2016 Summer Undergraduate and Graduate Research Colloquium

Abstracts

Thursday, August 11, 2016
9:30 – 11:30 am

Corwin Pavillion

University of California, Santa Barbara

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AIM Photonics Research Apprenticeship Program (AIM Photonics)

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The AIM Photonics Research Apprenticeship Program for Community College and UCSB Undergraduates is a summer research program designed to provide the technical and professional training required for university undergraduates to transition into careers within the photonics industry. Training and professional development activities are hosted by the West Coast Headquarters of AIM Photonics at the UC Santa Barbara campus. Science and engineering undergraduates will work alongside graduate student and postdoctoral researchers to gain first-hand experience in scientific investigation in a dynamic, collaborative research environment. The Apprenticeship Program is hosted by the UCSB Center for Science and Engineering Partnerships (CSEP) at the California NanoSystems Institute (CNSI).

Digital Control Electronics For Optical Gyroscopes
Marco Cerrato, Physics, University of California Santa Barbara
Sarat Gundavarapu, Daniel Blumenthal, Electrical and Computer Engineering

High-end rotational sensor technologies, such as optical gyroscopes- used in aircraft navigation, are bulky and expensive devices and be improved. The Integrated Waveguide Optical Gyroscope (iWOG) project focuses on miniaturizing the current optical gyroscope models to smaller chip versions which are as functional as their current counterparts, while smaller in volume and more economical to produce. To understand and evaluate the device performance, we have assembled a fiber optic gyroscope test setup that uses discrete optical and analog electronic components. Our current focus is on the use of on-board digital control electronics for the iWOG chip to improve compactness and reduce the cost, while retaining the performance. We aim to use this external hardware to apply signals of varying frequencies to the iWOG circuit and search for the proper frequency of the system, the frequency at which the sensitivity of the optical gyroscope is maximized. To do so, I am using a Field Programmable Gate Array (FPGA) device to synthesize signals of varying frequencies and duty cycles. The final goal is to program the FPGA to generate a signal that has a dynamically controlled frequency which can be divided and multiplied by using button inputs, without the need of any system restarts. Successfully establishing digital control electronics brings us closer to realizing the iWOG project. When complete, the iWOG project will yield a new model of sensitive rotational sensors for inertial navigation systems and also has potential use in industries such as autonomous and remotely controlled vehicles.

Synthesizing Agarose Microparticle Cell Mimics to Characterize µHammer Device
Bofeng Chen, Nuclear Engineering, Chaffey College
Luke Patterson, Megan T. Valentine, Mechanical Engineering

The µHammer device is designed to model traumatic brain injuries by applying dynamic forces on a single cell. To properly characterize this device, microparticles with known physical properties that mimic the stiffness (Young's modulus on the order of 1-10 kPa) and size (~10-15 µm) of neural stem cells need to be developed. To do this, microparticles were synthesized by utilizing shear forces generated by a vortex flow in oil to create microdroplets of agarose solution in suspension. To control the mechanical properties of the particles, agarose gels of varying weight/volume concentrations were created. To control the size of the particles, parameters such as duration of vortexing and sonication as well as various filtering processes were explored. Surfactant and fluorescent micro beads (0.2 µm) were also used to help prevent aggregation and prolong the lifespan of the particles. In conclusion,

agarose microparticles within the desired size range (~3-30 μm) were successfully synthesized with weight/volume concentrations ranging from 1-10% whose mechanical properties will be confirmed in future experiments.

Detection of Substances of Forensic Significance Using Microfluidics and SERS
Valentina Hallefors, Physics, University of California Santa Barbara
Rustin Mirsafavi, Carl Meinhart, Mechanical Engineering

Papaverine and noscapine are two opium alkaloids commonly used to track the source of heroin by law enforcement agents. While papaverine is vital in locating the source of pre-manufactured heroin, noscapine is useful in identifying the origin of seized drugs as it is found in street heroin. We utilize surface-enhanced Raman spectroscopy (SERS) on a microfluidics platform to detect these substances at 100 μM. The process requires minimal off-chip preparation and small sample volume. The microfluidic device exhibits laminar flow allowing for a gradual, diffusion-driven interaction between silver nanoparticles, salt, and analyte. These interaction conditions result in SERS aggregates, leading to an increased sensitivity of the assay.

Characterization of Quantum Cascade Lasers on Silicon
Daniel Leon-Gijon, Electrical Engineering, Cal Poly San Luis Obispo
Alexander Spott and Robert Zhang, John Bowers, Electrical and Computer Engineering

Mid-infrared (MIR) silicon photonic integration has the potential to enable inexpensive, compact devices for sensing and detecting applications on silicon chips. Silicon waveguides can be constructed with low optical losses at MIR wavelengths and MIR lasers can be used to build high-resolution gas spectroscopic sensors and nonintrusive biochemical diagnostic systems. Quantum Cascade Lasers (QCL) were recently heterogeneously integrated on silicon. These lasers were fabricated by bonding III-V gain material on top of silicon waveguides. The active region consists of a III-V mesa above a silicon waveguide, and III-V tapers are designed to couple light from the hybrid silicon-QCL active region into a passive silicon waveguide. The silicon waveguide and III-V mesa widths vary from laser to laser and in order to design an improved next generation of lasers, it is important to understand how these geometry parameters affect laser performance. We want to characterize the threshold current and differential efficiency of lasers of a variety of different active region geometries. Because the III-V taper performance varies unpredictably between lasers, these characterizations were performed on devices which have had the taper removed. By obtaining this data, we hope to form a theoretical model which accurately predicts the heterogeneously integrated laser performance.

Photonic Integrated Transmitter for Free Space Laser Communications
Jonathan Madajian, Electrical Engineering, University of California Santa Barbara
Victoria Rosborough, Jonathan Klamkin, Electrical Engineering

Fiber optic links have revolutionized terrestrial telecommunications, allowing instantaneous connection across the globe. Free space optical wavelength transmission can provide similar improvement in satellite-to-earth links. A free space laser transmitter has the potential to improve satellite data transmission rates by one-to-two orders of magnitude over state of the art radio frequency transmitters. Recent technology has showcased transmission of high definition video from the Moon to Earth during the Lunar Laser Communications Demonstration (LLCD) at a record downlink data rate of 622 Mbps. The LLCD transmitter was assembled from individually packaged, or bulk, optical components connected by optical fibers. When launching a space mission, the cost, size, weight, and power (CSWaP) of the on-board modules must be conserved. To reduce the CSWaP of free space laser transmitters for future missions, we propose to employ a photonic integrated transmitter. , Photonic integration provides drastic improvements in CSWaP by including the optical components on a semiconductor chip. This work encompasses the setup of a field programmable gate array (FPGA) for producing a pulse position modulation (PPM) electrical signal for controlling the photonic integrated circuit (PIC). The PPM format stores multiple bits of information in the temporal location of the laser pulses, thereby conserving power. To test the performance of the PIC, the goal of this work was to generate electrical PPM signals with varying frequency and duty cycle from the FPGA.

Thermo-Electric Control Board for Integrated Optical Beam Forming Network
James McKenna, Electrical Engineering, University of California Santa Barbara
Yuan Liu, Jonathan Klamkin, Electrical and Computer Engineering

As consumption of mobile data increases exponentially, there is a dire need for a wireless communication revolution. Using millimeter wave is a promising solution due to its higher frequency and therefore has a much higher bit rate as well as a more directional beam than that of current microwave frequencies. This highly directional beam is helpful to increase the gain of antenna and security of communications, however, this requires more precise techniques to transmit the beam in the proper direction. Photonic Integrated Circuit technology based Optical Beamforming Network(OBFN) is used to perform this task for its low loss, compact size, large bandwidth, etc. Optical Ring Resonators(ORRs) are used as the delay component with thermal tuning. To precisely control the temperature of the ORRs, a programmable control board with high resolution was built which contains 64 independent current sources to control the temperature of each resonator. The design of the board is an optimized op-amp feedback circuit built to fulfill the requirements of the heater. Microcontrollers and high resolution digital-analogy converters(DACs) are used to enable the high resolution programmable control. This device will allow us to more precisely tune the delays of the OBFN. Once the OBFN is complete, we will be one step closer to implementing millimeter wave technology in the real world and revolutionizing wireless communication.

Multimode Interference Waveguides
Jesus Perez, Mechanical Engineering, Santa Barbara City College
Akhilesh Khope, John Bowers, Electrical Engineering

Multimode interference (MMI) waveguides- based photonic couplers integrated on silicon- on- insulator (SOI) substrates are designed, simulated, and optimized. Using principles of guided mode wave propagation with a given input field of 1.55 micrometers, a desired splitting ratio of 50:50 for a 1x2 MMI waveguide was optimal for future application. For specific applications, other spitting ratios can also be achieved through general interference in a 2x2 MMI waveguide, such as 15:85 splitting ratio. Low order multimode interference devices are now being integrated onto photonic integrated circuits and with their polarization- independent coupling, these components are desirable for silicon- on- insulator (SOI) ring resonators used for photonic filtering. Design parameters are dependent on materials implemented, such that the center core has a high refractive index, surrounded by a lower refractive index. In this 1x2 design we cover silicon and silicon dioxide respectively. Data suggests that there is potential for size reduction in these devices as well as high bandwidth and low inherent losses. Other devices such as directional couplers, require submicron gaps with lower tolerances to deviations in dimensions which become apparent in the fabrication process. Data suggests that multimode interference based couplers have a higher tolerance to subtle changes, effectively improving the efficiency of their application in photonic circuits.

Using Surface-Enhanced Raman Spectroscopy to Detect Biologically-Relevant Small Molecules
Moisses Rodriguez Hernandez, Biochemistry, Allan Hancock College
Katherine Kanipe, Martin Moskovits, Chemistry and Biochemistry

We are detecting ketones found in diabetes using surface-enhanced Raman spectroscopy (SERS), to develop a model platform for medical diagnostics. Diabetic patients check their blood various times a day to monitor sugar levels by pricking their finger. Using the spectra collected from ketones such as cyclopentanone, acetyl acetone and acetoin from breath-like samples we can develop a model "breathalyzer" system that can detect diabetic ketoacidosis non-invasively, taking advantage of the specificity and sensitivity of SERS while also increasing the level of patient comfort. SERS is a vibrational spectroscopy technique that has been well studied, for the collection of molecular information in many applications. The analysis of these diabetes-related ketones *via* SERS has field-ability and can be readily translated to handheld devices. The substrates used in this experiment are of an in-house design nanoscale silver coated gratings that aid in enhancing the signal uniformly over large areas during spectrum collection. The spectra of the three ketones were collected individually, followed by detection within of more complex solutions. When the substrate spectra were compared to pure liquid spectra, there are some similarities though notable peak shifts may indicate interaction with the silver surfaces or conformational changes. Moving forward the goal of this project is to better mimic breath samples by decreasing the concentrations of the ketones and by turning to gas phase analysis.

Mach-Zehnder Interferometer Design for Optical Isolation
Micaela Saunders, Physics, Ventura College
Paolo Pintus, John E. Bowers, Electrical and Computer Engineering

Photonics studies the properties and applications of light. One of the many goals have been making telecommunication faster and sending large amounts of data over long distances. Integrating these functionalities on a single chip can significantly boost the amount of data that are elaborated in clusters, servers, and data centers. Indeed, the advantages of using integrated photonic devices are offering the ability to run on large bandwidths, high-speed connections, low power use, and low cost. To accomplish this, photonic devices must be optimized so that photonic components can work with electrical and micro-electronic components. Our focus has been on optical isolators which allow propagation of light in only one direction. This device is useful to reduce the reflections caused by any number of factors, including roughness of waveguide walls and other optical components, that can re-enter and destroy the laser. To perform this function, a Mach-Zehnder interferometers is designed using nonreciprocal materials (magneto-optic material). The interferometer is used to cause constructive interference for propagating waves and destructive interference for backward propagating wave. To find the necessary dimensions of the isolator, we mathematically model the device and translated this into code using Matlab. We found multiple solutions showing that there are many possible ways to fabricate the device. The most robust design to counteract fabrication error have been chosen to guarantee the performance.

Optical Switches using Microring Resonators
Franklin Tang, Computer Engineering, University of California Santa Barbara
Akhilesh Khope, John Bowers, Electrical and Computer Engineering

Silicon microring resonators are a key component in today's development in data stream switches. These rings operate using optical coupling to redirect light and resonance to act as a filter for specific frequencies of light. With these properties, manipulating the refractive index of the rings by applying heat or current will change the frequency at which they resonate. Data is often made up of a range of mid-infrared frequencies superimposed onto a single waveguide thus ring resonators can filter and direct specific frequencies out desired ports. One of the main applications of such a device is in optical crossbar switches, a grid of straight waveguides with microring resonators in the corners. As light enters a waveguide port, the rings will resonate and guide light around the grid. However, data can often get corrupted and there can be bit errors from the photonic circuit. In simulated optical crossbar switch configurations, bit error rates (BER) of 2.29×10^{-21} have been observed with a Q factor of 16.34. Data shows that increasing the free spectral range will raise the BER.

Preparing Templated Silicon Surfaces for III-V Epitaxy
Didiel Vazquez-Morales, Chemical Engineering, Oxnard and Ventura College.
Daniel Pennachio, Christopher Palmstrom, Materials

The invention of optical fiber caused most long-distance data communication to shift from electrical to optical signals. Optical fibers have better bandwidth, efficiency, and reliability, as well as lower cost than electrical wires. Bringing optical communications to on-chip dimensions will increase device efficiency by reducing heat produced by electrical interconnects. While silicon is ideal for electronics, it is less efficient at producing light than III-V compound semiconductors. Making III-V light emitters next to electrical components on a silicon substrate will increase efficiency of photonic communication.
Silicon and III-V materials have different crystal structures, making it difficult to grow defect-free III-V material on silicon surfaces. Eliminating substrate surface contamination will drastically help increase the quality of grown material. Our experiment explores silicon cleaning methods for the best III-V growth. Substrates were cleaned with different procedures involving solvents, acids, and deionized (DI) water. The substrates were then introduced to ultra-high vacuum (UHV) to avoid contamination from the air during annealing and growth. Annealing in vacuum at 1200°C reduced carbon contamination and surface oxides. X-ray photoemission spectroscopy (XPS) was used to analyze the composition of the surface. XPS analysis after the anneal demonstrated that the presence of carbon and oxygen were reduced almost entirely for samples cleaned only with solvents and DI water. Carbon contamination remained in substrates cleaned with hydrofluoric acid. Atomic force microscope images revealed surface roughening

after the anneal. Preliminary tests of lower annealing temperatures have been conducted, but more work is needed to reduce surface roughness.

Simulating a Mach-Zehnder Silicon Photonic Switch

Aditya Wadaskar, Electrical Engineering, University of California Santa Barbara
Takako Hirokawa, Clint Schow, Electrical and Computer Engineering

As global Internet traffic increases rapidly, data centers continue to grow in size and complexity, making it more difficult to manage the associated physical and virtual resources. A photonic switch can be used to alleviate this complexity, because it reroutes information at different optical frequencies. A silicon photonic Mach-Zehnder switch designed at 1.31 μm was recently sent out for fabrication; however, its bandwidth and loss were not previously determined, and as a result, the range of frequencies that can be rerouted is unknown. First, checks were conducted using Lumerical FDTD to ensure performance at the design wavelength. It was determined that while optical inputs at 1.31 μm pass through waveguide bends with radii of 5 μm, at 1.55 μm they are highly lossy, suggesting that bend radius must be increased for better transmission of higher optical frequencies. Next, the effective refractive index, group index, loss, and dispersion of the directional couplers, interferometric regions, and bends were calculated using Lumerical MODE. Using the parameters found in MODE, a model of the switch was assembled in Lumerical INTERCONNECT to generate an eye diagram and the bit error rate (BER). The bandwidth of the switch is defined to be the range of frequencies about 1.31 μm for which the BER is less than 10^{-9}, and is to be determined.

The California Alliance for Minority Participation (CAMP)

www.mrl.ucsb.edu/CAMP

The Summer Research Program provides an 10-week intensive research experience for CAMP eligible students interested in a career in science, engineering, technology, or mathematics. CAMP participants work in a UCSB laboratory with a graduate student or postdoctoral researcher mentor. Mentors provide one-on-one training and support for the research project. In addition to research, the interns also participate in weekly group meetings to develop oral presentation skills, attend special seminars and present their results at an end-of-summer poster session. Students also present their research at the statewide CAMP symposium the year after completing their internship.

Electrochemical Production of Multi-Junction Nanorod Solar Cells
Rachel Alvelais, Chemistry, University of California Santa Barbara
Will Elliott, Martin Moskovits, Chemistry and Biochemistry

Multi-junction photovoltaic cells made of cadmium chalcogenides can obtain higher efficiencies than most silicon-based technologies, but their production is painstaking and costly. A cost-efficient method of creating such devices could make multi-junction solar cells viable source of commercial solar energy. With electrochemistry, we can produce nanorod photovoltaic devices with large usable surface areas. As a proof of concept, we have produced a solar cell by depositing cadmium telluride, followed by gold, onto silver nanowires fabricated in porous alumina. This work details the construction of such a device and the characterization that must be done to prove a device's merit.

Optimization of DNA Nunchuck Seed Design for Accurate Measurement of DNA Bend Angle
Sebastian Arias, Physics, University of California Santa Barbara
Lourdes Velazquez, Deborah K Fygenson, Physics

DNA has been studied extensively because its base pair sequence stores information that guides living systems. However, there is more to DNA function than its sequence. There is increasing evidence that DNA bending plays a crucial role in enzymatic processes as well as information storage and retrieval. In particular, DNA bending dynamics and its effects on gene regulation remain to be fully understood. This is due, in part, to the absence of a reliable method of measuring DNA bend angle and bend angle dynamics. We have shown that DNA structures resembling nunchucks can be formed via tile-based DNA nanotubes whose nucleation is controlled by DNA origami seeds. We aim to use these DNA nunchucks as mechanical amplifiers with which to visualize DNA bend angle and bending dynamics. To test this approach, we have made nunchucks with intrinsically straight and intrinsically bent linkers, and measured their bend angles over time via fluorescence video microscopy. However, the observed angles do not correlate with linker type. We hypothesize that the discrepancy is due to an unintended feature of the nunchuck design, which places a >4kb loop of single-stranded DNA protruding in the middle of each nucleating seed. We are using the asymmetric polymerase chain reaction (aPCR) to produce smaller DNA origami seeds void of any such loop. Here we compare DNA nanotube yields in order to describe the efficiency of aPCR at producing desired DNA sequences without affecting DNA seed formation and or function.

A Level-Set Approach to Solving Poisson Equations in Irregular Domains with Robin Boundary Conditions
Victoria Arias, Applied Mathematics, University of California Merced
Daniil Bochkov, Frederic Gibou, Mechanical Engineering

Several diffusion-dominated problems in science and engineering require the solution of Poisson-type equations in irregular domains. These types of problems include free-boundary (Stefan-type) problems that describe interesting physical phenomena such as the crystallization and solidification of different materials, where the evolution of the interface is not known a priori, and usually depends on the gradients of the solution. Therefore, it is important to develop numerical methods for solving Poisson-type equations that produce not only accurate solutions, but also accurate gradients of the solutions. In this work, we present a numerical approach for solving the Poisson equation in irregular domains with Robin boundary conditions. We employ the level-set method to represent irregular domains, and discretize the Poisson equation using a combination of a classical, second-order discretization for the internal nodes and first-order finite-volume discretization for the interfacial nodes. We demonstrate in several examples that our method is second-order-accurate in both the solution and the gradients of the solution.

