

Shaoxin Xu

Center for Faculty Innovations in Teaching and Learning

Faculty Advisor: *Steven Goss*

The creation of an essential database with user interfaces for faculty to use technical teaching equipment (such as software, hardware and accessories) in the newly created Center for Faculty Innovations in Teaching and Learning (FITL) at the Polytechnic Institute of New York University was the centerpiece of this project. Using Microsoft Office Access and Visual Basic, the project contains three primary parts: the user interface, the administrator interface and the product database. Via the user interface, faculty can search and explore each product in specific categories. The administrator interface is a page that administrators can access with his own user name and password to manage and update the database. Product database not only has basic information of each product, but also it offers three different format tutorials (html, pdf and Word) to faculty in order to provide them with a hands-on experience to use different products. The ultimate goal of this project is to create user-friendly interface for both faculty and administrator to access the product database for using and managing purposes.

Chemical and Biomolecular Engineering

Morpholino-DNA Hybridization Thermodynamics

Michael Furman

Department of Chemical and Biomolecular Engineering

Faculty Advisor: *Professor Rastislav Levicky*

Morpholinos are promising materials for the analysis of nucleic acids. Before diagnostic tests based on morpholinos can be developed, it is essential to understand the rules that govern their interactions with DNA. To this end, thermodynamic parameters of morpholino-DNA association, or hybridization are measured in this research. First, however, it is essential to ensure purity of the materials that will be used in such studies. One method of controlling purity of the materials is to use high-pressure liquid chromatography (HPLC). Running samples through an HPLC affinity column allows the user to isolate sequences of interest while discarding the impurities. However, morpholino has proven difficult to purify due to its ability to aggregate in solution and to possibly stick to the walls of the HPLC column. Increasing the pH level from 7.0 to 10.0 of the HPLC carrier buffer has made it easier to separate different sequences of morpholinos. The increase in the pH level of the buffer has introduced new nuances regarding the conformation of the morpholino strand. At high pH, these molecules become charged, possibly behaving more like DNA for which the HPLC protocols are well established. Changing the sequence to mainly A-T as opposed to C-G bonds can also make realization of pure materials much easier by eliminating depurinated (G-lacking) strands.

The Analysis of Polystyrene/Poly (Phenylene Oxide) Blends

Nataliya Furman

Department of Chemical and Biomolecular Engineering

Faculty Advisor: *Professor Jovan Mijovic*

Different polymers have characteristic traits that can be combined by blending to express the attributes of both. In this research, atactic polystyrene [PS] and linear poly(2,6-dimethyl-l,4-phenylene oxide), commonly known as just poly (phenylene oxide) [PPO], were studied. Individually, PS is brittle below about 100°C and PPO is highly heat resistant with a glass transition temperature of 210°C. Together they create a structurally and thermally stable blend commonly sold under the trade name Noryl, developed by General Electric in 1966.

The objective of this research is to study a series of PS/PPO blends by dielectric relaxation spectroscopy [DRS]. Various ratios of PS and PPO were investigated (in terms of PPO: 0%, 20%, 40%, 80%, 100%). All blends are solid at room temperature; therefore, they first had to be melted onto the electrodes. A fundamental detail is generally left out of most descriptions of PPO, which is that it easily oxidizes, and this was quickly observed with the color change it underwent as it was heated above 210°C. This meant that the structure of PPO changed, and the DRS results would be altered. That left only two samples that could be reliably tested; neat PS and the blend 20/80 PPO/PS blend where PPO had less chance to oxidize. Dipolar relaxation in both neat PS and the 20/80 PPO/PS blend was detected. PS is usually viewed as dielectrically inactive due to its benzene rings, known for their symmetrical shape and stability. However, the findings dispute the notion and provide the evidence that benzene rings form physical dimers and have a dipole moment.

Desorption Kinetics of Alkanethiols Observed with Electrochemical AC-impedance Spectroscopy

Reju Mathew George

Department of Chemical and Biomolecular Engineering

Faculty Advisor: *Professor Rastislav Levicky*

DNA-based biosensors have been used successfully in DNA biodiagnostics experiments. Probe DNA strands modified with an electrochemical tag are adsorbed onto a clean gold surface along with a monolayer of an alkanethiol, like 3-mercapto-1-propanol (MCP) or 6-mercapto-1-hexanol (MCH). The alkanethiol monolayer inhibits interaction of the negatively charged phosphate backbone of the probe DNA chains with the gold surface over a wide range of potentials and allows for effective target DNA hybridization. But MCH/MCP desorption under applied potential in a DNA-alkanethiol mixed monolayer could interfere with these hybridization experiments; so understanding their kinetics is important to the successful use of these biosensors.

The kinetics of MCP/MCH desorption were investigated with bare alkanethiol monolayers using electrochemical impedance spectroscopy (EIS), amperometric i-t curve (it) and cyclic voltammetry (CV) techniques. Desorption was observed in high (900mM), medium (330mM) and low (37mM) potassium phosphate buffer (KPB). The surface potentials were controlled by enforcing a constant dc bias, relative to an Ag/AgCl 3M KCl reference electrode. The EIS measurements with passivator in the bulk showed no increase in capacitance indicating that the surface concentration was intact. Desorption of the monolayer was completely inhibited by the presence of alkanethiol molecules in the bulk. Similarly, constant potential desorption showed no increase in capacitance. To increase the sensitivity of the EIS measurements, differential capacitance was measured while varying bias potential to optimize the measurement conditions. Desorption of a MCP monolayer was successfully captured through the EIS measurements. MCP being a smaller molecule than MCH tends to come off the gold surface faster and hence, shows a larger capacitance increase in the same time interval. Also, the presence of the alkanethiol in the bulk solution protects the monolayer by filling up holes in the layer as soon as they are formed. EIS measurements were most successful at high-ionic strength and high-bias surface potential which minimized extraneous capacitance contributions like the double-layer capacitance.

Aggregation of Alpha Synuclein

Sofia Golbert

Department of Chemical and Biomolecular Engineering

Faculty Advisor: *Professor Jin Ryoun Kim*

Parkinson's disease (PD) is a common, chronic, slow progressive, age-related disorder of the central nervous system in humans. There exists strong evidence that the aggregation of the protein, alpha-synuclein (AS), has a major role in PD. The 140 amino acid protein can be characterized by three different regions: an amphipathic N terminus (residues 1-60), a hydrophobic self-aggregating domain known as the NAC region (non-Aβ-component, residues 61-95) and an acidic C terminus (residues 96-140). The NAC region is believed to be critical for aggregation, resulting in β-sheet structured amyloid fibrils. The aggregated protein includes two linker regions encompassing residues 65-68 and 83-86, which connect β-strand structures of the aggregate in fibrils. The project involves producing a mutant AS protein, using DNA- recombinant methods, with mutations close to the linker regions, as well as in the linker region itself. The mutations are carefully selected so as not to disturb the general fibrillation propensity of AS. We will study whether our mutant AS modulates aggregation using thioflavin T, a dye that exhibits significant fluorescent signal upon binding to amyloid fibrils. In addition, FlAsH, a biarsenical dye that binds a specifically conformed tetracysteine motif, will be used in conjunction with the designed proteins containing cysteine mutations to study whether our proteins interact with soluble oligomeric species of AS, which are believed to be the toxic species responsible for the pathology of PD.

Actively Targeting Colon Cancer with pH-dependent Folate-labeled Liposomes

Gittel T. Gold

Department of Chemical and Biomolecular Engineering
Laboratory for Drug Delivery Systems

Faculty Advisor: *Professor Stavroula Sofou*

An ideal drug delivery carrier for treating solid tumors is characterized by sufficient circulation times, enhanced drug bioavailability at the site of the tumor and reduced toxicity everywhere else. Creating this ideal carrier is the goal of the Drug Delivery Systems Laboratory (DDS). In this experiment, the precise ratio of selected components of the liposomes was chosen to include the 21PC/DSPA lipids, a pair of lipids with non-matching tail lengths and differing head groups; cholesterol to add rigidity; PEG to increase circulation time *in vivo*; and PEG-folate, PEG lipid with the folate functional group conjugated to its end for specific targeting.

