1

Aqua Ammonia Scrubber

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The production of anthropogenic carbon dioxide has greatly increased in the 20th and 21st centuries. This greenhouse gas, which helps to trap heat in the atmosphere to warm the earth, is beginning to cause concern for the future. Scientists believe that a shift in the greenhouse gases equilibrium could be very dangerous. In an attempt to reduce anthropogenic CO2, the National Energy and Technology Laboratory (NETL) has developed a system to absorb CO2 in aqueous ammonia. Their samples are given to us to analyze. This is my research: to analyze their samples using an electrospray time-of-flight mass spectrometer (ESI TOF-MS). This machine is one of three in the world right now, and can analyze ions as whole molecules, without breaking them up. After the samples are run through the machine, the data from the spectra is used to determine which molecules are present in the samples and their relative abundances.

2

Isolation and Analysis of Amides form Mammalian Tissue

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Primary fatty acid amides (PFAMS) are known to be present in mammals in minute amounts. For the purpose of my research, the main PFAM of concern to be studied is oleamide, an eighteen carbon amide with one double bond, with the formula $C18:1^{9}$. Past research has proven that oleamide has hormonal activity in the mammal's body and may also act as an endocannabinoid. Other PFAMS are also known to have biological activity. However, little is known about the distribution pf PFAMS in mammalian tissue. During this project, amides were isolated from various tissue samples, including mouse kidney, liver, thymus, stomach, heart, and brain, along with the total lipid extract through Folch-Pi extraction. To do this, the tissue was homogenized using a chloroform-methanol solution. Solid Phase Extraction (SPE) was then used to isolate the PFAMS in pure form from the rest of the lipids. The PFAMS were then analyzed using gas chromatography/ mass spectrometry (GC/MS) to identify the types of amides and the amounts of those amides that have been isolated from the lipids.

3

Synthesis and Properties of a New Alkali Monothiophosphate

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Alkali monothiophosphates can be prepared by refluxing $PSCl_3$ in aqueous alkali hydroxide solution, followed by dehydration by stirring in anhydrous methanol. While sodium monothiophosphate has been known for some time, lithium monothiophosphate is a new material exhibiting a noncentrosymmetric crystal structure. Its stability in air makes it a practical material for technological applications. It may also be applied as a starting material to prepare new monothiophosphates, which may be useful for the removal of toxic, soft metals from drinking water. The presence of the monothiophosphate anion in Li_3PO_3S was confirmed by iodimetric titration. The material was characterized with powder X-ray diffraction (PXRD), differential thermal analysis (DTA), thermogravimetric analysis (TGA), and diffuse reflectance Mid-IR. Li_3PO_3S is also being tested for second harmonic generation (SHG) properties.

4

Investigation of Septum Placement Genes in the filamentous bacteria *Streptomyces coelicolor*

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Streptomyces coelicolor is a filamentous, sporulating, soil bacterium. Cell division is primarily used to divide multinucleoid aerial hyphae into a chain of spores. The mechanism of cell division in *S. coelicolor* is not well understood, however many normally essential division proteins are dispensable in *S. coelicolor*. I am investigating homologues of proteins DivIVA and MinD that might control the position placement of the division complex in aerial hyphae during sporulation. DivIVA is a cell division protein that may function to establish and maintain cell polarity during growth and morphogenesis. MinD is one member of the "minicell" family of three different proteins responsible for blocking division at the cell poles in rod-shaped unicellular bacteria. I am completing a Southern Blot analysis of a previously created *divIVA* knockout mutant. There are several *minD*-like genes in the relatively large genome of *S. coelicolor*. I will be creating a double mutant which will knockout two *minD*-like genes to investigate the effects on cell division and sporulation.

5

Predicting Development of Simian Immunodeficiency Virus Encephalitis Prior to Infection in Macaques

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Approximately 25% of AIDS patients develop a neurodegenerative disorder called HIV associated dementia (HIVD). Pathologically, this condition is associated with abundant activated and infected macrophages, known as HIV encephalitis (HIVE). It is believed that HIVE might develop when HIV-infected monocytes traffic into the brain. Simian immunodeficiency virus (SIV) infected macaques develop SIVE similar to AIDS patients. Testing the ability of non-infected macaque peripheral blood mononuclear cells to produce virus *in vitro* can determine whether macaques will be rapid or slow progressors upon infection. Since rapid disease progression is correlated with the development of SIVE, we hypothesize that testing the ability of non-infected macaque monocytes to produce virus will predict whether or not the animal will develop encephalitis. Supernatants from monocyte-derived macrophages infected *in vitro* will be analyzed for SIV p27 at various times post-infection. We predict animals that develop SIVE upon infection will produce more p27 prior to infection.

6

Investigation of Novel Routes to Common Heterocyclic Ring Systems

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It has been known for some time that the condensation of tryptophan and ninhydrin produces a novel pentacyclic heterocycle, which is referred to as a yohimbanone. Recently, the mechanism of this unique transformation has been elucidated, and the yohimbanone has been converted to a 1,3-disubstituted beta-carboline via an oxidative ring cleavage. Current work in our laboratories focuses on (1) exploiting this concise synthetic sequence for the preparation of novel beta-carbolines and (2) expanding the methodology for the preparation of other heterocyclic ring systems. Some of the target molecules are potential ligands for the benzodiazepine receptor.

7

Internal Asymmetric Induction With Metallated Nitriles

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Metallated nitriles provide inherent advantages in synthesis due to their nucleophilic sp^3 hybridized centers, which unlike planar enolates, provide chiral nucleophiles. The challenge of internal asymmetric induction with metallated nitriles is the imposition of chirality close to the formally anionic carbon. The stereoselectivity of metallated nitriles was examined using a range of electrophiles. Selectivity was greatest (4.7:1) in the alkylation of a lithiated nitrile using allyl bromide to create a quaternary center. Also investigated was the use of the Claisen rearrangement to create chiral nitriles. A computational analysis was performed to examine the favored conformation of a metallated nitrile. Further work includes the use of cuprated and magnesiated nitriles to develop additional stereoselective synthetic routes to chiral nitriles.

8

Synthesis and Characterization of Oxomolybdenum Complexes

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Molybdenum containing enzymes play significant roles in Biology. These enzymes catalyze an extensive range of reactions including the reduction of nitrate to nitrite and arsenate to arsenite which in turn affect the environment considerably. We are interested in understanding the fundamental aspects of the molybdenum center where the catalysis takes place. Our approach is to synthesize and characterize new molybdenum complexes as models for the active sites of these enzymes. To this end, we have synthesized KL [L= (3, 5-dimethylpyrazol-1-yl) borate, $MoO_2Cl_2(OPPh_3)_2$ and $LMoO_2Cl$. These materials will be used as precursors for a new set of molecules such as $LMoO_2$ (SPh) and
$LMoO_2$ (OPh).

9

Investigation into the Optics of an Endoscope and the Potential of a Three-Dimensional and a Wide View Angle Endoscope

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University of Pittsburgh

Endoscopes are used to assist surgeons in operations of various body parts. An endoscope not only reaches the region at which the surgery is to be performed, but also provides a constant image flow of the area which the surgery is being performed. Since the outcome of the surgery depends mainly on the quality of the image, my research this summer dealt with possible improvements to the endoscope.

Currently, neuroendoscopic surgery is performed using 2-D images, leaving the surgeon narrow view around the area and without depth perception. Although current wideview and 3-D endoscopes exist, they require goggles and are too large to use in neurosurgery. My purpose was not only to investigate the basic optics of existing two dimensional endoscopes but to also investigate current wide-view and 3-D endoscopes and compare them to one another. Once these designs have been compared, an ideal wide-view endoscope will be proposed, allowing surgeons to further improve their abilities within the operating room.

10

Microbial degradation of Roxarsone

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Roxarsone (4-hydroxy –3-nitro-phenylarsonic acid) is a FDA approved poultry feed additive. It acts as a growth promoter for better feathering, preventing coccidiosis and increasing egg production[1]. Over 90% of this additive is excreted unchanged with more than 1,100 tons being added to the waterways annually[1]. Interestingly little is known about the metabolism, environmental fate and impact of roxarsone. Roxarsone can be degraded by a variety of microbes. However the mechanism of degradation is not clearly understood. To gain the mechanistic insight we have developed analytical techniques that allowed the detection and quantification of different intermediates. The procedure involved high performance liquid chromatography (HPLC) coupled with UV-Vis and mass spectrometry. The separation of various phenylarsonic acids and the more toxic inorganic arsenic compounds was achieved by optimizing chromatographic methods using both reverse phase C18 column and an ion exchange column. Preliminary studies conducted with extracted chicken manure indicated that roxarsone is degraded to 3-amino-4-hydroxy phenylarsonic acid, As(V) and other intermediates.

11

A Mössbauer study of rutile-doped hematite

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Ferric oxides have found many applications ranging from pigment technologies to magnetic information storage and hazardous gas detection. In this research, the ferric oxide hematite (Fe_2O_3) was doped with the rutile phase of titanium dioxide (TiO_2) in varying proportions by ball milling. The structure and properties of the new compounds were studied through the use of Mössbauer spectroscopy, a technique that utilizes the recoilless emission of gamma photons—the result of nuclei being bound in a crystal lattice—known as the Mössbauer effect. The study showed that the prevalence of magnetic phases, and thus the hyperfine magnetic field strength, decreased as a function of proportion (*x*) rutile to (1-x) hematite.

12

Purification of Periplasmic Nitrate Reductase NapA from *Sulfurospirillum barnesii* SES-3

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Periplasmic nitrate reductase (Nap) is a membrane bound enzyme involved in anaerobic nitrate respiration of eplison proteobacteria. It shows high affinity for nitrate ($NO3^-$) as an electron acceptor and reduces it into nitrite ($NO2^-$). In the present studies, NapA was solubilized from membrane fractions of the eplison proteobacteria *Sulfurospirillum barnesii* by using a 2% CHAPS solution. This was followed by purification through size exclusion chromatography (Sephacrly S-300 HR) and consecutive anion exchange chromatography (DEAE- Toyopearl). Under anaerobic conditions, the enzyme activity was assayed spectrophotometrically by using reduced methyl viologen as an electron donor. From the activity assays, calculations were made to determine the specific activity of the enzyme and using the specific activity, V_{max} and K_m values for the enzyme were determined. The purification steps were further analyzed using Western blot with polyclonal antibodies targeting a specific amino acid sequence found in NapA.