Molecular Regulation of δ-catenin Protein Production in Neural Networks
Karla Bernardo, Pharmacology, University of California Santa Barbara
Elmer Guzman, Kenneth Kosik. Molecular, Cellular, and Developmental Biology

δ-catenin plays an integral role in neural communication and has been shown to affect cognitive function when mutated or insufficiently expressed. Inadequate amounts of δ-catenin present between synapses during neurodevelopment has been linked to Cri-du-Chat syndrome, Alzheimer's disease, and specific forms of autism. To further elucidate the processes by which δ-catenin expression is inhibited, our research genetically manipulates segments of the δ-catenin mRNA – more specifically, the 5' untranslated region (5'UTR), coding sequence (CDS), and 3' untranslated region (3'UTR) – to examine how molecular structure may regulate protein production. Each segment is incorporated in plasmids alongside a fluorescent reporter that allows us to visualize produced protein upon introducing the DNA in mouse primary cells. By photobleaching the primary cells prior to temporal analysis, we are able to detect the amount of new protein produced through fluorescence microscopy. We expect that, in cell cultures containing the 5'UTR mutation, non-specific ribosomal proteins may bind to the hairpin structure of the sequence, causing lessened δ-catenin expression over time. Interactions with microRNAs present in the cytoplasm by the 3'UTR may degrade expression at a greater extent than the 5'UTR. Thoroughly understanding these effects on δ-catenin production will ultimately aid in the development of neurological pharmaceuticals at a molecular level.

Towards a Quantitative Understanding of How Artificial Materials Affect Biomolecules
Amanda Caceres, Chemistry, University of California Santa Barbara
Martin Kurnik, Kevin Plaxco. Chemistry and Biochemistry

Proteins tend to misfold and adhere to artificial surfaces, limiting our ability to employ proteins and their many functions in technologies. Understanding the physics behind such surface-induced protein misfolding would enable design of improved biocompatible surfaces on which proteins retain their structure and function. Such materials could be used to design new protein-based biosensors for detection of a variety of biomarkers. Thus motivated, I aim to experimentally determine the origins of surface-induced protein adsorption and misfolding using a new, quantitative, technique to measure the thermodynamic stability of surface-tethered proteins. To this end, I have designed, produced, and purified proteins that can be site-specifically attached to surfaces, and characterized their thermodynamic stability in bulk solution. Comparison of the stability of the protein in solution to that of the surface-tethered protein will inform on the effect surfaces have on protein structure and function. Ultimately, I expect my work to lead to the first high-precision measurements of how artificial surfaces affect protein function and stability. These results can then be used to build new, quantitative theoretical models of protein-surface interactions, models that ultimately can be used to guide rational design of new artificial surfaces that are optimally compatible with protein structure and function.

Studying the behavior of SiPMs
Berenice Garcia, Physics, University of California Berkeley
Ryan Heller, David Stuart, Physics

To further study the fundamental particles of nature we need to develop new instrumentation. A new technology that can help achieve that goal is the use of Silicon Photomultipliers (SiPMs) to detect photons produced in scintillating fibers. Two instruments that will help achieve this goal is by using: Scintillating Fibers and Silicon Photomultipliers (SiPM). There are two aspects of SiPM performance that have been studied in this work. The signal output from the SiPM increases with higher bias voltage, but so does the noise. We have measured this increase to allow optimization of the bias voltage setting. The second study performed is development of software using GEANT4 to simulate the response of the detector (fiber+SiPM) to incoming particles. With this simulation we compare the simulated response with the response measured in the detector to make sure that we have everything functioning well.

Incorporating Nitrogen Functionality Into Small Molecules by Utilizing a Radical Trap Cyclization Process
Luis Limon, Chemistry, University of California Santa Barbara
Jamie Shaum, Javier Read de Alaniz, Chemistry and Biochemistry

Although many efforts have come forth towards the construction of sterically hindered anilines, methodologies for their synthesis have left room for refinement. Their utilization in medicinal chemistry has led to syntheses that employ highly reactive organometallic reagents to form these molecules. While the construction of these compounds often requires reactions such as Buchwald-Hartwig Coupling or reductive amination, we are instead employing a radical trap cyclization process that makes use of readily available starting materials. We are using a cheap and mildly reactive copper catalyst to incorporate nitrogen functionality into small molecules. We hope to develop new routes to the synthesis of pharmaceutical drugs that are cheaper and more versatile than the ones currently employed. The same reaction conditions have been utilized to construct several macrocycles that are often difficult to synthesize. Future work will focus on optimizing these conditions in hopes of applying this process to fabricate albuterol derivatives, a common commercially used bronchodilator used in inhalers.

Does a romantic partner's compassionate love predict the other partner's sense of feeling supported? Effects of compassionate love on empathy, responsive behavior, and perceived partner responsiveness
Michelle Marin, Biopsychology, University of California Santa Barbara
Lauren Winczewski, Nancy Collins, Psychological and Brain Sciences

Recent research suggests that empathic concern, or feelings of compassion and sensitivity towards others, motivates people to be responsive towards their partner. In the current study, we argue that partners who feel empathic concern in specific interactions are those who generally feel compassionate love towards their partner. We proposed a process model wherein *support-providers* high in compassionate love would feel greater empathic concern, which would facilitate an increase in responsive behavior. We further predicted that this responsive behavior would be associated with *support-recipients'* perceived partner responsiveness (i.e., beliefs that their partner understands, cares for, and accepts the self). To examine this interpersonal process, we recruited couples ($N = 91$) to discuss the support-recipients' personal or relationship stressor. Before the laboratory discussion, we measured support-providers' compassionate love. After the discussion, we assessed support-providers' empathic concern, responsive behavior, and the support-recipients' perceptions of their partner's responsiveness. Objective observers rated the degree of support-providers' responsive behavior. In line with predictions, we found support for the proposed process model: There was a positive association between support providers' compassionate love and empathic concern, which predicted more responsive behavior and support-seekers' perceived partner responsiveness. Findings indicate that people high in compassionate love not only felt more concern and expressed more responsive behavior, but their partners were also able to detect their partner's concern and ultimately felt more understood, validated, and cared for. The findings suggest a need for future experimental studies that would illuminate causal effects of compassionate love on benevolent responding and perceptions of responsiveness.

Assessing the Effects of Nearshore Brushfires on Heavy Metal Concentrations in Mussels near Pitas Point, California

Jacobo Pereira-Pacheco, Environmental Science, University of California Santa Barbara
Cruz Ortiz Jr., Arturo A. Keller, Bren School of Environmental Science and Management

Filter feeding mussels serve as bioindicators of intertidal coastal ecosystems, in particular for heavy metals that can be toxic to wildlife and humans. This study investigated the concentration of heavy metals (Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Se, Zn) in ocean water, beach sediment, and mussels (*Mytilus californianus*) near Pitas Point, California. The samples were procured before, during, and after the 2015-2016 rain season (October-July); during which time a nearshore brushfire broke out near the sampling site. Metal concentration in samples were determined with an Agilent inductively coupled plasma mass spectrometer (ICP-MS) 7900 series using EPA Methods 3052 and 3051A. Baseline (October) mean concentrations in mussels (dry weight) were 282±39 ppm, 1.46±0.2 ppm, 361±46 ppm, and 1.5±0.15 ppm for aluminum (Al), chromium (Cr), iron (Fe), and nickel (Ni), respectively. Mussels collected in January showed a percent increase of 130, 124, 143, and 120 for Al, Cr, Fe, and Ni, respectively. Overall, the data suggests that pyrogenic remobilization of trace elements can significantly alter water quality in intertidal coastal ecosystems with nearshore brush prairies. A cycle that can be exacerbated by drought conditions resulting from climate change in California.

The Role of Membrane Hydration in PEGylated Cationic Lipid Vectors for Targeted Gene Delivery

Andrea Ramirez, Pharmacology, University of California Santa Barbara
Emily Wonder, Cyrus Safinya, Materials

Gene therapy aims to provide an alternative method for treating a wide range of diseases by correcting, replacing, or silencing defective genes. Synthetic lipid vectors composed of cationic lipids that self-assemble with DNA form safe, efficient, and versatile gene delivery vehicles. Attachment of polyethylene glycol (PEG) chains to the outer lipid headgroups provides particles with steric stabilization and "stealth" but also inhibits cell-nanoparticle interactions. Attaching peptides to the distal ends of the PEG chains recovers interactions by facilitating binding to cell receptors for targeted delivery. Because the hydration repulsion layer on the surface of lipid membranes creates a hurdle for transfection efficiency, understanding the importance of neutral phospholipids and their role in hydration of targeted nanoparticles is key to optimization. However, because PEGylation inhibits membrane interactions with nanoparticles, we expect the effect of hydration to be reduced relative to non-PEGylated particles. In this study, we reduced the hydration repulsion layer by substituting in neutral lipids with smaller headgroups (e.g. phosphatidylethanolamine vs. phosphatidylcholine). Flow cytometry, fluorescence microscopy, and biological assays were used to measure cellular uptake and binding, endosomal escape, and transfection efficiency of different nanoparticle formulations. Preliminary results show the substitution of phosphatidylethanolamine does create a small effect in binding, uptake, and transfection efficiency, providing more information about their ability to fuse with the cell membrane and deliver genetic material.

Modular Synthesis of Conjugated Polymers to Systematically Probe Self-Assembly

Isaac Robledo, Chemical Engineering, University of California Santa Barbara
Brenden McDearmon, Craig Hawker, Materials

Conjugated polymers have proven to have remarkable and useful electrical properties, such as conductivity, which has stimulated a rapid growth in interest in these materials for semiconductor applications in both academia and industry. Their overlapping p-orbitals create a system of delocalized electrons that allows for conductivity. Organic semiconductors also present a unique set of characteristics such as flexibility, processability, low production cost, and versatility in synthesis that promise the advent of fully flexible semiconductor devices such as photovoltaic cells and large-area displays. Their electronic performance is linked to how efficiently charge carriers (electrons and/or holes) are able to move across the pi-conjugated network. Fundamental to charge mobility is the morphology of the material. The focus of our research is to study how side-chain architecture affects morphology. Using organic chemistry techniques we synthesized various benzodithiophene (BDT) based monomers with different side-chain architectures. These BDT based monomers are then co-polymerized with different co-monomers to generate a library of distinct donor-acceptor conjugated polymers. The effects of side chain architecture on the resulting

thermal, optical, and morphological properties will then be studied through differential scanning calorimetry (DSC), ultraviolet-visible spectroscopy (UV-Vis).

Temperature Controlled Electrodeposition for Low Platinum Loading on Proton Exchange Membrane Fuel Cells

Charlene Salamat, Chemistry, University of California Santa Barbara
Cynthia Cooper, Steven K. Buratto, Chemistry and Biochemistry

Proton exchange membrane fuel cells (PEMFC) are a promising power conversion technology with low emissions and power outputs that rival that of the internal combustion engines. One of the prevailing problems of PEMFCs is the high cost due to the platinum catalyst needed at both the anode and the cathode. Since most of the losses in performance happen during the oxygen reduction reaction at the cathode, a larger amount of Pt is needed here. Our approach utilizes pulse potential deposition (PPD) of Pt onto carbon electrodes to create platinum nanoparticles containing high surface area to lower the Pt loading. Using PPD, we also alloy Pt with non-precious metals such as cobalt to create Pt-Co nanoparticles, further reducing the loading while still improving the fuel cell performance. An increase in fuel cell performance has been reported using a seeding method accompanied by an increased temperature of a colloidal deposition solution. We are interested in studying how the temperature during electrodeposition influences the size, shape, and distribution of the nanoparticles and how these properties may affect catalytic activity at the cathode and overall fuel cell performance. Preliminary results indicate that raising the temperature of the deposition solution increases the performance of the electrode so much that it outperforms a commercial electrode with predictably less catalyst.

Unraveling the Mechanism of Transition Metal Sulfide Conversion Electrodes with Local Structure Methods

Catrina E. Wilson, Chemistry, University of California Santa Barbara
Vicky V.T. Doan-Nguyen, Joshua D. Bocarsly, Ram Seshadri. Materials

Energy storage for portable applications requires low cost batteries capable of high gravimetric capacity and reliable cyclability. Conversion electrodes operate by a different mechanism than intercalation electrodes, giving rise to theoretical capacities several times larger than current available technology. Titanium trisulfide (TiS_3) is a promising cathode material for conversion batteries due to its high theoretical capacity (186 mA.h g^{-1} per Li) and low materials cost. Electrochemical performance of TiS_3 batteries will be discussed in the context of a local structure investigation during galvanostatic cycling. The local atomic structure of the active material is probed with *in-situ* pair distribution function (PDFs) technique from total x-ray scattering. This type of analysis provides valuable quantitative insight into the local chemical environment of titanium and sulfur. A comparison of the as-prepared cathode before cycling, and during subsequent cycles of discharge and charge, shows formation of intermediate chemical moieties that correlate with the electrochemical performance of the battery and capacity fade. The evolution of local structure of TiS_3 with cycling may be tied with other transition metal sulfides to inform what chemistries are most promising for better conversion materials. Such fundamental understanding is essential for improving conversion battery technology and pursuing it as a viable alternative to the intercalation mechanism for next generation materials for energy storage.

Cooperative International Science and Engineering Internships (CISEI)

http://www.mrl.ucsb.edu/CISEI

The Cooperative International Science and Engineering Internships program, sponsored by the Materials Research Laboratory and the International Center for Materials Research, invites students from around the world to participate in a 10-week summer research experience on the UCSB campus. UCSB students participate in research at partner universities around the world in this unique intern exchange program. Interns come to UCSB from research centers in Eindhoven-Netherlands; Oxford-England; Shanghai-China, and Saarbruecken-Germany and Goethenburg-Sweden.

Investigating the thermodynamic behavior of Y-Si alloys for CMC applications
Ronja M. R. Anton, Materials Science, Saarland University
Rebecca B. Reitz, Carlos G. Levi, Materials

SiC/SiC ceramic matrix composites (CMCs) are promising to use for high temperature stable products like turbine blades. Furthermore, Y-Si alloys offer significant advantages when used instead of silicon in a process called reactive melt infiltration (RMI) to create these SiC/SiC CMCs. In the process, excess carbon in the preform reacts with silicon from the infiltrating liquid to produce SiC, but some amount of residual silicon or silicide is left behind. This investigation serves to elucidate the thermodynamic stability of the silicides (YSi, Y_3Si_5 and YSi_2) that are likely to be formed when a Y-Si alloy is used in this process. It seeks to clarify whether Y_3Si_5 and YSi_2 are both stable phases, and it also endeavors to determine whether a possible equilibrium between YSi and SiC exists at certain temperatures. The silicides for these experiments are manufactured with an arc melter. Diffusion couples are created and heat treated in a hot press to encourage reaction between the components. Characterization of the samples is accomplished by x-ray diffraction (XRD) and scanning electron microscopy (SEM). The initial results support previous research that indicates that YSi_2 and Y_3Si_5 are distinct phases. Being able to clarify the phase diagram of Y-Si has the potential of helping the development of robust SiC/SiC CMCs.

Investigating amorphous-crystalline transformation in polymer-derived ceramics for applications in jet turbine engines
Angus Braithwaite, Materials Science, University of Oxford
David Poerschke, Carlos Levi, Materials

Silicon carbide (SiC) based ceramic matrix composites (CMC's) are being developed to replace metals in turbine engines where their higher-temperature capabilities will improve the thermal efficiency of the engines. However, processing challenges have limited the implementation of CMC's. One promising route involves infiltrating a fiber preform with a ceramic forming polymer, heating the polymer to form an amorphous ceramic matrix (pyrolysis), and finally crystallizing the amorphous ceramic to form SiC. Our current investigation focuses on the amorphous-crystalline transformation with the aim of understanding the underlying kinetics and microstructural changes. Bulk amorphous specimens were heat treated in the range of 1300 °C to 1500 °C for between 1 h and 100 h. Based on Powder X-Ray Diffraction (PXRD) analysis, incomplete crystallization (65-70 wt%) occurred at 1300 °C and 1400 °C even at longer times, whereas more significant crystallization (80-85 wt%) only took place at the higher temperature of 1500 °C at times of 24 hr and longer. A quantitative PXRD method, validated as part of the study, was used to determine the crystalline content of each specimen separately. The same samples were analysed using scanning electron microscopy (SEM) and transmission electron microscopy (TEM) to observe microstructural changes. The microstructure became increasingly porous upon crystallization, accounting for changes in composition, mass loss, and the large shrinkage observed in the samples. The improved understanding of the

amorphous to crystalline transformation will be used to design heat treatments for CMC coupons with the aim of further optimising the processing of SiC CMC's.

Excluded volume effects as probed by pulsed Electron Paramagnetic Resonance using spin-labelled PEG sensor

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Ilia Kaminker, Songi Han, Chemistry and Biochemistry

The cell's interior contains a high concentration of macromolecules, which result in a highly crowded environment that affects the functionality of biomolecules due to excluded volume effects. These effects are often neglected in *in vitro* assays. Previous studies used poly ethylene glycol (PEG) based crowding sensors and artificial macromolecular crowding agents to investigate the crowding effects *in vitro* and were able to experimentally demonstrate a compression of the sensor as a result of a decreased accessible molecular volume. However, it is still unclear how the crowded environment affects the exact conformation of the sensor which precludes comparison with the molecular dynamics simulation results. We have developed a macromolecular crowding sensor based on a nitroxide spin-labelled 10 kDa PEG polymer to probe the crowding effect *in vitro* using Electron Paramagnetic Resonance (EPR) techniques. In particular, we compared the crowding effects of large soluble polymers 20 kDa PEG and 70 kDa Ficoll with small molecular weight Sucrose. Radical relaxation times as probed by pulsed EPR showed that they are invariant with the nature of the crowding agent and therefore are not the result of excluded volume effects. Preliminary results of inter-nitroxide distance measurements using Double Electron-Electron Resonance (DEER) suggest that this method is capable of detecting conformational changes depending on the sensor's concentration and nature of crowding agent. We are currently working on the synthesis of smaller molecular weight PEG polymer with shorter inter-spin distances, which should facilitate improved DEER measurements.

New experimental equipment for phosphor-converted solid state white lighting research

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Clayton Cozzan, Ram Seshadri, Materials

Scientific and public interest in phosphor converted light emitting-diode (pc-LED) devices has soared in the last two decades, mainly owing to their superior energy efficiency and durability compared to conventional light sources. One common approach to produce pc-LED white light is to use a blue LED to excite a yellow-emitting inorganic phosphor, often comprised of cerium-doped yttrium aluminum garnet ($Y_3Al_5O_{12}$), or Ce:YAG. The emission color of the phosphor depends on the relationship between the crystal structure and the dopant ion used. To obtain the coveted optical properties, the preparation of phosphors traditionally requires several hours of heating at temperatures above 1500 °C in a reducing atmosphere. However, recent studies have shown that the same material qualities can be obtained by using a conventional microwave oven, using a fraction of the time and energy. Currently, the atmospheric conditions of the heating procedure are not reliably regulated and thus not reproducible. The first goal of the work is to design, build, and test a more controlled setup for the microwave preparation of phosphors. The functionality and reproducibility of a custom made enclosure with nitrogen gas control is currently being tested and optimized. Once phosphor samples are successfully prepared, their structure and properties will be analyzed using powder X-ray diffraction and fluorimetry. Additionally, data on many canonical and novel phosphors are currently being collected for the development of an engineering database, where a user can easily search for phosphors with the desired properties, such as emitted color, absorption wavelength, and efficiency.