Exploiting the property of the SW620 colon cancer cell line to overexpress folate receptors, folate was chosen as the ligand to target these specific cells. The drug is encapsulated into these liposomes, which are directed to leak exclusively at the tumor site. Two different drugs, namely Doxorubicin (DXR) and 5-FluoroUracil (5-FU), are being explored in parallel experiments. DXR is detected by its intrinsic fluorescence using a spectrofluorometer; 5-FU is detected by its intrinsic absorbance using a spectrophotometer. When the liposomes are internalized by cells, they enter the endosomal pathway, where the vesicles are designed to release their contents in sync with the decrease in the endosomal pH. Preliminary content release experiments were conducted using the calcein fluorophore to model the drug. Content release studies in serum- supplemented media are being conducted now, and will be followed by *in vitro* cytotoxicity studies. As a basis for comparison, the same experiments are also

being conducted using the lipid compositions of commercially available liposomes. Superior release profiles, expected of the DDS signature liposomes, would be characterized by enhanced killing efficacy at the site of the tumor, distinguished by low pH, and reduced toxicity elsewhere, distinguished by physiological pH. The liposomes engineered in the Drug Delivery Systems Laboratory will prove their potential as the drug delivery vehicle of choice for treating advanced cancer.

Alkanethiol Passivation Kinetics in DNA-DNA Biosensors Determined by Electrochemical Methods

Michael G. Hailemariam

Department of Chemical and Biomolecular Engineering

Faculty Advisor: *Professor Rastislav Levicky*

In arrays of immobilized single-stranded DNA probes, a monolayer of alkanethiol is used as a passivation layer to inhibit non-specific adsorption of DNA to the gold surface. The kinetics of alkanethiols like mercaptohexanol (MCH) and mercaptopropanol (MCP) are investigated under applied potential with electrochemical impedance spectroscopy (EIS) and cyclic voltammetry (CV). The EIS measurements show a significant drop in capacitance in the first hour of adsorption of the alkanethiol, indicating that adsorption of the monolayer was quick and spontaneous in agreement with the literature. The adsorption results are repeatable for MCH and MCP monolayers assembled for 2 and 14 hours. Using cyclic voltammetry, mixed monolayer of probe DNA and MCP or MCH passivation were characterized between 0 V to 0.65 V. The CV results with both MCP and MCH passivation layers show an increase in background current. In preliminary experiments, the increase in background current has been attributed to the possible damage of the alkanethiol monolayer from continuous CV cycling. When CV measurements are taken with time, with no electrochemical processes, the current is found to increase at higher potentials. The CV results also show a continued increase in current after 1.5 hours and 14 hours of MCP adsorption consistent with the EIS measurements. This is attributed to desorption of the passivation layer.

Molecular Dynamics of Liquid Crystal Physical Gels

Kyle Hicks

Department of Chemical and Biomolecular Engineering

Faculty Advisor: *Professor Jovan Mijovic*

This research seeks to elucidate the molecular dynamics of the complex systems known as liquid crystal physical gels (LCPGs), which have experienced burgeoning interest in recent years. These systems are composed of rigid aromatic liquid crystals, seen in the LCD displays of televisions and computers, mixed with gelling agents. Thermotropic liquid crystals exhibit *isotropic* and *nematic* phases which display relative opacity and transparency, respectively. When combined with a low-molecular weight gelator, these systems can undergo thermoreverible changes that alter the viscosity, optical properties and electrical properties. Various combinations of gelator and liquid crystal exist whose properties depend on temperature and concentration. For example upon cooling, one system first gels, then undergoes a phase transition from *isotropic* to *nematic*. Yet

another system currently under investigation, first phase-transitions, then gels. Controlling the orientation of the dipoles, either in a *homeotropic* (perpendicular) or *planar* (parallel) alignment relative to the applied electric field is also attempted. The ability to control the orientation of a temperature-sensitive and thermally reversible system is critical to making LCPG's amenable to many practical applications, such as electrical switches, enhanced displays and medical devices.

The primary tool used to investigate this system is dielectric relaxation spectroscopy (DRS). This useful technique probes the electromagnetic orientation of molecules on a broad timescale (10^{-2} Hz to 10^{9} Hz). DRS can detect the motion of polymeric side chains, dipoles and charge carriers by measuring dielectric capacitance and loss as a function of frequency; it lets scientists 'see' motions and rotations on length and time scales too small for the human eye. Various empirical equations are used to quantify the relative strength of the relaxation processes. This lab is one of few dielectric laboratories that can attain the high frequencies needed to explore LCPG systems. Other tools being used include differential scanning calorimetry (DSC) to find the phase and gel transitions and polarized light microscopy (PLM) to observe the liquid crystal birefringence.

Effect of End-to-End Protein Fusion on an Enzyme's Stability

Tina Xiong

Department of Chemical and Biomolecular Engineering

Faculty Advisor: *Professor Jin Ryoun Kim*

Many proteins and enzymes lack kinetic and thermodynamic stability, indicators of how active proteins behave over a period of time and their reversibility under denaturing conditions. Instability occurs when secondary and tertiary structural domains responsible for the proteins function are changed, resulting in the unfolding of the protein's native structure. From an economic perspective, kinetic and thermodynamic stability of proteins is necessary to promote cost and production efficiency of enzymatic processes, since many of these processes are carried out for long periods of time, sometimes under denaturing conditions.

Previous methods used to stabilize proteins include site directed and random mutagenesis of amino acids. This research, however, utilizes rational protein fusion as a method of stabilization. Recent studies have shown that enzyme stabilization by domain insertion into a thermophilic protein has greatly improved the kinetic stability of the target enzyme (Kim et al, 2009). Here, the effect of end-to-end fusion of the highly stable *Pyrococcus Furiosus* maltose binding protein (*Pf*MBP) on its target penicillin hydrolyzing enzyme TEM1 β-Lactamase (Bla) is specifically investigated. Three variations of the end-to-end fusion hybrid are constructed, the first being the direct connection of the C- terminus of Pfmbp to the N- terminus of Bla, and the other two incorporating flexible peptide linkers namely DKS and GSGGG. The flexible linkers are expected to enable optimal distance and rotational freedom to both proteins to ensure favorable interaction.

Chemical and Biological Sciences

BSA-affinity Analysis for Iron-carrying Compounds

Javi Balroop and Robert Carey

Department of Chemical and Biological Sciences

Faculty Advisor: *Professor Charles Martucci*

This series of experiments were designed to test experimental compounds in order to determine their affinity for serum albumin, using bovine serum albumin (BSA) as a substitute for human serum albumin. The associated theory is that compounds with higher BSA affinity would dwell in the blood longer, resulting in less-frequent dosing for a potential drug. The experiments were run using divided cells, BSA on one side with tested ligand on the other and a membrane permeable to the ligand. Ligands were added in different concentrations in order to develop a scatchard plot to determine the strength and number of binding sites in BSA. In this case, the TPAK series (primarily TPAK-G and TPAK-AD) was tested. The tests were performed by measuring the amount of ligand remaining in the original ligand-side via UV spectroscopy. In the results, BSA has relatively high affinity for TPAK-AD when compared with the much smaller TPAK-G compound. This suggests that BSA's strong affinity for fatty acids could be the key to making a longer-lasting compound.