13

Optimization of the Crosslinker and Monomer in an Ammonia Sensing Polymerized Crystalline Colloidal Array

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Crystalline colloidal arrays (CCAs) are solutions comprised of monodispersed colloidal particles having highly charged surfaces, which allow them to self-assemble into a lattice structure. The structure of the lattice results in Bragg diffraction, which is dependent on the lattice spacing. The addition of a soluble monomer and cross-linker into the CCA followed by UV polymerization results in a PCCA. Analytical sensors have been developed with these PCCAs using a diverse range of chemical phenomena. We have optimized an ammonia sensor that is based on the formations of new cross-links in the hydrogel. Optimization includes improving the sensitivity, response time, and the spectral window by modifying the PCCA composition. Changes in the hydrogel content include modifying the cross-linker density, varying the length of the cross-linker molecule, and changing the hydrophilicity of the monomer.

14

Digital Simulation of Cyclic Votammograms of Selected Molybdenum Complexes

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Digital simulation of cyclic voltammograms for a series dioxo molybdenum VI complexes containing different *p*-substituted thiol ligands has been accomplished using the digi sim software package. This method allows for both simple and complex electron transfer mechanisms such that any differences resulting from the substituted thiol can be enumerated. Furthermore two distinct mechanisms were evaluated with the first involving electron transfer and the second involving electron transfer followed by geometric rearrangement. More concretely, the simple mechanism was defined as A_{ox} + e $\rightarrow$ A_{red} while the complex mechanism was defined as A_{ox} + e $\rightarrow$ A_{red} $\leftrightarrow$ B_{red}. In this way we were able to determine three heterogeneous chemical parameters, three homogeneous chemical parameters and two or three species parameters. The determined heterogeneous chemical parameters include the redox potential (Eo), the transfer coefficient (α/λ) and the electron transfer rate constant (k_s), while the homogeneous chemical parameters include the equilibrium constant (Keq), the forward rate (kf) and the reverse rate (kb). Lastly, the species parameters include the diffusion coefficients of all distinct chemical species in solution.

15

Simulation of the ATLAS Detector

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ATLAS is one of the particle detectors under construction as part of the Large Hadron Collider at CERN in Geneva, Switzerland. Utilizing higher energies, the ATLAS detector will investigate new areas of physics, including the search for the Higgs Boson, theorized as the cause of mass. The raw data will be complex, so it is necessary to use a computer display to view and interpret results. I am working on a graphical display, the HEPVis Event Viewer (V-Atlas), which provides 3-D renderings of the data. I will present details explaining capabilities, on-going testing, and debugging of the V-Atlas program. If space permits, I will also explain the process of generating simulated data and the testing and Modifications of this process in order to include parametrization for increased speed.

16

Probing Ferroelectric Phonons

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University of Pittsburgh

In ferroelectric materials, such as BaTiO3, PbTiO3, charges will have spontaneous polarization as long as the temperature is below the Curie point. When an external electric field is applied, the positive charges will move towards the field direction, whereas the negative ones will move the other way and thereby casing the change in polarization. This experiment uses lasers, which contains oscillating electric field, to excite ferroelectric dipoles, and to probe the response after the excitation. As soon as the data is obtained, information that indicates properties of the material can be obtained and useful calculations, such as deriving the magnitude of phonon energy, can be performed.

17

Developing an interactive computer- based tutorials for enhancing problem solving, reasoning, and meta-cognitive skills of introductory physics students .

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We are developing an interactive computer-based problem solving tutorials in order to help introductory physics students learn effective problem-solving heuristics and enhance their problem solving, reasoning, and meta-cognitive abilities. Students will be given problems to solve in a work sheet and if they need help they can access the computer-based tutorials at anytime. The self-paced tutorials will provide scaffolding support for a variety of problem solving techniques, and opportunities for knowledge and skill acquisition, rather than ``plug and chug'' tasks. The problem solving heuristics begin with a qualitative analysis of the problem, followed by decision making, implementation, assessment, and reflection stages. The continued assessment of the project will come from controlled studies that compare performance of the tutorial learners against those who receive identical content from non-interactive means. We are going to present the development and future of these tutorials.

18

Microwave Synthesis of the Ternary Chalcopyrite $CuInSe_2$

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Diluted magnetic semiconductors with diamond-like structures are of interest because of their nonlinear optical properties and their possible use in spintronic devices. The goal of our research is to produce a diluted magnetic semiconductor by doping the chalcopyrite $CuInSe_2$ with Mn and studying its magnetic properties. Compared to more traditional high-temperature, solid-state reactions carried out in furnaces, microwave synthesis is generally much faster, simpler, and more energy efficient. Furthermore, solid-state microwave synthetic conditions may be better able to stabilize doped materials which may be difficult to prepare via other methods. In order to produce $CuInSe_2$ in pure form, synthetic parameters such as molar ratio, irradiation time, tube position, and sample size were varied. The resulting materials were characterized via powder x-ray diffraction, differential thermal analysis and diffuse reflectance spectroscopy. Band structure diagrams computed using the program CAESAR will also be presented.

19

Epithelial Cell Extraction from Skin on Skin Contact: Active Versus Inactive Restraint

Angela Mitchell, Dr. Lisa Ludvico
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In the case of battery, manual strangulation, or rape, skin from the perpetrator and the victim come in contact with each other and have the potential to transfer epithelial cells which contain DNA via the Locard exchange principle. Eight pairs consisting of one female and one male were utilized to determine if a DNA sample can be taken from the wrist after being held by an inactive, still hold, and an active grip, struggling to be released, by another individual. Variables such as perspiration, lotion and perfume presence may play a significant role in the transfer of cell material. This experiment attempted to determine if samples taken from a ‘victim’ or in this case the person being held can be used to identify the individual whom committed the crime or did the holding.

20

Cell Adhesion and Viability on Polished and Unpolished 316L Stainless Steel Substrates

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Controlling the chemical and biological interaction between an implant surface and the human tissue is of the utmost importance. One must make sure that the surface provides superior hardness, strength, and corrosion-resistance without damaging the tissue or inducing apoptosis. Surface roughness may play a role in the biocompatibility of an implant. Therefore, we conducted cell adhesion experiments using 1cm x 1cm stainless steel 316L substrates (0.5mm thickness), which is a common biomaterial. The substrates were tested at two different sanding levels, roughly sanded and polished. The different metal substrates were then placed in a 24 well plate and seeded with approximately 10,000 3T3 human fibroblast cells each, along with several control wells which contained nothing in them. Live/dead tests, as well as CyQuant cell proliferation tests, were run to determine the viability and adhesion of the cells on the rough and smooth surfaces.

21

Expanding the Frontiers of Diversity Oriented Synthesis using Resin-to-Resin Cross Enyne Metathesis

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Enyne metathesis is an effective method for the synthesis of 1,3-dienes using a bond reorganization of an alkene and an alkyne[1]. The ruthenium metal carbenes, particularly the second generation Grubbs' catalyst, were selected because of their ease of use and availability. Our lab has recently developed a method on the solid phase for resin-to-resin cross olefin metathesis, reacting two olefins on two *separate* resins resulting in diverse small molecules. In an effort to expand the scope on the solid phase metathesis chemistry, we report a method of resin-to-resin enyne metathesis allowing the formation of molecules capable of further structural elaboration for library synthesis. Initially, cross enyne metathesis reactions, the intramolecular application of enyne metathesis, were employed in the solid phase but proved difficult to analyze results, presumably due to the acid cleavage work up of the protected 1,3-diene. As a result, the metathesis reactions were employed in solution as model studies for future resin-to-resin reactions. This has proven promising and studies on the solid phase will be subsequent.

22

Determination of the Energy Levels of Antiferromagnetic Spin Clusters

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My project entails the study of systems of particles possessing spin angular momentum, particularly those which have antiferromagnetic exchange interactions between individual spins. The importance of such systems lies in their application as quantum bits, or qubits, for quantum computing, and the energy levels determine the specific types of systems that may be used for this purpose. I have calculated the energy levels for various spin cluster systems by diagonalizing the corresponding Hamiltonians in order to determine the eigenvalues. Initially, I performed this calculation for two spins and open one-dimensional spin chains. The calculations for the larger systems were done umerically using Mathematica. The analysis will be extended to other systems, such as closed one-dimensional spin chains and systems within which exchange interaction strengths vary. I will attempt to generalize the method for calculating the energy states of spin cluster systems and predict theoretically the energies that would be measured in an experiment.

23

Building an RF coil for detecting breast cancer using magnetic resonance spectroscopic imaging

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A PCOS RF coil was developed for magnetic resonance spectroscopy (MRSI) of breast cancer at high field MR scanners to improve diagnostic specificity. To this end, the coil is required to produce a homogeneous B1 RF magnetic field and excellent signal-to-noise ratio. These conditions are difficult to fulfill for large RF coils in a strong magnetic field inducing dielectric effect. The vertical PCOS coil was successfully constructed and tested with phantom on 1.5T and 3T human MRI scanners. Additional testing will be performed to obtain images and spectroscopy data using human subjects.

24

Fe, Mg, and Mn in Quasar Spectra

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Quasars are very distant, luminous objects which can be used as a "background light bulb" that illuminates foreground gas in galaxies. A spectrum is taken of the quasar as the wavelength of light versus the flux of the quasar. Data that has been partially analyzed from the Sloan Digital Sky Survey outfitted us with the corresponding red shifts for the quasars and absorbing gas which means we know the distances of both objects. I have measured the full width at half maximums (FWHMs) and rest equivalent widths (REWs) of magnesium, iron, and manganese absorption lines in thousands of different spectra. By measuring the spectrum, we can determine properties of the gas cloud relating to chemical composition, ionization state, and velocity width. I will present the conclusions drawn from a principle component analysis of the measured data.

25

Broad Absorption Lines in QSO's: Orientation or not?