Structural Characterisation of Thin Film Barium Stannate Grown Using Molecular Beam Epitaxy

Arthur Hussey, Materials, University of California Santa Barbara
Santosh Raghavan, Susanne Stemmer, Materials

Barium stannate ($BaSnO_3$) has a high single crystal mobility ~ 300cm^2/V/s, compared to other perovskite oxides, due to the fact that the conduction band is made up of the tin 5s states. However, mobility in thin films of $BaSnO_3$ have not matched that of single crystals. In this study, we grow thin films of $BaSnO_3$ using the low-energy deposition technique called molecular beam epitaxy (MBE). In MBE, tin metal is normally used to supply the tin.

However, tin has a low oxidation potential and excess oxygen could damage the filaments in the MBE chamber. Therefore, we use tin dioxide powder to supply the tin, as it is pre-oxidised. The primary reason for low mobility in thin films is defects such as misfit dislocations due to lattice mismatch between the film and the substrate. Dislocations cause electron scattering, which reduces mobility, and decreased defect concentration in the film could result in higher mobility. We optimize growth parameters to improve the material quality and reduce the number of defects, leading to thin films with superior mobility. We perform X-ray diffraction and atomic-force microscopy to characterize the thin films grown using MBE. High mobility $BaSnO_3$ thin films would allow integration with other perovskite oxides and fabrication of high speed oxide devices.

Synthesis, Characterization, and Property Determination of the Novel Bismuth Cyanamide ($Bi_2(NCN)_3$)
Kai Rochlus, Materials Science, Saarland University
Brian Barraza, Ram Seshadri, Materials

Metal cyanamides have attracted interest in the past few years considering their promising electronic and magnetic properties. Bismuth cyanamide ($Bi_2(NCN)_3$) is a novel compound in this class of materials and is assumed to have similar properties to lead cyanamide due to the isoelectronicity of Bi^{3+} and Pb^{2+}. For this study, $Bi_2(NCN)_3$ was synthesized through a single-displacement reaction by stirring a suspension of bismuth nitrate ($Bi(NO_3)_3 \cdot 5\ H_2O$) and cyanamide (H_2NCN) in water with the use of ammonium hydroxide (NH_4OH) as a base. The chemical purity of the resulting orange powder was evaluated using x-ray powder diffraction and infrared spectroscopy. Optical and electronic properties were determined via ultraviolet-visible spectroscopy and time resolved microwave conductivity (TRMC), respectively. All properties were compared to lead cyanamide. This study has shown that bismuth cyanamide indeed displays similar properties to lead cyanamide and therefore may be a possible replacement in future applications.

Ionic gating of the electronic properties in Sr_2IrO_4
Lisa Sirén Gustafsson, Materials Chemistry, Chalmers University of Technology
Xiang Chen, Stephen Wilson, Materials

Since its discovery in 1911, superconductivity has been of significant interest due to its fascinating properties and broad potential applications. Most known superconducting materials are only superconducting at low temperatures (below 30K), which is why it is of importance to find new high temperature superconductors for practical applications. Despite tremendous efforts to search for possible room temperature superconductors the record holders are limited to the Cu-based families (without applying pressure) and the nature of their underlying superconducting mechanism are still not fully understood. Recently interest in realizing the potential superconductivity in the 5d Mott insulator Sr_2IrO_4 has arisen due to the similarities in crystal structure, electronic structure and magnetic coupling constants compared to the superconducting parent compound La_2CuO_4. Signatures of superconducting states have been reported in surface doped Sr_2IrO_4, but bulk superconducting states have still not been realized regardless of remarkable experimental efforts, including chemical doping. One potential solution for realizing superconductivity within Sr_2IrO_4 would be electric field controlled tuning of charge carrier density. Here we strive for tuning the charge carrier density of Sr_2IrO_4 by gating after laminating a thin film of ion gel on top of a clean and newly revealed fresh surface of the bulk single crystal. The usage of ion gel would potentially overcome the intrinsic limits of the amount of the carrier density tuned by chemical doping in bulk crystals by attaining a higher carrier density. The electronic and entangled magnetic properties of Sr_2IrO_4 are explored through this relative new technique, and it could lead to future possible applications utilizing strong spin-orbit coupling in 5d compounds.

Synthesis and characterization of hydrophilic-fluorinated block copolymers obtained via ATRP
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Athina Anastasaki, Craig Hawker. Materials

Surfactants consisting of hydrophilic and fluorinated blocks are promising for drug delivery as these surfactants can solubilize otherwise immiscible fluorinated drugs in aqueous environments by reducing the surface tension of water. For this study, a series of hydrophilic-fluorinated block copolymers, comprised of poly(ethylene glycol) (PEG) and a semi-fluorocarbon block, is synthesized. The one pot, UV- light-mediated polymerization required only ppm

concentrations of copper, simplifying the work-up. The reaction utilized a bromine functionalized poly(ethylene glycol) (PEG) chain as a macroinitiator from which different semi-fluorinated acrylates could be polymerized with near quantitative yields. These yields combined with simple deoxygenation of the reactants and the narrow dispersities obtained ($Đ$<1.10) prove the usefulness of this facile reaction for the synthesis of well-defined block copolymers. The synthesized polymers varied in PEG-macroinitiator length (1kDa, 2kDA and 5kDa), degree of polymerization (DP) of the fluorinated block (7, 13, 26 and 52) and the degree of fluorination of the fluorinated repeat units. Pendant drop tests demonstrated that both a decrease in the hydrophilic length and fluorinated block length and higher concentrations of amphiphilic block copolymer gave a greater drop in surface tension. The lowest surface tension (35 mN/m) was observed for the block copolymer consisting of 1kDA PEG and 7 repeat units of trifluoroethyl acrylate.

Edison-McNair Scholars Program (Edison)

http://mcnair.ucsb.edu/edison.html

The Edison-McNair Summer Research Program is designed to encourage talented undergraduate students to participate in research under the direction of a faculty mentor in Environmental Sciences (Earth Science or ,Environmental Studies), Computer Science, or Engineering (Computer, Electrical, or Mechanical). The Edison-McNair Scholars is designed to increase the number of women, low-income, first-generation, veterans, and those historically underrepresented in Engineering and Environmental Science to pursue research and graduate education in those fields. This program was established through funding from Edison International and during the 8-week summer research program students gained professional skills and graduate school preparation in addition to conducting ground breaking research.

Biotic and abiotic constraints on natural succession in old agricultural fields
Carina Bilodeau, Environmental Studies, University of California Santa Barbara
Madeline P. Nolan, Carla D'Antonio, Ecology Evolution and Marine Biology

Agriculture and livestock grazing in California altered the land and allowed exotic grasses to dominate what are now endangered native grasslands. These altered communities remain even after agricultural fields are abandoned, and, unfortunately, native grasslands are some of the most difficult habitats for restoration practitioners to establish. To successfully restore native California grasslands, we need to determine what factors prevent the return of native grasses. We hypothesize that abiotic stressors like drought or biotic stressors such as competition and dispersal limitation prevent the natural succession of native grasses. To study these factors, we will carry out a field experiment that involves different seed bank removal techniques, water availability treatments, and varied native plant seeding mixes. Our results will enhance future restoration efforts by providing insight into the processes underlying natural grassland succession in old agricultural fields.

Controlling the Controller: Creating Auxiliary Systems to Aid in Characterizing Magnetic Levitation Engines
Brian Canty, Electrical Engineering, University of California Santa Barbara
Ilan Ben-Yaacov, Electrical and Computer Engineering

The Hyperloop pod travels through an evacuated tube at high speeds made possible through levitation. One possible way to achieve levitation is with magnetic engines that rotate at high speeds to produce thrust. In order to characterize the rotational speed, output, and consumed power of these engines, an Arduino microcontroller was chosen to interface with the motor controller and operate the engines while data is collected. The Arduino outputs a signal that the motor controller changes into a rotational speed. Rotation and current sensing methods will be implemented to both gather performance data and allow implementation of safety methods; the Arduino will shut down the engines if it measures that they spin too fast or consume too much power. The collected data will provide the information necessary to safely operate the engines once they are installed.

Stylometry: Linguistic Fingerprinting Using Machine Learning on SeekingAlpha
Veena Chandran. Computer Engineering, University of California Santa Barbara
Ben Zhao, Computer Science

Text can be attributed to a certain writer through the use of machine learning algorithms on the statistical variations of various authors' writing styles. This strategy is applied on finance articles from the crowd-sourced content service Seeking Alpha. Features, such as amount of punctuation, are extracted from text samples of each author. These features are normalized and fed into Support Vector Machine classifiers to train them on the styles of each author. To establish ground truth data, certain authors are chosen at random to have their articles split. Each group of articles is attributed to a newly created fake author, and these authors are determined to be the same using these methods. New features will be added to improve accuracy. Accurate authorship attribution can detect fake accounts, which in turn can help keep users well-informed and the stock market free of manipulation.

Small scale changes in drought tolerance of *Stipa pulchra*
Teal Coppock, Hydrology with a Chemical and Physical Emphasis, University of California Santa Barbara
Madeline P. Nolan, Carla D'Antonio, Department of Ecology, Evolution and Marine Biology

Native grasslands in California are highly imperiled due to the replacement of native species by exotic annual grasses. The presence of the native drought-tolerant bunchgrass *Stipa pulchra* is particularly important for the restoration of California grasslands because this species is historically the foundational species in grasslands across the state. Previous research has found that populations of *Stipa pulchra* differ in their drought tolerance depending on the environmental conditions of any particular site. The differences in drought tolerance have been found on a large spatial scale across California but it is unknown if *Stipa pulchra* varies in drought tolerance on a smaller scale (meters/kilometers). Eight populations were sampled from Sedgwick Reserve in the Santa Ynez valley and tested for drought tolerance in a greenhouse experiment. In the face of climate-change drought tolerance is going to become a trait that is increasingly important in California restoration efforts.

Constructing a Rehabilitation Laboratory
Martin Grabau, Mechanical Engineering, University of California Santa Barbara
Tyler Susko, Mechanical Engineering

Lab D4H (Design For Humans) is a new lab at UCSB in the Engineering Science Building that will allow the testing of rehabilitation devices. The construction of a body weight suspension harness is a first and vital step in the development of this lab. The majority of the work done was designing and building this suspension system. After evaluating the strength of the existing lab ceiling structure, the design chosen was a ten foot track with a roller cart from which the harness hangs. This track allows natural walking movement along the floor or on a treadmill. Using this suspension system, devices can be safely tested that will improve the quality of life for people with disabilities.

Monitoring Cellular Interactions with High Resolution Thermography
Ryan Kaveh, Computer Engineering, University of California Santa Barbara
Luke Theogarajan, Computer Engineering

Long Wave Infrared (LWIR) Sensors have reached an incredible level of thermal resolution and can now affordably expose phenomenon at the cellular level. In order to take advantage of this opportunity, we designed and built an Infrared microscope that can help characterize cellular thermal profiles and monitor intracellular interactions. To demonstrate our system, we will use FLIR system's lepton camera (thermal sensitivity of < 50 mK) to image the effects of patterning cells using surface acoustic waves. We believe this added thermal imaging dimension will provide insight into the role of thermal stresses during cell growth and intracellular communication, especially for neural networks.

Electrical Characterization of Etch Damage in GaN Trench MOSFETS
Junqian Liu, Electrical Engineering, University of California Santa Barbara
Chirag Gupta, Umesh Mishra, Electrical and Computer Engineering

As the demand for more energy efficient electronics rises, Galium Nitride (GaN) is showing great promise for use in next generation devices. However, bombardment of ions for etching GaN, introduces detrimental lattice defects due to the energy transferred from the ions to the GaN crystal structure. To examine the effects of these defects on device performance, several samples were processed under ion bombardment of varying power levels. These samples were then characterized with capacitance-voltage and current-voltage measurements. From these measurements, it can be concluded that more powerful ion bombardments will reduce flat band and threshold voltages of metal-oxide semiconductor (MOS) devices. By implanting at lower power levels, transistors can experience less current leakage while operating at higher voltages thereby reducing the energy consumed when installed in commercial products.

Expansion of the Morphable Mirror Telescope
Calvin Louie, Mechanical Engineering, University of California Santa Barbara
Philip Lubin, Physics

The Morphable Mirror Telescope aims to develop a low-cost, ultra-low mass telescope to study the origins of the universe. The telescope is designed for ground-based, airborne, and space-based missions to capture images of the radiation from the early universe. The telescope is comprised of a segmented mirror, a laser metrology system, and a carbon fiber support structure, which includes an extended truss attached to the backing structure. The backing structure is similar to a honeycomb-like web, making it light yet durable. Using the SolidWorks program, the proposed backing structure was modeled. Individual parts were updated with current adjustments and applied to the SolidWorks assembly. With a computer-aided drafting (CAD) model of the full backing structure, the structure is modeled with finite elemental analysis to determine its structural stability and integrity. A partial version of the full structure is complete and plans to build the full structure are being developed.

Validating the Fast Sweeping Method for Seismic Wave Propagation Analysis
Franklin Ly, Mechanical Engineering, University of California Santa Barbara
Frederic Gibou, Mechanical Engineering and Computer Science

The Eikonel equation is a non-linear partial differential equation which can be used to understand wave propagations. Simulating seismic wave propagations is primarily done by discretizing this equation. Current computational methods for wave propagations can improve in efficiency by using a parallel fast sweeping method. The parallel fast sweeping method allows for fewer iterations of computing giving personal users the ability to analyze large data sets in a timely manner. Compared to traditional methods of discretizing the Eikonel equation, this method allows for everyday computer users to obtain wave propagation data and run simulations. Users will be able to input different geological data sets into the program helping them understand how seismic wave propagations affect those geological areas.

Geologic History of Norway
Maximilian Ochoa, Earth Science, University of California Santa Barbara
Bradley Hacker, Earth Science

Norway has a complex geological history. Regions of high - grade metamorphosed rock formed in ultra – high pressure (UHP) systems are of interest because they provide snapshots of usually invisible processes which occur up to 150 Km below the surface. U – Pb dating of Amphibolite - Faced samples from UHP regions within Norway will be used to broaden understanding of the processes that have formed the region and ultimately the geosphere as a whole. Once the mechanisms which engineer Earth are understood, the exact ‘why’ and ‘how’ our planet looks and behaves the way it does - so uniquely from other planets within the solar system - will be known.

Lithium-polymer Battery Use in Low Pressure Environments
Alejandra Santos, Electrical Engineering, University of California Santa Barbara
Ilan Ben-Yaacov, Electrical and Computer Engineering

The Hyperloop is a proposed method of transportation originally designed to travel at speeds of up to 760mph in a low-pressure tube using an air cushion, although travel using magnetic levitation is another option. The UCSB Hyperloop pod utilizes six maglev motors powered by lithium polymer (LiPo) battery banks. The fully charged batteries will be discharged into five different high power rated resistor banks mounted atop an aluminum plate, a heat sink and an ice pack for cooling. Temperature, voltage, current and power measurements will be continuously recorded to create discharge profiles for the batteries. Measurements will be taken at both atmospheric pressure and in a vacuum chamber. In characterizing the LiPo batteries, more information regarding performance in the desired low-pressure environment will be available to set a precedent for further in-depth testing of the motor with the batteries.

Hyperloop Levitation System Integration
Paymon Shariat-Panahi, Mechanical Engineering, University of California Santa Barbara
Tyler Susko, Mechanical Engineering

The Hyperloop Pod is a prototype of Elon Musk's vision of a mode of transportation consisting of high speed pods traveling in a low pressure tube. UCSB is one of 20 out of 1200 teams chosen to race their pod prototype at SpaceX Headquarters in January. A key component of the pod is the implementation of six Arx Pax magnetic motors, used to levitate the 550lb frame. There are several hurdles associated with the implementation of these motors. The behavior of the motors must be characterized and a thermal dissipation system, sufficient for low air pressure cooling, must be implemented. A motor testing rig was designed and built to analyze the response of the magnetic motors under different loading conditions and input control techniques. Thermal images were taken of the motor to identify critical heating components and to design a conduction system that safely diffuses heat to the aluminum frame.

Early Undergraduate Research and Knowledge Acquisition (EUREKA!)

http://eureka-csep.cnsi.ucsb.edu/

The Early Undergraduate Research and Knowledge Acquisition (EUREKA!) program is designed to enrich the academic experience of undergraduates at UCSB in science, technology, mathematics and engineering (STEM) disciplines early on in their educational careers. The program is focused on introducing students in their first year to the broader science community on campus and providing exposure to research through academic year internships. Students who have participated in the Summer Institute in Mathematics and Science (SIMS) are especially encouraged to apply. EUREKA is hosted by the Center for Science and Engineering Partnerships (CSEP) at the California Nanosystems Institute (CNSI). We aim to nurture student's academic achievement through financial support and opportunities to actively engage in the science community through early preparation that addresses the academic skills, social networking, and career exploration needed for success in the sciences.

Connecting to the Beginning: Circuit Boards for CERN
Dillon Acker-James, Electrical and Computer Engineering, University of California Santa Barbara
Aditya Dalakoti, Forrest Brewer, Electrical and Computer Engineering

Extracting more information from high-energy experiments at CERN requires better connections that can quickly and safely transport data collected by an array of silicon detectors. High-speed connections created by the combination of printed circuit boards and integrated circuits can help to extract more information faster, with less risk of corruption caused by radiation. A long printed circuit board, roughly a meter and a half, would allow for a sturdy connection that can overcome the power and space constraints inside of the collider. However, since it is very uncommon for circuit boards to be that large, our group decided to make a ladder of smaller PCBs connected together. Each circuit board will be three inches in length so roughly twenty boards are required to make up a meter and a half connection, but the demands of high frequencies may cause problems with the integrity of the signal. These connections also must be able to withstand radiation and transmit data at high speeds in order for more information to be extracted.

Magnetic and Electronic Transitions in a Highly-Doped Mott Insulator
Michael Aling, Mechanical Engineering, University of California Santa Barbara
Julian Schmehr, Stephen Wilson, Materials

$Sr_3Ir_2O_7$'s insulating nature has been attributed to the combined effects of crystal field splitting, spin-orbit coupling, and a Coulomb interaction. This combination makes it an interesting subject of study, particularly since its cousin $Sr_3Ru_2O_7$ is a fully-metallic conductor. $Sr_3(Ir_{1-x}Ru_x)_2O_7$ undergoes both metal-insulator and antiferromagnetic-paramagnetic transitions across the range of doping. Previous work by this group mapped out the phase diagram, focusing primarily on doping levels up to x=0.4; this project seeks to better understand the region x=0.4 to 0.6, in which at low temperatures the metallic compound settles from paramagnetic disorder into antiferromagnetic order. In the higher-dopant regimes, this also captures the demise of any low-temperature antiferromagnetic order, thus including the yet-unstudied low-temperature end point of the magnetic phase transition. It is possible that a new magnetic or electronic phase could develop in that region. Both the phase transitions and the bulk properties of $Sr_3(Ir_{1-x}Ru_x)_2O_7$ are items of study. Early work has focused on the flux growth of samples in the desired dopant ranges, XRD and EDX analysis to confirm their composition, and electric transport measurements to begin

identifying both metal-insulator and magnetic transitions. Samples of x=0.33 and 0.5 have been successfully grown and characterized, and higher-dopant-level growths are in progress. The approximate phase boundary has been mapped out. An uncommon form of single-crystal XRD is also utilized to obtain the c-lattice (long axis) parameter of the samples, which correlates to their dopant level. Future work will include magnetization and heat capacity measurements, as well as resistivity at sub-Kelvin temperatures.