Activity, Stability and Characterization of tGCN5 Single Mutants

Yan Mei Chan

Department of Chemical and Biological Sciences

Faculty Advisor: *Professor Jin Kim Montclare*

The goal of this project is to utilize fluorine chemistry and machine learning bio-computational techniques to optimize the activity, stability and specificity of Histone acetyltransferases (HAT). HAT is a class of enzymes attracting the interest of researchers because of its important role in gene regulation. Our target HAT, *Tetrahymena thermophilia* GCN5 (tGNC5), acetylates both the histone H3 and the non-histone p53 peptides. Previous studies from the Montclare group have shown that not only can fluorine in the form of para-fluoro-phenylalanine confer stability of tGCN5, but it can also increase specificity towards H3 by diminishing activity for p53. Although specificity is enhanced upon fluorination, activity for H3 is diminished ten-fold. In order to improve the activity as well as stability, we attempt to design variants. Sets of variants were generated using the Placket-Burman algorithm, which aims to find the smallest set of experiments for a set of variables. Fragments bearing mutations within tGCN5 are generated by PCR and ligated together to form a complete tGCN5 with the desired mutations.



Cloning into vector is done by TOPO cloning, a technique which differs from the conventional method by minimizing the time needed for cloning, ligation and transformation. Variants were then subject to specificity, kinetics and biophysical analysis.

Study of Chemical Polymerization of Aniline Using UV Spectrometry

Ying Chen

Department of Chemical and Biological Sciences

Faculty Advisor: *Professor Kalle Levon*

Polyaniline is one of the oldest and most studied conducting polymers since its discovery at the beginning of 20th century. Polyaniline can be obtained through polymerization of aniline monomer. There are many methods for polymerization of aniline, such as electrochemical, chemical, UV-induced polymerization and so forth. In the present study, the process of chemical polymerization via oxidation of aniline by ammonium persulfate in acidic medium is observed using UV spectrometry. The same method is then applied to study the polymerization mechanism in the presences of poly (styrene sulfonic acid) as template.

Non-photochemical Laser-induced Nucleation (NPLIN) of Super-cooled Phenyl Salicylate (Salol)

Quinn Gibson and Radu Iliescu

Department of Chemical and Biological Sciences

Faculty Advisors: *Professors Bruce Garetz and Janice Aber*

In 1996 Garetz et al. found that a high-powered IR laser pulse could induce crystallization in a super-saturated urea solution. In 2002, Garetz et al. found that varying the polarization of the laser induced the nucleation of different crystal polymorphs in a super-saturated glycine solution. Recently, there has been interest in performing NPLIN experiments on super-cooled compounds. An ideal substance for this study is salol, due to its convenient melting point of 42°C. It is a solid at room temperature and it is also easy to melt and manipulate. So far, we have devised a protocol for super cooling salol to ambient temperature, allowing it to maintain a metastable liquid state, thus simplifying our future NPLIN experiments on the salol melt. We have found that cooling rate has a significant effect on the stability of the super-cooled liquid state, while other factors such as sample size and hold time at the melting temperature have little to no effect. We have begun exposing the super-cooled salol to IR laser pulses and optimizing the optical apparatus used in the laser experiments. Further studies will include continuing laser experiments on the metastable state and determining whether different polarizations of the laser will induce the formation of different crystal polymorphs.

Studying the Interaction between Lectins and Sugars Using the Potentiometric Method

Wendy Hom

Department of Chemical and Biological Sciences

Faculty Advisor: *Professor Kalle Levon*

Lectins are proteins that selectively bind to sugars with a high degree of specificity and participate in biological recognition involving cells and various proteins. They have been found to play a key role in the immune system through identification of specific carbohydrates that are adorned on pathogens' cells. Using the potentiometric method, this research studies the binding potential of lectin from *Helix pomatia* to a PANI-Nylon 6 electrode with the goal of immobilizing the lectin to glass slides and to study the degree of binding lectin has with various sugar moieties.

Conversion of Hydroxyl-fatty Acids to Unique Bio-based Materials

Ou Jin

Department of Chemical and Biological Sciences

Faculty Advisor: *Professor Richard Gross*

Biotransformation of fatty acids from renewable feedstocks to ω-oxidized fatty acids is a new and powerful

technological platform developed in our laboratory. Since PEG-based amphiphiles are important commercial materialism, the current research involves using simple methods to further diversify the structure and corresponding properties of triglycerides. By incorporating the ω-oxidized fatty acids, this work seeks to develop new PEG-based amphiphiles and higher molecular weight triglycerides.

Newly available ω-hydroxyl fatty acids will be utilized to form amphiphilic PEG-polyesters that exploit the slow reactivity between PEG and W14 and the self-assembly characteristics of products. These will be useful new non-ionic surfactants and emulsifiers. Furthermore, a new family of triglycerides that have controlled quantities of tetra- and pentaglycerides will be prepared. This is to our knowledge a new concept that can be exploited to control the rheology and physical characteristics of agroderived triglycerides for a range of applications.

Polyproline Racemization as a Model System for the Consequences of Epimerization in a Peptide with a Helical Conformation

Sean Mahase

Department of Chemical and Biological Sciences

Faculty Advisor: *Professor Mark Green*

Chirality and life intertwine through biological molecules existing as left-handed or right-handed enantiomers. Chemists regularly perform asymmetric reactions, steering a reaction towards products in one particular left or right form, creating drugs that are active within the body in only one chiral form. Why biological molecules exist in nature as one mirror form at the exclusion of the other form, and how life became homochiral despite even numbers of each enantiomer originally existing in nature remains an unsettled anonymity in chemistry. The "why" question can be attributed to an enzymatic reaction's free-energy profile being optimized upon possessing the ability to distinguish between enantiotopic moieties. Thus, chiral distinction in nature is a consequence of evolutionary pressure pursuing enzymatic catalytic perfection. The "how" question is more intriguing as the free-energy profile and products of a respective enzymatic reaction would be identical regardless of which enantiotopic group it evolved to accommodate. This alludes to enzymes choosing one enantiomer over the other by chance, as both mirror forms existed equally in nature. Holding that both mirror forms are equally probable candidates for enzymatic selection, if the chiral hydrogen of a system consisting of an oligomer of exclusively one enantiomeric form was reversibly deprotonated and reprotonated, the system will eventually reach equilibrium as a racemic mixture.

Polyproline is an ideal system to test this idea due to its ability to form a stable left-handed or right-handed helix and the lack of an N-H proton present in other peptides, which can compete with the alpha-H during deprotonation with the base. Furthermore, one critical parameter is the oligomer length; for example, a 20-mer oligomer could be a reasonable length for which helical reversal is accessible, allowing only a small energy barrier to switch from left to right. A CD spectrometer evaluated changes in polyproline's optical activity upon addition of a series of bases/solvents (NaOH/Methanol, t-BuOK/t-Butanol, t-BuOK/acetonitrile, LDA/acetonitrile, Cs2CO3/DMF, NaOH/Water). No changes in CD occurred using a NaOH/water mixture over the course of several days. In addition, no significant change in intensity was observed in t-BuOK/t-Butanol (pKa = 18), or t-BuOK/acetonitrile solutions, suggesting that the base is too weak to remove the alpha-H (pKa = 26). Despite LDA's strong basic properties, racemization did not occur in LDA/acetonitrile, suggesting steric hindrance in the alpha-proton's surrounding environment prevented the reaction. Within minutes, Cs2CO3/DMF caused a quick loss in CD intensity due to hydrolysis, as was confirmed by LC-MS analysis. Finally, in NaOH/Methanol, a quick decrease in CD intensity resulted from the peptide precipitating immediately upon

addition of the base. By making the mixture 20% water, the precipitate disappears and the CD was identical to that obtained in only water or methanol without the base, suggesting the precipitate was the initial polyproline's N-deprotonated form, rather than the expected racemic mixture.