Ben Mohlie
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Using data from the Sloan digital sky survey, I have studied the spectra of two types of quasars. Broad absorption line quasars are those which show absorption features in their spectra that stretch over a wide range of wavelengths. Non-BAL quasars do not show such features. I have measured properties of emission lines corresponding to many different elements and compared the BAL quasars to the non-BAL quasars. Preliminary results show that the two types of quasars do differ in some respects, such as strength of O [III] emission, and the redshift offset of H-Beta broad and narrow emission lines. These results and any others obtained before the end of the summer will help astronomers and astrophysicists constrain future computer models of quasars, and determine if BALs in QSOs are due to a line of sight effect.

26

Identification of Unique Molecular Targets in Breast Cancer Cells Using Difference 2D Gel Electrophoresis

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Breast cancer is the most frequent cancer for females and the second leading cause of cancer death in women. The most common drug to slow ER+ breast cancer progression is tamoxifen, an antagonistic estrogen receptor (ER) ligand. Unfortunately, almost 40% of patients treated with tamoxifen eventually relapse and die from the disease. A different approach is necessary – namely the identification of targets associated with estrogen signaling other than the ER. To discover these targets, we are using human breast carcinoma MCF-7 cells treated with tamoxifen or a DMSO vehicle and performing differential two dimensional electrophoresis. Analysis of the gels with DeCyder software permits us to identify proteins that are differentially expressed between the two treatments. These proteins are extracted from the gel and identified with MALDI-TOF/TOF. In the future, the proteome of these cells will be probed with more compounds toxic to ER+ cells to identify a new molecular target.

27

Synthesis of Quaternary Metal Sulfides with Interesting Nonlinear Optical Properties

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Diamond-like semiconductors (DLS) exhibit technologically interesting optical properties such as second harmonic generation (SHG), which leads to the frequency doubling of light. One class of DLS ripe for development is quaternary metal sulfides of the formula I_2-II-IV-VI_4 (where the larger number represents the number of valence electrons and the subscripted number indicates the number of that element in the formula). Therefore we were motivated to prepare new quaternary sulfides with the formula $Li_2M^1M^2S_4$ (where M^1 = Cd, Zn or Mn and M^2 = Ge or Sn) and study the optical properties of these materials and the trend in SHG response in relation to the substitution of various metals for M^1 and M^2. These materials were prepared from a stoichiometric mixture of Li_2S, M^1, M^2 and S heated in a programmable furnace. Powder X-ray diffraction, differential thermal analysis and optical characterization of these new materials will be presented in addition to second harmonic measurements.

28

Cellular Assessment of Calcium Aluminate Materials for Bone Tissue Engineering

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The treatment of bone diseases and fractures represents one of the largest markets for regenerative medicine, estimated to reach $1.8 billion by 2008. Calcium aluminate (CA) materials with controlled porosity and high strength show potential as bone replacement materials. Our results indicate that CA are biocompatible with human MG-63 osteoblast-like cells and human adult mesenchymal stem cells (hAMSC) in both dynamic and static *in vitro* culture conditions. Attachment, proliferation, and viability of MG-63 cells and hAMSC were assessed using the CyQuant assay, scanning electron microscopy, and fluorescent viability and nuclear stains. The viability of cells when attached to CA is above 90%, and cells proliferate when attached to the CA surface. Over the course of 14 days in an osteogenic supplement, differentiation is visible as indicated by increased alkaline phosphatase activity, a marker for osteoblast differentiation. *In vivo* chick chorioallantoic membrane (CAM) assays also indicate the biocompatibility of CA. From the CAM assays we plan to move to larger animal studies and implant CA into rat calvarial defects. Based on the *in vitro* and preliminary *in vivo* studies, calcium aluminate-based materials may be an effective material for bone regenerative medicine.

29

Synthesis of Lanthanide Metal Oxythiophosphates

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Since there are only about 20 metal oxythiophosphates known, the search for new metal oxythiophosphates is imperative. Lanthanide oxythiophosphates may be interesting materials due to their potential technological application as phosphors. It has been shown that sodium monothiophosphate, Na_3PO_3S, can react with metal chlorides to form new metal oxythiophosphates[1]. The combination of Na_3PO_3S with $LaCl_3$ at 600°C has produced what we believe to be $LaPO_3S$. Fourier transform infrared spectroscopy (FT-IR) suggests the presence of the monothiophosphate anion. Powder X-ray diffraction (PXRD) suggests that the new material has a structure similar to that of $LaPO_4$. A variety of reactions were used in attempt to produce this lanthanum oxythiophosphate. Solution reactions, high-temperature solid-state reactions, and room-temperature grinding reactions were carried out. The high-temperature, solid-state reactions seem to be the most successful in creating this compound. We have also synthesized what we believe to be $NdPO_3S$ by heating a stoichiometric mixture of Na_3PO_3S and $NdCl_3$ to 800°C. PXRD indicates that the structure of this material is similar to its analogous phosphate, $NdPO_4$, as well as $LaPO_4$, which is not unexpected due to the close relationship between the properties of these two elements. The following analyses were utilized in the characterization of these two new materials: thermogravimetric analysis (TGA), differential thermal analysis (DTA), PXRD, and FT-IR.

30

Secondary anchor substitutions in an HLA-A2.1-restricted epitope derived from HER-2/neu

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The purpose of this study was to identify variants of IISAVVGIL (denoted as GP2), an HLA-A2.1-restricted T cell epitope derived from the Her2/neu protein. Her2/neu is a tumor-associated antigen that is over expressed in breast and ovarian cancer. It is therefore possible to use GP2 to activate cytotoxic T lymphocytes in cancer patients to eliminate the tumor cells. One limiting-factor of GP2, however, is its poor stabilization of HLA-A2.1. In this study we found that variants of GP2 substituted at the sixth position (P6) or seventh position (P7) possess improved binding strength to HLA-A2.1. Using cell-based binding assays, we found that G7F was 10.3 fold better in binding compared to the cells that consisted only of the 2m-FITC alone (background). When P6 was mutated to a threonine (V6T) or serine (V6S) binding was not altered. Although threonine and serine did not improve binding, when a glutamine was placed at P6 (V6Q) binding was enhanced 2.6 fold over background. After three rounds of in vitro stimulations, G7F-activated T cells recognized GP2 pulsed targets. GP2-stimulated T cells recognized V6Q pulsed targets. In light of the positive effect of a glutamine at P6 and phenylalanine at P7, we explored the structural consequences of mutating P6 or P7. This work shall lead to an in-depth understanding of GP2 structure and activity, and may lead to identification of novel tumor vaccine candidates.

31

Validation of the mtDNA VNTR Region as a Population-level Marker in Percid Fishes

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The control region of mtDNA is becoming a popular tool as a genetic marker. In Percid fishes, the 5' portion of the control region contains a series of tandem 10 base repeats that are highly variable in repeat number among individuals. This study intended to show the repeatability and heritability of this region in the walleye *(Sander vitreum)*. DNA was extracted from known crosses of walleye and the corresponding eggs. The region was amplified through PCR, analyzed through fragment analysis and sized using GENESCAN. Qualitative analysis demonstrated repeatability and maternal inheritance without paternal contribution. These two characteristics, along with the variability of repeats, make this an appropriate method to analyze genetic variation in a population and could provide estimates of female effective population size (N_ef). We intend to use this method to estimate N_ef in natural populations of the state threatened bluebreast darter (*Etheostoma camurum)*.

32

Flow Through Two-dimensional Pipes: The Effect of Friction

Jo Ellen Narron, Dr. Walter Goldburg
University of Pittsburgh REU 2005

Experiments with three-dimensional pipes show a discontinuity in the graph of friction factor, which depends on the roughness of the pipe, verses Reynolds number. This is the first experiment to study the friction factor in two dimensions. My setup is a vertically hanging soap film flowing through two parallel nylon wires. Velocity measurements are made with a LDV (laser Doppler velocimeter). For nylon wires of different roughness, velocity is measured: while measuring the flow rate, moving the LDV probe horizontally across the pipe, moving the LDV probe vertically along the center of the pipe, and changing the width of the pipe.

33

Analysis of Pilin Distribution Among Clinical Isolates and Sequencing of Possible Novel Pilin Genes

Michael Quinn and Peter Castric
Duquesne University

Pseudomona aeruginosa, a Gram-negative, opportunistic pathogen commonly isolated from infections, expresses type IV pili. Type IV pili are polymers of pilin subunits in which at least 5 different phylogenic groups have been discovered among *P. aeruginosa* strains. In a previous study, 23/50 clinical isolates produced pilin that reacted to a group I pilin-specific polyclonal antibody. In this study, 26 of the remaining isolates, and an additional 16 isolates, were screened via PCR to determine the prevalence of pilin subgroups. Out of the 65 total *P. aeruginosa* strains analyzed, 61.54% of the clinical isolate strains expressed either group I or group II pilin. In addition, nucleotide sequencing revealed a *pil*A that coded for pilin similar to K122-4, which contains two disulfide loops, unlike other *P. aeruginosa* pilins. Phylogenic analysis has shown this pilin to belong to a different group than other described pilins.

34

Isolation and Analysis of Amides from Mammalian Tissue

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Primary fatty acid amides (PFAM's) are known to be present in mammals in minute amounts. The main PFAM of concern is oleamide, an eighteen carbon amide with one double bond; formula C18:1. Ikeanude has proven to have hormonal activity in the body from past research and may also act as an endocannabinoid. Other PFAMs were found to have functions. In this project, PFAMs were extracted from various tissue samples along with the total lipid extract through Folch-Pi extraction. The tissue samples analyzed were rabbit heart, and brain; as well as mouse brain, heart, liver, kidney, thymus, stomach, and pituitary. Solid phrase extraction (SPE) was used to isolate the PFA<'s in the single sample. The amides were then separated and quantitated using gas chromatography/mass spectrometry (GC/MS). This method allowed for the identification of the amides isolated from each of the different tissue samples and determined the relative amounts of each that were present by comparison to an internal standard. Typical results provide signal peaks for the internal standard and the amides present in the sample along with the formula weights of the molecules.