Light Controlled Delivery of P53 Using Plasmonic Gold Nanoparticles
Dorian Bruch, Chemical Engineering, University of California Santa Barbara
Demosthenes Morales, Norbert Reich, Chemistry and Biochemistry

There are currently a limited number of methods that allow spatial and temporal control of protein activity in cells. One of these methods involves the use of highly modified proteins that are light activated, called an optogenetic protein. However, these proteins require substantial time and effort to engineer in order to confer both light activation, while maintaining its native function, making the approach to the time resolved study of proteins challenging. Plasmonic gold nanoparticles can provide an alternative method that not only has spatial and temporal control, but can be applied to virtually any protein to study diverse cellular processes. In this study, native human p53 will be purified and then tethered to a nanoparticle using an affinity tag. P53 will then be delivered to human cell lines and released using infrared radiation. Successful delivery of p53 will induce expression of red fluorescent protein in the exposed cells with spatial control. This technology has the potential to greatly improve the efficiency of introducing exogenous proteins into cells to greater than 60% compared to conventional methods. This may expedite the research and understanding of the fundamentals of cellular processes.

The Effect of WDR5B on Cell Adhesion in Cancer Metastasis
Van Hsieh, Biology, University of California Santa Barbara
Zach Ma, Molecular, Cellular, and Developmental Biology

Cell adhesion plays an important role in cancer metastasis. The dysfunction of cell adhesion makes it more likely for cancer cells to escape from the primary tumor to colonize other organs, causing cancer metastasis. We discovered that when we knockdown the WDR5B protein, there is an alteration in cell morphology, suggesting the change in cell adhesion. WDR5B is a protein little studied that is homologous to the WDR5 methyltransferase subunit and previously thought to have played the same role as WDR5. However, when we knockdown the WDR5 protein, we do not have the same change in cell morphology as when we knockdown WDR5B. This indicates that WDR5B has different function from WDR5. To verify this, we used Western Blot to detect the change in level of the two main cell adhesion proteins, cadherin and integrin. Through Western Blot, we concluded that there is decrease in both the integrin and a mature integrin level, showing that both are possibly down regulated with the decrease in WDR5B. We are currently testing other downstream pathway proteins that are involved with integrin to clarify what changed. We are also further investigating the change in level of cadherin as the result from Western Blot is promising. Our research could possibly help further the understanding of cell adhesion mechanisms as well as the function of WDR5B.

Aptamer Directed Synergistic Drug Delivery
Valerie Lensch, Chemistry, University of California, Santa Barbara
Anusha Pusuluri, Samir Mitragotri, Chemical Engineering; Tom Soh, Mechanical Engineering

Cancer patients suffer from extreme side effects of traditional chemotherapy due to the inability of chemotherapeutic drugs to exclusively inhibit the growth of cancer cells thereby harming healthy cells. Triple negative breast cancer is the form of breast cancer that is most difficult to treat because the cells lack HER2 receptors and hormone receptors that are targeted on other breast cancer cells. Oligonucleotide aptamers have been shown to target cancer specific biomarkers on tumor cells with high affinity and specificity. Our targeting molecule is a single-stranded DNA aptamer, AS1411, which binds to overexpressed nucleolin receptors on MDA MB 231 triple negative breast cancer cells. Furthermore, combining chemotherapeutic drugs at specific molar ratios leads to higher cell growth inhibition as compared to single drugs. Hence, we coupled targeted drug delivery with combination drug therapy to deliver drugs specifically and synergistically to triple negative breast cancer cells. We conjugated the aptamer with

chemotherapeutic drugs, doxorubicin and camptothecin, using a peptide scaffold as the carrier. We evaluated several free drug and peptide-conjugated drug combinations to determine the most synergistic combination. Molar ratios of 1:4 for free doxorubicin to free camptothecin and 1:1 for peptide-doxorubicin to peptide-camptothecin were found to be the most synergistic combinations. Conjugating these drugs to the aptamer at the optimal molar ratios will potentially enable us to specifically deliver chemotherapeutic drugs at significantly lower doses.

How Winds and Sea Level Differences Control Coastal Ocean Currents
Brett McKim, Physics, University of California Santa Barbara
Libe Washburn, Marine Science

Wind relaxations occurring at Point Conception, a major biogeographic boundary, lead to a reversal of the coastal ocean circulation pattern. These flows propagate poleward around Point Conception, running opposite of the prevailing wind, and are important for their role in larval delivery to tidal and intertidal habitats along the central Californian coast. The relationship between the characteristics of these flows and their structure will be examined. 4 Oceanographic moorings collected temperature and velocity profiles of the water column as well as pressure measurements along the 15 m ocean depth line. Bottom pressure time series indicated that a sea level differences developed between north and south of Point Conception when the winds were blowing. When they weaken, the water moves from the high region in the Santa Barbara Channel to the lower region north of Point Conception. Nearly simultaneous temperature increases across the water column indicate a vertical front associated with these flows. The flow can be partitioned into a nose region with alongshore and cross shore components of velocity and a tail region where the alongshore flow is farther offshore. The alongshore and cross shore scale of the nose region is roughly 10 km and 10-20 km respectively. Understanding the temporal and spatial scales of poleward flow events will improve our ability to understand the mechanisms of larval delivery across biogeographic boundaries.

Reacting CMAS with Yttrium Disilicate Environmental Barrier Coating
Melissa Morales, Chemical Engineering, University of California Santa Barbara
William Summers, Frank Zok, Materials

Motivated by unprecedented demands for more powerful jet engines, the development of SiC/SiC ceramic matrix composites (CMCs) pushes potential material temperature capabilities to upwards of 1300^{o}C resulting in a 9-10% increase in cycle efficiency. The final step in fully adopting this technology lies in designing more capable barrier coatings to protect the SiC/SiC CMCs from water vapor induced oxidation. Yttrium Disilicate environmental barrier coatings (EBCs) are auspicious due to their favorable coefficients of thermal expansion, low volatility, and phase stability. However, a new problem arises when operating temperatures exceed 1300^{o}C. Siliceous materials ingested by the engine melt and adhere to the surface. These siliceous materials vary from desert sand to volcanic ash and, in general, contain oxides of Calcium, Magnesium, and Aluminum, hence the abbreviation CMAS for Calcium-Magnesium-Alumino-Silicate. When the engine is brought back to non-operating temperatures, say after landing, the CMAS deposits solidify forming a layer with a vastly different coefficient of thermal expansion, and cracks form in the multi-layered system. In order to prevent or mitigate the reaction between the EBC and CMAS, we must first be able to understand how these cracks form and use this information to predict how the system will behave. Designing more capable EBCs is key to fully adopting CMCs and revolutionizing the aerospace industry.

The Effect of Biodiversity Loss and Climate Change on Tick-borne Disease
Carina Motta, Pre-Biology, University of California Santa Barbara
Devyn Orr, Hillary Young, Ecology, Evolution, and Marine Biology

Small land mammals can serve as hosts to vectors of disease, which carry and transmit bacteria (e.g. *Borrelia*) that pose a potential threat to human health. The loss of large land mammals due to urbanization combined with continuing global climate change could result in a cascading environmental effect impacting other inhabitants of the ecosystem, such as small land mammals, and indirectly causing a change in vector population. By investigating how small land mammals impact their environment through herbivory and serving as hosts for ticks, we sought to demonstrate how mammals can influence prevalence of zoonotic disease, such as Lyme disease. In this study, we conducted field research at Tejon Ranch in Southern California. We measured herbivory rates by conducting

cafeteria trials in a set of experimental plots located at different microclimates of varying elevations. The prevalence of ticks was determined through the trapping of small vertebrates such as deer mice and Western fence lizards. The results showed a higher rate of herbivory at the experimental plots at higher elevation where there was more moisture, providing the small land mammals with the environment to succeed. Trapping of small vertebrates allowed for the collection of ticks which will be tested for zoonotic diseases. The low capture rate of small land mammals reflects the current environmental stresses such as drought and season. These data collected will be used as baseline data in the years to come of this long-term experiment as herbivory rates change with the exclusion of large and small land mammals.

Implementing Machine Learning Based Image Recognition for Animal Detection

Andy Rosales-Elias, Computer Science, University of California Santa Barbara
Nevena Golubovic, Chandra Krintz, Rich Wolski, Computer Science

Today, ecologists are aiming to improve the monitoring and safekeeping of animal wildlife. In an effort to make data more reliable for wildlife researchers, ecologists are increasingly turning to environmental measurement and data analysis. Computing systems can help automate this process to provide more reliable data in a completely automatic manner. This project focuses on the use of computer vision combined with machine learning to detect animals in photos taken by motion-triggered camera traps. With the use of open source, pre-trained Convolutional Neural Networks a machine learning model can "learn" to recognize wild animals to some extent. After setting up the CNN framework trained on the default ImageNet dataset, we ran the classifier on 12210 images and found the model to be inaccurate. We further extended the accuracy and range of the recognition by re-training this model with labeled images from the motion-triggered camera traps. The re-training phase requires a set of labeled animal images that the model uses to create its recognition database. The next step is to use the recognition data and combine it with the image's metadata – that is, extra information such as time, date, and temperature. Combining the recognition data with its metadata can help us learn more about how animals are affected by the environment. Further data analysis can help predict endangered animal species by noticing unusual trends. The information extracted from the images can help us address important scientific concerns, while providing a unique view into the hidden world of wildlife.

Regulation of Microtubule Stability by a Histone Methyltransferase Subunit

Justin Su, Chemistry, University of California Santa Barbara
Adeel Lakhani, Hayley Nguyen, Dzwokai Zach Ma, Molecular, Cellular & Developmental Biology

Microtubules are dynamic protein polymers that form the cellular cytoskeleton. Their dynamics play a crucial role in proper cell division, among many other important functions. On the other hand, WD repeat-containing protein 5 (WDR5) is a regulatory subunit of histone H3 lysine 4 methyltransferase complexes (H3K4MTs), a complex that serves in epigenetic regulation by methylating histone H3 at lysine 4. WDR5 has roles in the process of abscission, whereas abscission requires the depolymerization of microtubules. Knocking down WDR5 increases midbody microtubule stability. Kinesin heavy chain member 2A (KIF2A), a microtubule depolymerizing enzyme, has been found to localize to midbody microtubules and interact with WDR5. This project aims to test whether KIF2A is the link between midbody microtubule stability and WDR5. The results of an *in vitro* microtubule assay suggest that WDR5 binds directly to KIF2A and inhibits its ability to depolymerize microtubules. However, this conflicts with the increase in midbody microtubule stability when WDR5 is knocked down. Future investigations will examine whether WDR5 is able to interact with proteins which are closely related with KIF2A. If so, these interactions could help reconcile our *in vivo* and *in vitro* observations. Another future aim is to test whether a WDR5 homolog, WDR5B, is also involved in regulating midbody microtubule stability. These efforts will reveal unconventional functions and roles of H3K4MT subunits in regulating microtubules. Since both H3K4MTs and microtubules are tightly linked to several basic cellular functions and diseases, this insight can have broad impact and valuable applications to many biomedical fields.

Future Leaders in Advanced Materials (FLAM)

http://www.mrl.ucsb.edu/FLAM

Science and engineering students from UCSB and other universities acquire research experience in a variety of exciting fields through these internships. This program includes students from Jackson State University and the University of Texas at El Paso funded by the NSF Partnerships for Research and Education in Materials (PREM) program. FLAM interns meet regularly to share their experiences and report on their progress. Our research interns often present at conferences such as SACNAS, SHPE, ACS, APS and others.

Thermally Reconfigurable Mie resonances in InSb Metasurfaces
Nicholas J. Antonellis, Physics and Economics, Wesleyan University
Prasad P. Iyer, Jon A. Schuller, Electrical and Computer Engineering

Dielectric metasurfaces have emerged as low-loss and tunable alternatives to plasmonic antenna systems with potential to form ultrathin optical elements (mirrors, lenses, etc.). Here, we investigate the thermal and geometric dispersion of fundamental Mie resonances in InSb wire and disk resonators on an intrinsic InSb substrate. Resonant properties of these dielectric antennas depend on the size and the refractive index of the wire or disks. Due to its high refractive index ($n \sim 4$), low electron effective mass ($m_e \sim 0.014\ m_0$) and low band gap (0.17 eV at 300 K), InSb is a suitable candidate for temperature dependent tunable metasurfaces. We fabricate individual InSb antennas of different sizes (0.5μm-5μm) to map geometric shifts of the fundamental scattering resonances in the mid-infrared wavelength region (2-16 μm). We experimentally identify these scattering resonances of InSb wires and disks as dips in the reflection spectra from our FTIR microscope. We track those dips as a function of the resonator size and substrate temperature for both TE and TM polarization states. The generation of thermal free carriers upon heating (300K-600K) gives us a reconfigurable 750nm-shift of the resonant wavelength around 13-14μm. Using FDTD software, we simulate single antenna resonances to plot their geometric dispersion and study their resonant field profiles. Developing the experimental models for the dispersion of the fundamental resonances of dielectric resonators will facilitate the design of large-scale tunable metasurfaces.

Measuring Surfactant Surface Coverage of Biomimetic Cargos from Interfacial Tension
Dennis Huang, Bioengineering, University of Pennsylvania
Jamianne Wilcox, Megan Valentine, Mechanical Engineering

Kinesin motor proteins play an important role in intracellular transport by moving different types of cargo such as vesicles and filaments along microtubule tracks in living cells. The principles behind single kinesin intracellular transport are well known; however, little is known about collective kinesin behavior. In particular, we predict that kinesin motor proteins will behave differently when attached to cargo with a rigid vs. a fluid membrane. To better understand kinesin behavior when interacting with fluid membranes, biomimetic sunflower oil droplets were created with two surfactant types (ceramide-PEG(2000) and biotinylated DSPE-PEG(2000)). The ratio of the two surfactants determines how many kinesins can bind to the droplets through a biotin-streptavidin-biotin linkage. Equilibrium interfacial tension was measured using an optical tensiometer for different concentrations and different ratios of the two surfactants. The kinesin surface coverage was calculated from the equilibrium interfacial tension and the ratio of biotinylated surfactants. Based on the calculated surface coverage of kinesin motor proteins, we can control the number of kinesins present on each biomimetic sunflower oil droplet by manipulating the concentrations and ratio of the two different surfactants. Once the biomimetic sunflower oil droplets are optimized to attach the desired number of kinesins, tests can be performed using an optical trap to determine the kinesin behavior when pulling the fluid membrane droplets.

Investigation of Molybdenum--doped Porous Metal Oxides as Catalysts in Biomass Conversion
Grace Hubbell, Biochemistry, Chemistry, Lake Superior State University
Megan Chui, Peter C. Ford. Chemistry and Biochemistry

The search for alternative energy sources has become an important task for society as carbonaceous fossil fuels continue to deplete. Lignocellulosic biomass is a renewable, affordable, and non-food competing feedstock suggested. High in aromatic and oxygen content, comprising up to 40% of lignocellulosic biomass, lignin is an attractive alternative energy source. The selective disassembly of lignin can lead to liquid products that may be upgraded to higher commodity fuels and chemicals. Previously, a porous metal oxide (PMO) catalyst comprised of copper, aluminum, and magnesium demonstrated itself as an efficient catalyst in the disassembly of lignocellulosic biomass. MoS_2 is industrially used to enhance deoxygenation and desulfurization. We aim to explore the effects of molybdenum on the selectivity and reactivity of our system. Mo-deposition was performed on the existing Cu_{20} PMO catalyst for selective lignin disassembly. PMO catalysts with varying molybdenum compositions (1.25, 2.5, 5.0, 10.0 wt%) were synthesized via equilibrium deposition filtration. Catalytic activity was measured by reacting these catalysts with the model compounds 2,3-dihydrobenzofuran, benzyl phenyl ether, and methyl-p-toluene sulfonate in supercritical methanol at 300 °C. Liquid products were analyzed by GC-FID and GC-MS to determine selectivity and reactivity. Molybdenum-doped Cu_{20} PMO catalysts displayed selective and variable reactivity towards these model compounds. These results suggest that based on its activity towards model compounds reflective of lignin, a robust catalyst comprised of abundant metals and minimal molybdenum may be utilized to disassemble lignin to produce useful fuels and chemicals.

Exciton Diffusion Length in P3HT with the Presence of Additive F4TCNQ
Aldo Jordan, Chemistry, University of Texas at El Paso
Brett Yurash, Thuc-Quyen Nguyen, Materials

Exciton diffusion is an imperative process for organic solar cells. Excitons are excited states of molecules, Coulombically-bound electron-hole pairs, created upon the absorption of light. These pairs must be separated into free charges in order to generate current in solar cells. In order for an exciton to be separated in a bulk heterojunction, excitons must diffuse to a donor-acceptor interface. Thus, exciton diffusion is a critical, but often overlooked, process in organic solar cells. This study aims to explore (i) the effects of morphology on exciton diffusion and (ii) how the presence of a molecular dopant affects exciton diffusion. Doping of organic semiconductors has been shown to moderately improve solar cell performance, but characterization has not been done on how the presence of dopants affects exciton diffusion. We measure the exciton diffusion in Poly-3-hexylthiophene (P3HT) using a method developed by Dr. Oleksander Mikhneko. This method measures fluorescence bulk heterojunction films with Time-Correlated Single Photon Counting and a Monte Carlo Simulation to model exciton diffusion from experimental parameters. Thermal Annealing was done on the films to influence the degree of crystallinity in P3HT and these morphological changes were observed through UV Vis Absorption Spectroscopy. 2,3,5,6-tetrafluoro-tetracyanoquinodimethane (F4TCNQ) was the molecular dopant used for this analysis. The studies done show that exciton diffusion length of P3HT increases slightly by annealing, which is thought to be caused by increases in crystallinity and reduction in amorphous domains. Even at low concentrations of F4TCNQ, the lifetime of excitons is reduced significantly, which correlated to reduction in exciton diffusion.

Construction of a Microcalorimeter
Ji Hyun Kim, Materials Science and Engineering, University of Florida
Tom Hogan, Stephen Wilson, Materials

Heat capacity is a helpful way to study physical changes of a material of interest; it is a thermodynamic quantity that is related to many fundamental properties of a physical system. A microcalorimeter has been constructed to measure the heat capacity of sample sizes on the order of milligrams down to temperatures of near absolute zero (~7 K) using the thermal relaxation of heat pulses. The motivation behind using a microcalorimeter can be explained by the proportional relationship between the thermal relaxation time, τ and the sample heat capacity, C. A small sample mass, and thus a smaller C, aids in avoiding inordinately long measurement times. This system employs a thin film heater and a temperature sensor that have been thermally anchored on a specially designed sapphire plate measuring only 3 mm in diameter. The diminutive size of the calorimeter reduces the absolute heat capacity of the measuring

apparatus to optimize the precision and accuracy of the collected data with the goal of outperforming currently available commercial calorimetry solutions. To accompany the extremely sensitive hardware of the system, MATLAB and LabVIEW were utilized for the programming of the data collection and analysis software. A Chebyshev polynomial fit is used for the fitting and optimum interpolation of the heat capacity and thermometry calibration data. The software is designed to provide a user-friendly interface for data collection and analysis, with the goal of implementation in a dilution refrigerator system for testing in the exceptionally low millikelvin temperature regimes.

Pouch Cells for Zinc-Bromine Batteries
Jason Lipton, Chemistry, University of California Santa Barbara
Brian Evanko, Galen D. Stucky, Chemistry and Biochemistry

Zinc-bromine batteries have drawn a great amount of interest for their potential applications in grid scale energy storage due to their high cycling stability and energy efficiency. Bromide is an attractive candidate for the oxidation half reaction due to its oxidation potential just within the potential window for aqueous electrochemical cells, however, halide ions are corrosive to metals. In this work, a novel pouch cell design using conductive polyethylene as current collector, structural support, and seal is reported. This pouch design seeks to overcome the problems associated with bromide and tribromide ions while maintaining a simple cell design with, good cycling stability, coulombic efficiency of 95%, and energy efficiency of 90%.