It is expected that when the alpha-H of a polyproline system, consisting of alternating L- and D-proline (LDLDLDLD....) is reversibly removed, the system will equilibrate as a 50:50 ratio of two enantiomers (LLLLLLLL... and DDDDDDDD...), producing a circular dichroism of zero. This experiment exemplifies that the enzymatic choice to evolve using one oligomeric enantiomer over another was arbitrary given both mirror forms were energetically similar and thus, existed in equal abundance in nature. However, this racemic state lost efficiency as life evolved and increasingly complex structures conforming to physical configurations consisting exclusively of one optical configuration gained an energetic advantage, resulting in life's homochiral state.

Protease-catalyzed Synthesis of Oligo (L-lysine)

Qi Su

Department of Chemical and Biological Sciences

Faculty Advisor: *Professor Richard Gross*

Oligopeptides are readily synthesized by established approaches such as solid-phase peptide synthesis (SPPS) and solution-phase synthesis (SPS) with a precise sequence of amino acids. However, when a single product with a precise amino acid sequence is not required, there is an opportunity to introduce new technologies if they are sufficiently simple, cost-effective and environmentally friendly. For this purpose, Protease-catalyzed reverse equilibrium synthetic methods were developed that offer some degree of sequence control as well as enantio- and regioselectivity.

Oligolysine is successfully synthesized in aqueous phase catalyzed by bromelain with precise pH control by pH stat. Four proteases (papain, bromelain, a-chymotrypsin and trypsin) are studied in catalyzing oligomerazion of L-lysine ethyl ester. In one hour with medium pH 7, 8, 9 and 10 oligolysine is synthesized by four proteases, and bromelain is selected with the highest catalysis activity based on both yield and DP_{avg} of L-Lysine oligomerization. Protease added to reaction was normalized based on their activities for casein hydrolysis published before. The effects of medium pH, medium buffer concentration, enzyme concentration, substrate concentration on synthesis of L-lysine oligomer are studied. Precise pH control by pH-stat is critical to keep bromelain at high activity and give us oligomers with highest yield and DP_{avg} at pH 7.6. Higher buffer ion strength induces increase of yield with decrease of longest chain length. Since both monomer and oligomer are soluble in aqueous phase, there is no strong driving force like precipitation to push equilibrium to oligomerization direction. Time course reactions are, therefore, studied to look in detail into both enzyme catalyzed aminolysis and proteolysis. Oligomers with chain length more than 10 are formed at the beginning of the time (5 mins). Yield rapidly increases as DPavg increases during the first hour, while at the same time there is almost no change in longest chain length. After approaching the maximium DP_{avg} at one hour, the longest chain length and DP_{avg} drop presumably due to bromelain-catalyzed proteolysis.

Computer Science and Engineering

Games to Enhance Computational Thinking

Carmine Elvezio, May Thazin, Sai Ke Wang

Department of Computer Science and Engineering

Faculty Advisor: *Professor Joel M. Wein*

In the last several years, there has been interest in the computer science community in the notion of computational thinking—a mode of thinking that underlies much of computer science, but also constitutes a set of models, structures and perspectives that are of value across many disciplines. At the same time, there has been an explosion of interest in the use of digital games for teaching and learning. This project is born of the intersection of these two trends.

This project consisted of two parts. In the first part, we conducted a substantial survey and classification of many commercial computer games that have effectively conveyed principles of computational thinking through intuitive game play. In an attempt to define these games, it was necessary to compile a list of the games representative of the respective principles and genres. The majority of the games were commercial titles, as they proved to be in much greater supply and the player responses thoroughly documented. All titles, regardless of classification, platform and genre, were grouped by the elements of computational thinking they employ. In addition, consideration was taken as to whether the games alert the player to the aforementioned principles at work.

With the list completed, the next step was to develop one example in the vein of the definition of these games. The game would need to actively teach the principles, but utilize game play that would be as enjoyable as commercial "entertainment" titles. The final product has the player in the role of a bank teller. As time and customer patience are limited, the player has to determine the order in which he/she helps customers, as each customer will have various conditions that will affect the time they will take at the teller window. The intention of the game is to teach scheduling techniques, such as FCFS (First-Come, First-Served). While slightly unrealistic, as most banks follow a strict FCFS methodology, the user is encouraged to experiment with different techniques. The game will attempt to create situations in which FCFS alone may not be feasible in order to finish. Thus, the user is allowed to change the order in which he/she handles customers. If this is done with some consistency, the player will have adhered to a different scheduling style (of which they would have been made aware of earlier in the game). If the player can reflect upon his play and recognize it as distinct from the simpler FCFS method, the game will have been successful at teaching the principle it was created to convey.

Virtualization Support for Distributed Gaming

Carmine Elvezio, May Thazin, Sai Ke Wang

Department of Computer Science and Engineering

Faculty Advisor: *Professor Joel M. Wein*

The distributed gaming system represents the numerous challenges including failure models, lack of global information, lack of global clock synchronization and heterogeneity. The game itself is an example of a complex distributed system. It consists of several components. Each component is implemented using a best suited programming language/technology; Google Web Kit and Flash for web-based console; C/C++ for background daemons; MySQL for data storage; PHP for providing required data and issuing commands for break cases; and XML (Extensive Markup Language) for seamless message exchange between each component. The game for each team consists of a number of virtual machines: one DNS server, one MySQL server, and multiple machines each of which hosts an Apache web server, a chat server, a video upload server, and a replication server. The game servers can be run on most Linux distributions (tested on Debian Lenny and Ubuntu Hardy Heron).

The main foci of the project for summer 2009 are to research on how best to use the underlying virtualization technology to support the platform. After debugging several bugs and modifying some codes to the existing game systems, the game includes more even and balanced traffic generation in virtualized environments and maximization of virtual machine capacity per unit physical server. In addition, research was done on the development of appropriate characters and topic sequencing to enhance scaffold learning in the simulation. During the game, a web-based user interface is provided for students to monitor the status of their servers and interact with each other. Friendly flash characters were developed to guide them to get familiar with the game, and offer them hints for problems that they may encounter. The result of this research will allow educators to assign a group of students a set of virtualized servers and give students experience with creative problem solving through investigating and understanding complex distributed systems which they are not intimately familiar, and provide experience in evaluating a large number of possible causes in order to find root cause and fix it.

