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UNDERGRADUATE RESEARCH PEER REVIEW BOARD
Foreword

The Spring 2010 edition of the WUURD continues to introduce the work of outstanding undergraduates to the Washington University community as well as the broader academic community. In this edition we feature the work of two young scientists already making significant discoveries in their fields. Michal Hyrc’s research is important to the interdisciplinary field of material science. Michal is an engineer working in the laboratory of a physical chemist and the work reported in this volume was completed while he was only a rising sophomore. Michal modeled Optically Pumped Nuclear Magnetic Resonance (OPNMR) signals for Indium Phosphide, a material of growing importance in the semi-conductor industry used for high-end electronics. OPNMR is novel analytical tool in the early stages of development and Michal’s work adds to the body of knowledge that will be used to broaden the scope of its applications. The work of Emily Lebsack, an Arthur Holly Compton Fellow at Washington University, may ultimately contribute to a better understanding of the history of our solar system. She has refined a process to isolate and analyze presolar grains extracted from meteorites using transmission electron microscopy. The techniques and devices developed in this work will significantly improve the success rate of the grain picking process leading to a decrease in sample loss and an increase in efficiency. More complete information about the composition and morphology of presolar grains may lead to a greater understanding of the processes that formed the stars from which they came. These articles provide further evidence of the significant impact that undergraduates can make in their chosen disciplines. The editor and members of the Peer Review Board hope you find them stimulating as well as informative and that the feature articles motivate readers to investigate the topics further.

Readers are also directed to the Summaries of Student Work section of this volume. Each summary results from a significant body of work. We hope that you will be inspired to dig deeper into the projects that these represent as well. Each student was mentored by a faculty member who contributed to the growth of that researcher and for whom we owe a debt of gratitude. Please feel free to contact faculty members if you would like more information regarding the research described in any work published in this digest. A primary goal of the WUURD is to encourage the exchange of ideas and new knowledge.
The authors, members of the Peer Review Board, and editor are pleased to present the research of outstanding Washington University undergraduates and we look forward to hearing from you.

Respectfully,

KRYSTIN SOBOTKA
Editor
Modeling of InP OPNMR Signals

Author:
Michal Hyrc

Michal Hyrc is a sophomore majoring in Chemical Engineering with a minor in Environmental Engineering. His interest in Dr. Hayes' research was piqued in a seminar class on the research of Chemistry Department faculty he took in his first semester at Washington University. Since then he has decided on a major in engineering, but physical chemistry and in particular OPNMR have remained of great interest to him, especially potential environmental applications of OPNMR.

KEY TERMS
- Optically-Pumped Nuclear Magnetic Resonance (OPNMR)
- Solid-State Nuclear Magnetic Resonance
- Indium Phosphide (InP)
- Gallium Arsenide (GaAs)

ABSTRACT
While a detailed understanding of the nature of OPNMR in GaAs has been shown in the successful modeling of the OPNMR signal in GaAs, no equivalent work has to date been done for InP. This project attempts to create such a model for InP, a semiconductor with unique electronic properties that is used in high-end electronics applications. Understanding the OPNMR signal of InP would perfect current uses and perhaps lead to new applications. To create such a model, the working GaAs model was altered and all the inputs were redone so as to represent InP. The new InP model was successful in preliminary modeling of the OPNMR signal, though initial attempts at modeling magnetoabsorptive phenomena were unsuccessful.

FACULTY MENTOR: SOPHIA HAYES PH.D., ASSOCIATE PROFESSOR OF CHEMISTRY
The goal of Professor Hayes’ research is to probe the interplay between dopants, defects, and interfaces and electronic properties of various semiconductors and other optically active materials. To that end, her work focuses on developing experimental strategies based on modern solid-state nuclear magnetic resonance (NMR) spectroscopy, which help elucidate the structure and dynamics of complex systems (e.g., thin films, nanoclusters, and amorphous materials).

ACKNOWLEDGEMENTS
I would like to thank the Office of Undergraduate Research at Washington University in St. Louis for the summer research fellowship that made this paper possible. I would like to thank Dr. Sophia Hayes for allowing me to research in her lab and advising me throughout the research process, Katie Wentz for her input to the model and Erika Sesti, Dustin Wheeler, Sarah Mattler, Kimberly Hartstein and P. J. Morrison for their support.

Peer Editors:
Ashley Brosius and Akhila Narla, sophomores majoring in Women, Gender, and Sexuality Studies and Environmental Studies respectively.
INTRODUCTION

Over the last several decades, nuclear magnetic resonance (NMR) has emerged as a powerful spectroscopy technique for accurate, precise and non-destructive characterization of both liquid and solid chemicals. In 1968, Lampel showed that the NMR signal in silicon could be greatly amplified by irradiating the sample with light, giving birth to optically pumped nuclear magnetic resonance (OPNMR). His discovery allowed NMR to overcome its principle inhibition, low sensitivity. Used by a handful of groups in the scientific community, OPNMR is poised to become an even more popular technique as its applications broaden in scope. Tycko et al. have suggested that OPNMR could be used to characterize biological samples, while Luo and Zang have stipulated that OPNMR could be used to manipulate electronic and nuclear spins as well as the interaction between them to create a quantum computer. Hayes, Michal and Goto have all used OPNMR to characterize semiconductors, in particular gallium arsenide (GaAs) and indium phosphide (InP). Unfortunately, the potential of OPNMR is hampered by poor understanding of the physical phenomena that make it possible. One area of intensive research is the modeling of OPNMR signals as a function of photon energy. Mui et al. have done this for GaAs, but no such model exists as of now for InP. However, since GaAs and InP are electrically quite similar, in principle adapting the GaAs model to InP should be possible and relatively straightforward.

BACKGROUND

NMR and OPNMR

NMR and by extension OPNMR are possible because of an intrinsic property termed “spin” that electrons, neutrons and protons all have, causing them to behave as if they possess angular momentum.

In elements where the number of protons and neutrons is equal and even (²He, ¹²C, ¹⁶O) nuclear spin is zero. However, isotopes exist where the total spin of a nucleus is non-zero. This spin causes the generation of a very small magnetic field, which will align itself parallel to an external magnetic field. Two such alignment states are possible: a lower energy state, where the magnetic field generated is aligned with the external magnetic field; and a higher energy state, where the magnetic field generated is opposite the external magnetic field. While this energy difference is extremely small, it can be amplified in the presence of strong magnetic field (>1 T). An energy map of this phenomenon can be seen in Figure 1. Nuclei can then be irradiated in the radio frequency regime such that the energy of incident radio
waves exactly matches the energy between the +1/2 and -1/2 spin states, which causes resonance to occur. Because nuclear spin properties are affected by bonding, different molecules and materials generate different NMR signals. Consequently, NMR can be used to determine the structure of a compound.\textsuperscript{8}

The low energy nature of NMR spectroscopy results in the technique being non-destructive; however, it is also problematic. Since the energy difference of the two spin states is so small, at room temperature thermal energy causes spins to be almost entirely randomly aligned. Only a very small amount of atoms (parts per million amounts) align with the external magnetic field. OPNMR resolves this insensitivity by using circularly polarized light (denoted $\sigma^-$ and $\sigma^+$ for sigma minus and sigma plus light, respectively) from a laser to polarize the spins of electrons in a given direction. The electrons interact with the spins of the nuclei they surround via the hyperfine interaction. Consequently, they impart alignment of spins in the nuclei, which can be detected in a manner similar to that of traditional NMR. Samples are typically kept in liquid helium temperatures (~6 K) to minimize thermally induced relaxation of spin polarization. As a result of this process, the NMR signal is greatly amplified.\textsuperscript{9}

**Semiconductors**

All materials can be roughly grouped into three categories based on their conductivity: metals, semiconductors and insulators. Metals conduct electricity freely and with very low resistance, while insulators do not conduct electrons at all. Semiconductors lie in between the two. These electrical properties are a result of the band structure of the three different classes of materials. In all bulk compounds, molecular orbitals interact to form bands. Two different types of bands are formed: a valence band and a conduction band. The valence band and conduction band in metals overlap or are energetically very close. In insulators, the gap between the two bands is very high. In semiconductors, a gap exists but it is small enough that it is possible for electrons to be promoted from the valence band into the conduction band. A graphical depiction of the band gap separation in different types of materials can be seen in **Figure 2**.