Incorporation of Donor-Acceptor Stenhouse Adducts onto Polymer Chains
Michael Martinez, Chemistry, California Polytechnic State University
Zachariah Page, Craig Hawker, Chemistry and Materials

Donor–acceptor Stenhouse adducts (DASAs) are a new class of photoswitches that respond to visible light by converting from a triene form to the corresponding cyclopentenone form, resulting in a simultaneous colored-to-colorless, hydrophobic-to-hydrophilic, and extended-to-collapsed transition. This project aims to integrate DASAs into polymeric systems to take advantage of these unique properties, generating new stimuli responsive materials with applications in amine-detection. Here, we describe how an activated furan precursor to DASA can be functionalized with a norbornene-handle useful for ring opening metathesis polymerization (ROMP) under facile conditions. First, 2-aminoethanol was reacted with ethylisocyanate to yield 1-ethyl-3-(2-hydroxyethyl)urea, followed by a Steglich esterification with exo-5-norbornenecarboxylic acid. The norbonene-urea adduct was reacted with malonyl dichloride to form a functional barbituric acid derivative capable of undergoing a rapid Knoevenagel condensation with furfural to provide the desired activated furan-norbornene monomer. ROMP of this novel monomer is currently under investigation.

Characterization of magnetron sputtered WOx-TiOx thin films
Jorge Mata, Mechanical Engineering, University of Texas at El Paso
Michael Gordon, Chemistry and Biochemistry

Magnetron sputtering has become the process of choice for the deposition of a wide range of industrially important coatings. In this work, tungsten-doped TiO_2 thin films for optical and dielectric applications (e.g., anti-reflective coatings and signal filters) were synthesized using high-temperature, reactive RF magnetron sputtering at the Air Force Research Lab (AFRL), and characterized at UCSB using photoconductance measurements, Raman and Fourier transform infrared spectroscopies (FTIR). Deposition follows when target erosion occurs due to energetic particle bombardment by either reactive or non-reactive ions produced in the discharge at pressure in the mTorr range by the application of a high voltage. The effect of sputtering conditions (e.g., power delivered to the titanium and tungsten sputtering targets) on film electrical properties was investigated and found to significantly decrease film resistance (i.e., $10^9 \rightarrow 10^3$ ohms) above a threshold tungsten source power of 80-100 W. Films were also seen to be optically active, with conductance increasing upon exposure to 514 nm laser light. It is hypothesized that this effect is due to tungsten doping on the Ti site, which results in an excess of free carriers that in turn increase conductance. Raman and FTIR reflectivity measurements have been done to explore if W modifies the vibrational characteristics of the TiO_2 lattice and if the NIR reflectivity echoes the change in electrical conductivity.

Expanding Transition Metal Ketimide Complexes to the Group 10 Elements

Daniel Najera, Chemistry, The University of Texas at El Paso
Peter Damon, Trevor Hayton, Chemistry and Biochemistry

The electron-donating properties of ketimide ligands, $[R_2CN]^-$, are known to stabilize oxidation states in transition metal ions. For example, ketimide complexes of V(IV), Cr(IV), Mn(IV), Fe(IV), and Co(IV) have been synthesized and effectively characterized. Furthermore, the ketimide ligand set can stabilize multiple oxidation states of the same metal. The purpose of this project is to determine whether oxidation states in Pd and Pt complexes can be stabilized by using a ketimide ligand. In this work, we report the synthesis of new group 10 ketimide complexes through addition of $Li[NC^tBu_2]$ to $MCl_2(PhCN)_2$ (M = Pd, Pt) and $PtCl_2$ under an inert atmosphere. The isolated products were characterized by Nuclear Magnetic Resonance (NMR), Infrared (IR) and UV-Vis spectroscopies, and single crystal x-ray diffraction. The addition of two equivalents of $Li[NC^tBu_2]$ to $PdCl_2(PhCN)_2$ produces a unique Pd_7 cluster where the metal centers have been reduced. A Pt analogue is currently being isolated, and is expected to also exhibit a reduction at the metal center. We conclude that, while ketimide ligands can stabilize higher oxidation states of transition metal ions, ketimide complexes of the group 10 elements present lower oxidation states at the metal center.

Functional Organic-Inorganic Hybrid Materials for Optoelectronic Applications

Brenda Ontiveros, Chemistry, University of Texas at El Paso
Hayden Evans, Ram Seshadri. Chemistry and Biochemistry

Hybrid organic-inorganic lead halide perovskite materials have recently emerged as excellent and cost effective light harvesters in single junction solid-state solar cells. However, though these materials have remarkable performance they also suffer from air sensitivity and degrade within hours. In order to address this issue, it has been shown that chemically modifying and incorporating simple hydrophobic organic amines into the material's atomic structure increases air stability. We are currently expanding off of this this strategy by using novel chromophores as our hydrophobic organics to potentially boost photo absorption and efficiency. Due to strong visible light absorption and photostability, we have chosen to explore materials with unsubstituted dipyrrin chromophores. We utilize one-pot solvothermal preparation techniques to access thermodynamically stable single crystal quality materials. Current work is still ongoing but we have so far successfully isolated and characterized one bismuth iodide hybrid material.

Preparation, Characterization and Electrochemical Testing of Transition Metal Sulfides for Conversion Battery Materials

Minue Perez, Chemistry, California State University Long Beach
Megan Butala, Claudia Goebel, Shiri Arnon, Ram Seshadri, Materials

Lithium (Li) ion batteries that function by intercalation exhibit excellent performance as electrochemical energy storage for portable electronics and electric vehicles. Some disadvantages include high cost, toxicity, and limited storage capacity of less than one mole of Li per formula unit mass. We investigate conversion systems based on elemental sulfur as alternatives for next-generation secondary batteries in view of its lower cost and higher abundance. Li–S batteries promise a considerably higher storage capacity than intercalation Li-ion systems. To design an improved material for conversion batteries, various transition metal sulfide cathode materials are prepared. The cathode materials consist of a transition metal to be readily reduced and oxidized in the cell; binary and ternary compounds are synthesized, including CoS_2, FeS_2, and $CuTi_2S_4$. To synthesize our sulfur-based cathode materials, the elements are mixed, pressed into bar pellets and sealed in silica tubes. We carry out conventional solid-state preparation, which consists of multiple heating steps, each lasting five to seven days. We introduce an efficient and quick microwave-assisted heating as an alternative that significantly decreases preparation time for these compounds. Phase purity as well as particle size and morphology of the transition metal sulfides are confirmed through Powder X-Ray Diffraction (PXRD) and Scanning Electron Microscopy (SEM), respectively. Subsequently, batteries are assembled with prepared materials as the cathode with a liquid electrolyte. Electrochemical cycling is investigated by constant current cycling. We present a novel, rapid microwave-assisted preparation for transition metal sulfides of interest as alternative battery materials.

Conductivity in 3D Printing Ink using Acoustically Focused Microparticles
Terrence Polk, Physics, University of Houston
Leanne Friedrich, Tyler Ray, Matthew Begley, Materials

3D printing is a growing field of engineering and design with its ability to produce products made entirely in one piece that are much lighter than multicomponent parts made of similar materials while still being strong and rigid. The ability to print conductive inks using acoustically focused particles will allow us to print multifunctional components that can be made conductive or non-conductive by toggling focusing. Acoustical focusing is achieved by using a piezo and signal generator to create a standing wave inside our printing channel. When the particles flow through the channel, the standing wave pushes the particles towards the center creating a line of particles in the ink. We tested various concentrations of silver coated copper spheres and dendrites inside an epoxy base insulator to see trends in conductivity. We found a formula that had good conductivity and took it to our linear printing stage to print lines and retest the conductivity. The linear printing stage utilizes a linear stage, a mass flow controller, two cameras, and a Matlab script to control it all. We found that 20% spheres, 40% dendrites and 40% epoxy base exhibited the best conductivity with around 2 MΩ; however, this concentration is not printable as that concentration of dendrites will clog the tubing. We took this information and scaled down the concentration of spheres and dendrites using the 1:2.02 ratio from the 20%/40% ink to achieve similar conductivity in a printable concentration by forcing less the particles into close proximity.

Development of an Accurate Assay for the Detection of Tumor Necrosis Factor-Alpha
Breirra Raynor, Chemistry, Jackson State University
Tracy Chuong, Galen Stucky, Chemistry & Biochemistry

Protein detection plays an essential role in early disease diagnosis and biodefense applications. One commonly used clinical technique for protein detection is the Enzyme Linked Immunosorbent Sandwich Assay (ELISA) which utilizes antibodies to capture targets to produce colorimetric signal. However, signals generated from unaccounted non-specific binding by antibodies result in high false-positive readouts, leading to misdiagnosis in patients. To address these issues, we use Surface Enhanced Raman Spectroscopy (SERS) together with the ELISA sandwich model to create a more accurate assay. Recently, SERS has been gaining momentum as a highly sensitive technique for detecting biomolecules in complex media. Using the model protein tumor necrosis factor-alpha (TNF-α), a protein with fundamental functions in inflammation and immune system development, we created an assay that eliminates non-specific binding while also reporting a precise readout of true protein binding. In this assay we immobilized two distinct affinity reagents specific to TNF- α onto gold nanoparticles (AuNP) and gold film pre-labelled with Raman reporters. TNF- α mediates the joining of the AuNP with the film to produce surface enhanced Raman signals that correlate the concentration of the protein to the intensity of the signal. A series of passivating agents were also considered to decrease non-specific binding. With this construct, standard curves were produced in buffer solution with a limit of detection around 100 pM, well within the range of TNF- α found in the body. This assay demonstrates the possibility of monitoring disease states through quantification of key biomarkers.

Characterizing Diamond Optomechanical Resonators
Alison E. Rugar, Engineering Physics, Cornell University
Jeffrey V. Cady, Ania C. Bleszynski Jayich, Physics

Hybrid quantum systems have recently garnered attention for their potential to combine the strengths and minimize the weaknesses of different quantum systems. Here we investigate hybrid quantum systems consisting of nitrogen-vacancy (NV) centers in diamond optomechanical crystals (OMCs), which host high-quality factor (Q), gigahertz-scale mechanical modes. NV centers are atom-like defects in diamond whose highly coherent spin states can be prepared and read out optically. The spin and orbital states of NV centers can also couple to phonons in an OMC via mechanical strain, thus enabling a hybrid quantum system that may mediate interactions between photons, phonons, and spins. For NV centers in a hybrid qubit-mechanical oscillator device, coherent quantum information exchange is possible if the figure of merit cooperativity, $\eta = g^2/\kappa\gamma$, is greater than 1, where g is the strain coupling rate between the mechanical resonator and the NV center spin or orbital excited states, κ is the NV spin or orbital decoherence rate, and γ is the mechanical rethermalization rate. We have built an optical setup that will measure the reflected

power from OMCs as a function of incident wavelength. With our collaborators at Stanford, we detected optical modes in our diamond OMC devices at wavelengths below 1500 nm, out of range of the components of our setup, which operate in the 1530-1560 nm band. Using the finite element method software package COMSOL and the optimization function fminsearch in MATLAB, we developed an improved resonator design that gives a zero-point strain of 6×10^{-8}, an optical Q of 6×10^{5}, and optical modes in the desired 1530-1560 nm band. Future integration of this system with a confocal microscope would enable the study of the interactions of mechanical modes in OMCs with NV centers at room temperature, a step towards experimentally realizing a hybrid quantum system.

The Synthesis of Sterically Hindered Amines For the Creation of Pharmaceutical Drugs
Miranda Sroda, Biochemistry and Cell Biology, University of California San Diego
David Fisher, Javier Read de Alaniz. Chemistry and Biochemistry

Sterically hindered anilines are important to medicinal chemists due to their ability to increase the lipophilicity and metabolic stability of drug molecules. Current methodologies for the synthesis of hindered anilines often require harsh basic and acidic conditions and can be limited by over alkylation. We utilize a new methodology that overcomes these drawbacks and uses readily available starting material and abundant copper salt catalysts in a radical coupling reaction. We synthesize sterically hindered anilines through a radical mediated coupling process using alkyl halides and nitrosoarenes. This reaction occurs under mild reaction conditions with high functional group tolerance. We are currently developing an intramolecular process to access amino alcohols of various substituents. Currently we have synthesized amino alcohols utilizing the following nitroso compounds: 1-methoxy-4-nitrosobenzene, methyl 4-nitrosobenzoate, 1,3-dimethyl-5-nitrosobenzene, 1-iodo-2-nitrosobenzene, 1-chloro-3-nitrosobenzene, and 1-bromo-4-nitrosobenzene. The compounds are purified using column chromatography and characterized using NMR, Mass Spectroscopy and IR. We anticipate constructing a library of small molecules with a variety of functional groups using this process. This work will be applied in synthesizing new pharmaceutical drugs.

Computational Modeling of a Unique Region in Ribosomal RNA
Denis Victorov, Biochemistry, University of California Santa Barbara
Nathaniel Charest, Joan-Emma Shea, Chemistry and Biochemistry

One of the most remarkable nanomachines identified in biological systems is the ribosome. In particular, there exists an unidentified three-way junction (3WJ) in the ribosome that is highly conserved across biological kingdoms which appears to reflect some propensity for motion. This region is unique in that while its nucleotide secondary structure can be accurately determined, when in the context of the ribosome, it folds in a completely unprecedented manner, with unusual tertiary contacts guiding its stable, interned structure. We intend to use NVT dynamics with a CHARMM force field and explicit solvent to probe the conformational landscape of the 3WJ and its associated molecular motions. We hope to use these methods to guide future experiments and strengthen existing theories regarding this portion of the ribosome.

Comparison of two mussel-derived compounds for applications in mussel-inspired underwater adhesives
Hannah Viola, Chemical Engineering, The University of Texas at Austin
Razieh Mirshafian, Chemistry and Biochemistry, Herbert Waite, Molecular, Cellular, and Developmental Biology

Mussels attach to a variety of substrates in sea water, an environment that is ordinarily hostile to adhesion. Previous research has shown that the catechol group found on 3,4-dihydroxyphenylalanine (dopa), an amino acid found in the mussel foot, is responsible for mussel adhesion. The catechol moiety is highly susceptible to oxidation and forms a quinone that cannot participate in adhesion. This oxidation process is reversed by cysteine, another amino acid found in mussels. We believe that the dopa quinone may also tautomerize to produce α,β-dehydro-dopa, a compound that can still participate in adhesion. The tautomerization could serve as a chemical pathway to keep catechol groups present in mussel plaques despite their oxidative environment. To gather evidence for this hypothesis, we are interested in determining whether α,β -dehydro-dopa has an impact on adhesion in mussels. Two model compounds, representative of dehydro-dopa and dopa, were studied: caffeic acid and 3,4-dihydroxyhydrocinnamic acid (DHC), respectively. We studied each compounds' response to cysteine using cyclic

voltammetry. Compared to DHC, caffeic acid reacts more readily with cysteine. If dehydro-dopa is present in mussels, cysteine may be more efficient at reducing dehydro-dopa quinones than dopa quinones, an advantageous situation for mussels. To compare the adhesive capabilities of DHC and caffeic acid, we made adhesives using coacervates and a chelating agent in addition to a model compound. We measured the force required to pull apart metal plates glued with the adhesive, and we did not find a difference in the adhesive strengths of caffeic acid and DHC.

Using microscopy to assess the duration of stability of a hydrophobic drug within lipid membranes

Natalie White, Chemistry, Jackson State University
Victoria Steffes, Cyrus Safinya, Materials, Chemistry and Biochemistry

Targeted drug delivery is a method of bringing higher concentrations of anti-cancer drugs directly to the targeted site in the body while simultaneously attempting to minimize interaction of cytotoxic drugs with healthy tissue. Paclitaxel (PTXL), a small molecule drug, is one of the most widely-used anti-cancer agents for the treatment of breast cancer and ovarian cancer. However, PTXL has poor water solubility and low bioavailability due to its hydrophobicity. EndoTAG (™), a liposome-based formulation to deliver PTXL, is currently in phase three clinical trials in Belgium. EndoTAG (™) is a known three component formulation consisting of DOPC, DOTAP, and PTXL. We want to understand what benefits come from using these components in the trademarked formulation, and how altering the formulation may enhance drug delivery properties. Polyethylene Glycol (PEG) is a hydrophobic polymer ubiquitously used to coat nanoparticles of all types for drug delivery. This coating is necessary to allow enhanced therapeutic delivery and to augment in vivo retention time. We want to understand if including PEG lipids in the liposome formulation has an effect on the particles' ability to solubilize PTXL. We can study this further by checking how this varies as a function of PEG length and the amount of PEG-lipid that is incorporated in liposomes. During our experiments, we varied the composition of liposomes in EndoTAG (™) to contain different amounts of PTXL in particles with and without a PEG polymer coating. The series of samples were analyzed using Differential Interference Contrast (DIC) Microscopy to optically observe phase separation of PTXL into crystals and thus determine the relative duration of stability imparted by different membrane properties.

Gorman Scholars Program (Gorman)

http://gorman-csep.cnsi.ucsb.edu/

The Gorman Scholars Program provides UCSB undergraduates across all STEM majors an opportunity to receive invaluable mentoring from faculty, postdoctoral researchers, and graduate students, while pursuing innovative interdisciplinary research projects. The internship begins in the summer and continues through the academic year. Each scholar is mentored by a member of the UCSB faculty, who assists the student in designing a plan of research and enrichment activities fitted to the individual interests and academic goals of the student. Support through the Gorman Scholars Program includes: written and oral communication training, leadership and professional development opportunities, networking with academic and industry professionals, and resources to attend one professional conference. This program is hosted by the Center for Science and Engineering Partnerships (CSEP) at the California NanoSystems Institute (CNSI) and the Office of the Dean, Math, Life & Physical Sciences. The Gorman Scholars program is graciously funded by a gift from the Gorman family.

Shear Flows of Dense Suspensions
Meital Carmi, Mechanical Engineering, University of California Santa Barbara
Bernhard Vowinckel, Edward Biegert, Eckart Meiburg, Mechanical Engineering

We are researching the behavior of a dense suspension of particles experiencing a shear force. Understanding this fluid behavior has a wide variety of applications, including rivers and canals with large amounts of sediment and debris. Controlling these flows can prevent flooding and jamming, and increase the efficiency of such systems. In dense suspensions, a very small increase in the shear force often causes the viscosity of the mixture to increase abruptly. This effect, called discontinuous shear thickening (DST), occurs only in flows with a large amount of suspended particles. This suggests that DST is caused by some element of the particles' behavior, particularly their spatial distribution, clustering, and mixing. We use numerical simulations to model the flow of a dense suspension when a shear force is applied. We then apply the Voronoi tessellation to perform a statistical analysis, quantitatively measuring the particles' clustering and mixing behavior.

New Apparatus for Double Nuclear Magnetic Resonance Experiments
Ian Jenkins, Physics, University of California Santa Barbara
Ting Ann Siaw, Song-I Han, Chemistry and Biochemistry

Nuclear Magnetic Resonance (NMR) spectroscopy is a widely used technique in chemistry that gives an insight into structure of molecules, properties of materials, and dynamics of molecular systems. Many attempts to do solid state spectroscopy have been thwarted by the spectrum broadening that occurs because the molecules are close together, tightly bound, and thus interact easily. We wish to show that using a combination of dynamic nuclear polarization and cross polarization of nuclei can result in successful static solid-state experiments. We believe that this can be accomplished by a chain of spin polarization from electron, to proton, to finally, carbon thirteen. Though we do not have data yet, similar experiments involving transfer of spin have shown a significant improvement in detected signal. Additionally, we have a unique probe design that will allow us to do a variety of experiments on many different nuclei.