Using Graphics Processors for Data Compression

Madhurya Nangia

Department of Computer Science and Engineering

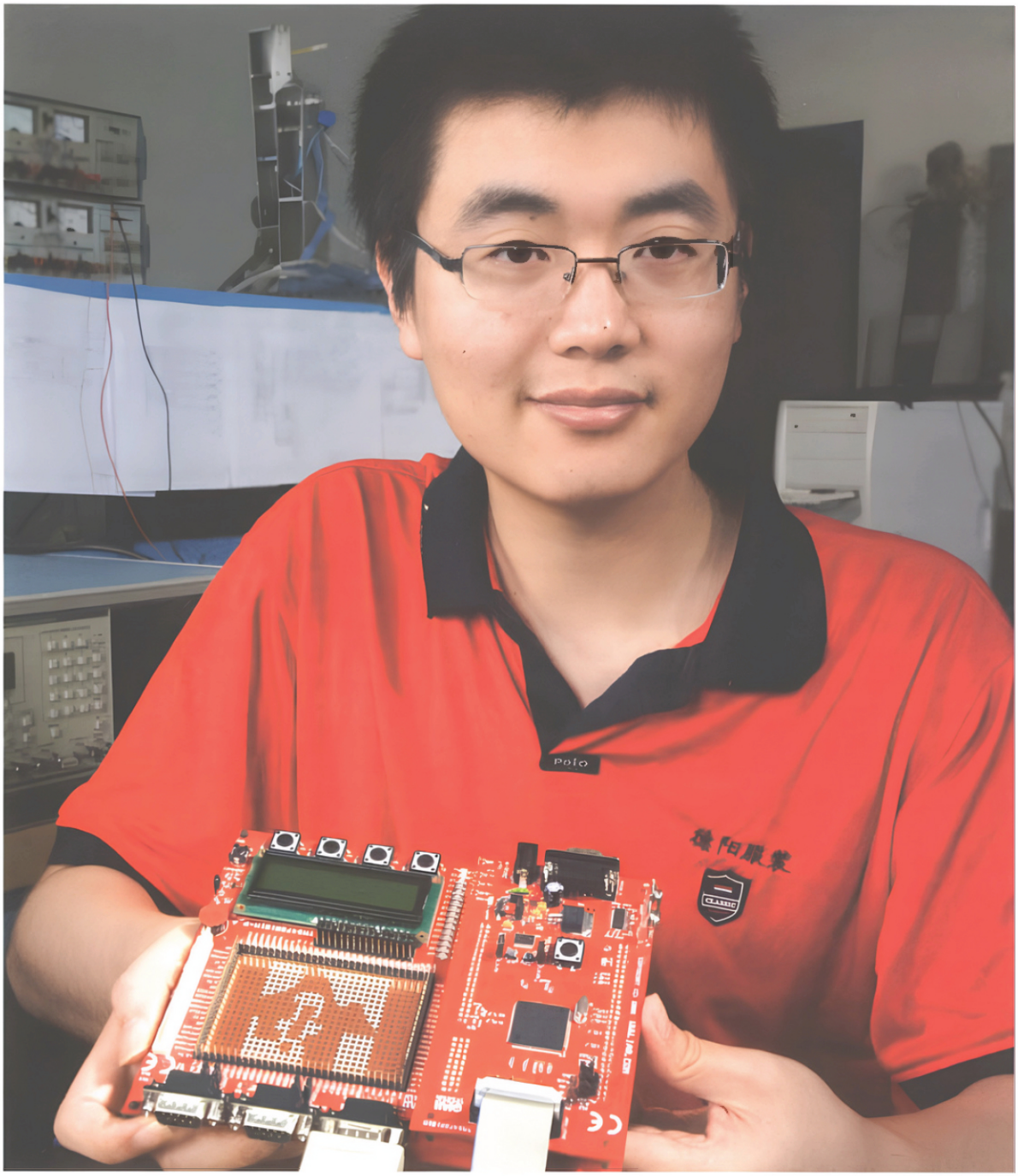
Faculty Advisor: *Professor Torsten Suel*

Data compression is a set of techniques used to reduce the size of a file, thereby increasing the rate of transmission and saving storage space. It is a very important tool for managing and transferring huge amounts of data. Text compression is one part of data compression. As the name suggests, it deals with compressing files that contain textual data, such as text files, source files, web pages, etc. There are many tools that deal with text compression, such as *gzip* and *ZIP*. These work by finding repeating patterns and replacing them with codes. Thus, for strings that appear several times in a document, there would be a code that will replace all occurrences for that string. Other tools find a pattern, and whenever the same pattern is found, it is replaced by the location of the first occurrence. This helps reduce the overall size of the file.

Recently NVIDIA released their own parallel programming architecture called Compute Unified Device

Architecture (CUDA) for its graphics processing units (GPUs). GPUs comprise of many cores, and thus can compute much faster and, therefore, increase the performance of an application significantly.

The purpose of this research is to find a way to compress large amounts of redundant data and to use GPUs to increase the overall compression speed. Our first goal is to compare the speed of text compression in a GPU with that in a central processing unit (CPU). Our second goal is to find a more efficient string matching mechanism. For this, we need to experiment with the size of the strings we are comparing and also the amount of memory being used to store the file in the temporary storage.



Electrical and Computer Engineering

Image Reconstruction of Optical Tomography

Yixin Cao

Department of Electrical and Computer Engineering

Faculty Advisor: Professor Ivan Selesnick

Optical tomography is a new tomography technology that creates a 3-D image of an object. It has been studied in the application of biomedical imaging, such as brain and breast imaging, in recent years. The image reconstruction in optical tomography is the procedure that transforms the detector data into an image. The basic idea of image reconstruction is to inverse the transforming operation from the real image of the object to the detector data. However, this kind of transformation is non-invertible since it is an underdetermined matrix multiplication equation. Therefore, it is necessary to add pre-knowledge of the object as a constraint to optimize the image solution.

The objective of this project is to find an appropriate algorithm for the image reconstruction that is efficient and accurate. The constraint that was used is that the image signal is sparse, meaning that most of the values in the signal are zero. With this constraint, the problem lies in minimizing an objective function that involves the difference of the data to reconstruct the image and the data that should be produced by the reconstructed image, and the 1-norm or 2-norm of the reconstructed image. From the experiments, the algorithm based on 1-norm of the image was determined to have a good accuracy, but takes a relatively long time; the algorithm based on 2-norm of the image was found to be fast, but less accurate than the image created using 1-norm. By applying singular value decomposition on the transform matrix, the 2-norm algorithm is largely accelerated without losing accuracy.

Fuel-cell Emulator

Justin Rossi

Department of Electrical and Computer Engineering

Faculty Advisors: *Professors Francisco De Leon Gomez Maqueo and Dariusz Czarkowski*

Proton exchange membrane fuel cells are a promising technology for the future of many electrical power applications. Not only are they "green technology", but they run on the Earth's most abundant resource, hydrogen. It is speculated that fuel-cell technology can be utilized by various transportation applications. Fuel

cells generate direct current at set characteristic voltage levels. The voltage levels that are produced by the fuel cell are not necessarily directly usable. So depending on the application, various converters need to be designed, such as buck converters and boost converters, to produce desired voltage levels. It is not always desirable to test these converters on the fuel-cell stack, so a fuel-cell emulator was needed to test various converter topologies.

The fuel-cell emulator serves the purpose of imitating the load characteristics of a fuel-cell stack. The emulator consists of a six-pulse, three-phase buck rectifier, which converts AC current to DC current, and several stages of interleaving buck converters to convert DC-voltage levels to voltages that imitate the fuel-cell characteristics. To control various components of the circuit, a digital signal processor (DSP) is used to implement various control algorithms that are instrumental in emulating the performance of the fuel-cell stack.

Development of a Hardware-In-the Loop Simulator for Unmanned Vehicles

Chao Wang

Department of Electrical and Computer Engineering
Control/Robotics Research Laboratory (CRRL)

Faculty Advisor: *Professor Farshad Khorrami*

The objective of this project is to develop a hardware-in-the-loop (HITL) simulator to test and validate control designs for unmanned vehicles. The hardware-in-the-loop simulator is real-time software mimicking the dynamics of the vehicle as well as providing all the sensory and actuation signals for the vehicle. Depending on the type of vehicle, these signals may be outputs of GPS, inertial measurement unit (IMU), pressure sensors, magnetometers and etc. The hardware-in-the-loop simulator serves as a development platform to validate an actual control code for the vehicle on a computer, i.e., an auto-pilot for an unmanned aerial vehicle will be tested on ground without flying an actual aircraft. The actual control system code is implemented on a custom designed auto-pilot board based on a Texas Instrument TMS470R1B1M digital signal processing processor. The HITL simulator will be implemented on a personal computer and will be interfaced with the auto-pilot board via the available input/out channels (mainly the serial ports) on the auto-pilot board.