![Figure 2](image-url)
Thermal energy at room temperature allows for a small number of electrons to be promoted from the confines of the valence band to the conduction band. Here, they are freely able to flow, enabling the material to conduct current. Moreover, an electron promoted to the conduction band leaves behind a “hole” in the valence band. This hole is a charge carrier in the valence band.\(^\text{10}\)

In nominally pure semiconductors, there are relatively few electrons and holes because the valence band is energetically preferable. In the purest manufactured silicon, only 1 in \(10^{11}\) electrons are in the conduction band (and the same number of holes in the valence band) at room temperature.\(^\text{11}\) In order to increase the carrier concentration in semiconductors so that they have less resistance, controlled amounts of impurities are introduced. This process is termed doping, and can either increase the number of carriers by using an element with more valence electrons (n-type) or can increase the number of holes by using an element with fewer valence electrons (p-type). Dopants in minute concentrations can have drastic effects on resistance in a semiconductor.\(^\text{12}\) Industrially, dopants are most often added to increase conductivity in a semiconductor. However, of some interest to OPNMR research is the addition of dopants that result in increased resistance, creating so called semi-insulating semiconductors. An important example is the addition of iron, a p-type dopant, to InP, an inherently n-type semiconductor. For poorly understood reasons, semi-insulating InP gives the best OPNMR signal found so far.

InP is an important semiconductor to investigate, because while silicon has long been the semiconductor of choice for most industry applications, replacements for more demanding electronic applications are becoming necessary. Silicon has some limitations in performance as a semiconductor and is only used so extensively because of the abundance of silicates in the earth’s crust and subsequent availability of cheap silicon. Research has been ongoing in semiconductors made of rarer elements. In particular, GaAs and InP show promise in high-end semiconductor applications. GaAs is used in the solar panels that power the Mars rovers Spirit and Opportunity. InP is becoming increasingly important in electronics and fiber optics because it has the highest electron velocity of any known semiconductors,\(^\text{13, 14}\) allowing it to have very fast responsiveness in circuits.

**EXPERIMENTAL METHODS**

This paper concerns the modeling of the OPNMR signal of InP based on similar work with GaAs. The GaAs model, which runs in a Mathcad environment, was altered to model OPNMR data of InP provided by collaborating laboratories.

**DATA**

Various OPNMR studies have been done on InP, with conflicting results. Pictured are several sets of data of the \(^{31}\text{P}\) signal, with relevant experimental parameters. The signals are split up for discussion into two regions: the large peak at the left and the oscillating peaks on the right. The oscillations are caused by magnetoabsorption; they are more difficult to model and are explored in less detail than the main signal in this paper.
THE MODEL

The following is a brief summary of the mathematical model used for simulating OPNMR signals in InP that was derived from the model for GaAs described in the paper by Mui et al. The analysis of OPNMR begins with two separate calculations, one for probability of the excitation of a nucleus by laser irradiation, termed occupation probability; the other for the polarization of electron spins by the laser.
The first step towards determining occupational probability is the calculation of the intensity of laser light as a function of the depth in the sample and energy of the light:

\[ I(z, E) = I_0 e^{-\alpha(E)z} \]

where \( I_0 \) is the surface intensity of the laser, in W/cm\(^2\), \( \alpha(E) \) is the absorption coefficient at a given photon energy and \( z \) is the depth of penetration into the sample. This is used to calculate the number of carriers activated by the laser light:

\[ n(z, E) = \frac{I(z, E) \tau_e \alpha(E)}{E} \]

where \( \tau_e \) is the electron lifetime and \( E \) is the energy of the incident photons used to irradiate the sample. Dividing this by \( n(z_{\text{min}}, E) \), the total number of carriers, gives the occupational probability:

\[ \Gamma(z, E) = \frac{n(z, E)}{n(z_{\text{min}}, E)} \]

The occupation probability is then used in the calculation of the electron-nuclear cross relaxation rate, which expresses the relationship between activated carriers and nuclei:

\[ T_{10}(z, E) = \Omega^2 \Gamma(z, E) \tau_c S(S + 1) \frac{3}{2} \]

Where \( S \) is the electron quantum number (1/2) and omega is the hyperfine coupling constant, defined to be:

\[ \Omega = \frac{1}{12\pi^2} \mu_0 \gamma_0 \gamma d_0^3 \]

This quantity is then expanded to include one more variable, \( r \), the radial distance from the center of the laser spot:

\[ T_r(x, E, r) = T_{10}(x, E) e^{\frac{-4r}{d_0}} \]

This expression describes the electron-nuclear cross relaxation rate as a function of depth, radius and energy of incident light. It will play a large role in further calculations, but before those are arrived at, independent polarization calculations are necessary. These begin with calculation of polarization of the spin of electrons at thermal equilibrium, \( S_0 \):

\[ S_0 = -\frac{1}{2} \tanh \left( \frac{\mathcal{g}_{\text{eff}} \mu_B B_0}{2k_B T} \right) \]
This is a key input into calculating the polarizations of electrons when irradiated with sigma plus and sigma minus light, which ideally is expressed as:

\[
S_{\sigma^+} = \frac{-0.25}{1 + \frac{\tau_e}{\tau_{1e}}} + \frac{S_0}{1 + \frac{\tau_{1e}}{\tau_e}} \\
S_{\sigma^-} = \frac{+0.25}{1 + \frac{\tau_e}{\tau_{1e}}} + \frac{S_0}{1 + \frac{\tau_{1e}}{\tau_e}}
\]

But more realistically as:

\[
S_{\sigma^+} = \frac{-b}{1 + \frac{\tau_e}{\tau_{1e}}} + \frac{S_0}{1 + \frac{\tau_{1e}}{\tau_e}} + d \\
S_{\sigma^-} = \frac{b}{1 + \frac{\tau_e}{\tau_{1e}}} + \frac{S_0}{1 + \frac{\tau_{1e}}{\tau_e}} + d
\]

Where \( b \) is a factor currently under much scrutiny in the Hayes Group. Previously set at a fixed \( \pm 0.25 \), recent work by the group has demonstrated that this is in fact variable. \( d \) is a fictitious variable we used to obtain a good preliminary fit. These electron spin polarization equations are an extremely important part of the mathematics involved in modeling OPNMR signals and play a large role in determining the shape of the signal in the end of the simulation. They are discussed in greater detail later in this paper, but for the time being are of concern as they form the basis for the next set of expressions, of infinite polarizations. These are:

\[
I_{\infty\sigma^+} = \frac{I(I+1)}{S(S+1)} \left( S_{\sigma^+} - S_0 \right) \\
I_{\infty\sigma^-} = \frac{I(I+1)}{S(S+1)} \left( S_{\sigma^-} - S_0 \right)
\]

where \( I \) is the nuclear quantum number. At this point we finally combine the two disparate calculations to arrive at an expression for the average nuclear polarization:

\[
I_{\sigma^+}(z, E, r) = I_{\infty\sigma^+} \left( 1 - e^{-\frac{r}{T_1(z,E,r)}} \right) \\
I_{\sigma^-}(z, E, r) = I_{\infty\sigma^-} \left( 1 - e^{-\frac{r}{T_1(z,E,r)}} \right)
\]

This is the fundamental input for the calculation of magnetization of nuclei:

\[
M_{\sigma^+}(z, E, r) = \gamma N_a r^2 I_{\sigma^+}(z, E, r) \\
M_{\sigma^-}(z, E, r) = \gamma N_a r^2 I_{\sigma^-}(z, E, r)
\]

Where \( \gamma \) is the gyromagnetic ratio and \( N_a \) is the natural abundance of the resonant isotope. Finally, the magnetization function is integrated across the vertical and radial dimensions to obtain a signal function in one variable, photon energy:

\[
\text{Signal}_{\sigma^+}(E) = \int_{z_{\text{min}}}^{z_{\text{max}}} \int_{r_{\text{max}}}^{r_{\text{min}}} M_{\sigma^+}(z, E, r) dr dz \\
\text{Signal}_{\sigma^-}(E) = \int_{z_{\text{min}}}^{z_{\text{max}}} \int_{r_{\text{max}}}^{r_{\text{min}}} M_{\sigma^-}(z, E, r) dr dz
\]

These are the two functions that are graphed in the Results section.
All the equations described above run seamlessly in Mathcad, the results from early expressions feed directly into later expressions, and consequently, changing any parameter causes all expressions to be calculated, allowing its impact on the final signal to be analyzed. One can also check the values of any expression to assess how exactly an input is affecting the signal simulation. The entire simulation takes approximately 10 seconds to run.