Enhancing Spectral Usage Through Full Duplex Communication
Fernando Mendoza, Computer Engineer, University of California Santa Barbara
Hussam AlShammary, James Buckwalter, Electrical and Computer Engineering

In the following years, network speeds, devices connected to the internet, and data traffic will continue to increase. As a result, the demand for the radio spectrum will also increase. Due to the inefficient method in which the radio spectrum is used today, in the upcoming years, the radio spectrum will be reallocated and used to its potential. In order to reallocate the spectrum, one must understand how it is used today. In this project, I study LTE bands in the radio spectrum to determine underutilized frequencies. My advisor, mentor and I, use a software defined radio (SDR), model NI USRP 2930, to receive the signal, then follow this with a combination of Matlab/ LabVIEW to pre-process the signals and then apply the Fast Fourier Transform (FFT) and a detection algorithm to identify the frequencies present in the spectrum.

Increasing Organic Photovoltaic (OPV) Efficiency
David Nakazono, Physics, University of California Santa Barbara
Ryan DeCrescent, Jon Schuller, Electrical and Computer Engineering

Organic photovoltaic cells -- being lightweight, durable, flexible, and cost-efficient -- present novel opportunities for optoelectronic devices, wearables, and other technologies. Unfortunately, they lag behind inorganic cells in energy harvesting efficiency. The Schuller Group theorizes that this efficiency can be enhanced by optimizing the orientation of organic polymers used in these devices. In order to demonstrate this theory, we use Momentum-Resolved Spectroscopy to characterize the substrate's plasmon dispersion relation and absorption characteristics. We find that our experimental setup is capable of determining, with high accuracy, the location of maximum absorption in our substrate.

Separating Particles Using Tangential Flow Filtration and Inertial Microfluidics
Amanda Singleton, Mechanical Engineering, University of California Santa Barbara
Mike Garcia, Sumita Pennathur, Mechanical Engineering

The separation of micron-sized particles is a crucial component in a myriad of applications. Recently researchers have attempted to use inertial microfluidics to separate particles because the technique requires smaller sample volume, has a high throughput, and is inherently robust. Unfortunately, inertial microfluidics lacks versatility: geometric considerations limit variation of particle size. To overcome this limitation, we experimentally investigate the effect of adding permeate flow to refocus particles into tunable equilibrium locations. Specifically, we experimentally investigate the effect of permeate flow on the equilibrium location of 5, 10, and 15-micron polystyrene particles in a MEMS fabricated tangential flow filtration device. We see that contrary to inertial focusing in straight microfluidic channels, smaller particles focus closer to the center than larger particles. Furthermore, the particle equilibrium location is a function of streamwise distance, and equilibrium location at the exit is a function of the ratio of outlet to inlet flow. Taking advantage of this data, we aim to create in-situ control of particle equilibrium locations resulting in real time separations of particles of unknown size distribution. This method can be combined with on-chip devices for diagnostic applications, benefitting the fluids and separations community.

Institute for Collaborative Biotechnologies
Summer Applied Biotechnology Research Experience (SABRE)

The ICB Summer Applied Biotechnology Research Experience (SABRE) is designed to recruit and train a diverse group of students whose interests lie in the STEM (Science, Technology, Engineering, and Mathematics) research areas. The program provides a 10-week, full-time research experience for graduate and undergraduate students with all research projects being conducted in our state-of-the-art ICB labs. Each trainee is partnered with a mentor of similar interest and has an opportunity to network with other graduate students within the STEM areas. The interns are engaged in research projects under the direction of a faculty advisor and a lab mentor. In addition to hands-on learning, the program integrates professional development through research seminars, career development workshops, practice talks and presentations, as well as weekly oversight meetings. ICB is committed to providing strong foundations in the STEM areas for undergraduate and graduate students while establishing a pipeline into UCSB STEM graduate programs through ICB research labs.

Effects of Transcranial Magnetic Stimulation on Memory-Based Decision-Making
Tsion Andine, Biology, Jackson State University
Evan Layher, Michael Miller, Psychological and Brain Sciences

Memory-based decision-making is the cognitive process of determining whether something was previously encountered or not. To improve the outcomes of our memory-based decisions we must gauge the strength of our memories as well as take into account the likelihood of the memory and consequences of a wrong decision. Decision criterion is an essential factor in recognition memory that determines the amount of evidence or memory strength required to judge an item as previously encountered. A conservative (cautious) criterion establishes a higher standard of evidence for recognition and designates fewer items as previously studied, while a liberal (lax) criterion establishes a lower standard of evidence and designates more items as previously studied. According to previous results from fMRI studies, the inferior frontal gyrus (IFG) showed the greatest activation during conservative versus liberal decision-making. To verify that the IFG provides an essential contribution to conservative decision-making, transcranial magnetic stimulation (TMS)- a noninvasive method of stimulating targeted brain regions - was used to create a transient lesion in the IFG in an attempt to disrupt conservative decision-making and cause people to establish a more liberal criterion. Preliminary results contrarily suggest that people tend to become more cautious with their decision-making after TMS of the IFG.

Contextual Information Influence on Steady-State Visually Evoked Potentials during Visual Search
Desiree Conton, Jackson State University
Amir Meghdadi, Miguel Eckstein. Psychological & Brain Sciences

Humans are able to perform visual search efficiently; however, researchers do not fully understand how the brain processes sensory and environmental input to achieve target detection among distractors. To study visual search mechanisms, researchers use electroencephalography (EEG) to observe neural activity and subsequent behavior. Steady-state visually evoked potentials (ssVEPs) are EEG waves elicited by stimulating the visual system at a fixed frequency (Hz). Previous research has shown that contextual information expedites object recognition. The purpose of this study is to assess the contribution of contextual information on subject EEG ssVEPs while they are monitored for target detection performance. Our results show a comparison of ssVEPs power between variables Target Mouse Absent and Target Stapler Absent. The keyboard in this study is a co-occurrence contextual cue, an object that is

spatially close to a target. The keyboard and cup were tagged at 14.1923 Hz and 12.1648 Hz, respectively. We expected when Target Mouse is absent subjects would display a higher ssVEP power at 14.1923 Hz and lower ssVEP power at 12.1648 Hz than Target Stapler. A t-test of standard error of means between the two variables at both frequencies for all subjects, all channels determined there is no significant difference. For future work, we could modify the study by generating two images, an in-context tagged at 14.1923 Hz and an out-of-context tagged at 12.1648 Hz. We suspect this change will result in a significant difference between Target Mouse Absent and Target Stapler Absent.

Combining Top-Down and Bottom-Up Approaches in Deep Learning

Temesgen Fiseha, Computer Engineering, Jackson State University
Soorya Gopalakrishnan, Upamanyu Madhow. Electrical and Computer Engineering

Backpropagation**,** the standard learning algorithm for neural networks, is a supervised algorithm that trains the network in top-down fashion. In contrast, Adaptive Hebbian Learning (AHL), a recent approach based on the 'fire together, wire together' neuroscience principle, is completely unsupervised and trains the neurons bottom-up. In this project we combine the two different algorithms and observe how they interact.

Generating Isogenic Cell Lines to Study the Influence of the CRB1 Gene on Retinal Degradation

Sebastian Fonseca, Biomedical Engineering, Arizona State University
Mei Jiang, Dennis Clegg. Molecular, Cellular, and Developmental Biology

Retinitis pigmentosa (RP) is a chronic genetically inherited disease that afflicts over 100,000 patients in the United States. Patients with RP suffer from a progressive degeneration of their photoreceptors, photosensitive cells in the retina of vertebrate animals, resulting in severe vision impairment. Several mutations in the CRB1 gene are associated with varying phenotypes of RP, however the p.Cys948Tyr amino acid substitution is one of the most prevalent ones. By using the latest genome-editing tool, CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats), we can create isogenic cell lines with the desired CRB1 mutation to study the pathogenesis and potential therapy for RP. During this experiment we carried out the initial steps of the CRISPR/Cas9 genome editing technique to construct plasmids expressing guide RNAs. In this process, bacterial vectors were digested, dephosphorylated, and gel purified. Later on, a ligation was done in order to insert a short 20bp DNA fragment (annealed and phosphorylated) into the vector. The ligated DNA was then transformed into chemically competent cells (NEB Turbo). Turbo bacteria were grown on ampicillin plates and surviving colonies were those with the constructed plasmids that carried the specific DNA sequences, coding for the sgRNAs that are to be used in the future procedures of the CRISPR methodology. Individual clones were picked out and grown in LB media with ampicillin. Mini-preps were then carried out to extract and purify the plasmid DNA from the bacteria. It was confirmed by sequencing that the purified plasmids did in fact have the desired sequence inserted inside.

Maximizing Access to Research Careers
Undergraduate Student Training in Academic Research
(MARC U*STAR) Program

http://marc-csep.cnsi.ucsb.edu/

The Maximizing Access to Research Careers - Undergraduate Student Training in Academic Research (MARC U*STAR) Program is funded by the National Institutes of Health (NIH). The program seeks to increase the number of highly-trained biomedical and behavioral scientists, from disadvantaged or underrepresented backgrounds, in leadership positions to significantly affect the nation's health-related research needs. MARC Scholars embark upon a two-year program of scientific research, leadership development and graduate school preparation guided by individual biomedical faculty mentors across UCSB science and engineering departments and staff at the Center for Science and Engineering Partnerships.

Detecting and Quantifying Bacteriophage M13 on Human Skin
Young Hun Kim, Biochemistry, University of California Santa Barbara
Baoqing Zhou, Samuel Verbanic, Irene A. Chen. Chemistry and Biochemistry

The rise of antibiotic-resistant bacteria necessitates alternatives to antibiotics for disease treatment. Bacteriophages, natural viruses that infect bacteria, are an under-utilized resource for treatment alternatives. Though studies have demonstrated the potential of phage therapy, the prevalence and composition of phages in human skin infections remain insufficiently understood. This lack of understanding comes in large part from the absence of a phage characterization protocol for human skin samples. In this project, we develop a protocol to detect and quantify *E. coli* phage M13 from human skin swabs. Using the PureLink Viral DNA/RNA Mini Kit and quantitative polymerase chain reaction, we have established a limit of detection for phage M13 at 10^6 PFU. Further phage quantitation will be conducted by Illumina high-throughput sequencing. Though this protocol targets the recovery of phage M13 only, it provides a preliminary model for skin swab metagenomics of other phages in the microbial wound community.

Facile Chain End Modification of RAFT Polymers
Shelby Shankel, Chemistry, University of California Santa Barbara
Emre Discekici, Javier Read de Alaniz. Chemistry and Biochemistry

Reversible addition-fragmentation chain transfer (RAFT) polymerization is a widely utilized method to prepare polymers with control over molecular weight and chain end composition. However, there is ongoing effort for the modification of RAFT polymer chain ends due to instability, undesired odors, and potential toxicity. Current methods for chain-end modification include reactions with nucleophiles, thermal elimination, radical cross-coupling reactions, and Diels-Alder reactions. To further contribute to the field, our research involves the modification of RAFT chain ends to bromine in order to make further functionalization easier. In this way, the chain end of RAFT polymers could easily be tailored to fit an array of applications from plastics in materials to micelles for drug delivery. The polymer chain ends are first transformed into thiols by undergoing a known aminolysis reaction. A commercially available brominating reagent is then employed to replace the thiol with a bromine chain end. Optimization is being done on this system by investigating different reagent equivalents, temperatures, solvents, and atmospheres. Currently, the transformation to bromine can be achieved on small molecule systems, but further optimization is needed to modify the chain ends of RAFT polymers.

UCSB Mathematics Summer Research Program for Undergraduates 2016

http://math.ucsb.edu/REU/

The UCSB Summer Research Program for Undergraduates offers upper division undergraduate students with outstanding academic potential the opportunity to work closely with faculty mentors on mathematics research projects for eight weeks during the summer. This program is financially supported by the National Science Foundation.

The program has been designed for students who wish to learn more about the research experience and possibly pursue an academic career in teaching and research. Each student participant works individually or in a small group with a faculty mentor in one of the proposed research projects. The students also attend a weekly colloquium, participate in some workshops for professional development, and develop oral and written skills through weekly talks and reports.

Participating students receive a stipend of $4,000. Housing at the university and an allowance for travel expenses is also provided.

Students participating in this program must be United States citizens or permanent residents. Also, students who have received their bachelor's degree and are no longer enrolled as undergraduates are not eligible to participate.

Representation Theory of the 2×2 Reflection Equation Algebra $\mathscr{A}_q(2)$

Erica Clark; Mathematics, East Carolina University; **Thomas Retzloff**; Mathematics and Physics, Marquette University; **Ian Texeira**, Mathematics, Wesleyan University; **Susan Ye**, Mathematics, Brown University.
Ebrahim Ebrahim, Mathematics Department, UC Santa Barbara.

The 2×2 reflection equation algebra $\mathscr{A}_q(2)$ is a quantization of the algebra of polynomial functions on the space of 2×2 matrices over $\mathbb{C}$. It arises in quantum linear algebra as an alternative to the usual quantized matrix algebra $\mathscr{O}_q(M_2(\mathbb{C}))$. We study the structure of $\mathscr{A}_q(2)$ using the tools of modern noncommutative ring theory. Our work focuses on the case where q is a root of unity. We investigate the structure of this noetherian $\mathbb{C}$-algebra by expressing it as an iterated skew-polynomial algebra over a commutative domain. We use the skew-polynomial structure to get information about its center, and to make progress on the problem of classifying its irreducible representations.

Combinatorial Model of Quantum Skew Symmetric Matrices

Eleanor Campbell; Mathematics, Carleton College; **Phoebe Coy**; Mathematics, UC Santa Barbara.
Karel Casteels, Mathematics Department, UC Santa Barbara.

The quantized coordinate ring of $m \times n$ Quantum matrices, or simply quantum matrices, holds deep connections to the theory of totally nonnegative matrices, wave interactions and knot theory. We examine the less understood theory of quantum skew-symmetric matrices $O_q(Sk_n)$ over a field k. This algebra is known to be generated by a set of generators y_{ij}, $1 \leq i < j \leq n$, which satisfy certain commutativity relations dependent on some element $q \in k$. We view $O_q(Sk_n)$ from a combinatorial perspective. We prove that $O_q(Sk_n)$ is isomorphic to an algebra called A_n over k, defined graphically. A_n is generated by elements x_{ij}, where each x_{ij} is the sum of the weights of paths from i to j in a particular directed graph. The weights are obtained from elements of a space with simpler commutativity relations dependent on q. Using inductive methods on the graph, we prove that the generators of A_n satisfy the same commutativity relations of $O_q(Sk_n)$, allowing for a new combinatorial perspective that may be used to study this algebra.

A Simplified Approach to Block-Symmetric Linearizations of a Matrix Polynomial

Madeleine Martin, Mathematics, Brown University; **Alexander Song**, Mathematics, UC Santa Barbara; **Irina Viviano**, Mathematics and Computer Science, Wake Forest University.
Maribel Bueno, Mathematics Department, UC Santa Barbara.

Applications in physics and engineering often require knowledge of the eigenvalues of a matrix polynomial $P(\lambda) = \sum_{i=0}^{k} A_i \lambda^i$, that is, a polynomial with matrix coefficients A_i. The prevailing technique for solving this problem uses pencils, i.e., degree-one matrix polynomials, that preserve the eigenstructure of $P(\lambda)$, known as linearizations.
Structured matrix polynomials (e.g., polynomials with symmetric, skew-symmetric, or palindromic coefficient matrices) arise frequently in applications. Since the structure of a matrix polynomial is reflected in its spectrum, it is crucial to use linearizations that preserve the structure of the original polynomial.
Our work considers block-symmetric linearizations in particular. In the literature, there are two main approaches to such linearizations: the vector space $\mathbb{DL}(P)$ introduced in 2006 by Mackey, Mackey, Mehl, Mehrmann; and the block-symmetric generalized Fiedler pencils with repetition (GFPRs) discovered in 2015 by Bueno, Dopico, Furtado, and Rychnovsky. While certainly useful, both approaches have practical limitations—GFPRs are defined in terms of matrix multiplication, making them difficult to construct, while the matrix coefficients of pencils in $\mathbb{DL}(P)$ are not operation-free. We introduce a family $\mathbb{SLD}(P)$ of block-symmetric pencils containing all block-symmetric GFPRs, including the standard basis of $\mathbb{DL}(P)$. Not only does this family partially generalize the above block-symmetric pencils, but its members are also easily constructible as well as operation-free.

A unified approach for Fiedler-like pencils via block minimal bases pencils

Rafael Saavedra, Mathematics, UC Santa Barbara; **Bradley Zykoski** , Mathematics, University of Virginia.
Maribel Bueno, Mathematics Department, UC Santa Barbara.

Matrix polynomials are polynomials P whose coefficients are matrices with entries in a field. The polynomial eigenproblem, which asks for the eigenvalues of matrix polynomials, arises in the numerical solution of certain differential equations. However, due to the lack of appropriate numerical algorithms when the degree of P is greater than one, the eigenproblem is instead solved for linearizations of P, which are matrix polynomials of degree 1 sharing its finite eigenstructure.
In the past decade, intense research has been done on Fiedler-like pencils, linearizations whose block structure consists only of identity and zero matrices, coefficients of P, and particular chosen matrices. Beginning with the Fiedler pencils (2003, 2004), the family was generalized to Fiedler pencils with repetition (2011), and then generalized Fiedler pencils with repetition (GFPRs) (2015). However, the use of these linearizations has been impeded by their involved definition as products of matrices or outputs of symbolic algorithms.
This year, Dopico, Lawrence, Pérez, and Van Dooren demonstrated that all Fiedler pencils may be expressed in a block form avoiding these definitional complications. We unify the study of these Fiedler-like families by extending their work to GFPRs. We introduce a family of matrices, also with a simple block form, called Λ-dual pencils, and prove that all generalized Fiedler pencils with repetition may be expressed as Λ-dual pencils. In fact, our family is larger than the GFPRs, and lays the foundation for an extension to matrix polynomials expressed in nonmonomial bases.

$\mathscr{H}$-Primes of the Quantum Grassmannian

Christopher Keane, Mathematics, Reed College; **Samuel Kater**, Mathematics and Computer Science, Dartmouth College.
Karel Casteels, Mathematics Department, UC Santa Barbara.

While the structure of the prime spectrum of the algebra of quantum matrices has been understood for some time to be controlled by primes that are invariant under the action of an algebraic torus, finding generating sets for these primes was a much more recently solved problem. A 2014 paper of Casteels gave a new interpretation to quantum matrix algebras via a combinatorial model that represents algebra elements as sums of weights of paths in a certain directed graph, moving the problem from the field of algebra closer to the field of combinatorics. This interpretation made it possible to compute generating sets for those torus-invariant primes of the algebra of quantum matrices. We extend these results, using the paths model to compute generating sets for similarly invariant primes in a different algebra known as the quantum Grassmannian.

McNair Scholars Program

http://mcnair.ucsb.edu

The McNair Scholars Program prepares qualified undergraduates for entrance to a PhD program in all fields of study. The goals of the program are to increase the number of first-generation, low-income and/or underrepresented students in PhD programs, and ultimately, to diversify the faculty in colleges and universities across the country.