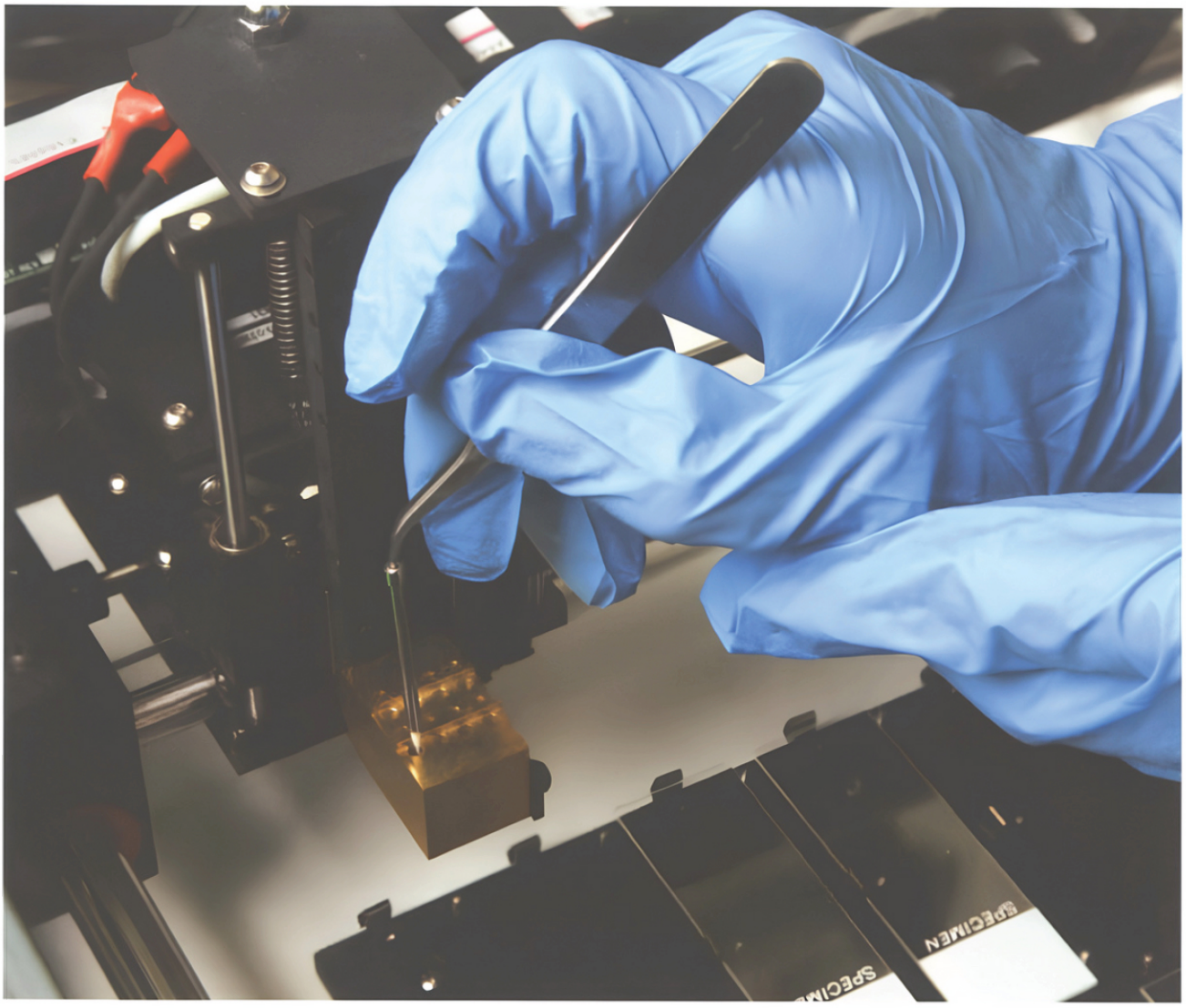
Market Analysis for Secure Hardware Testing Products

Jiawei Wu

Department of Electrical and Computer Engineering

Faculty Advisor: *Professor Ramesh Karri*

JTAG, Automatic Test-pattern Generation, Built-in Self-test and Fault Simulation are fundamental designs for testing (DFT) tools in the EDA industry. After the Microsoft Xbox 360 "Red Ring of Death" incident in 2006, JTAG undoubtedly became the most popular DFT tool for electronics companies. JTAG, which is also called Boundary Scan, is the common name used for the IEEE 1149.1 standard. The tool designed to test chips according to this standard is also called JTAG. Though considered to be an expensive DFT tool, the potential economical harm it will mitigate is beyond price.



However, there is little free market analysis available online to encourage engineers in this field to focus their research on this black horse technology. On the other hand, consulting companies such as Gary Smith EDA charges over $3,000 for one JTAG annual market report which would most likely be found to be too expensive and wordy for engineers. Therefore, collecting information of the JTAG market analysis is important for the JTAG team. The entire project consists of five steps, the first four of which being: study relative company profiles and their financial report for public information, contact university professors whose concentration is on JTAG for private information, browse electronic consulting companies for free analysis and read papers from major journal magazines for creative insight. After these four steps, an information pool is created. Then information was logically selected from the pool to form and independent analysis.

Humanities and Social Sciences

The Trends and Changes in Fashion from 1787-2004

Nicholas Castillo

Department of Humanities and Social Sciences

Faculty Advisor: *Professor Francis David Mulcahy*

This project is centered on the women's evening gown and how it has evolved from 1787-2004 and what factors caused this progression. This is a continuation of a study done in the 1940s by anthropologists Richardson and Kroeber whose mathematical abilities and technology were limited. Thus, this project extends their studies in order to either prove or disprove their conclusions with certainty. Six measurements taken each year that give the best description of the dress in terms of size and appearance are considered: the length of the skirt, width of the skirt, length of the waist, width of the waist, length of the décolletage and the width of the décolletage. The mean and the variance for each of these six measurements have been calculated for each year. The goal is to mathematically describe the relationship between the mean and variance and how they move together and what factors cause them to move. Mathematically modeling the cycles and trends that each measurement undergoes as well as determining the relationship between all measurements are goals of this research. To achieve this goal, standard statistical methods, time series are used and Fourier Series is also utilized to describe periodic trends.

Green Building Design and Human Behavior

Ka Leung Kwan

Department of Humanities and Social Sciences

Faculty Advisor: *Professor Richard Wener*

This project consisted of conducting a Post-occupancy Evaluation survey at Maplewood Police Station, Maplewood, New Jersey, which is a Sliver LEED certified building. First, the building system and green architectural design were analyzed from observation and data. From this data the advantages and inadequacies of the building and human behaviorial changes due to green design will be concluded. Occupants' productivity, attitude and health status in green and conventional buildings were analyzed with various factors. How human behavior effected the operation of the green building will also be investigated so that mistakes and problems will be avoided when planning future green buildings. Green architecture and its advantages will be promoted by this environmental psychology research.