Small modifications are necessary for simulating magnetoabsorptive effects, (the second region of the plotted data) though the mathematical backbone is identical to what is described above. The sample thickness input (zmax) is set to 10 micrometers or less (whereas in the regular calculation it is 300-400 micrometers), and the driving input of the model is no longer \( \alpha(E) \) but the \( b \) factor in the electron polarization equations. The magnetoabsorption model takes longer to run, and a simulation of both sigma plus and sigma minus signals can take as long as 30 minutes.

Very little has been altered in these expressions from what is described in the original model in GaAs, as it is thought that OPNMR signal is manifested through similar physical mechanisms in InP and GaAs. The only change was the addition of a third term, \( d \), to the steady state polarization equation, whose value is -.0195 for this particular data set. This value lets us know the approximate size of any needed change in the model that we must search for to obtain a satisfactory final result.

**MODEL INPUTS**

Our model of the photon energy and helicity dependence of OPNMR signals is constrained in its simulation of signals in two ways: the mathematical nature of the model itself, that is, the equations that we use to represent phenomena occurring in resonant InP are flawed representations of what is actually occurring, and the data that we input into the model. This data can be roughly grouped into two categories: a matrix of values for the absorption coefficients of InP at different photon energies and single values that include universal constants, constants concerning InP, and relevant experimental parameters. A table describing the single numeric inputs into the model follows this section. The table contrasts InP and GaAs values and discusses the meaning and relative importance of the input parameters. It should be noted the table does not include universal constants such as Boltzmann’s constant, the speed of light, the Bohr magneton, etc., because they are constant values that do not specifically pertain to InP or GaAs. All constants that are related to InP and GaAs, as well as variables whose value is uncertain or unknown, are included in the table.

The single most important input into the model is not a single number but rather a matrix of values describing the absorption coefficient of InP at different photon energies. Optically pumped NMR can only occur if light is absorbed by the sample that is being investigated, and the absorption coefficient is critical in determining how much the laser light that irradiates the sample augments the NMR signal. Unfortunately the absorption coefficient changes drastically (over four orders of magnitude, see Figure 5) over the energy regime of interest: from 1.34 eV to 1.40 eV at 6 K. It is consequently very important to include the absorption coefficient of InP in calculations.
The best known InP absorption data were published by Turner et al. in 1964.\textsuperscript{15} Figures 5 and 6 are reprinted figures from W. J. Turner, Phys. Rev. 136 A1476 (1964). Copyright 1964 by the American Physical society. Figure 5 shows the general trend in the absorption coefficient of InP, at 3 temperatures. At 6K, where we conduct experiments, there is a very small coefficient for energies less than 1.36 eV, sharply changing into a very large coefficient for energies greater than 1.42 eV. Figure 6 is a close-up of the excitonic feature in the absorption coefficient spectra. The largest OPNMR signal in InP occurs in the energy region where the absorption coefficient is sharply increasing, and the magneoadsorption-dependent OPNMR signal starts to occur immediately higher than that of the excitonic feature, which will be described in future work.

\textbf{Figure 5}

InP Absorption as Function of Photon Energy.

\textbf{Figure 6}

Expansion of InP Absorption as a function of Photon Energy in the region of interest.
### Table of Input Values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Unit</th>
<th>GaAs ((^{69}\text{Ga})) Value(^7)</th>
<th>InP ((^{31}\text{P})) Value(^{14,17,18})</th>
<th>Physical Representation</th>
<th>Manifestation in InP Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Dimensionless</td>
<td>1.5</td>
<td>0.5</td>
<td>Value of angular momentum of nucleus</td>
<td>Negligible</td>
</tr>
<tr>
<td>S</td>
<td>Dimensionless</td>
<td>0.5</td>
<td>0.5</td>
<td>Value of angular momentum of electron</td>
<td>Negligible</td>
</tr>
<tr>
<td>(N_a)</td>
<td>Dimensionless</td>
<td>0.604</td>
<td>1</td>
<td>What fraction of the resonant isotope is present in a sample occurring in nature</td>
<td>Negligible</td>
</tr>
<tr>
<td>(\gamma)</td>
<td>rad/Ts</td>
<td>(6.4323 \times 10^7)</td>
<td>(10.841 \times 10^7)</td>
<td>Ratio between magnetic field strength and rotational speed of nuclei</td>
<td>Negligible</td>
</tr>
<tr>
<td>(g_{\text{eff}})</td>
<td>Dimensionless</td>
<td>-0.44</td>
<td>1.2</td>
<td>A proportionality constant that relates magnetic properties of electron to their quantum state</td>
<td>Very drastic, causes large changes in signal amplitude, sign and shape</td>
</tr>
<tr>
<td>(a_0)</td>
<td>Å</td>
<td>100</td>
<td>120</td>
<td>Separation between electron and hole in excited state</td>
<td>Negligible</td>
</tr>
<tr>
<td>(a)</td>
<td>Å</td>
<td>5.653</td>
<td>5.86674</td>
<td>The length of a side of a unit cell of semiconductor crystal</td>
<td>Negligible</td>
</tr>
<tr>
<td>(d_5)</td>
<td>cm(^{-3})</td>
<td>(5.8 \times 10^{25})</td>
<td>(5.8 \times 10^{25})</td>
<td>Density of conduction band electrons at a nucleus being investigated</td>
<td>Very drastic, causes large changes in signal shape</td>
</tr>
<tr>
<td>(T)</td>
<td>K</td>
<td>6</td>
<td>6***</td>
<td>Temperature at which OPNMR data was collected</td>
<td>Moderate, causes changes in signal shape and amplitude</td>
</tr>
<tr>
<td></td>
<td>Symbol</td>
<td>Unit</td>
<td>GaAs ($^{69}$Ga) Value7</td>
<td>InP ($^{31}$P) Value14,17,18</td>
<td>Physical Representation</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------</td>
<td>---------</td>
<td>--------------------------</td>
<td>-----------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td><strong>Field Strength</strong></td>
<td>B</td>
<td>T</td>
<td>4.7</td>
<td>9.39***</td>
<td>Magnetic Field strength at which OPNMR data was collected</td>
</tr>
<tr>
<td><strong>Irradiation Time</strong></td>
<td>$T_L$</td>
<td>s</td>
<td>20</td>
<td>60***</td>
<td>How long the sample was irradiated or optically pumped</td>
</tr>
<tr>
<td><strong>Correlation Time</strong></td>
<td>$T_C$</td>
<td>s</td>
<td>$2 \times 10^{-8}$</td>
<td>$10 \times 10^{-9}$</td>
<td>Amount of time that electron and nuclear spins are coupled</td>
</tr>
<tr>
<td><strong>Electron Lifetime</strong></td>
<td>$T_e$</td>
<td>s</td>
<td>$10 \times 10^{-9}$</td>
<td>$9.3 \times 10^{-9}$</td>
<td>Amount of time that electron spends in the excited state</td>
</tr>
<tr>
<td><strong>Electron Spin Lattice Relaxation Time</strong></td>
<td>$T_{le}$</td>
<td>s</td>
<td>$10 \times 10^{-9}$</td>
<td>$2.7 \times 10^{-9}$</td>
<td>Amount of time it takes an electron spin to relax by exchanging energy with the lattice</td>
</tr>
<tr>
<td><strong>Polarization Coefficient (below $E_g$)</strong></td>
<td>b</td>
<td>Dimensionless</td>
<td>0.25</td>
<td>0.25</td>
<td>Transition of valence electrons to conduction electrons occurs in a 1:3 ratio</td>
</tr>
<tr>
<td><strong>Polarization Coefficient (above $E_g$)</strong></td>
<td>b</td>
<td>Dimensionless</td>
<td>Variable</td>
<td>Variable</td>
<td>Transition of valence electrons to conduction electrons occurs in a 1:3 ratio</td>
</tr>
<tr>
<td><strong>Polarization Correction</strong></td>
<td>d</td>
<td>Dimensionless</td>
<td>0</td>
<td>-0.0195</td>
<td>Correction term suspected to result from the presence of Fe in the InP lattice</td>
</tr>
</tbody>
</table>

*This factor is by far the largest change between GaAs and InP. All other parameters slightly alter the signal, the sign and magnitude change in the effective g-factor wreaks havoc on the signal.