35

Synthesis of Aza-bis(oxazoline) SAMs on Gold and Diels-Alder Solution Reaction

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The design of catalytic, asymmetric reactions that proceed with high enantioselectivity is an important goal in chemical synthesis. It has been reported that aza-bis(oxazoline) ligands, when activated with copper(II) triflate complexes, produce such reactions. Specifically, it has been shown to be very useful in Diels-Alder cycloaddition reactions. However, the mechanism of this chiral catalyst is still uncertain. It is hypothesized that the immobilization of enantioselective catalyst in defined monolayers can help determine the mechanism of the aza-bis(oxazoline) Cu catalyst. Through the catalyst's chemical interactions with the surrounding molecules and the catalyst's steric constraints on the gold surface we hope to better understand the mechanism of the aza-bis(oxazoline) Cu catalyst.

36

A Computational Study of the Geometry and Electronic Properties for $[Cd_{17}S_{32}H_{28}]^{2-}$ and $[Cd_{32}S_{50}H_{40}]^{4+}$ Bare Quantum Dots and $[Cd_4(SPh)_{10}]^{2-}$ and $[Cd_4(SePh)_{10}]^{2-}$ Phenyl-Capped Quantum Dots

Crystal L. Young and Jeffry D. Madura
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Quantum dots are "designed" nanoparticles that have quantum properties. Of particular interest are organic and peptide capped nanoparticles since the capping agent can be used to influence the quantum dot size and electronic properties. In this study, *Gaussion 03* was used to determine the geometry and electronic properties of the $[Cd_{17}S_{32}H_{28}]^{2-}$ and $[Cd_{32}S_{50}H_{40}]^{4+}$ "bare" quantum dots and the $[Cd_4(SPh)_{10}]^{2-}$ and $[Cd_4(SePh)_{10}]^{2-}$ phenyl-capped quantum dots. Each structure was determined using the Hartree-Fock and density functional methods and a hybrid basis set, LANL2DZ/6-31G*. A comparison to the experimental bond lengths, band gap energies and density of states was made. These preliminary results suggest similarities between the theoretical and experimental data, but further conclusions will be presented in the poster.

37

The Role of THF in the Solvation of a Lithioacetonitrile Anion Dimer

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The role of solvent in lithiation reactions has been the subject to a number of investigations because it has been established that solvation of organolithium compounds influence aggregation and reactivity. Nuclear magnetic resonance (NMR) spectroscopic studies are used to probe solvated organolithium compounds. However, the results are often complicated due to fast ligand exchange rates. To understand the role solvation plays in organolithium compounds, a series of electronic structure calculations have been done. The systems studied consisted of a lithioacetonitrile anion dimer explicitly solvated by four tetrahydrofuran molecules. Three plausible structures were investigated using HF/6-31+G* level of theory. Each solvated dimer complex was built and optimized to an energy minimum using Gaussian03. NMR calculations were done to determine the chemical ^{13}C-shifts of each complex. The calculated chemical shift results are compared to the experimental data to determine which dimer complex exists in solution.

38

Binding of a Triaza-Cyclopenta[b]phenanthrene to G-Quartet DNA

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DNA forms many conformations other than the well know double-Helix. One conformation, the G-Quartet, forms via Hoogstein bonds between G-Rich DNA sequences. It is known that the formation of G-quartets results in the inhibition of telomerase and in the silencing of oncogene expression. Because telomerase and oncogene function are strongly correlated with cancer, agents that promote the formation of G-quartets are often anti-cancer agents. Recently, our lab has described the synthesis of a triaza-cyclopenta[b]phenanthrene and preliminary investigations showed this agent to bind selectively to G-quartets. Computational and spectrometric studies were initiated to allow us to better understand the binding of this agent to G-quartet DNA. Using the computational program MOE, potential docked structures of the compound and its analogs were investigated. We found that the lowest energy conformations appeared when the aromatic chains were planar over the G-tetrad. The NMR was run to visualize the shifts of the G-tetrad peaks as different concentrations of the synthesized drug was added. The shift in peaks allows us to see where the drug

39

Development of a Liquid-Liquid Extraction System for the Purification of the Fluorous Mitsunobu Reaction

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The development of fluorous chemistry has introduced perfluoroalkyl tags as a convenient method for the separation of target compounds from byproducts in organic reactions. One reaction where this technique can be utilized particularly well is in conjunction with the Mitsunobu reaction, which is used for the direct substitution of primary and secondary alcohols and their subsequent conversion to esters, amides, or thioethers. Traditionally this reaction has encountered purification difficulties in separating the phosphine and diazo byproducts from the desired compounds. Recent developments of Fluorous phosphine and F-DIAD, both fluorous derivatives of Mitsunobu reagents, have greatly improved the purification using Fluorous Solid Phase Extraction (FSPE) with a Fluoro*Flash* SPE cartridge. While FSPE works well, greater simplification through the development of a liquid-liquid extraction system would be beneficial. Therefore, the focus of this research has been the development of a fluorous liquid-liquid extraction system for a successful, easier separation of Mitsunobu products in an attempt to further simplify the Mitsunobu reaction and expand the implementation of this reaction in additional research.

40

Studies on the Interactions of the Fragile X Mental Retardation Protein with a G Quartet Forming RNA Sequence

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The most common form of inherited mental retardation is fragile X syndrome, which affects 1 in 4000 males, and 1 in 8000 females. The syndrome occurs in individuals who are unable to produce the fragile X mental retardation protein (FMRP). FMRP has been hypothesized to bind with high affinity to RNA sequences that fold into G quartet structures. Fluorescence spectroscopy and gel shift assays were employed to study the interactions of FMRP with a G-quartet forming sequence known as sc-1 RNA. The sc-1 RNA sequence utilized in the fluorescence studies was labeled using the highly fluorescent purine analog 2-amino purine. The relative stability of the FMRP- sc1 RNA complex was determined by measuring its dissociation constant under varying temperatures and salt (KCl) concentrations.

41

Expression of Munc-13 RNA, a negative control for the interactions of G quartet RNA with the FRAGILE X MENTAL RETARDATION PROTEIN

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Fragile X syndrome is the most prevalent form of genetically inherited mental retardation. It occurs in approximately every 1 in 3600 males; whereas in females, the frequency is roughly between 1 in 4000 to 6000 females. The fragile X syndrome is directly linked to the absence of the fragile X mental retardation protein (FMRP) which is believed to be involved in the regulation of both mRNA translation and localization. FMRP contains three domains principally, two tandem KH domains and a RGG box. In this study, we examined FMRP interaction with MUNC-13; a known negative control since it does not form intramolecular G-quartets like some of its other RNA counterparts namely, MAP 1, sc-1 and s3F. In this project, MUNC-13 (33 nucleotides) was expressed by in vitro transcription using a synthetic DNA template and subsequently purified using ELUTRAP and dialysis methods. Other experimental techniques employed in this study included native gel electrophoresis and UV-Vis spectroscopy.

42

CopY Dimerization and Its Role in Gene Regulation

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CopY is a Zn(II) binding repressor protein that plays an important role in biological copper control systems. Its dimer form binds to DNA and represses the production of other copper control proteins. When in the presence of Cu(I), CopY binds Cu(I) and changes conformation, releasing it from DNA and allowing copper transport protein production. This change is due to the arrangement of cysteine residues in CopY, which provide sulfur atoms to bind metals. The orientation of these cysteines, as well as other key residues, ultimately determines how the active dimer regulates gene transcription. Understanding the formation of the CopY dimer will contribute knowledge about Cu(I) transport in cells. This can be used to better comprehend illnesses like Menkes and Wilson's Diseases, which are characterized by malfunctioning copper control systems. The CopY dimerization process was studied through the utilization of the computer software CHARMM, MOE, and ClusPro to orient and dock two CopY peptides

43

Assessment of human brain tumors using 1.5T multivoxel PRESS

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UPMC Presbyterian Hospital MR Center

This study was undertaken to evaluate human brain tumors noninvasively using proton NMR spectroscopy. Multi-voxel Point Resolved Spectroscopy (PRESS) was used to scan for metabolites including N-acetyl aspartate ((NAA), choline, creatine, and lactate. Patients were also scanned at echo times of 35 ms, 144ms, and 288 ms. Using signal analysis with localized water suppression, the areas of metabolite peaks were found and used to find the T2 relaxation time at their respective voxel. The relaxation time was then used to find the absolute concentration of metabolites, which can then be used to increase specificity for predicting tumor malignancy.

44

SEPARATION OF FATTY ACIDS BY NON-AQUEOUS CAPILLARY ELECTROPHORESIS.

Candace H. Payne, John T. Williams and Mitchell E. Johnson, Duquesne University

Within recent years, Capillary Electrophoresis (CE) has become extremely popular in the separation of biological sample analytes such as fatty acids. Although CE allows for the use of minute volumes, which improves separations; the technique often has issues with adsorption of analytes to the capillary walls. The development of means to reduce this problem is fundamental. In this work, fatty acids were derivatized with a positively charged, near-infrared absorbing, fluorescent dye. To prevent adsorption, two approaches were used: one capillary was coated with trimethylsilane (TMS) with a positively charged surfactant added to the run buffer; while another with Successive Multiple Ionic Polymer Layers (SMIL). Separations were done using a similar series of saturated and unsaturated fatty acids. Adsorption was assessed by monitoring the quality of the separations.

45

Analysis of *Lozenge* Isoforms using Quantitative PCR

John Holleran[1] and Dr. John A. Pollock[2]
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2. Associate Professor, Department of Biological Sciences, Duquesne University, Pittsburgh PA

Eye development in *Drosophila melanogaster* is dependent on specific and time sensitive gene expression. The *lozenge* gene is critical for the construction of a functioning compound eye. Early in development, *lozenge* is responsible for suppressing cell death, however later it is implicated in promotion of cell differentiation. Our focus on *lozenge* is directly related to its human ortholog, AML1, which in the event of mutation causes leukemia. The expression and levels of *lozenge* during various stages of development is essential in determining the ultimate fate of the eye. Therefore, examining the abundance of two different isoforms of *lozenge* in wild type and mutant animals will offer a comprehensive insight to crucial steps in eye development. To obtain an accurate assessment of gene expression, quantitative PCR is utilized. In addition, analysis includes PCR of multiple genes, simultaneously in the same reaction. This eliminates any variability and ensures confidence for a fair comparison of expression.