Integrated Digital Media Institute

Betaville

Skye Book

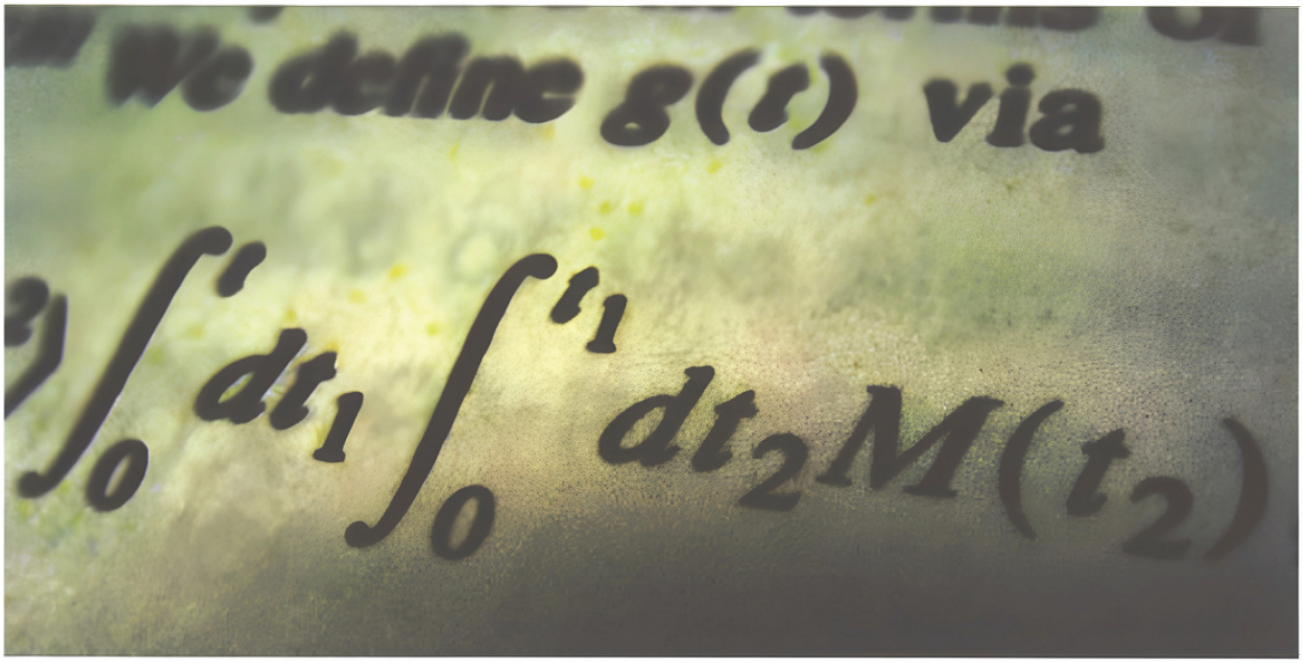
Department of Integrated Digital Media

Faculty Advisor: Professor Carl Skelton

One of the biggest problems facing the computer gaming industry today is market penetration. Myriad factors such as differing operating systems, limited administrative privileges for some end users such as installing software and low-end hardware not only keep games off of computers, but it shields users from any number of possibilities.

We find the rationale for wanting to present "possibility" by making a game that is both socially meaningful as well as engaging to users. Betaville is a real-life representation of your city both as it stands and how a user would change it given the opportunity. Users are able to create and propagate their vision of what an area should have. By allowing a creative voice to the residents and workforce (the "end users") of a locale, they are able to effectively communicate with each other and the decision makers as to what improvements would positively affect their lives.

Keeping with the idea of an open city whose design is the decision of its inhabitants, Betaville is written to be accessible on the highest possible number of computers and thus, to the highest number of users. The open source application is written within the context of jMonkeyEngine, a Java-based, OpenGL game engine which enables deployment to any target system capable of OpenGL and Java. By making smart use of 3-D assets and efficient visual techniques, we are striving to create software that does not require the latest and greatest hardware to run.



Mathematics

Applications of Group Theory to Differential Geometry

Kaloyan Marinov

Department of Mathematics

Faculty Advisor: *Professor Deane Yang*

The abstract concepts that form group theory find a wide range of applications in the field of differential geometry, and especially within the study of Lie groups. Lie groups are mathematical groups with a smooth manifold structure in which group multiplication and taking inverses are smooth operations.

In computer graphics, the Lie group SO(3) is of central importance as it forms the group of all rotations of Euclidean 3-space. However, creating animations of rotations by using SO(3) is not the best way to do so. A more efficient solution is provided by the Lie group SU(2); this group is isomorphic to the group of unit quaternions and gives rise to a 2-1 surjective homomorphism of SO(3). Therefore, examining and utilizing the relations between the group of unit quaternions and SO(3) enables one to efficiently rotate objects in 3-dimensional Euclidean space.

Mechanical and Aerospace Engineering

Mechanical Design of Force-balance Systems for Drag Measurements in Water Channels

Nicholas Cavaliere

Department of Mechanical and Aerospace Engineering

Faculty Advisor: *Professor Maurizio Porfiri*

Drag measurements on submerged bodies are important for both optimization of vehicles' shape design and modeling. In this project, a force-balance system for underwater measurements has been designed and assembled. The system is an integral part of a water channel that is currently used in the Dynamical Systems Laboratory.

Drag acting on a submerged body is determined by measuring the tip displacement of a cantilevered thin hollow supporting tube by alternatively using strain gages and Hall Effect displacement sensors. The design and construction of the balance system for axial drag measurement is focused on precision two-axis motion and optimized dynamical behavior. Testing includes calibration and applications on bio-mimetic robotic fish, ionic polymer metal composites and a scaled model of the DSL ROUV (Remotely Operated Underwater Vehicle).

Dissemination of Federal Emergency Management Association (FEMA) Fire Project

David Lee and Karlen Tam

Department of Mechanical and Aerospace Engineering

Faculty Advisors: *Professor Sunil Kumar and Prabodh Panindre*

The traditional method of videogame creation, for example by the use of the Torque Game Engine, goes through a pipeline process, where 3-D models must be created so that they satisfy certain technical specifications which include the component polygons as well as the file type. Then a game environment must be created, and the physics engine and interface must be coded or imported for the game to be functional. Using this traditional method, it takes no less than a team of 10 people to create a functional game. If even one item is faulty, the whole game will not work.

During this research, a different method of creating a game using the open source Blender Engine has been explored. The task of making a game to teach fire fighters new methods of putting out fires in high-rise buildings

was researched through experiments devised by the mechanical and aerospace engineering department. By the usage of the Blender Game Engine, 3-D models, character rigging and UV textures were created and all features were made interactive. The best feature of the Blender Game Engine is that it allows the user to edit any component at anytime, even while the game is running. This seamless process is permitted by the use of Dropbox, an online server that automatically syncs the files as they are changed by the game developers. In the process of creating realistic fire particles in the game, a bit Python language was learned that worked with Blender's logic bricks to create the game logic.

Characterization of Schooling Behavior in Danios

Jenny Lin

Department of Mechanical and Aerospace Engineering

Faculty Advisor: *Professor Maurizio Porfiri*

This project is part of a large study on the guidance and control of fish schools using a bio-mimetic swimmer. In the Dynamical Systems Laboratory, experiments are conducted on giant danios to understand their collective behavior under different external stimuli in constrained physical environments. Fish are placed in a ring-shaped tank that approximates a one-dimensional environment and light conditions are continuously varied. Videos of schooling behaviors are recorded and the danios are tracked for their Cartesian coordinates using ProAnalyst software. Data are used to uncover the role of visual cues in the schooling behavior of giant danios and understand the effect of light-induced fear on the collected motion. Further, experiments on the interaction between the one-dimensional school and a bio-mimetic swimmer are conducted. The vehicle is mechanically connected to a stepper motor that drags the robotic fish around the tank at different cruise speeds. In addition, the effect of a bio-mimetic propulsor on the live fish response is investigated.

Testing of IPMCs as Flutter-driven Energy Harvesters

Shashank Varma

Department of Mechanical and Aerospace Engineering

Faculty Advisor: *Professor Maurizio Porfiri*

This project explores the feasibility of using ionic polymer metal composites (IPMCs) as flutter-driven energy harvesters in aqueous environments. IPMCs are a class of novel active materials comprising an ionomeric membrane, e.g., Nafion, plated by noble metal electrodes. An experimental test-bed comprising a spontaneously flapping (i.e., fluttering) flag made out of mylar sheets/packing tape and strips of copper have been assembled. A water tunnel has been used to generate a mean flow and the flow speed has been measured by using Laser Doppler Velocimetry (LDV). The IPMC has been mounted on the fluttering flag that serves as a mechanical source of energy. An extensive parametric study has been conducted to determine the optimal parameters for energy harvesting, including flag dimensions, mass, flow field velocity, and clamping system. Additionally, synchronization phenomena between two flags in tandem have been studied.

Physics

Measuring the State of a Spin Ensemble with a Microstrip Resonator

Thomas Fan

Department of Physics

Faculty Advisor: *Professor Vladimir I. Tsifrinovich*

A microstrip resonator is an important tool in quantum information processing. This research suggests a simple classical model for the analysis of the interaction between the microstrip resonator and a spin ensemble. Based on the model, an analytical expression for the resonator frequency shift due to the interaction with the spins was derived. A method for measuring a quantum state of the spin ensemble using the microstrip resonator is suggested.