**We were unable to find or calculate this parameter for InP so the GaAs value (itself calculated from InAs values) was used.

***For the A data set.

****These quantities do not act independently, rather, their ratio can cause very drastic changes in the sign and amplitude of the signal.
RESULTS

The following graphs are the best results we have from the model. Triangles represent experimental data set A (from Figure 3), while the lines are the model. Black is excitation by sigma minus helicity light and gray is excitation by sigma plus light.

**Figure 7**  
Experimental Data and Simulation for OPNMR signal intensity as a function of Photon Energy.

**Figure 8**  
Expansion for sigma minus data and model.

**Figure 9**  
Expansion for sigma plus data and model.
Figure 7 depicts the entire model. Figure 8 is an expanded view of the sigma minus experimental data and simulation, and Figure 9 is the sigma plus data and simulation. It should be noted that the simulation in Figure 9 is shifted to the right by -0.0145 eV to create a good match to the experimental data. The nature of the model is such that the peaks of the sigma plus and sigma minus signals always occur at the same energy. However, in the data used (Data set A in the Data section) the positions of maximum intensity are not symmetric as is typical of GaAs OPNMR signals. The OPNMR peaks of InP in those experimental conditions occur at different energies. Our model cannot yet account for these different transitions and will have to be altered in order to do so.

Aberrations in the shape of the simulated data could arise partly as a result of inaccurate extraction of absorption coefficient data. The Turner data are only available graphically and furthermore are presented on a logarithmic scale, so measuring these data points so that they can be inputted into a computer program is difficult. The lack of data at energies of 1.43 eV and above is intentional, since magnetoabsorption coefficients are needed to accurately model that region. Different features are present in this region and are not well represented by the flat line visible in the model. The more advanced magnetoabsorption model is required for this and is not yet at a level that it accurately simulates data. Initial attempts to model the magnetoabsorptive signal used an absorption coefficient that was measured in the presence of a high magnetic field. However, the only published data on this subject was not detailed enough and did not extend to the necessary photon energy.

Consequently a different approach was taken, namely using b, an input into the equation for steady state electron polarization. While ideally b is .25 (and this constant value is used in the main signal simulation), it is thought that the actual value might deviate significantly. Using predicted values of optically generated electron spin polarization from a colleague at the University of Florida, Gainsville, Christopher Stanton, gave promising preliminary results (unpublished data, not shown).

Finally, it should be noted that the model provides a relatively good prediction of OPNMR data shown in Figure 3 but not that shown in 4 and other unpublished data not shown herein. We are working to understand this variation in the experimental measurements, hoping to use a combination of sample-specific magneto absorption measurements, elemental analysis of Fe content, and our modeling inputs (b and d) to determine the origin of such variability from sample to sample.

CONCLUSION

$^{31}\text{P}$ OPNMR signals of InP can be successfully modeled by theoretical simulations. Using an adaptation of previous work done on GaAs, the OPNMR signal of InP was simulated with the model closely matching peak amplitude and position as well as matching the low energy regime over large portions of the plot. Both sigma plus and sigma minus signals were simulated with a single model. While much work still has to be done to perfect the simulations, especially for magnetoabsorptive features, the basic shape of the signal can be demonstrated based upon constants concerning InP and relevant experimental parameters. Some aspects of the model are not fully understood; especially the expression for steady state polarization, but further exploration seems very promising and may yield interesting insights into the OPNMR of InP.
FUTURE WORK

While the modeling of the OPNMR signal of InP is an important step in OPNMR research, much remains to be done in the investigation of InP. It is critical to obtain reproducible data for the OPNMR signal of InP. At the moment data sets are sparse and conflicting. The model needs to be perfected, in both its inputs and inner workings. The Turner absorption data needs to be replaced with absorption data for iron-doped, semi-insulating InP. Finally, the model needs to start being used as a deductive tool and not just an inductive experiment, that is, instead of just perfecting the model to more accurately fit data, the model should be used to forecast data that has not yet been collected and explore how experimental parameters affect OPNMR signal without the necessity of going into the laboratory.

Notes

Laboratory Study of Presolar Carbonaceous Stardust

Author:
Emily K. Lebsack
Emily Lebsack is a May 2010 graduate of Washington University in St. Louis. She majored in physics as a Washington University Compton Scholar, and minored in music. Emily will be attending graduate school at Princeton University in the fall in physics, where she will be joining an experimental dark matter group. She will be accompanied by her fiancé, also a recent Washington University graduate.

ABSTRACT
Presolar grain research is an exciting new field in which stardust, formed in ancient stellar outflows of red giants and supernova ejecta and subsequently recovered from primitive meteorites, is studied in the laboratory. These precious grains give us unprecedented information regarding the evolution and age of our galaxy, nucleosynthesis, supernova mixing processes, the composition of the stellar atmospheres in which the grains were formed, and the processes operating on the meteoritic parent bodies of the grains and in the interstellar medium. In this investigation we discuss the methods of finding and preparing these rare dust particles for study. In particular, we draw attention to the development of new methods for preparing grains for ultramicrotome sectioning. Through the use of these new techniques, we decreased the number of grains lost in the preparation process, increasing our success rate from less than 50% to 75-85%. We also focus on the importance of, and methods by which one can find, “pristine” presolar SiC grains—those that have not been exposed to corrosive chemicals commonly used to isolate the grains. We found that using a scanning electron microscope to do elemental scans of the meteorite matrix and overlaying the oxygen and silicon maps allows us to isolate these pristine grains at a higher rate.

KEY TERMS
- Presolar
- Stardust
- Asymptotic Giant Branch Star
- Supernova
- Astrophysics
- Transmission Electron Microscopy

FACULTY MENTOR: THOMAS BERNATOWICZ, PH.D., PROFESSOR OF PHYSICS
The current research of Professor Bernatowicz focuses on detailed laboratory observations of presolar grains (literally ancient stardust) from meteorites to draw inferences about the physical conditions in ancient circumstellar environments and about the formation of dust in the Galaxy. His research utilizes isotope mass spectrometry and transmission electron microscopy (electron diffraction, electron energy loss spectrometry and energy dispersive X-ray spectrometry).

ACKNOWLEDGEMENTS
I would like to thank Professor Thomas Bernatowicz for advising me in this project and in the production of this paper, as well as his continued support and friendship. I would also like to acknowledge the efforts of Kevin Croat, Manavi Jadhav, and Mairin Hynes, with whom I worked closely on each of the three projects. I thank the Washington University Undergraduate Research Office for funding my research for two summers. Finally, I would like to acknowledge the technical savvy of Tim Smolar, who fixes everything that inevitably breaks.

Peer Editor:
Michael Brodsky, a sophomore majoring in History
INTRODUCTION

For the last half-century, it has been known that nearly every element present in the universe was formed in stars. To understand the nucleosynthetic processes of stars is to understand the astronomical origins of most of the matter that we see in our world. Thus, it is of great scientific interest to further our knowledge of the red giant stars and supernovae that produce the majority of the heavy elements. Indeed, we can learn much about a given kind of star if the solids that it produces can be identified and isolated. However, vaporization of solids during the formation of the Solar System homogenized the pre-existing matter so much that it was once thought that the materials from individual stars could not be studied directly. Instead, stellar processes had to be observed through spectral data. Meteoritic data was thought to only offer an aggregate sum of the contributions of many stars—solar isotopic ratios, for example.

Fortunately, it has been found that many individual grains of ancient stardust survived this homogenization and became incorporated into the parent bodies of meteorites. Some of these meteorites have fallen to the earth, where small samples of the matrix can be analyzed in the laboratory. Through the study of these grains, we can discover much about the stars that gave birth to our Solar System. The analysis of presolar grains yields information about stellar nucleosynthesis, mixing in supernovae, galactic chemical evolution, stellar evolution and the composition and physical properties of the environments in which the grains were formed. Already presolar grain research has yielded corrections to nucleosynthesis theory, in the neutron-capture cross-section of Ba isotopes, for example. Furthermore, the study of presolar grains offers information about the nuclear processes in their parent stars that cannot be revealed by remote astronomical data. Thus, the study of presolar grains can be used to augment and clarify traditional astronomical investigations.