46

Peanut Veto Wall

Nichelle Madison, Dr. V. Paolone, Dr. D. Naples
University of Pittsburgh
Peanut Veto Wall

A scintillator veto wall to be used in an emulsion based experiment at Fermilab is currently being designed, constructed, and tested. The emulsion based experiment, which is called "Peanut," will directly measure the beam composition of the NuMi beam, specifically the electron neutrino composition. The NuMi beam is a neutrino beam at Fermilab, which will be used in several upcoming experiments, including MINOS and Minerva. The veto wall we are constructing will be used to reject interactions in the emulsion based detector, which are initiated by muons from the interaction sample.

47

UV-Vis Spectroscopy Study of G-quartet forming RNA Targets of the Fragile X Mental Retardation Protein

Patrick Lackey and Dr. Rita Mihailescu
Duquesne University

Fragile X Syndrome is one of the leading causes of inherited mental retardation, affecting 1 in 4000 males and 1 in 8000 females. The syndrome is caused by the silencing of a protein named the fragile X mental retardation protein (FMRP). FMRP is an RNA binding protein that appears to play a role in regulating the translation of specific messenger RNAs (mRNA). The mRNA targets of FMRP are unknown; however, it has been shown that the protein has a high affinity for guanine-rich mRNA that have the potential to fold into G-quartets. Among the G-quartet forming mRNA potential targets of FMRP is the sc1 sequence. The sc1 RNA molecule was produced by *in vitro* transcription reaction off a synthetic DNA template. The stability of the sc1 molecule was studied by UV-Vis spectroscopy by monitoring the changes in absorbance at 295 nm (wavelength specific for G-quartet dissociation) upon increasing of temperature. Through this we have observed FMRP has a stabilizing effect on the sc1 molecules.

48

Building an Apparatus for Single-Capillary Microcoil Electrophoretic NMR

Jeremy Spater, University of Pittsburgh REU, Kenyon College
Dr. Qiuhong He, University of Pittsburgh
University of Pittsburgh Medical Center, Presbyterian Hospital, Magnetic Resonance Research Center

We are attempting to construct an apparatus for electrophoretic NMR, a nascent technique for spectroscopic analysis of multiple biomolecules in solution. Novel elements of the probe's construction are a capillary for sample transport, which allows a higher electric field per unit voltage compared to a macroscopic array, and an RF microcoil for better sensitivity and signal-to-noise ratio. In addition, magnetic susceptibility matching fluid (FC-43) is used around the microcoil to improve sensitivity. The design and construction process is related in detail. If circumstances permit, the results of proof-of-concept runs at 11.7T will be presented

49

Controlling an Interferometer With Shape Memory Alloys

Michael Baker and Dr. Albert Heberle
University of Pittsburgh Physics REU

The purpose of my experiment is to test the use of Nitinol, a Shape Memory Alloy, in a position-control apparatus. Shape Memory Alloys could provide an inexpensive, compact and low-voltage alternative to stepper motors and piezo devices currently in use. Nitinol undergoes a heat-based contraction but needs a restoring force to return to the initial position. In my setup I use two antagonistic actuators for restoration. The contraction is highly nonlinear, so two closed-loop feedback methods check the position of the stage through contraction. First, a Michelson interferometer is a source of non-linear feedback to tell position and direction of motion on a given cycle. A second source uses varying electrical resistance of the actuator wires themselves as they expand and contract as a linear source of feedback. I will present progress in what degree of control can be obtained and how successfully each feedback setup performs.

50

Anatomical and Functional Image Reconstruction

Sarah Rugheimer and Dr. Sun
University of Pittsburgh

Recent developments in technology have allowed non-invasive imaging of not only the anatomy but also the function of the brain. The images obtained allow localization of functional areas, such as language and sensory cortices. The convoluted brain surface inhibits imaging within the gyri (valleys), and presently functional surface data has only been mapped on the sulci (ridges). We would like to have an image of functional activation for the entire surface of the brain (both gyri and sulci).I have been working with a program called FreeSurfer to attempt to map magnetoencephalograph (MEG)source locations on surface MRI data. Through FreeSurfer, I can computationally "inï¬,ate" the brain, causing the gyri to be visible on the surface alongside the sulci. So far, I have mapped the MEG data on MRI volume slices, but the eventual goal is to create an inï¬,ated surface of the brain mapped with the MEG activation sources.

51

More Luminescent Lanthanides Reporters: Polymetallic Dendrimer Complexes

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Lanthanide complexes have been studied for years due to their unique luminescence properties. Because of their long luminescence lifetimes and sharp emission bands, biological and medical applications of the complex are being researched. Typically single lanthanide cation complexed with ligands has been studied. Unfortunately, most of the luminescent lanthanide complexes reported in the literature are not suitable for biological applications due to insufficient luminescence intensity. We are investigating the strategy of incorporating numerous lanthanide ions in dendrimers having a large number of absorbing naphthalimide groups, in hopes of creating stronger luminescent species. The dendrimer complexes have been characterized by spectrophotometric titrations. Detailed photo-physical properties of the luminescent dendrimers complexes are analyzed by measuring quantum yield (to quantify the efficiency of the intramolecular energy transfer), luminescence lifetimes, and triplet state energies.

52

Molecular evolution of *LIF* and *LIFR* in primates

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Humans differ from their nonhuman primate relatives in several aspects of reproductive physiology, including a more deeply and rapidly implanting trophoblast, and the extensive invasion and remodeling of maternal arteries delivering larger amounts of nutrients and oxygen to the fetus early in development– necessary for the development of a large-brained infant. Little is known about the molecular basis for the evolution of these adaptations. *LIF* and *LIFR* are known to play an important role in implantation and placental development. Using PCR and DNA sequencing, we obtained the entire coding sequence of these two genes from human, chimpanzee, gorilla, orangutan, gibbon, and macaque. The data revealed that *LIF* is highly conserved, suggesting strong purifying selection as its mode of evolution, and *LIFR* has somewhat higher rates of molecular evolution, indicating relaxed or possibly positive selection. These results provide insight into the molecular basis for these physiological adaptations important in human reproduction.

53

Designing, building and characterizing a laser diode system

Koji Masuda
Physics at the University of Pittsburgh

This summer, I am designing, building and testing a diode laser system which consists of a laser diode, a laser driver, temperature control unit and a moisture shield. This diode laser will replace with a dye laser which has been used by Dr. Snoke's group to investigate properties of *excitons*, electron-hole pairs. A reason for the replacement is that a diode laser is more convenient for certain experiments such as luminescence measurement.
This poster will present the design of the diode laser system, electrical circuits of a laser driver and a temperature controller and results of performance tests including the threshold current and wavelength tenability which tells you how wavelength changes with temperatures.

54

Backbone and Side Chain Effects on Conjugated Polyelectrolyte Biosensors

Laura Anzaldi, Jennifer Treece, Palwinder Kaur, Min Liu, and David H. Waldeck
Chemistry Department, University of Pittsburgh

Considerable interest in conjugated polyelectrolytes has been driven by the exceptional properties they exhibit in aqueous solution. These conjugated polyelectrolytes, for example, display high fluorescence quantum yields and an ability to interact electrostatically with other charged species. In an attempt to harness these materials as biosensors, spectroscopic tools are being used to study the effects that the backbone and side chain composition have on the fluorescence properties. In our present work we are trying to understand the mechanism behind fluorescence quenching of polyphenyl phenylenes and polyphenyl ethynylenes in the presence of macromolecules. We are also exploring the effects that side chains have on the fluorescence quenching by studying both sulfonate and carboxylate terminated side chains. These comparisons should offer insight into building better biosensors with conjugated polyelectrolytes

55

Characterization of a Novel *Xenopus tropicalis* Protein Containing a Cys-x-Cys-xxxx-Cys-x-Cys Motif

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Putative Cys-x-Cys-xxxx-Cys-x-Cys metal binding motifs are found in a myriad of proteins throughout nature. In bacteria, the motif is a key dimerization and regulatory element in metal sensing pathways. We are characterizing an unknown protein from *Xenopus tropicalis* that is similar to the bacterial proteins in order to confirm that this motif functions in a similar manner - we hypothesize that the protein will specifically bind metal ions and form a dimer that is dependent on metal binding. The *X. tropicalis* gene was subcloned from a cDNA commercial sequencing plasmid into a pET-14b expression vector that produces an N-terminal his-tag fusion. The expressed protein was purified using metal chelate chromatography. In future experiments, the ability of the protein to bind metals will be assessed by atomic absorption spectroscopy, and the monomer-dimer status will be observed through the use of size exclusion chromatography.

56

Two Isoforms of Lozenge are Expressed at Different Points in Drosophila Development

Margaret Walker, Dr. James Pollock
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Mammalian RUNX proteins are a group of transcription factors that have long been associated with disease. Expression of different isoforms of the RUNX gene AML1 lead to many forms of Leukemia. An analogous gene, Lozenge has been found to direct axon development in the *D. melanogaster* eye. Lozenge has two isoforms with the same splice sites as its mammalian homologue, AML1. It is hypothesized that the shorter isoform of Lozenge lacking the fifth exon is expressed in the undifferentiated cells of second in-star larvae. Also, that the full length form of Lozenge is expressed in the differentiated cells of the third in-star larvae (Behan). Here, Real-Time PCR was used to examine Lozenge expression levels of both second and third in-star larvae. Product size was then determined by agarose gel electrophoresis.
Behan, KJ. Double Tiered Interactions Between Lozenge and ETS Factors in Drosophila Ee Development. Dotoral Thesis. Department of Biological Sciences, Carnegie Mellon University, Pittsburgh, PA. 2001.

57

Benchmark Quantum Chemical Computations on Acid-Catalyzed Diels-Alder Reactions.