This federal program was established in memory of physicist and Challenger astronaut Dr. Ronald E. McNair. It is one of several TRIO programs funded by the Department of Education supporting the academic achievement of students from groups traditionally underrepresented in higher education. The UCSB McNair Scholars Program is supported by the Office of the Executive Vice Chancellor and the deans of the College of Letters and Sciences and the College of Engineering. Additionally, our science, technology, engineering, and mathematics (STEM) scholars are being funded by Edison International.

The UCSB McNair Scholars Program provides undergraduates with opportunities to participate in academic year and summer research activities. McNair Scholars attend courses, seminars and workshops on topics related to graduate school preparation; complete a research project under the guidance of a faculty mentor; and have the opportunity to present their research at local, regional and national conferences.

Newspaper Coverage and Representation of the 2007-2009 Recession
Juan Carlos Banda, Sociology, University of California Santa Barbara
Denise Bielby. Sociology

The Great Recession spanned from 2007 to 2009 and is considered the second worst recession in U.S. history. The economic crisis that ensued had a disproportionate effect on minority groups, who lost massive personal wealth during this time. This research investigates how four newspapers in the Western, Midwestern Southern, and Eastern regions in United States covered the Great Recession. This research has two goals, to analyze: (1) when these newspapers made the public consciously aware of the recession; and, (2) the discursive practices of these newspapers to identify how they promoted conscious awareness of the impacts of the Great Recession regarding unemployment and layoffs of particular ethnic groups in various regions of the country. This research aimed to identify how the media presented the recession and what information was conveyed to its consumer. Analyses of newspaper discourse reveled regional differences when when presenting the impacts of the recession.

Targeting IEP Social Goals in a Community Summer Camp Setting for Children with Autism
Fernanda Castellon, Psychology and Chicana/o Studies, University of California Santa Barbara
Lindsay Glugatch, Lynn Koegel. Education

Children with Autism Spectrum Disorder (ASD) demonstrate challenges in various areas, with one being that of socialization. Socialization issues can persist and worsen if not addressed, which can have a profound impact on a student's life. The purpose of this study was to assess whether Individualized Education Program (IEP) goals for ASD children could be targeted and improved during a short term inclusive summer camp program. In addition, goals were developed for children who lacked social goals on their IEPs based on their symptomology. Data were observationally collected using a concurrent multiple baseline design across four children. Results showed that following a two week intensive intervention all children reached their yearlong IEP goals and demonstrated improvement with peers in social areas. Findings will be discussed in terms of the importance of ongoing intervention and the feasibility of providing social interventions in inclusive settings during the summertime.

Digital Control Electronics For Optical Gyroscopes
Marco Cerrato, Physics, University of California Santa Barbara
Sarat Gundavarapu, Daniel Blumenthal, Electrical and Computer Engineering

High-end rotational sensor technologies, such as optical gyroscopes- used in aircraft navigation, are bulky and expensive devices and be improved. The Integrated Waveguide Optical Gyroscope (iWOG) project focuses on miniaturizing the current optical gyroscope models to smaller chip versions which are as functional as their current counterparts, while smaller in volume and more economical to produce. To understand and evaluate the device performance, we have assembled a fiber optic gyroscope test setup that uses discrete optical and analog electronic components. Our current focus is on the use of on-board digital control electronics for the iWOG chip to improve compactness and reduce the cost, while retaining the performance. We aim to use this external hardware to apply signals of varying frequencies to the iWOG circuit and search for the proper frequency of the system, the frequency at which the sensitivity of the optical gyroscope is maximized. To do so, I am using a Field Programmable Gate Array (FPGA) device to synthesize signals of varying frequencies and duty cycles. The final goal is to program the FPGA to generate a signal that has a dynamically controlled frequency which can be divided and multiplied by using button inputs, without the need of any system restarts. Successfully establishing digital control electronics brings us closer to realizing the iWOG project. When complete, the iWOG project will yield a new model of sensitive rotational sensors for inertial navigation systems and also has potential use in industries such as autonomous and remotely controlled vehicles.

Daniel Cha, Mathematics, University of California Santa Barbara
Nathan Schley, Bill Jacobs. Mathematics

Cohomology of Groups finds its historical origin in the early 1900s with Schur's work on projective representations [$PGL(n,k)$]. The topological motivation comes from Hurewicz's work stating that if X is a connected aspherical space, then all the homology and cohomology groups of X are determined by the fundamental group $\pi = \pi_1(x)$. The question is asking which groups G are extensions of H by K is known as the *Extension Problem* and has been studied extensively in the nineteenth century. Solving the extension problem is equivalent to classifying all the extension of H by K and is in general a non-trivial task.

On the Precipice of Change: the Fifth Monarchists
Katie Corriea, History, University of California Santa Barbara
Sears McGee. History

The seventeenth century in England saw a splintering of religious groups, some of which, like the Fifth Monarchists, turned toward radicalism. In this study I traced the spread of religious ideas from mainstream Puritans to Fifth Monarchists and examined the catalyst for movement into radical thought. The idea of the Puritan Millennium was not new, but for the Fifth Monarchists the radical idea was that through historical analysis of the Bible the precise date for the beginning of the Millennium could be discerned. In some cases, this religious radicalism led to political radicalism, like the Thomas Venner and his followers. This study examined what factors cause a person or a group to fracture into a radical sect apart from the mainstream, through a case study analysis of the process of change, which focused on the Fifth Monarchists and the factors spurred them into radicalism.

Fashion, Power & Identity: Traditional Dress as a Symbol of Resistance in 20th Century Nigeria
Zingha Foma, Theater, University of California Santa Barbara
Holly Roose, Mhoze Chikowero. History

Colonialism was pivotal in Nigeria's history, especially as colonial domination was achieved through force and intimidation. British economic and political interests were not just anchored in the colonial endeavor, various forms of violence proliferated in ensuring these interest. As a British 'protectorate', from 1901 to 1960, Nigerians resisted colonialism in various ways. One important way was through dress. This study examines how dress, in the 20th century provided Nigerians unique frameworks of contestation and reclamations of African identities. This form of resistance was crucial because colonialism was a far-reaching ideological project premised on reforming the

'uncivilized native'. The methodology consists of bibliographic reviews of key texts that cover dress in Nigeria. Furthermore, this project utilizes primary resources, such as original African textile creations as well as photographic imagery. Findings provide insight into the dynamics of Nigerian dress, identity politics, and cultural transformations, especially as they evoke modes of resistance.

Latino Adolescents' Mental Health
Maria Garcia Garcia, Psychology and Applied Psychology, University of California Santa Barbara
Erin Dowdy. Counseling, Clinical, and School Psychology

Approximately 20 percent of children and adolescents experience mental health problems. Latinos are the largest growing population in the United States, with significant mental health needs that are not being met compared to the general population. Mental health issues are associated with academic problems and poorer life outcomes. Given that adolescents spend a majority of their time in schools, schools are an optimal environment to address the mental health needs of Latino adolescents. This study seeks to better understand how universal screening for complete mental health aligned with the two-continua model is useful in identifying Latino students' mental health functioning. Online surveys were administered to students (N = 1,889) at a high school in central California to screen for complete mental health, which involves assessing for psychological distress and personal strengths. Results can help school staff develop resources and programs that can positively impact students' mental health and promote well-being.

Volcano Infrasound: An Overview
Angel Gonzalez, Earth Science and Geophysics, University of California Santa Barbara
Robin Matoza. Earth Science

Infrasound is being used to study a variety of natural phenomenon including storms, tornadoes, and volcanic eruptions. Infrasound is effective for detecting, locating, characterizing, and quantifying volcanic activity. Infrasound can be monitored remotely to provide a continuous record of a volcanoes eruptive activity. With an increased study to further understand a volcanoes eruption dynamics, infrasound data could give an early warning system for airplanes in the flight path of an imminent eruption. Microbarometer infrasound arrays are the primary instruments being deployed to gather data from infrasound signals. Overall, the purpose of my project is to understand the methods used to study a volcanoes infrasound wave field that it emits to re-create the findings from Matoza *et al*, 2007 "An infrasound array study of Mount St. Helens" and eventually conduct an infrasound study of regional volcanoes in Ecuador.

Land of Injustice: the Community Struggles over Land Redistribution in South Africa
Joshua Hudson, Global Studies and Sociology, University of California Santa Barbara
Holly Roose, Mhoze Chikowero. History

South Africa has a rich history of activism and resistance. South Africa's apartheid practices can be traced back to the 1913 Native Land Act, which racially segregated the African population onto reserves. The Native Land Act laid the foundation for official apartheid policy that would be legally in effect from 1948-1994. Despite removal of the legal language, apartheid continues to plague the country in practice. In response to contemporary apartheid practices by the local government, activists are igniting protests across the country. My research argues that apartheid still exists in contemporary South Africa and examines the ways that South Africans have organized to resist current racist policies. To carry out this study, I analyze activists' responses toward their government and land redistribution. Findings suggest that contemporary activists are claiming that divisions of rural populations, forced removals, and ineffective regional action are still in effect just as they were under formal apartheid.

Mapping Mexico's Narcotrafficking: Analyzing the Spatial-Temporal Distribution of Cartel Violence and Political Control

Monica Lemus Valencia, Geography, University of California Santa Barbara
Keith C. Clarke. Geography

Cartel violence in Mexico commenced with the demise of Colombian cartels and the shift to Mexico as the main smuggling route for cocaine to the US. Violence and homicides have increased due to a cartel war over territories. Major changes in political control have strengthened and weakened certain cartels. This research will examine data gathered from the government of Mexico, as well as reports the Drug Enforcement Administration (DEA). GIS and mapping software is used to map data by Mexican states and municipalities to visualize the spatial-temporal change of cartel violence, in relation to the changes in political control from 1990-2015.

Staying Relevant: A Comparison of Popular Media and the Linguistic Portrayal of Latinas/os

Victoria Melgarejo, Linguistics and Spanish, University of California Santa Barbara
Mary Bucholtz. Linguistics

The Latina/o population is the fastest growing in the United States accounting for 17%. However, in entertainment media Latinas/os account for less than 5% of screen performances. Moreover, when Latinas/os are given roles in film and television they oftentimes are subjected to offensive and hurtful stereotypes; evident even in the scripted language they are given. The present study examines the linguistic portrayal of Latinas/os in several seasons of five scripted television comedies that center on Latina/o families. Through a qualitative analysis we examine the show's representation of Spanish interactions as portrayed through the intergenerational interaction of Latina/o characters, their different levels of bilingualism, and the use or non-use of subtitles. In addition, we compare the emergent themes and patterns from the data to scholarly work that describes the linguistic complexity of Latinas/os' language use. Our preliminary findings suggest that the use of Spanish words creates an authenticity effect.

Utilization of Campus Student Services among Latino/a College Students: a Mixed-Methods Approach

Andrea Mora, Psychology and Applied Psychology, University of California Santa Barbara
Sabrina Liu, Diana Capous, Maryam Kia-Keating. Counseling, Clinical and School Psychology

Latino/a students' enrollment rates in higher education are proliferating, and there is a dearth of research on their utilization of university mental health and student services. Latino/a students report greater alienation, isolation, and stress when compared with their Caucasian counterparts. Therefore, it is critical for Hispanic Serving Institutions (HSIs) to examine service utilization patterns and preferences among Latino/a college students to address their mental health needs. Two studies were conducted with first year students at a large public HSI university in California. In study one, 44 Latino/a students responded to open-ended questions regarding their use of campus resources**.** Responses were coded using thematic analysis and pointed to two major barriers: time and awareness about resources. Study 2 used online surveys with a diverse group of students (N=432; 38% Latino/a) to compare the frequency of visits to campus services. Significant differences in utilization patterns were found between Latino/a and Caucasian students.

The Rise of China:A Look into How China Is Solidifying Its Position as an East Asian Major Power

Jorge Moran, Global Studies, University of California Santa Barbara
Bridget Coggins. Political Science

There are two sides to the debate on the rise of China: (1) will China be aggressive in its military expansion forcing surrounding states to balance against it, or (2) will China's ascendance prompt states to join their creation of a paradigm of stability, peace, and prosperity for East Asia? To investigate the political tactics employed by China, an array of political science literature on both sides of the spectrum will be content-analyzed. This research uses a classification scheme of China's policies and both operationalizes and defines important concepts related to the debates of East Asian specialists and scholars and investigates the importance of stemming away from traditional western models by providing discussion on the tensions between two disparate schools of thought. This is significant

in that it facilitates the development of new perspectives, methods, and models when confronting this contemporary issue.

A World I Never Made: Identity Dualism in the Fictional Novels *George Washington Goméz* and *The Autobiography of a Brown Buffalo*
Francisco Olvera, English, University of California Santa Barbara
Felice Blake. English

Identity, a construction of the surrounding world (society, culture, etc.), is "the essential core of who we are as individuals, the conscious experience of the self inside" (Kaufman). For racial minorities living in the United States, however, their identities, their "essential cores", reflect a history of alienation and oppression. For this project I conducted a close reading of the fictional novels, *George Washington Goméz* and *The Autobiography of a Brown Buffalo*, written by Américo Paredes and Oscar Zeta Acosta, respectively. I highlight the malevolent roles law and practices play in the formation of a fragmented and split identity, one of a "double-consciousness", and how this fragmentation further complicates the manifestation of Chicano masculinity. Acting as artistic mediums, these fictional novels expose racial formation in a way that differs from that of other disciplines/ studies, thus allowing for individual unique accounts of the psychological turmoil that defines a fragmented identity.

HIV Risks among Men Living in Rio de Janeiro, Brazil: Medical History, Sexual Behavior, and Attitude
Marina Quintanilla, Global Studies and Feminist Studies, University of California Santa Barbara
Laury Oaks. Feminist Studies

High-risk sexual behavior among men is a major concern to health educators, community health workers and health policy officials throughout the world. Previous studies demonstrate that medical history, sexual behavior, and attitudes regarding gay identity are associated with high-risk behaviors. The aim of this study is to assess levels of HIV risk among men residing in Rio de Janeiro and examine how medical history, sexual behavior, and attitude correlate with HIV-status. Through a cross-sectional approach, data was collected between 2014-2015. An online survey in Portuguese was completed by 346 participants. The study population included men residing in Rio de Janeiro, 18 or older, who had sex with other men in the last 6 months. Microsoft Excel and SPSS were used to analyze the data. Results demonstrate the need to focus on multi-directional and complex interrelationships between behavior and sexual risks.

Designing a Novel Telescope for Exoplanet Research
Christian Rodriguez, Physics, University of California Santa Barbara
Benjamin Monreal. Physics

Since the time of Galileo, telescopes have had an immense impact on our understanding of the Cosmos. However, most telescopes have been unable to tell us much about the composition of planets orbiting other stars (i.e. exoplanets). This project aims to find a design for a novel telescope concept. The design is meant to reduce construction costs by decreasing the reflector size in one dimension, while also accommodating for exoplanet direct imaging and spectroscopy. The current study searches for the best telescope design by comparing optical aberrations, such as coma and astigmatism, via optical simulations on Zemax OpticStudio. We hypothesize that a Ritchey-Chretien design is the best prescription for this novel telescope concept. In comparison to similar class telescopes, this telescope has the ability to yield lower costs and therefore is an excellent option for exoplanet direct imaging, making it possible to determine planet composition and habitability.

Is Readability an Open Invitation to Rejection or Solution?: the Effects of Self-Esteem on Self-Disclosure When Feeling Readable

Sirenia Sanchez, Psychology and Communications, University of California Santa Barbara
Lauren Winczewski, Nancy Collins. Psychological and Brain Sciences

Low self-esteem individuals (LSEs) receive different kinds of social support from close others, but little is known about the ways self-esteem affects support-seeking behavior. Participants (N = 162) were asked to write an email to their romantic partner about a current personal problem. We measured how readable they felt their note was to their partner, and a team of objective coders rated the degree of positive outlook and anxiety disclosed in the notes. Results revealed that when LSEs felt more readable, they disclosed their problems by expressing their fear and anxieties. When individuals of high self-esteem (HSEs) felt more readable, they sought support that conveyed a greater positive outlook about their personal problem. The findings illustrate how support seeking is affected by the interplay of personality and situational factors, and not necessarily the problem itself.

Determining Propane Consumption by Marine Microbial Populations in Seawater

Nancy Torres, Environmental Studies, University of California Santa Barbara
Frank Kinnaman, Ellie Arrington, David Valentine. Earth Science

There is little known about the effects of the long term effects of catastrophic oil and natural gas release on the marine environment. Natural gases have been found to directly affect the ocean's biogeochemistry, as seen during the Deepwater Horizon Oil Spill. Finding the true extent of the impact of these abundant hydrocarbon compounds is meaningful towards building a greater understanding of the ability of the ocean as a natural microbial filter on hydrocarbon release. To further research this natural gas input, 100 μL of propane was injected in seawater collected at Goleta Pier. These samples were subsequently analyzed with oxygen respirometry by optode, nutrient analysis, and gas chromatography. This experiment is ongoing, and the rates of propane consumption as well as oxygen respiration will be quantified to create a clearer picture of these processes and their contribution to the ocean's capacity to degrade harmful compounds.

Stochastic Series Expansion Quantum Monte Carlo Simulations for Investigating Eigenstate Thermalization

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Keith Fratus, Mark Srednicki. Physics

The mechanism by which thermalization of isolated quantum systems occurs has been a subject of considerable debate. One possible explanation is the eigenstate thermalization hypothesis (ETH), which posits that the expectation value of an observable in an energy eigenstate equals the thermal value at that energy. The ultimate goal of this study is to revise ETH in order to incorporate systems with spontaneous symmetry breaking (SSB), which have observables with multiple values within the broken symmetry phase. Previous work on this subject has shown that SSB and ETH compatibility is possible. However, small system sizes cast doubt on whether its observed critical energy locations and expectation values agree with those found in larger systems. As such, computations of and comparisons to thermodynamic values from stochastic series expansion quantum Monte Carlo, C++ simulations are being performed. Results are expected to demonstrate SSB and ETH compatibility, and hence further understand thermalization.

Undergraduate Experience in Network Analysis and Synthesis (Network Science IGERT)

http://networkscience.igert.ucsb.edu

The Network Science Program at UCSB is an interdisciplinary effort comprising scientists across seven different academic departments. A part of this research, we are examining networks in multiple domains (e.g. information, biological, social) to understand their underlying structure and dynamic behavior. Of special interest are methods to infer and synthesize networks, and to correlate the content of information flow with the static structure of networks. Our summer research experience for undergraduates stems from our NSF-funded IGERT grant (DGE-1258507) and the matching support provided by the various colleges at UCSB.

News Bias in Online News
Angel Ortega, Computer Engineering, University of California Santa Barbara
John O'Donovan, Saiph Savage, Tobias Höllerer. Computer Science

With recent developments in technology, distributed information on the web can be leveraged to influence decisions made by crowds on critical issues. This leverage is strengthened by the 'filter bubble' effect where information is curated for a user by social connections in online networks such as Twitter or Facebook, commonly leading to a narrowed or biased perspective on real events. This study explores the effects of journalistic biases on crowds across a range of topics and biasing methods. In particular, we conducted a 5 by 3 between subjects experiment where we varied topics and bias types. We surveyed 300 crowd workers from Amazon Mechanical Turk to quantify three measures: (1) a crowd's perception of news article bias, (2) a crowd's tolerance for action against an issue, and (3) a crowd's evaluation of an article's key subject before and after reading a biased news article. Five separate methods for adding bias were evaluated, and a unique set of news articles were chosen that met typographical criteria for these bias types. Specifically, the issues we chose were the 'Brexit' vote in Britain, the 2016 Rio Olympics, and a popular fiction scenario as a control. Each scenario had dichotomous stances on the key issue, for example, anti-Rio-Olympics or pro-Brexit. Our results show that in the Brexit case, when presented with pro-Brexit biased news articles and a control, crowds were shifted to a pro-Brexit stance, while participants' perception of bias remained unchanged.