Elemental synthesis occurs deep within stars, but the elements created cannot condense into a solid form inside the star because of the extremely high temperatures. Stardust grains either form in the stellar outflows of red giants in the last stages of their lives, or they are born in the ejecta from supernovae explosions. Either way, after being ejected into the stellar medium, such grains eventually became incorporated into clouds of gas and dust such as the one that formed the Sun, the planets and meteorites. Once one of these meteorites has fallen to the earth and small portions are recovered for laboratory testing, the challenge is to find, isolate, and study the grains individually (Figure 1).

Because most of the material in the solar system is homogeneous in its isotopic composition, presolar material can be identified by isotopic compositions that vary significantly from solar values. However, ancient presolar stardust is exceedingly rare, being on the order of several parts-per-million (ppm) by weight. The grains are normally isolated by a process developed by Amari et al., cheekily referred to in the field as “burning down the haystack to find the needle.” The meteorite matrix is exposed to harsh chemical treatments that dissolve most (99%) of the non-presolar material. The grains can then be found more easily by isotopic analysis.

The raw information generally gathered from presolar grains comes in two types: isotopic information and grain morphology and structure. Detailed study of the isotopic
composition of a grain helps determine what kind of star the grain came from, as well as information about nucleosynthesis, mixing processes in the stars, and the elemental history of the star. Study of the structure and morphology of a grain yields information about the conditions in which the grain formed in the stellar envelope and the subsequent processes it underwent in the interstellar medium (ISM) and the meteoritic parent body.

With regard to morphological and structural information, the use of transmission electron microscopy (TEM) allows us to view the molecular structure and chemical composition of the grains. Because TEM requires samples to be very thin, one way to view the inner structure of a grain is to slice it into ultra-thin sections, on the order of 100 nm. This is done by “picking” the grain off of a gold-foil mount and embedding it in dental resin, which is then cured and sliced using an ultramicrotome. In the past this process was very risky; many precious grains were lost due to their diminutive size (~1 µm) and the difficulty of manipulating such grains in the presence of static charges and fluid currents. However new techniques have significantly improved our success rate. The thin slices are then collected on copper grids, which are covered by holey-carbon for TEM study. TEM analysis reveals many otherwise unobservable characteristics of the grains, such as tiny subgrains included within host grains or around which such grains might have nucleated.

Of the grains that have been studied so far, carbonaceous grains—presolar SiC, graphite, and nanodiamonds—have been the primary focus of presolar grain research (Figure 2). The stellar origins of presolar SiC, for example, are mostly understood and are marked by subtypes that correlate with their type of stellar origin and metallicity. SiCs come in the form of A, B, X, Y, Z, Mainstream, and Nova types (Figure 3). In this study, we focus on AB grains, which make up about 5% of the SiC population. These grains are marked by an extremely low \(^{12}\text{C}/^{13}\text{C}\) ratio (less than 10) and their stellar origin is poorly constrained. TEM analysis might reveal crucial information about the environments in which these AB grains formed, helping us to determine the nature of their parent stars.
Graphites are known to come from Asymptotic Giant Branch (AGB) carbon stars and supernovae. Supernova graphites from the primitive carbonaceous Murchison meteorite have already been subjected to TEM analysis, but graphites from the very primitive carbonaceous meteorite Orgueil—which show significant differences in size and morphology—have yet to be studied in this way. However we are now studying these grains in the TEM and have already found subgrains with mineral compositions not found in Murchison low-density graphites. These grains seem to come from a different population of stars than the Murchison graphites. Thus, the TEM study of these grains may give us information about an entirely different group of stars than have been previously studied.

Though the TEM study of carbonaceous grains yields bountiful information about the stellar environment in which these grains originated, surface morphologies reveal the conditions under which the grains finished their formation and resided in the ISM. Unfortunately, the harsh chemical processes that the grains are normally exposed to while isolating them damage their surfaces. Grains in their “pristine” state can give
us a better idea of the processes undergone by SiCs during the end of their formation and time spent in the ISM (Figure 4). Difficulties created by the rarity of the grains can be addressed through elemental analysis of the matrix, and work has already been done to isolate approximately one-hundred presolar SiC grains by scanning the matrix in a scanning electron microscope (SEM). However this process is very time-consuming. We have recently developed a technique that finds the grains more quickly and accurately, thus allowing their morphologies to be studied. These cutting-edge techniques for finding and picking grains improve our ability to analyze these bountiful sources of information about stars, as well as the history of our solar system.

GRAIN PICKING FOR TEM STUDY

AB SiC grains were sliced from the Murchison mount KJGN4 and graphites from Orgueil.

A specialized aluminum mount was prepared by embedding a screw in an aluminum base, which served as a holder on which we glued a gelatin capsule with RTV cement (Figure 5). A small red dot was made on the bottom of the gel capsule at the center to mark the ideal location for the grain. When the mount was ready, it was cleaned of contaminating dust particles with nitrogen. A single drop (~.02 ml) of LR White hard-grade acrylic resin was deposited into the gel capsule using a syringe.

The grains were moved to the gel capsule with a finely sharpened tungsten needle, shaped so that a small, shallowly-inclined tip could be easily lowered into the capsule using a micromanipulator and sharpened until the tip was on the order of 1 μm in width.

After the needle was determined to be the correct shape and of sufficient sharpness,
A slide of carbon fibers, 25 and 100 µm in length, was placed on the microscope to serve as markers for the location of the grain. A fiber was placed slightly below the focal point of the microscope, and the tip of the tungsten needle was brought into focus. The stage was raised until the fiber touched the needle. The needle was then raised slightly, and if the fiber stuck due to Van der Waals forces, the stage was lowered. We then plunged the needle into the resin directly above the red dot. Generally, the carbon fiber would dislodge from the needle and sink to the bottom. This was then repeated two more times, so that the fibers would ideally form a triangle around the prospective grain location. If the carbon fibers were too far apart, they could be nudged closer together with the needle, but generally this was avoided—many of the carbon fibers had grain-sized pieces that would detach and sit on the bottom of the gel capsule if the fibers were moved too much. Numerous pictures were taken of the gel capsule, in order to ensure that any “false” grains were documented. Once the carbon fibers were set, the needle was freshly cleaned. All blowers and the air-conditioner in the room were turned off to minimize losses of grain samples. Samples were placed on the microscope and a picture was taken of the target grain for shape and size information (*Figure 6*).

**Figure 6**

AB type SiC grain KJGN4 275-3 (left) and Orgueil graphite d30 (right) on a gold-foil mount. Presolar grains are circled. Grains were picked from these mounts and cured in resin for ultramicrotome slicing. Graphites are generally much larger (3-20 µm) than SiCs (1-3 µm).

A picture of the grain on the needle was also taken for reference (*Figure 7*). The needle was then lifted well out of view, and the target area was centered in the microscope. The stage was then lowered to bring the surface of the resin approximately into view (though it is

**Figure 7**

Large graphite d25 (diameter 18 µm) on the tungsten needle used to transport the grains from the gold-foil mount to the resin-filled gel capsule. The grain is held underneath the needle by Van der Waals forces and is deposited at the bottom of the capsule.
impossible to see this). The needle was then lowered very slowly toward the resin. The needle would make contact with the resin shortly after its shadow on the surface came into focus. Subsequently, the needle was lowered until it became visible. If the grain remained on the needle, it was slowly lowered to the bottom and dislodged there (Figure 8).

If the grain could not be found on the needle, it meant that the grain had dislodged at the surface and was still floating there. The needle would then be moved to the side and raised out of the liquid, and the surface scanned for the grain. If the grain was slightly below the surface, it would sink to the bottom without interference and could be relocated with the needle. If the grain was on the surface, it would float indeterminately and the needle would have to be lowered into the resin near the grain in order for it to break the surface and sink.