Ryan A. Newton, Joshua Plumley, and Jeffrey D. Evanseck
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Experimental activation energies, enthalpies and entropies are well known for the $AlCl_3$ catalyzed and uncatalyzed Diels-Alder reaction between butadiene and methyl acrylate in benzene. Experimental geometries for butadiene and methyl acrylate are also known in the gas phase. Activation barriers and geometries have been computed for the $AlCl_3$ catalyzed and uncatalyzed Diels-Alder reaction between butadiene and methyl acrylate in the gas phase and in solvent at different levels of theory. The HF, MP2, and B3LYP quantum chemical methods have been employed with a variety of basis sets ranging from small inflexible basis sets to large basis sets with additional polarization and diffuseness. Computed and experimental results have been compared to determine the best level of theory to describe accurately the $AlCl_3$ catalyzed Diels-Alder reaction between butadiene and methyl acrylate as well as the uncatalyzed parent system. The focus of this work is to identify appropriate levels of theory in describing acid catalyzed Lewis acid Diels-Alder reactions. The different levels of theory and their performance will be discussed.

58

Understanding C_2-Substituent and Counter-Ion Effects of Bis(oxazoline) Copper(II) Catalyzed Diels-Alder Reactions by Density Functional Computations

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Large-scale density functional calculations of C_2-substituent effects of bis(oxazoline) copper(II) catalyst complexes on the rate and selectivity of Diels-Alder reactions have been performed. Using Becke's three-parameter density functional theory with the nonlocal correlation of Lee, Yang, and Parr and the 6-31G(d) basis set, the steric and electronic effects of *tert*-butyl, isopropyl, and phenyl substituent substitution are reported with regard to the Diels-Alder reaction of cyclopentadiene and acrylate imide. Consistent with experimental studies, the computed ground state structures and rates of reaction are in good agreement. Additionally, counter-ion effects of hexafluoroantimonate and triflate are discussed in terms of their relative effects upon the coordination geometry about the Lewis acid center and the resultant differences in rate and selectivity of the model reaction. The computed transition structures provide an understanding of how the C_2-subtituents and counter-ion effects modulate the copper(II) catalyst, which ultimately impact the catalytic power and selectivity of the system..

59

Performance of Protein Structure Prediction Methods using Alternative Alignments and Scoring Functions.

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For even moderately difficult protein comparative modeling projects, there are often variable regions for which the alignment between target and template is highly arbitrary and hence structures generated through such an alignment can have significant errors. Improving the accuracy of protein structure prediction methods would further facilitate functional annotation. In an effort to overcome these errors, we have developed a protein structure prediction pipeline that generates alternative sequence alignments and ranks the resulting structures with several methods. In this presentation, we will discuss the performance of probA for generating correct sequence alignments between target and template and three statistical potentials (Prosa2003, GA341 and DOPE), a neural network based predictor (ProQ) and a physics-based energy function for identifying the structure closest to native.
In this presentation, we will discuss the performance of probA for generating correct target-template sequence alignments and three statistical potentials (Prosa2003, GA341 and DOPE), a neural network based predictor (ProQ) and a physics-based energy function for identifying the structure closest to native.

60

Transforming Metabolic Energy into Electricity For Powering Implantable Devices.

Molly Snyderman
Department of Neurological Surgery, University of Pittsburgh

The purpose of this research study is to see whether electrons produced during metabolism can be used to run implantable devices to help in the treatment of diseases. We would attempt to obtain these electrons from the Pentose Phosphate Pathway (PPP). The PPP is a subset of glucose metabolism in which NADPH is generated and pentose (five-carbon) sugars are synthesized. This pathway is one of the ways by which the body creates free radicals that lead to oxidative stress. Oxidative stress is a term used to describe damage to a cell, tissue, or organ caused by free radicals. Free radicals are highly reactive atoms or molecules with unpaired, free electrons. Traces of free radicals have been found in many disease states, such as Parkinson's Disease, Alzheimer's Disease, and Epilepsy. By obtaining the electrons produced in the PPP, implantable devices, such as pace makers, could be run without batteries.

61

Neurogenesis in the Vomeronasal Organ

Jessica Furnier and Sarah Woodley
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The vomeronasal organ (VNO) is a sensory epithelium that detects pheromones, chemical cues that influence reproductive behavior and physiology. As in other epithelial tissues, neurogenesis occurs in the VNO throughout adulthood and is hypothesized to function to replace old or damaged cells. In *Plethodon cinereus*, the red-backed salamander, the rate of neurogenesis changes seasonally, with a peak in the spring when animals are mating. This may serve to enhance pheromone detection involved in seasonally changing behaviors. Pilot studies using 5-bromo-2'-deoxyuridine (BrDU), a marker for neurogenesis, have demonstrated neurogenesis in the VNO and telencephalon of adult *Plethodon shermani*. In this study, we expand upon initial results and measure levels of neurogenesis in three species with differing seasonal reproductive cycles. I compared *Desmognathus ochrophaeus*, at the peak of their reproductive cycle, and *P. cinereus* and *Plethodon glutinosus*, past their most active reproductive stage. I hypothesized that the rate of neurogenesis will correspond to reproductive condition due to the importance of the VNO in behaviors that are seasonally expressed.

62

Quantum Chemical Treatment of the Ene Reaction Activation Parameters

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The experimental activation energies and entropies have been reported for the ene reactions of simple alkenes. High level quantum chemical methods with moderately sized-basis sets have been used to compute the activation parameters. The reactions include ethene and propene to pentene, propene and propene to hexene, propene and propene to 4-methyl pentene, and ethane and 2-methyl propene to 2-methyl pentene. The common employed 6-31G(d) basis set gives poor results using all quantum chemical methods utilized; however density functional theory gives acceptable results for two reactions. Larger basis sets show a divergence across all quantum chemical methods used in this investigation. Continued studies are required to determine appropriate levels of theory in computing the activation parameters of the ene reaction.

63

MgII Absorption Features in Quasar Spectra

Anna Quider
University of Pittsburgh, Department of Physics and Astronomy

This presentation explains an aspect of quasar research which deals with studying foreground gaseous regions throughout the universe, focusing on the motivation for the creation of a catalog of absorption lines due to singly ionized magnesium atoms (MgII) and its potential uses. To date, this catalog is the largest collection of identified and measured MgII absorption lines using the Sloan Digital Sky Survey spectroscopic data for quasars. Approximately 50,000 quasars were searched for MgII absorption doublets and about 15,000 doublets were identified and measured. Due to the nature of the MgII absorption doublet, it is a useful tool for studying the properties of gas clouds in the universe. Interesting results, for example a relation between gas kinematics and metallicity of the absorbing galaxies, have already been obtained. This catalog has also been used to create large-scale observing programs for the Hubble Space Telescope. Other ongoing projects will also be described.

64

Electron Transfer Kinetics of Cytochrome C covalently attached to Carboxylic acid-terminated self-assembled monolayer

Kathryn Knorr*, Hongjun Yue[+], Rose A. Clark*, David H. Waldeck[+]

Cytochrome c is an electron transfer protein that plays an essential part in the natural respiratory and photosynthetic chains. In this study, we immobilized cytochrome c to mixed carboxylic acid/hydroxyl group-terminated self-assembled monolayer (SAM) by covalent bonding to confine its conformation on the surface. Carboxylic acid-terminated thiols with 3, 5, 7 and 15 methylene groups were used. The electron transfer rate constant (k^o) was studied on each cytochrome c/SAM combination as a function of ionic strength and SAM thickness. When ionic strength was lower than 100 mM, k^o increased with ionic strength; this was attributed to solution resistance. The k^o had no dependence, though, on ionic strength at higher ionic strengths. No difference in k^o was observed on two SAMs with chain lengths of 5 and 7 methylene groups, but much lower values were observed for SAMs with 15 methylene groups.

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65

Structural determination of the phenol dimer through high-resolution electronic spectroscopy with comparison to ab initio calculations: investigating biomolecules in the gas phase.

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University of Pittsburgh

Certain molecules are capable of interactions leading to the formation of molecular clusters. Phenol, with two potential noncovalent interactions—hydrogen bonding and aromatic dispersion forces, is a prime example of a molecule that can form several dimer structures. Using high-resolution electronic spectroscopy in the gas phase, the phenol dimer structure is currently being investigated. Preliminary spectra obtained at low resolution confirmed both the phenol monomer and dimer origins cited in the literature. Yet to be observed is the second, proton-accepting band of the dimer spectrum, which has only been determined theoretically. In order to interpret any resulting high-resolution spectra, *ab initio* calculations will be run. The geometry of the dimer will be resolved by comparison to our theoretical calculations. Structure determination will involve comparisons of experimental and calculated electronic transition moments, moments of inertia, and electric dipole moments.

66

Study of the von Kármán vortex street using non-circular shaped cylinders

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When flowing fluid encounters an obstacle, two rows of vortices, known as a von Kármán vortex street, are formed. To study this phenomenon in two dimensions, a vertical soap film and high-speed digital camera are set up.

The current study focuses on the structure of vortex streets created by triangular and square rods. While many features of vortex streets are unknown, we are interested in the relationship between the dimensionless vortex shedding frequency (the Strouhal number St) and the ratio of inertial forces to viscous forces in the fluid (the Reynolds number Re) in vortex streets created by differently shaped rods. The Strouhal number dependence on the Reynolds number is measured for triangular and square shaped cylinders and compared with a recent proposal with mathematical form $\mathrm{St}=\frac{1}{\mathrm{A}+\frac{\mathrm{B}}{\mathrm{Re}}}$ to see if the relationship is universally applicable to different shaped cylinders.

67

Genetic Population Structure of the Tippecanoe Darter

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The Tippecanoe darter (*Etheostoma tippecanoe*) is a threatened freshwater fish species with a fragmented distribution in the Tennessee, Cumberland, and Ohio River Systems, including the Upper Allegheny River system of Pennsylvania. The recent appearance of new populations in the lower Allegheny River system near Pittsburgh produces local concerns for stream-impact development projects. In this study, we conduct molecular phylogenetic analysis to determine the population structure of this species. Samples were collected from two Ohio River drainages (the Muskingam River and Big Darby Creek), the Allegheny River system, and two of its tributaries (Deer Creek and Pine Creek) for comparison to samples from two drainages in Tennessee. Phylogenetic analysis of mitochondrial ND2 gene sequences revealed little phylogeographic stucture between the disjunct populations of the Ohio, Allegheny, and Tennessee drainages. This is possibly the result of recent fragmentation of a formerly continuous population distribution throughout the Ohio River system.