Computational Complexity of Solving Network Dynamics
Taom Sakal, Ecology, Evolution, and Marine Biology, University of California Santa Barbara
Hari Sivakumar, Stephen Proulx. Ecology, Evolution, and Marine Biology
Joao Hespanha. Electrical and Computer Engineering

The dynamics of many networks are described by a system of equations. Traditional methods for solving these systems do not work for more complex networks. Instead we can solve them by cutting the network apart via a *partition strategy*, solving the sub-systems, and then combining the pieces back together. The total difficulty of solving the system depends on which partition strategy we choose. We present two algorithms: one for calculating the complexity of a strategy over a given network, and one for finding effective partition strategies for a network. Together, these algorithms can transform a computation that would normally takes months into one that takes only hours.

Problem-based Initiatives for Powerful Engagement and Learning in Naval Engineering and Science (PIPELINES)

http://pipelines-csep.cnsi.ucsb.edu/

The Problem-based Initiatives for Powerful Engagement and Learning In Naval Engineering and Science (PIPELINES) program is an 8-week immersive experience, where teams of undergraduate students compete in finding the most innovative and effective design solutions to real-world Naval engineering and science design projects. Interns attend weekly meetings, special seminars, and sharpen their problem-solving and entrepreneurial skills through a course on Applied Creativity and Innovation.

Corrosion Resistant Reinforced Concrete for Marine Environments
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Aaron Lovato, Chemical Engineering Department, University of California Santa Barbara
Isaac Norales, Civil Engineering, Los Angeles Southwest College
Brent Goodlet, Materials, University of California Santa Barbara
Justin Foster, Capital Improvements, Naval Facilities Engineering Command, United States Navy

Corrosion of internal rebar is the leading cause of failure for reinforced concrete in marine environments. The natural permeability of concrete to water and salt ions from the environment leads to chlorine ions diffusing through the concrete and into contact with the underlying steel reinforcement—accelerating oxidation and corrosion of the rebar. The resulting oxidation products exhibit a positive volume change that is constrained by the surrounding concrete, creating internal tensile stresses. Internal stresses facilitate cracking of the overlaying concrete, further accelerating chloride permeability and rebar oxidation that eventually leads to spallation and failure of the concrete. This research explores the efficacy of modifying the concrete composition with additions of: silica fume, Hycrete, and fly ash to resist corrosion and to increase its service life. As chloride permeability is difficult to measure, surface electrical resistivity is leveraged as a proxy measure of chloride permeability, with chloride permeability and electrical resistivity exhibiting a negative correlation. Four select concrete compositions were developed and tested for initial workability; with surface and bulk resistivity, compressive strength, and splitting tensile strength evaluated on cylindrical test specimens at 7 day intervals post-cure, up to 21 days. With considerable effort to consider cost and sustainability, a ranking system was also developed to select the optimal concrete composition to meet the demands of the Navy. This lead to the selection of a concrete composition modified with 10% silica fume in place of Portland cement as the optimal solution, when considering resistivity, workability, and cost.

Ladder for Amphibious Systems
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Corey Stein, Mechanical Engineering, California Baptist University
Marcela Areyano, Mechanical Engineering, J.P. Ortuno, NAVFAC EXWC, Amphibious Department

The current boarding system of the Lighter Amphibious Resupply Cargo (LARC-V A1/A2) craft is unusable with respect to size and weight and unsuitable during operations. Currently, the Beach Master Units (BMUs) and Underwater Construction Teams (UCTs) use the hub of the hydraulic wheel motor to climb on board the LARC-V A1/A2 during land operations, which removes corrosion-resistant coatings from the motor carcass, resulting in accelerated corrosion and ergonomics. The project entailed a design solution to develop a passenger boarding system which can be used by BMUs and UCTs. Research was conducted by interviewing LARC-V users and evaluating current boarding systems used by commercial and military watercraft. The proposed ladder combines

commercial off the shelf items (COTS) readily available with minor modifications to meet the user's operational requirements. The proposed design was chosen based on cost, weight, size, simplicity and manufacturing capabilities. The design is adaptable to different cargo loads and mission types, and is to be easily stowed, deployed, and lifted by one person. The boarding system implementation will provide the LARC-V A1/A2 a safe and efficient method of embarkation/debarkation of personnel during the craft's lifecycle.

Optical Fiber Link for Small Buoys
Ben Kennedy, Mechanical Engineering, Allan Hancock College
Marshall Laminen, Manufacturing Systems Engineering, Ventura College,
Mario Moreno, Electrical Engineering, University of California Santa Barbara
Mike Garcia, Mechanical Engineering, Bradley Hunter, NAVFAC EXWC Oceans Department

In an era of large volume digital data transfer, the Navy requires rapid communications with a variety of sea-floor-based ocean sensors. These sensors record vital information such as salinity, temperature and ocean currents. The data transmitted to monitoring stations is used for both research and defense. Optimally, the tethering system would incorporate an optical fiber cable because of its ability to transfer large amounts of data quickly. However, optical fibers may break if subject to large tensile stress. Our team has been tasked with designing a prototype tethering system for small buoys that incorporates an optical fiber cable that is stiff enough to alleviate excessive strain caused by ocean waves and currents, but soft enough to keep the buoy afloat. We first used analytical spring models to design a system that would meet the requirements. After brainstorming different suspension methods we chose a coiled spring. We developed a manufacturing process that includes an oven and a mandrel to form the spring. We tested the system by hanging weights and using a motor to cycle the spring at different extensions. We compiled our results and compared it against our theoretical data. Our testing indicates that the prototype shielded the optical cable from experiencing excessive strain by maintaining a negligible transmission loss. Additionally, our measured spring constant suggests that our spring system is soft enough to keep the buoy afloat. These promising results provide the groundwork for further exploration as the Navy continues to develop this technology.

RE-IT: Renewable Energy Integration Tool
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Nathan Lubega, Mechanical Engineering, Santa Barbara City College
Argin Petrosian, Mechanical Engineering, Pasadena City College
Tony McFadden, Bruce Garrett, Bill Anderson, Public Works

The Navy relies heavily on fossil fuels to power its operations. This dependence poses a threat to the Navy’s energy security, independence, and endurance, in the case where commercial power is lost. The Navy has a mandate to reduce this reliance by increasing its consumption of renewable energy. However the variable nature of renewable energy creates a challenge to the Navy's needs for continuous operation and mission success. Interconnect agreement requirements restrict feeding excess energy back into the grid. We needed to provide a feasible solution to the problem "How much renewable energy can the Navy add to their existing grid without a loss in reliability or compromising mission success, and most importantly, without further engineering?" We researched academic journals, interviewed multiple experts in the field, and conducted in-depth field studies. We visited the National Renewable Energy Laboratory and different solar arrays and wind farms located at several naval installations. We concluded that due to the complexities of each individual grid – power quality, generators, size, age etc. – up to 15% of renewable energy can be integrated before needing to conduct an individualized grid analysis. With this knowledge we developed a tool that determines the specific amount of each renewable energy resource that can be added to any electrical grid depending on multiple factors – such as location, weather, and rate of consumption. We did all this without requiring further engineering. This tool is a first step towards maximizing the Navy's renewable energy integration and reducing their dependence on fossil fuels.

Toward NetZero CLUS: a New Method to Minimize Dust-induced Efficiency Losses in Solar Panels

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Jaclyn Avallone, Materials, David Chavez, NAVFAC EXWC

Naval Facilities Engineering and Expeditionary Warfare Center provides solutions using innovative technologies that focus on fleet readiness and minimizing energy usage. The SuperCLU, a containerized living unit, is meant to be energy efficient and to improve living conditions for the nation's warfighters abroad. The purpose of this research is to create a solution that will restore energy output of photovoltaic cells due to particle build up on SuperCLU solar panels in Camp Lemonnier, Djibouti, Africa. This project contributes to reducing military fuel costs and carbon footprint by the ability to use renewable energy without a decrease of energy from PV soiling. Researching the power output of soiled solar panels gave insight into the best prototype design. Various amounts of particle deposition were tested and a relationship was established with decreasing power output. An automated solar panel cleaning system (ASPCS) was designed specifically for the conditions of SuperCLU and climate needs. The final design considers the types of soil found in Djibouti, the weather in that region, the specific dimensions of the solar panels and CLU, as well as the efficiency of the cleaning device. This information is vital for successfully mounting solar panels on the CLU and will be used when finalizing the solution to particle build up.

University of California
Leadership Excellence through Advanced Degrees (UCLEADS)

https://www.graddiv.ucsb.edu/admissions/outreach/uc-leads

The University of California Leadership Excellence through Advanced Degrees (UC LEADS) program is designed to engage and educate California's future leaders by preparing promising students for advanced education in science, technology, mathematics and engineering (STEM). UC LEADS is designed to identify upper-division UCSB undergraduate students with the potential to succeed in these disciplines, but who have experienced situations or conditions that have adversely impacted their advancement in their field of study.

UC LEADS Scholars embark upon a two-year program of scientific research and graduate school preparation guided by individual Faculty Mentors. Scholars are provided an excellent opportunity to explore their discipline, experience a research environment, and improve their opportunities for future study in their chosen field. The Scholars gain valuable educational experience from the University, and are better prepared and more diverse graduate applicant pool, and the State, well-educated future leaders.

An Affordable, Open-Source System for High-Resolution, High-Speed Measurements of Fluid Velocity Fields for Engineering Research and Education
Omar Curiel, Mechanical Engineering, University of California Santa Barbara
Samaneh Sadri, Balaji Subramanian, Paolo Luzzatto-Fegiz. Mechanical Engineering

Understanding the dynamic behavior of fluids is crucial for many engineering disciplines, including the layout of wind turbine farms, the design of aircraft, as well as sound production and attenuation. Particle Image Velocimetry (PIV) is a nonintrusive technique, which images the displacement of microscopic particles in the fluid in order to deduce instantaneous flow field properties, such as velocity and vorticity. However, the cost of a commercial PIV system starts around $100,000. This has limited the adoption of this technique in research and education. In this project, we build an affordable PIV system, by leveraging recent advances in sensors, microcontrollers, and open-source software. Our design uses a green semiconductor diode laser to produce a two-dimensional light sheet that illuminates tracer particles, which move with the flow. A high quantum efficiency CMOS camera, with a 100Hz frame rate, images the particles, and is synchronized with the laser by using the popular “Arduino” microcontroller. We use the open-source image analysis software, ImageJ, to filter image noise generated by camera sensor pixel deficiencies followed by cross-correlation analysis of the image pairs to measure the displacement of particles in two successive images. With a known time interval, the local, instantaneous velocity vectors can be derived throughout the flow. The resulting system performs as well as commercial ones, but for an overall cost of just $3,000. This enables the adoption of PIV to make discoveries and provide training in a broad range of new applications in research and education.

Effects of Tau Proteins and Counterions on Microtubules
Ximena Garcia Arceo, Physics, University of California Santa Barbara
Bretton Fletcher, Cyrus P. Safinya. Materials, Molecular, Cellular, and Developmental Biology

Microtubules are microscopic tubes made out of proteins, and their dynamic structure allows them to serve a variety of crucial functions in eukaryotic cells. The microtubule-associated protein (MAP), Tau, is found in neurons where

it regulates microtubule (MT) function by promoting their growth, stability, and bundling. High levels of phosphorylation, aggregation, or dissociation of Tau from microtubules can lead to pathological MT behavior, but the mechanisms related to these "tauopathies" are not completely understood. Little literature exists on the combined effects of charge screening from the biologically-relevant counterions Mg^{2+} and Ca^{2+} and Tau's physical and electrostatic properties, such as the positive charges of its proline-rich region and MT-binding domains, the number of binding domains, and the negative charges of its amino and carboxy termini, on the structure-function relationship of MT. With the use of differential interference contrast (DIC) microscopy, I monitored the effects of various tau protein isoforms and counterions on the assembly, disassembly, and bundling of microtubules over time. I seek to corroborate optical microscopy images with TEM and SAXS data collected by group members under the same conditions. A complete understanding of the structure-function relationship will help identify the physical mechanisms that correlate with microtubule dysfunction and lead to neurodegenerative diseases like Alzheimer's which currently affects 5.3 million people in the United States alone.

Improving Signal-to-Noise Ratio of DNA-Based Biosensors through the Increase of Electrode Surface Roughness

Ramces Gonzalez, Chemistry, University of California Merced
Philip Ducharme, Netz Arroyo, Kevin Plaxco. Chemistry and Biochemistry

DNA has recently emerged as an important platform for biosensing applications due to its relative ease of synthesis and ability to bind to target molecules with high specificity. Electrochemical DNA (E-DNA) sensors, for example, exploit a target-induced conformational change in their structure to produce a signal. The binding-induced change in conformation is transduced to signal using a redox reporter covalently attached to the DNA probes. E-DNA sensors are wash-free, rapid, and can even achieve accurate continuous measurements for hours in complex matrices, for example, whole human blood. Although E-DNA sensors are versatile, the relative increase in signal produced upon binding to targets remains low in some cases, making the general applicability of these sensors difficult for real-time measurements. To address this issue, here we have studied two factors that may contribute to the net signal transduced by these sensors and the relative signal gain produced after binding to their targets: 1) the electrode surface roughness; and 2) the concentration of DNA probe in solution. We have found an electrochemical method that roughens the electrode >3 times. This increases electrochemically-active surface area and produces an increase in signal gain of 480% at saturating concentrations of the target, which in turn improves significantly signal-to-noise ratios. Our investigations indicate that both roughening the electrode and reducing the DNA probe concentration will lead to both higher signal gains and signal-to-noise ratios. This may be due to both factors reducing the DNA packing density.

Eliminating the Cytotoxicity of DAC

Shannon Grossman, Biochemistry, University of California Santa Barbara
Erin Morgan, Norbert Reich. Chemistry and Biochemistry

In recent years, epigenetics has begun to burgeon with novel breakthroughs that have greatly advanced cancer research. Epigenetics focuses on regulating gene expression rather than genetic code itself, mainly through alteration of methylation patterns of DNA. Creating tools to further understand how epigenetic alterations influence phenotype is critical to progress in drug design. Drugs that regulate methylation have proven successful in delivery and effectiveness, but are toxic to cells which render their ability to show altered phenotype limited to just cell death. Here we propose a way utilize the therapeutic effects of a hypomethylating agent known as 5-aza-2'-deoxycytidine (DAC) while reducing its cytotoxic effects in hopes that it may be used to regulate gene expression. Since the small size of DAC is what allows for its incorporation into the cell's genome and thus its cytotoxicity, we are constructing an oligonucleotide containing DAC that would be delivered into the cells' cytosol. This will potentially eliminate the cytotoxicity while remaining a potent hypomethylating agent. By developing this technology, we will potentially be able to control methylation and therefore gene regulation for epigenetic applications. Thus far we have been working on the reproducibility of assays from literature as well as developing our own to assess changes in the level of genomic methylation.

Atomic Layer for Transistor Scaling

Emmanuel Kayede, Electrical and Computer Engineering, University of California Santa Cruz
Brian Markman, Mark Rodwell. Electrical and Computer Engineering

Gordon Moore's law predicts that the number of transistors per square inch on an integrated circuit will double every 18 months. Because scaling of metal-oxide-semiconductor field effect transistors (MOSFETs) and heterojunction bipolar transistors (HBTs) has reached the 10 nm and 32 nm nodes respectively, precise fabrication techniques are needed. Since modern MOSFET oxide thicknesses are <5 nm, there is significant gate leakage current due to quantum mechanical tunneling between gate and source requiring the adoption of high permittivity (k) dielectrics. Additionally, high drive current densities and stringent planarization requirements have caused new challenges for emitter metal deposition. Atomic layer deposition (ALD) has been widely used for its nanometer scale thickness control, uniform and conformal material deposition. We report ALD dielectric films of HfO_2 grown with TEMAHf/H_20 and ZrO_2 grown with TEMAZr/H_2O. For ZrO_2 deposition, chamber seasoning with TEMAZr/H_2O and nitrogen plasma/ TMA results in an interface thickness of 23.660 and 13.481Å respectively. Metal-oxide-semiconductor capacitors (MOSCAPs) were fabricated on 1e17 cm^{-3} InGaAs/n^+InP by ALD with a Ni gate metal. A ZrO_2 and HfO_2 based MOSCAPs were measured to have a capacitor density of 1.5 and 1.39 uF/cm^2 in accumulation at 1V for 100 Khz respectively. Initial characterization of TiN/Pt emitter metal has begun and a transmission line method process flow has been determined; details are left to future study.

Feeding Marine Microbes: Toluene Biodegradation in the Gulf of Mexico

Rachel Liu, Biology, University of California Santa Barbara
Eleanor Arrington, David Valentine. Earth Science

Natural and anthropogenic petroleum inputs to the ocean are estimated to be up to 1,322,000 tons per year, which occur via natural seeps, illegal dumping, terrestrial runoff, and oil spills. Marine microorganisms can act as a biofilter to these inputs by metabolizing the various hydrocarbons present. Volatile short-chain hydrocarbons that are soluble in seawater and abundant in petroleum may play a role in eliciting the initial microbial response to oil spills. BTEX compounds (benzene, toluene, ethylbenzene, and xylene) are naturally occurring components of crude oil and were the most abundant mid-range hydrocarbons in the petroleum spilled during the 2010 Deepwater Horizon incident. To study the rate of microbial consumption of toluene we conducted a series of microcosm experiments, using seawater collected from 1000m depth in the Gulf of Mexico at stations with varied proximity to natural seepage. These seawater samples were injected with toluene, and dissolved oxygen concentration was measured over the course of a five week incubation to track metabolism. At different time points in the microbial bloom, signified by a drop in oxygen levels, samples were processed for nutrients, cell counts, single cell genomics, and DNA sequencing work. Using the Illumina MiSeq platform in conjunction with the aforementioned analyses, we will characterize the microbial communities that are associated with toluene respiration and gain a greater understanding of its impact on the biodegradation processes associated with past and future contamination events.

Anastasis: an *In Vivo* and *In Vitro* Approach to Understanding Reversal of Apoptosis

David Lowe, Biology, University of California Santa Barbara
Christopher Conner, Denise Montell. Molecular, Cellular, and Developmental Biology

Apoptosis, a form of cell death, is an essential cellular process in development and removal of damaged tissues. Apoptosis is characterized by the activation of executioner caspase enzymes that result in classic morphological hallmarks such as cellular shrinkage and membrane blebbing. This form of programmed cell death is generally considered to be irreversible. Recently, however, it has been shown that a variety of cell types readily reverse apoptotic cell death after caspase activation. This reversal is termed anastasis, Greek for "rising to life". Here we propose a two-pronged approach to illuminate when and where anastasis occurs in cell culture as well as in the development of the fruit fly, *Drosophila melanogaster*. First, in order to elucidate if anastasis occurs in response to a variety of different chemicals that cause apoptosis, mouse fibroblast cells will be exposed to either ethanol, sorbitol, or hydrogen peroxide and then be assessed for survival and proliferation. Second, to identify genes that promote anastasis, our lab has generated a transgenic fruit fly with a sensor that marks cells that survive caspase 3 activity. Using these flies, we will screen for genetic deletions that will increase or decrease the number of cells that activate the sensor's activity to elucidate the genetic pathways that control anastasis.

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