To address problems that resulted from the use of additional resin in previous methods, we designed and built a novel vacuum oven (Figure 9) to determine whether

Figure 8
AB type SiC KJGN4 531-3 (left) and Orgueil 13 C-rich graphite d7 (right) after curing in a thin layer of hard-grade acrylic resin. The grains are circled and marked with carbon fibers to denote their location when the samples are prepared for slicing.

Figure 9
Vacuum-oven apparatus. A sealed chamber is attached to a high vacuum. The temperature is regulated by a thermocouple attached to the outside of the chamber and covered in aluminum foil. Samples are placed in the chamber through the door on the front, and are cured between 60 and 70°C and at a vacuum pressure of ~3x10⁻⁶ torr.
the resin would cure in vacuum and whether vibrations might change the location of the grain and carbon fibers. The endeavor succeeded and increased our success rate with SiC from less than 50% to between 75% and 85%. Success rates were calculated based on the number of grains successfully picked compared with the number lost.

Grain samples were embedded in the resin and cured for approximately 48 hours at temperatures between 60 and 70º C and a vacuum pressure of approximately $3 \times 10^{-6}$ torr. After the sample had sufficiently cured, the gel capsule was removed from the mount and placed inside another uncut capsule. This was filled with resin and cured in an oven for 24 hours at 60º C in order to provide a bullet of cured resin of sufficient size to be gripped in the chuck of the microtome.

Both layers of gel capsule were carefully removed with a glass knife in the ultramicrotome. To remove any excess gel, the sample was ultrasonicated in boiling water for ten minutes, and heated at 60º C to remove any moisture. With a sharp glass knife, we cut a pyramid structure into the sample around the grain, so that the top layer was approximately 250 x 250 µm and was centered on the carbon fibers (Figure 10).

![Figure 10](image)

Resin bullet with AB grain KJGN4 531-3. The grain and locating carbon fibers are located at the top of the pyramid, shaped using a glass knife in the ultramicrotome. This top layer is gradually sliced in the ultramicrotome to remove thin 70 nm sections of the grain for TEM study.

We then used a diamond knife and the microtome to make ultra-thin sections 70 nm thick. These sections were manipulated using a pig’s eyelash, which is remarkably smooth and will not stick to the sections. The pig’s eyelash guided the sections together so they could be picked up using a 3 mm wire loop and deposited on a holey carbon TEM grid, ready for study in the TEM.

**LOCATING PRISTINE SiCS IN THE SCANNING ELECTRON MICROSCOPE**

Pristine SiCs on the mount MD2e were located using a NORAN Spectral Analysis System. Scans were conducted in the SEM to determine a method for isolating grains in an image map and to find the fastest scan that would accurately locate presolar
grains. Pristine grains were previously found by the technique outlined in Bernatowicz et al., in which the assumption was made that the silicon signal from a SiC grain (where half of the atoms are silicon) would be stronger than the surrounding material, mostly comprised of silicates that are less than half silicon. We used a combination of spectral images of silicon and oxygen images to make potential grains “pop” out (Figure 11). In the image, a grain is marked by a high Si signal and a low O signal.

In addition, we found that increasing the magnification of the image makes up for the longer scanning time by decreasing the number of grains missed by the scan. At the old magnification grains were a single pixel in size, and if the grain was slightly in-between pixels, the grain would not be detected. At the new magnification, the grain is between one and two pixels in diameter, thus ensuring that most grains will not be missed. The scan is done so that the background silicon count is around 20 and a grain is between 35 and 50.

RESULTS AND CONCLUSIONS

In this study, between 15 and 17 AB grains and 12 Orgueil graphites were picked. The changes made to the grain picking process improved the success rate from less than 50% to between 75% and 85%. Thus far, seven of the graphites and five of the ABs have been studied in the TEM. The results of the TEM studies for the Orgueil graphites are described in abstracts for the 40th and 41st Lunar and Planetary Sciences Conference, as well as the 72nd Meteoritical Society Meeting. The current results of TEM study of SiC AB grains are brought forward in the 41st Lunar and Planetary Sciences Conference and the 73rd Meteoritical Society Meeting. Finally, the results of our work with pristine SiCs are described in Croat et al. (2010). In using the new techniques described in this paper, we have been able to significantly reduce sample preparation time. Thus we have increased our capacity to study more grains and prevented the loss of many of the precious samples that will be studied in the future.

Transmission Electron Microscopy provides crucial information about the environments that produced presolar grains. This study focused primarily on Orgueil graphites and AB SiC grains, both of which have never been studied under TEM and many of whose origins are unknown. TEM study of many other kinds of grains—such as supernova X grains would also be beneficial. Though a little more than a dozen of these have already been studied by Croat et al., the supernova grain formation environment is likely to be so diverse that much more could be learned from a larger sample size.

Further study of AB grains in the TEM could provide information that would help determine their stellar origin. Currently, AB grains are thought to come from J type carbon stars or born-again AGB stars like Sakurai’s object. Just as the X grains studied to date show signs of their violent origins in supernovae, so too might the inner structure of AB grains help to reveal from what kind of star they originated.

Each of the Orgueil graphites studied thus far has been found to have unique properties markedly different from the graphites studied in the Murchison samples. This suggests that the Orgueil graphites come from a different population of presolar grains than the Murchison variety. Developing a large base of TEM analyzed grains would thus be very beneficial to understanding an entirely different population of stars.
The study of presolar SiC in its pristine state is essential to understanding the various processes undergone by the grains during their formation and journey through the ISM. The surface morphologies of these grains, undamaged by the harsh chemical processes generally used to isolate the grains, tell us a great amount about the time spent during formation, protective coatings that may have helped them survive the ISM, and the conditions of their formation, among other details. Because of the rarity of these grains, developing fast, effective ways of locating and identifying them is crucial to the success of our endeavor. In the future, the novel scanning methods will be tested on other mounts and will be used to find a new supply of pristine SiCs.

Figure 11
Elemental spectral maps of mount MD2e. On the left (A), a silicon contour map makes potential SiC grains pop out as red dots (indicating a higher silicon count). On the right (B), an oxygen map serves to eliminate false positives. The SiC grain MD2e8-13 is the small grain on the left side of the image, marked by a high silicon count, but a low oxygen count (it is not yellow). This scan was done with a magnification of 600x and a resolution of 256x192 pixels per image. Below (C), the grain is shown at a higher magnification.
In using the new techniques described in this paper, we have been able to significantly reduce sample preparation time for picking and slicing presolar stardust. Thus we have increased our capacity to study more grains and prevent the loss of precious samples.

Notes


2 Ibid., 5.


7 Ibid.


Extracellular matrix (ECM) is largely composed of hyaluronic acid (HA), proteoglycan (PG), collagen fibers, and elastin globules. The ECM has an intimate relationship with the plasma membrane (PM), and interactions between the two occur at regular intervals approximately 20 nm apart. We postulated that the mechanics of PM-ECM microdomains might assist in the assembly of elastic fibers and limitation of stress propagation through the ECM. PGECM, short for ProteoGlycan ExtraCellular Matrix, simulates the response of the ECM to deformation of the PM. Modeled mechanical stress and electrostatic interactions determine the behavior of the in silico matrix. While HA and collagen give tension-resistant properties to the ECM, charged glycosaminoglycans (GAGs) on PG molecules allow the ECM to resist compression. Simulations predict that electrostatic interactions contribute negligibly to uniaxial stress development when the matrix is in tension but resist lateral matrix compression. The model also predicts that collagen molecules form effective barriers for stress propagation through the ECM, and that elastin (Eln) globules approach one another following deformation of the plasma membrane. Future models of ECM microdomains will incorporate frequency dependence and accurate geometries.
The magnetic transition temperatures for ferromagnets EuAgMg, EuAuMg and GdAgMg, as well as the antiferromagnet GdAuMg, were measured at several hydrostatic pressures using helium as the pressure medium as high as 0.7 GPa. These materials were chosen because it has been reported that their magnetic ordering might be suppressed at only a few GPa. GdAgMg shows a strong negative pressure dependence, while GdAuMg has almost zero pressure dependence. The Eu compounds show small, positive dependences.
Defying Bubbled Circle Classifications: Identity in African Immigrant Populations in St. Louis