68

Voltammetric study of extracellular dopamine in the striatum of anesthetized rat

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The neurotransmitter dopamine is believed to contribute to addictive behavior associated with drug abuse. In this study, we employed fast scan cyclic voltammetry (FSCV) in combination with carbon fiber microelectrodes to monitor extracellular dopamine concentrations in the section of the brain known as the striatum. Male Sprague Dawley rats weighing between 250 to 325 g were anesthetized with chloral hydrate (400 mg/kg i.p.) while dopamine levels were monitored. After an intrastiatal infusion of raclopride (50 M in 200nL), a dopamine antagonist, the animal received a systemic dose of cocaine (30 mg/kg), a dopamine uptake inhibitor. Cyclic voltammograms obtained prior to and following drug administration were used to identify whether extracellular dopamine concentrations were effected by the cocaine injection. These voltammograms verified an increase in extracellular dopamine after cocaine administration, only when preceded by the infusion of raclopride.

69

Sex Determination from Fingerprint DNA

Carolyn Oleyar, Lisa Ludvico
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When a fingerprint is found at the scene of a crime it is often not clear enough to be lifted. It may be smudged or only a partial print. In addition, prints are simply processed and entered into the AFIS data base without any biological analysis. The objective of my analysis is to attempt to acquire useful evidence from these otherwise useless prints. I will test whether it is possible to extract any DNA from superglue fumed prints, magnetically dusted prints, and the residual print left behind on the surface once a print is tape lifted in addition to using the actual tape itself in an extraction protocol. The ultimate goal is to determine whether there is enough DNA present to do a sex determination using three different sex specific primer sets. Finally, if DNA is successfully extracted from these prints, the quantities of the clear print sample and smudge sample shall be compared in order to conclude if one yields substantially more DNA than the other.

70

Determining Affinity of DNA Binding Agent by a Restriction Exonuclease Protection Assay

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The goal of my research is to determine how effective different compounds are at binding to double stranded DNA. To do this, a restriction exonuclease protection assay is employed. In this assay, specific concentrations of the compound are incubated with DNA and digested by a restriction enzyme. If the drug binds to the DNA effectively, it will prohibit the restriction enzyme from cleaving the DNA strand. After digestion occurs, electrophoresis is employed to determine how much of the DNA is cleaved by the enzyme. The gel is analyzed to determine what percentage of the DNA remained uncut and the higher the percent of uncut DNA, the more effective that drug is at binding to DNA. We have analyzed two compounds for their binding to linear plasmid DNA, pUC19. Compound **1** displayed a K of 3.3×10^{6} M^{-1}, close to the previously measured value. Compound **2** is currently under investigation.

71

Wild Horse Forensics

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A behavioral study on wild horses' reproductive strategies was conducted on Assateague Island National Seashore, Maryland, USA. Genetic material was obtained using a biopsy dart and subsequently analyzed in an effort to elucidate the social organization and mating strategies of wild horses. Unfortunately, a large band stallion was absent during the collection phase. A few horse bones were later obtained from the study site and were believed to be from the missing stallion. We hope to identify the missing stallion using the femur bone and DNA extracted from his numerous offspring.

72

The effect of *lozenge* expression on photoreceptor axon extension and targeting in *Drosophila melangaster*

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Lozenge is a fruit fly transcription factor involved in regulating gene expression in the eye thereby playing a crucial function in cell differentiation. It has been established that mutations of *lozenge* produce abnormal eye phenotypes in addition to abnormal photoreceptors that exhibit defective axon targeting into the optic lobe. This study examined the impact of *lozenge* expression on genes specifically participating in photoreceptor axon extension and targeting in the fly eye. Real-time PCR was utilized to evaluate transcript levels in wild type and *lozenge* mutants. Additionally, immunohistochemisty was conducted to visualize and compare the relative developmental differences in the cephalic complexes of wild type and *lozenge* mutants. Determining the influence of Lozenge on such genes is significant in characterizing the molecular signaling cascade during fly eye development. Ultimately, this information will contribute to a basic understanding of the human homolog AML1, which is equivalent to *lozenge* in regulation and function.

73

EFFECTS OF SELF ASSEMBLED MONOLAYER COMPOSITION ON ADSORBED CYTOCHROME *C* ELECTROCHEMISTRY

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Cytochrome *c* (cyt*c*) is a biological electron transfer protein that has been studied in detail due to its small size, availability, and ease of handling. Many of the scientists that have investigated cyt*c* have reported changes in the voltammetric response with changes in the environment of the protein. The majority of the studies conducted to date have been performed with cyt*c* in solution. A few studies have investigated cyt*c* adsorbed to individual and mixed self-assembled monolayers(SAM) on gold in pH 7.0 phosphate buffers (ionic strength, 10 mM). Excellent voltammetric responses are obtained for cyt*c* adsorbed to the SAM structures under these conditions. To further probe adsorbed cyt*c* electrochemical properties on mixed SAMs, the protein microenvironment is changed systematically. The voltammetric response for cyt *c*/mixed SAM/gold electrodes are monitored to ascertain how the microenvironment around the protein affects the protein function. The microenvironment perturbations underway involve changes in SAM composition.

74

Evaluation of the role of strategically places amino acids on the folding of α-conotoxins

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Evaluation of the significance of disulfide bridges is an important part of understanding the concept of protein folding. Our group is involved in determining how slight changes in the sequence of small peptides influence their folding properties. Our present studies focus on the folding of a group of multiple disulfide bridge containing small peptides, -conotoxins SI, SIA, GI, GII and MI. These thirteen-fourteen amino acid containing peptide amides have two disulfide bridges leading to three possible regioisomers. Most reduced forms of native conotoxins are able to fold to form the natural isomer. However, under certain conditions the oxidation of these peptides yields this native isomer in a mixture of the other two isomers. This poster describes our results on the affects of different amino acids in some key position in the sequence of -conotoxins and compares oxidation results obtained under folding and denaturing conditions.

75

Development of Biodegradable Polymeric Carriers for Vitamin B_{12} Delivery

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Cyancobalamin, commonly known as vitamin B_{12}, has many useful applications such as lowering homocysteine blood levels for risk factor of heart diseases, and deterrence of dementia. Biodegradable copolymer carriers at the micron level were investigated to determine the effectiveness with microencapsulation of the drug cyancobalamin in controlled release. Using an oil-in-water emulsion and solvent extraction procedure, microspheres between the sizes of 20-120 m were formed. Size and internal structure of microspheres were determined by scanning electron microscopy and confocal fluorescence microscopy. Various polylactide-co-glycolide copolymer ratios were used to conclude whether zero-order drug release could be obtained. Results are compared to and calculated with a Fickian model and equation. The aim of this project is eventual use of these microspheres intramuscularly to provide a zero-order release of the drug during the period of 4-6 month with a tunable rate.

76

A Monte Carlo Based Simulation of the Effect of Action Potential Broadening on Neurotransmitter Release

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Previous studies have found the broadening of the active potential (AP) curve during repolarization in the neuromuscular junction to affect the amount of calcium influx and neurotransmitter release within the active zone of the pre-synapse. The broadening of the AP curve increased calcium influx but decreased synaptic vesicle release rate in certain conditions. Based on previous experiments modelling the active zone using MCell, we synthesized several AP curves to better understand their relationships to synaptic vesicle release and calcium release rate. Distributions were then obtained from accumulation of thousands of simulations. Our results found that delaying AP curve broadening early on was found to increase synaptic vesicle release rate and calcium influx at a rate much greater than when broadening the AP curve after 50 percent repolarization. Whereas previous works indicated synaptic vesicle release rates may decrease, our results only showed increases due to AP broadening.

77

Genetic Analysis of the Metazoan and Fungal Heat Shock Protein Subfamily

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Heat Shock Proteins (HSP) are involved in many cellular functions and are present in every organism. During times of stress, extreme heat or cold, glucose or oxygen deprivation, these proteins are induced to repair the three dimensional conformations which degraded proteins have lost. The sequences of the HSPs from the Kingdoms Metazoa and Fungi were first obtained from iProclass and aligned using the T-Coffee program. Conservation motifs were then obtained from a MEME analysis. The resulting alignment was manipulated in GeneDoc. Next, a phylogenic Bootstrap analysis was performed and the results were visualized using Treeview and Sequence Space. The group entropy was calculated using the GEnt program. Finally, the group entropy, MEME patterns, and conservation data was converted to Rasmol scripts to provide a medium for viewing. This data is valuable in determining the exact function and groupings of the HSPs of the Metazoa and Fungi Kingdoms.

78

Macroscopic structures formed by quantum dot interactions

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Quantum dots are extremely small particles, on the scale of a few nanometers, which exhibit quantum mechanical behavior. Due to their size and special physical properties, they are useful in the development of biosensors and imaging devices. When placed on a surface, quantum dots often form complex structures, including aggregates and rings. A model of quantum dot interactions is needed to fully understand the structures that they form under various conditions. Rabani et.al. proposed a coarse-grained model which simulates evaporation on a lattice using Monte Carlo simulation with very simple rules. Their model qualitatively matched the structures that they observed in the laboratory. In addition to reconstructing their model and results, our team has added additional interactions to their model, including both short-range and long-range interactions. Specifically, we allowed each quantum dot to carry charge. We then varied the simulation's initial conditions to observe the formation of new structures.

79

Structural and Functional Analysis of Inosine Monophosphate Dehydrogenase using Sequence Based Bioinformatics

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The enzyme inosine monophosphate dehydrogenase (IMPDH) catalyzes the unique initial step in guanine nucleotide synthesis. IMPDH is unregulated in rapidly dividing tumor cells and has therefore been identified as an excellent target for pharmacological intervention by several studies. In this study, we applied sequence-based bioinformatics to elucidate both the structural and functional characteristics of IMPDH. Specifically, a multiple sequence alignment of 78 IMPDH sequences was constructed and the program MEME was used to identify the most highly conserved motifs within the enzyme family. A phylogenetic tree analysis was performed which facilitated the separation of sequence into groups and the identification of distinguishing characteristics. Visualization of the conserved residues and motifs within a 3-dimensional atomic model of human IMPDH revealed the crucial interactions for binding both the cofactor and substrate, maintaining the structure of the catalytic core and for catalyzing the production of xanthine monophosphate from inosine monophosphate.