Light-force Transport of Viral Nano-particles: A Means for Altering Nano-particle Transport in Fluids

Mariya Gelman

Department of Physics
MicroParticle PhotoPhysics Lab (MP^3L)

Faculty Advisor: *Professor Stephen Arnold*

Miniature bio-sensors have the capability to detect single virus particles, such as influenza A, at extremely low concentration. A major hurdle to overcome at micron size scales is that transport of the nano-particles to the sensing area becomes diffusion limited, and detection times become impractically long. However, it has recently been discovered that light-forces can alter the transport of nano-particles in fluid near a microspherical optical sensor. This phenomenon enhances the rate at which miniature sensors can collect bio-particles at ultra-low concentrations ($<10^{-15}$ M).

The details of the interactions between light forces and nano-particles causing the observed enhancement in transport are not yet fully understood. It is believed that when light is circulated through the microsphere detector, the evanescent wave exerts a polarizing potential that attracts particles toward the sphere. My research project includes the deterministic stresses caused by light along with pure diffusion in order to explain the experimental findings. This work is expected to be a forerunner for micro-fluidic structures driven by light in as much as it (1) goes beyond conventional convective transport and diffusion theory and (2) can overcome the boundary-layer limitations posed by these mechanisms.

Surface-enhanced Raman Spectroscopy

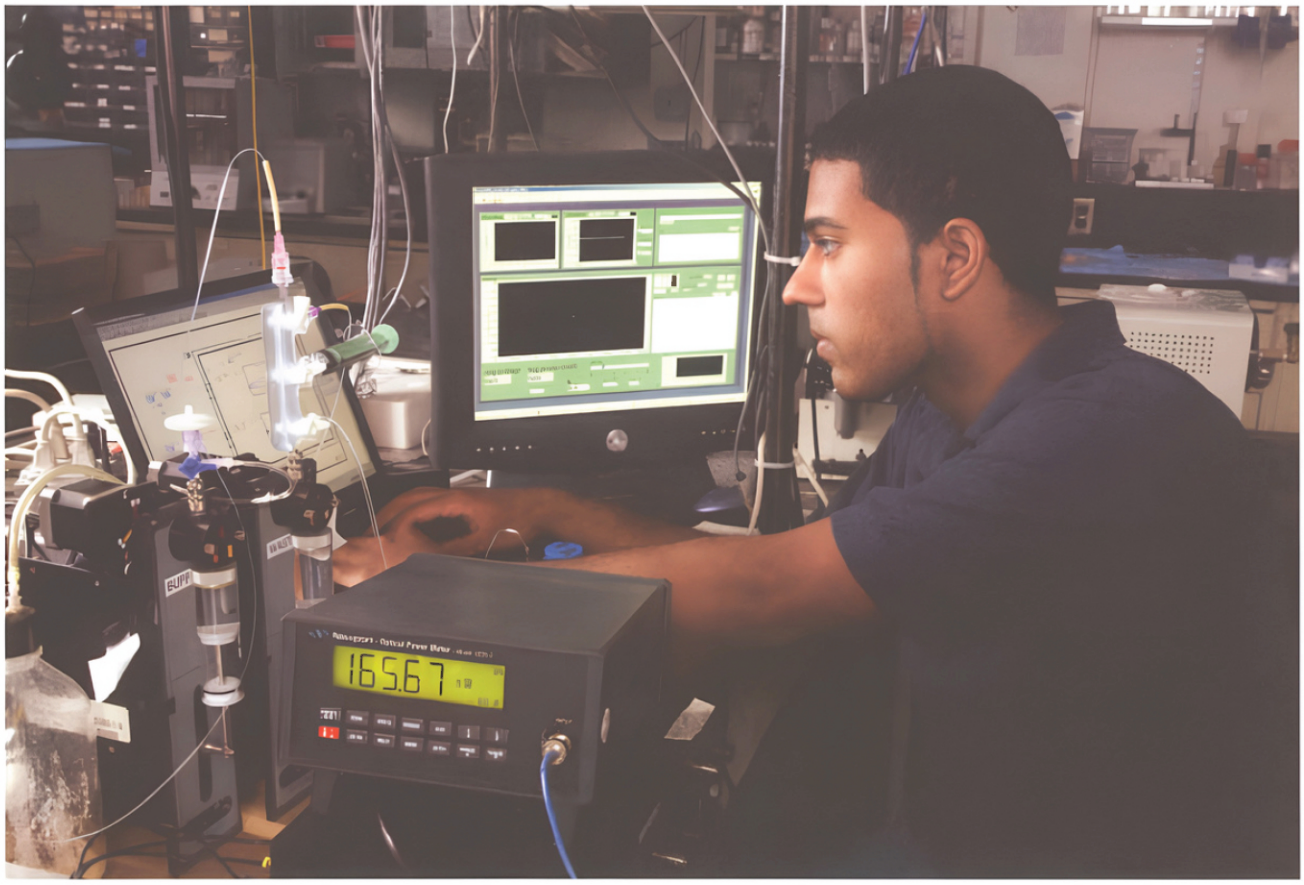
Vladislav Zakharov

Department of Physics

Faculty Advisor: *Professor David Mugglin*

In Raman scattering, a photon excites a molecule to a virtual level, after which the molecule relaxes to a vibrational level in the electronic ground state other than the initial vibrational level. For this reason, Raman spectroscopy is a tool for analyzing the vibrational structure of molecules and for detecting trace amounts of certain molecules. Since the probability for Raman scattering is typically many orders of magnitude less than that for Rayleigh or fluorescence scattering, Raman signals tend to be comparatively very weak. Surface-enhancement Raman Spectroscopy (SERS) occurs when surface plasmons in metal nanoparticles enhance the local electric field, thus increasing the Raman scattering cross section by many orders of magnitude.

This research observed SERS signals using the laser dye Rhodamine 6G (R6G) mixed in a silver colloid and NaCl solution. The research has indicated that when the silver colloid solution is mixed with the NaCl solution before the Rhodamine is added, the observed Raman signal intensity is much weaker. The order in sample preparation seems to have a significant effect. Our next step is to study Raman shifts associated with amino acids toward the goal for the detection of certain biological molecules.



The 2009 Undergraduate Summer Research Program Seminar Series

6/24/2009 **Stephen Arnold,** *Institute Professor, Thomas Potts Professor of Physics*
Department of Physics, Polytechnic Institute of NYU
"Inventing the World's Most Sensitive Biosensor"

7/1/2009 **Charles Camarda,** *'74 AE, NASA Astronaut and Distinguished Engineer in Residence*
Polytechnic Institute of NYU
"Failure Is Not Option...It's a Necessity!—Creativity, Innovation and Engineering"

7/8/2009 **Keith Ross,** *Department Head and Leonard J. Shustek Distinguished Professor of Computer Science*
Department of Computer Science and Engineering, Polytechnic Institute of NYU
"Unraveling the BitTorrent Ecosystem"

7/15/2009 **Kurt Becker,** *Associate Provost, Research and Technology Initiatives and Professor,* Department of Physics, Polytechnic Institute of NYU
"The Science and Technology of Microplasmas"

7/29/2009 **Erich Kunhardt,** *Institute Professor*
Department of Physics, Polytechnic Institute of NYU
"Science/Technology: Education and Entrepreneurship"

8/5/2009 **Nasir Memon,** *Professor*
Department of Computer Science and Engineering, Polytechnic Institute of NYU
"File Carving"

8/12/2009 **Maurizio Porfiri,** *Assistant Professor*
Department of Mechanical and Aerospace Engineering, Polytechnic Institute of NYU
"Smart Materials and Structures for Underwater Applications"

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