Lurit Bepo

Mentor: Carolyn Sargent

This work studies the enculturation process of black African immigrants in St. Louis and investigates the role that this process plays in the formation of an ethnic and social identity. In particular, I look at how black African immigrants define themselves in modern American society, how they adapt to life in St. Louis, the extent to which they retain their native culture, and the historical, social, political, and economic factors that affect each of these issues.
Perceiving a space through the sensory faculties of the human body is the most basic way that we collect information about our world, and it is at the basis of all scholarly fields. Using as case studies a botanist and an installation artist, in this project I make an elemental study of the way that a scientific/empirical researcher studies and represents complexities of the outside world in comparison to the methods of an artistic/intuitive researcher. I first worked with a Ph.D. student in botany, Nicole Miller, assisting with extensive field work, and secondly with artist Ann Hamilton, participating in a workshop which examined cultural institutions of St Louis in preparation for an installation she will be doing at the Pulitzer Foundation for the Arts in 2010. The study manifests itself in a short scholarly essay and in an art installation constructed in papier-mâché, wood, paint, and yarn. Through the use of symbols, diagrammatic relationships, scale, and topography I represent a relationship between knowledge and physical perception that is intended to be both ambiguous and evocative to the viewer.
Interest in energy solutions from renewable sources has grown significantly in the last decade. With the current movements in public opinion as well as renewable mandates from the state and federal government, finding ideal sources of renewable energy has become a topic of great importance. The utilization of technology can be very site specific, whether it be wind, solar, tidal, etc. These sites, combined with current land use, legislation, and load demand, all factor into the efficient use of a renewable resource. This work researches the leading technologies in renewable generation with the goal of compiling a comprehensive set of locations with the varying capacity factors available for each technology. Attention to cost effectiveness, as well as environmental impacts, and underlying legislation will be paid to ensure the quality and feasibility of the data. Attention to PV Solar and Wind will be emphasized.
Previous research has shown that marital attitudes and behaviors are affected by the types of areas people live in and their parents’ marital status. The present study takes the effects of regional differences a logical step further and examines participants’ political ideologies in relation to marital attitudes. Participants’ parents’ marital status and couple type are also examined. Participants completed a computerized survey to determine their regional influences, their likelihood of marriage, their ideal age at marriage, the marital status of their biological parents, and which of 4 couple types most consistently described their parent’s relationship. Participants then completed the Marital Attitude Scale (MAS) and the Social Dominance Orientation (SDO) scale. Several significant correlations were identified between MAS scores and other variables, and it was found that a high MAS score and a SDO independently predict a high ideal age at marriage. Further analyses of the regional data are needed in order to determine the most critical influences on participants’ marital attitudes.
Produced in 2006, Cars vividly depicts the story of Lightning McQueen, a hotshot rookie race car new on the circuit via detail oriented animation, vibrant colors and a trip down the historic Route 66 to deliver a film that is captivating for children and adults of all ages. Rather than serving as mere entertainment, this Disney favorite sends a moral message to its audience, particularly impressionable children. The moral messages contained in this film, however, are twofold. While the film’s central premise hinges on the notion, “Life is about the journey, not the finish line,” in actuality the movie also sends a subliminal message about gender and the journey Lightning McQueen embarks upon. This work examines and questions masculinity in Disney Pixar’s Cars as well as the representations of gender within the film. Analysis of whether the Disney film drives home differences in gender is followed by an application of Michael Kimmel’s “Masculinity as Homophobia” to the main character, Lightning McQueen. While initially McQueen conforms to masculine stereotypes, it is only in taking on more “feminine” qualities that he is able to become a more complete, developed individual.
Akoya/Bandit is an ongoing student-built docking mission. Bandit’s mission is to flight-test proximity operations technologies, including docking, safe navigation within 5 m of a target vehicle, on-orbit charging, and image-based navigation. The project was started in 2003 by students and faculty at Washington University, and proto-flight hardware and documentation were presented on 20 January 2009 as part of the Flight Competition Review of the University Nanosat-5 Program, culminating in a 2nd place finish in the national competition.

The mission elements are a 35-kg host spacecraft (Akoya) and two 3-kg proximity-operations vehicles (Bandit-1 and Bandit-2). The minimum-success mission is to release Bandit-1 to a distance of one meter and recapture it, and can be accomplished open-loop using only Bandit-1’s clock and cold-gas thrusters. This mission is made possible by an error-tolerant “soft dock” consisting of a hook-and-loop fastener on an extended capture boom. Proximity operations are of significant interest in the aerospace community, and Bandit is unique in its docking method and its small size and cost. Over the past year, proximity operations using image-based navigation on a free-flying vehicle have been shown to be feasible and work on the mission is continuing to move forward.
Concerns about global climate change have led to research efforts aimed at sequestering anthropogenic carbon dioxide (CO$_2$). These include precipitation of carbonate minerals with magnesium silicates in engineered reactors or following CO$_2$ injection into deep saline aquifers. In this study experiments were performed to test the influence of temperature and magnesium carbonate (MgCO$_3$) saturation on the nucleation and precipitation of carbonate minerals. The conditions studied are relevant to full-scale sequestration systems. Aqueous phase analysis by inductively coupled plasma mass spectrometry (ICP-MS) quantified the rate and extent of precipitation of solid phase from solution. Temperature significantly affected the species of solid obtained, which is supported by thermodynamic calculations. Initial MgCO$_3$ saturation level was a strong control on the rate and extent of solid precipitation. X-Ray diffraction (XRD) analysis was conducted to identify solids, which at 21°C and 56°C were magnesium carbonate minerals. At 98°C the solid phase was identified as magnesium hydroxide, Mg(OH)$_2$. This suggests that at low- and mid-range temperatures carbon sequestration may be feasible, but other variables such as ionic strength, presence of nucleation sites, and pressure remain untested.
Aluminum oxide is a useful material in engineering applications such as environmental remediation for the removal of heavy metals from water, and advanced materials such as ceramics and coatings. The structure of the clean and hydroxylated aluminum oxide (11-20) surface has been studied using density functional theory. The lowest-energy surface structure has been found to be the stoichiometric surface, which is in stark contrast to the results on other aluminum oxide surfaces (e.g., (0001), (1-102)). The hydroxylated surfaces have also been studied with density functional theory, where four water molecules have been dissociated per unit cell. The results show that the stoichiometric surface termination is favored in aqueous environments as well.
Electronic sensing technology is a developing field of study that has greatly advanced over the last decade. Currently, most research focuses on classifying odors within a limited odor set. Also of interest is detecting and distinguishing specific odors and the particular compounds within each odor, which may be relevant for developing novel medical diagnostic tools, for example.

The goal of this project is to understand the responses of electronic nose sensors when exposed to specific food odors. In order to achieve this, we built an experimental setup consisting of an array of three chemical sensors, their corresponding signal conditioning circuitry, and a data acquisition device. For acquiring and processing the data measurements, a graphical user interface (GUI) was implemented in Labview. A protocol was developed for calibrating the sensor responses to odorless air such that useful signals are obtained when the sensor array is exposed to food odors. We tested the experimental setup on a small set of foods and built their characterization profiles based on the sensor measurements.

The designed GUI and experimental setup can be used as a starting point for future research exploring chemical array signal processing applications, such as food classification and chemical source localization.
This study emerged from a need for the theoretical application of the current asylum law guidelines, positioned by the United Nations and its member organizations, to the prevailing phenomena of femicide, specifically in Guatemala. Interest in the topic materialized from previous study of the case of Fauziya Kassindja, the Togolese woman who fled to the United States to escape female circumcision. In this situation, what legal precedent would apply to a Guatemalan woman seeking asylum in another country through the claim of the threat of femicide?

To research the topic, several UN experts including those from the Office of the High Commissioner for Human Rights and the High Commission for Refugees, the Geneva Democratic Center for Armed Forces, and the International Organization for Migration were interviewed. I also read many documents including the Guatemalan Femicide Law, the work of anthropologist Victoria Sanford, and documents from the Guatemalan Human Rights Commission and the Center for Gender and Refugee Studies in California. Several recommendations were made to ease the asylum application process for women applying under the threat of femicide. It was also discovered that in order to bridge the gap between gender asylum law and femicide, further study into femicide, specifically its causes, consequences, and context must be undertaken. Through this research, I conclude that as femicide becomes a growing issue of international concern, it should be integrated into the gender asylum legal framework. In the future, I plan to find specific cases, classifiable as pursing asylum under the threat of femicide, and demonstrate how the gender asylum legal framework, including UN guidelines can be applied.
Toward a Better Understanding of...