80

Assessment of Genome-Scale Predictions of the Transcription Factor Binding Sites of Cys_2His_2 Zinc Finger Proteins in Yeast Using the FOOTER Algorithm

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The identification of the short, degenerative DNA sequences that make up Transcription Factor Binding Sites (TFBSs) in the regulatory regions of DNA provides a challenge to bioinformatics and computational biology. The probabilistic phylogenetic foot-printing algorithm FOOTER(Corcoran *et al.,* 2005) was developed to identify putative binding sites by using human and mice species. The identification of the genes controlled by the family of Cys_2His_2 zinc finger DNA-binding domain transcription factors in three yeast species (*Saccharomyces cerevisiae*, *Candida glabrata*, and *Schizosaccharomyces pombe*) would help to expand and assess the accuracy of this algorithm on the three related yeast species. Genome-scale predictions of the binding sites of all Cys_2His_2 zinc finger proteins were determined using this algorithm on the orthologues of the three yeasts. The resulting predictions were evaluated with yeast gene expression data (microarrays) and known binding site data to help assess and expand the accuracy of the FOOTER algorithm.

81

The Utilization of Monte Carlo Techniques to Simulate the Repressilator: A Cyclic Oscillatory System

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The repressilator is a synthetic transcription regulator that operates in a cyclic oscillatory manner. This system is comprised of three proteins (LacI, tetR, cI) which act as transcription regulators on one another. Previously the repressilator has been simulated using ordinary differential equations. The underlying assumption with using this method is that the system overall is in a properly mixed state at all times. However there is a flaw in this assumption because oscillatory systems tend to locally evolve into inadequately mixed states. To overcome this problem MCell (Monte Carlo Cellular Simulator) was used to simulate molecule positions, movements and interactions of the repressilator with spatial realism. The results demonstrate a more accurate representation of the oscillator and ultimately this method can be used to study systems of much shorter oscillation periods.

82

The effect of Vascular Endothelial Growth Factor (VEGF) promoter polymorphisms +405 G/C and -460 C/T on repeat cardiac outcomes PCI and CABG in Heart Failure patients.

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The goal of this experiment was to determine the importance of two particular SNP's, 405 G/C and the 460 C/T, within the VEGF gene in heart failure patients. To determine whether VEGF, which facilitates blood vessel formation and tumor growth, also affects heart failure patients, the genotypes of the patients first had to be determined. Using the program Oligo, both a forward and reverse primer was designed for use in Polymerase Chain Reaction. PCR was run using DNA from 100 different patients and the PCR product was analyzed using 2% agarose gels check for amplification. When DNA from all 100 patients was successfully amplified, a digestion was performed in order to cut the DNA at a specific site in order to determine the genotype of the patients. This was performed for both SNP's using primers specific for each one. After digestion, all samples were run out on a 2% agarose gel. From the photographs of the gel, the genotypes of all 100 patients were decided. However, to be more accurate in the genotyping, Real-Time PCR was then performed. Using the program Oligo, new primers were again designed and the process was repeated only this time Real-Time PCR was done instead of regular PCR. Currently this project is not finished. The results so far indicate that the genotype frequencies in the 405 SNP are approximately 50% GC, 15 % CC and 35% GG. There are no accurate numbers for the 460 genotype because as of yet there has not been successful PCR of the 460 SNP.

83

Molecular Modeling of the Catalytically-Relevant Ternary Complex of Inosine Monophosphate Dehydrogenase

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Although much is known from x-ray crystal structures on the binding mode of inhibitors of the enzyme inosine monophosphate dehydrogenase (IMPDH), the binding mode of the inosine substrate is less certain. IMPDH is a huge tetramer, each monomer approximately 460 amino acids and presents special challenges to molecular modeling methods. In this presentation, we will discuss our results on 1) building a model of the human tetrameric ternary complex of IMPDH 2) the molecular dynamics (MD) simulations of the solvated ternary complex and 3) the ab initio quantum chemistry calculations on a model of an intermediate state in the catalytic cycle. These results are beginning to elucidate the crucial interactions responsible for binding inosine monophosphate and for catalyzing the subsequent reactions.

84

Structural Analysis of the EGR Family of Transcription Factors: Templates for Predicting Protein – DNA Interactions

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The EGR family of transcription factors is activated in cells exposed to growth factors. The overall structure of the family is highly conserved while the amino acid sequence can be quite diverse allowing for a wide array of DNA recognition sequences. Through homology modeling we have found we are able to reproduce the structure of the DNA binding domain of EGR proteins, which consists of three zinc fingers. We have also determined through molecular dynamic simulations that most side chains within the domain reach an equilibrium state. Furthermore, the three recognition residues in each zinc finger are found to have side chain conformations that are optimal for recognition. These studies help to show a possible mechanism for zinc finger recognition of DNA.

85

A Brownian Dynamics Simulation of Molecular Crowding

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The effects of molecular crowding are investigated using a Brownian Dynamics simulation. The simulation allows for a study of the interaction of any concentration of particles. The Brownian particles are each assigned a charge, diffusion coefficient and radius and then randomly placed along a plane at a predetermined height above a charged surface. The charged surface is represented as a planar array point charges creating a corresponding charge density. The trajectory of each particle is then moved mathematically according to a multivariate Gaussian distribution, to simulate the Brownian motion created by collisions in the surrounding media, and according to the summation of the total electrostatic forces acting on each particle. Although numerous experiments have examined the anomalous effects of molecular crowding, they have not allowed for predictive ability in complex solutions. This computational simulation will allow researches to predict the behavior of a variety of different types of molecules in a crowded media.

86

Computer Simulation of Transcranial Electrical Activity for Intraoperative Monitoring of Brain Surgery

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Transcranial Electrical Stimulation (TES) is a new intraoperative monitoring technique utilized during brain surgery to evaluate anesthetized patients. In TES, high-voltage, short-width electrical pulses are applied to electrodes on the scalp, generating action potentials (APs) within the Cortico-Spinal Tract (CST). Clinical neurophysiologists can then monitor the elicited electrical waves and warn the neurosurgeon when surgical errors, e.g., pinching motor axons, occur that would result in serious surgical complications. Currently, selecting scalp electrode sites and stimulation parameters are experimentally based. This collaborative research in USA and The Netherlands utilized a sophisticated electrostatic volume conduction model and the finite element method which produced, for the first time, a functional map for the TES in realistic head geometry. Our computer simulation allows direct observation of the electrical activity within the brain in the form of 3-dimensional graphics as the results of varying scalp sites and stimulation parameters, gives insight on AP generation and propagation in the CST, and provides valuable information to optimize TES procedures.

87

Comparison and Analysis of Heat Shock Proteins in Organisms of the Kingdom Viridiplantae

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Heat shock proteins are a group of proteins found in all living cells that are activated when the cell is subjected to environmental stresses such as extremes of temperature, oxygen deprivation, or toxins. They also have a role in the immune response and serve as chaperones for protein folding, and consequently can bind to nearly every type of protein in the cell. One hundred and sixty one sequences of heat shock proteins found in organisms in the Kingdom Viridiplantae were isolated from the iProClass database. A multiple sequence alignment was created using the T-Coffee program and the resulting patterns from a MEME analysis. Phylogenetic trees were created with the PHYLIP programs followed by a Sequence Space and a Group Entropy analysis. These were used to separate the sequences into distinct subfamilies and define the characteristics unique to each. These unique features were then modeled in RasMol to visualize the variations between subfamilies.

88

Docking of Dictyostatin, 16-Normethyldictyostatin, Discodermolide and 14-Normethyldiscodermolide, to □-Tubulin

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Due to their crucial role in cell division, microtubules have become a primary target for chemotherapeutic drugs. Two families of compounds, the taxanes and epothilones function by binding to -tubulin, thereby strengthening the lateral contacts between protofilaments and stabilizing microtubules against disassembly. By hindering the dynamic behavior of microtubules, they inhibit mitosis, eventually causing the cell to die by apoptosis. Despite exhibiting similar mechanisms, these two families of compounds, based on cryoelectron crystallography analysis, have unique binding modes and interact with different residues of -tubulin. Two other families of compounds – discodermolides and dictyostatins – have been found to competitively inhibit the binding of and have activities similar to the taxanes and epothilones. No crystallographic studies of the complexes of tubulin with discodermolides or dictyostatins have been reported. Therefore, docking simulations were performed with CAChe and MOE in order to develop hypotheses about their binding that agree with experimental data.

89

Building a Homology Model of the Human Glycine □-1 Receptor Based on the Nicotinic Acetylcholine Receptor

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The glycine alpha 1 receptor is a member of the superfamily of ligand-gated ion channels which are essential to the transfer of information within the nervous system. Since the glycine alpha 1 receptor is a transmembrane protein, it tends to denature when removed from the membrane environment, so x-ray crystallography cannot be used to determine its native folded state. Other methods which could be used to predict structure, such as cryo-electron microscopy, could only give images of intermediate resolution at best. In this project, we use homology modeling to develop a model of the transmembrane domain of the glycine alpha 1 receptor based on the refined structure of the nicotinic acetylcholine receptor at 4Å, which was found using cryo-electron microscopy. The two proteins are in the same superfamily, thereby suggesting similar structures. The programs used to model and analyze the structure include ClustalW, Modeller, VMD, and PROCHECK.

90

Determination of an Optimal Method of Deconvolution for Images of Microtubules

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Microtubules play an important role in the reaction of a killer T cell to an infected cell. Using fluorescently stained tubulin, microtubules within T cells can be visualized in three dimensions using wide-field microscopy, and the recorded images can be analyzed to computationally model microtubule structure and movement. Deconvolution algorithms correct for blurring in images, but many of the algorithms cause discontinuities to appear in biological filaments within an image. The blind deconvolution and Lucy-Richardson algorithms included in the Matlab Image Processing Toolbox were used to deblur images of fixed T cells. Methods of processing the images and processing the point spread function (PSF) were explored and analyzed. Some methods and parameters were more successful than others, and these suggest future directions for this research.