**Determination of the Thermodynamics and Kinetics of Iron Nanoparticle Self-Assembly on an Alginate Substrate**

*Mentor: Young-Shin Jun*

The early stage aggregation kinetics and thermodynamics of the self-assembly process undertaken by iron nanoparticles in the presence of an alginate substrate are measured with atomic force microscopy (AFM). Samples of clean quartz substrate are exposed to solutions of iron nanoparticles and alginate in order to characterize the aggregation of iron nanoparticles on the surface, the coating of the surface with alginate, and the self-assembly process itself. This is determined by observing changes in the surface morphologies of the quartz substrate. No definitive information concerning the kinetics could be obtained, but aggregation and assembly patterns similar to those previously found by other researchers were observed.
Haiti, the western hemisphere’s poorest country, is finding relief from its malnutrition woes through an innovative peanut butter. Meds and Food for Kids, an organization based out of St. Louis, runs a factory in Haiti that produces enough peanut butter to cure 3,000 malnourished children every year. The factory buys its peanuts from Haitian farmers, but due to mold growth caused by inadequate drying, approximately 40% of those peanuts are thrown out. Washington University’s Engineers without Borders is working to solve this mold problem by developing a simple, affordable peanut dryer that can be built by farmers in Haiti. A passive solar peanut dryer which will ultimately help farmers reduce peanut mold and allow Meds and Food for Kids to produce more of their life-saving peanut butter was built and tested.
This research represents an integral part of a larger project which attempts to explore the significance of communication between literary media through the work of authors Gustav Freytag and Berthold Auerbach in the years between 1848 and 1871. This period is often judged as one in which political and literary activity was at a low point, and especially in which nationalism was relatively unpopular among the middle class. Furthermore, the reading public at this time began to prefer journals and newspapers to books, which threatened the “national” significance of literature. I attempt to demonstrate that the work of these authors poses a challenge to these generalizations. Both wrote popular novels during the period that maintained a nationalist agenda, and both recognized the usefulness of periodical publications to supporting their goals. Furthermore, their work in journalism and literature, taken together, can show how the “unpopular” ideas of nationalists could be further developed and popularized through the integrated workings of literary production and the periodical press. This research focuses specifically on the authors’ engagement with the periodical press and examines how they used journalism to advance a political and literary agenda.
More than just a purveyor of reliable medical information, amongst the pages of WebMD users can experience a cyber-catharsis and feel a virtual sense of connection to nameless strangers. However, the same hyperlinks building communities have foundations in fear. The message boards give license to complete strangers to advise and sympathize with no MCATS or accountability necessary. On the WebMD message boards the members of the community are the authors, editors, and critics, sustaining the pages of paranoia and therapy with each keystroke. As the availability of once limited medical knowledge changes the dynamics of power in the doctor-patient relationship, there is a need for doctors to address Internet informed patients and define new norms for behavior in the clinical setting. Many doctors take the advent of the proactive nature of the health consumer as a threat to their authority and paternalistic role. It is the responsibility of the physician to inform patients about the credibility of information online and to respect the patients’ desire for autonomous decision-making. The purpose of this research is to determine methods in which people are consuming and using information obtained from WebMD, how this information translates into the clinical setting, and consider the implications this knowledge has on health outcomes. The key to avoiding resentment and self-diagnosis that eventually lead to negative health outcomes, is proper education of medical professionals, bridging the gap between consumer knowledge and clinical relationships through positive communication. This work may further be applied to developing new research into the reactions of physicians presented with Internet informed patients, and to teaching standardized dialogue and clinical behaviors to doctors in the age of the health consumer.
As people participate in and observe the continuous flow of actions and events that compose their everyday lives, they segment the stream of action into discrete events. The brain constantly makes perceptual predictions about what will occur next and perceives event boundaries when transient prediction errors peak. Prediction of rewarding stimuli is correlated with activation of dopaminergic nuclei and the striatum. Although making predictions during event segmentation does not result in a tangible reward, we hypothesized that the substantia nigra (SN), ventral tegmental area (VTA), and the striatum would be activated when prediction errors are made during event segmentation, i.e., at event boundaries. In this study, subjects underwent fMRI scanning while watching movies of everyday activities. During pauses located either within events or at event boundaries, subjects completed a forced-choice task in which they predicted what would occur next in the movie. We traced the right and left SN, VTA, caudate, and putamen and performed region of interest analyses. Activity in the right SN was significantly higher during prediction across event boundaries than within events, meaning that this area is likely involved in prediction.
Sleep consumes nearly a third of our lives. Nevertheless, the mechanisms governing sleep regulation are poorly understood. In recent years, approaches to sleep research have focused on the hypocretin/orexin system, which is a sleep/wake regulator that has been implicated in the sleep disorder narcolepsy. Previous research has characterized a sleep-like state in zebrafish that is regulated by hypocretin/orexin. In zebrafish, the hypocretin receptor is expressed in many different neural tissue clusters, positing a distributed role for the hypocretin peptide. We are primarily interested in the role of hypocretin in modulating locomotor aspects of the sleep wake cycle. By understanding the regulatory factors controlling the expression of the hypocretin receptor, it may be possible to target neurons involved in the modulation of locomotion. Here, we attempt to identify putative regulatory noncoding sequences that drive fluorescent protein expression in neurons containing the hypocretin receptor. To test for potential enhancer activity of candidate sequences, we injected 21 DNA constructs into wild-type, 1-2 cell zebrafish embryos. Injected embryos were analyzed for putative enhancer activity by visualization of expression patterns, via fluorescence microscopy, at 96 hours post fertilization. We hope an understanding of hypocretin expression regulation may yield insights into the genetic regulation of sleep.
Toward a Better Understanding of...

Sequences Located within the N-Terminus of the Parkinson’s Disease-associated Gene, LRRK2 Lead to Increased Aggregation

Mark Fahey

Mentor: Karen O’Malley

Mutations in the large, multi-functional protein, LRRK2, are associated with both familial and idiopathic Parkinson’s disease hence understanding its biological and pathological functions may lead to novel therapies. Because LRRK2 forms aggregates in vitro and in vivo, we used bioinformatics approaches to identify regions of LRRK2 likely to induce cross-linked β-sheet formation. Using two different algorithms the same unique region in the N-terminus of LRRK2 was identified as being aggregation prone. To test this region, GFP fusion constructs targeting the first 938 amino acids of LRRK2 as well as the C-terminus (967-2527) were generated. The LRRK2 fragments as well as wild-type clones were analyzed for aggregation propensity following transfection and expression in SH-SY5Y cells using an unbiased, automated high-content imaging paradigm. Results verified that the region predicted did indeed lead to increased aggregation of N-terminal LRRK2 compared to other regions. Moreover, deletion of amino acids within this region dramatically decreased aggregation suggesting that this region may be an important determinant in the propensity of LRRK2 to form higher order structures. Similar results were observed after transfection in dissociated cultures of dopamine neurons. Because wild type LRRK2 also forms aggregates albeit much smaller ones in heterologous cell types, we tested whether the full length protein was cleaved when overexpressed in SH-SY5Y cells. Cells were transiently transfected with WT LRRK2 plasmid containing an N-terminal GFP tag and then allowed to develop aggregates for 24 hours. Following fixation cells were scored for co-localization of GFP and cy3-labeled anti-C-terminal LRRK2 antibody. Only 4% of aggregates defined as ≤ 5 micrometers exhibited co-localization suggesting that cleavage was occurring. Western blots of cell lysates were consistent with LRRK2 cleavage in a time-dependent manner. Thus, WT LRRK2 can undergo cleavage such that a truncated form of the protein is produced which has a high propensity to aggregate. It is not yet clear whether increased aggregation accelerates or retards cell death due to LRRK2 overexpression.
The Trans-Activation Region (TAR) of HIV-1 is a short RNA transcript that the virus requires to up-regulate transcription of its genome. Its function is based largely on its three-nucleotide bulge region, which recruits an essential transcription factor known as Tat protein. It has previously been demonstrated that Neomycin-B acts as a ligand to TAR RNA, causing the bulge region to assume a conformation that is not recognized by Tat protein. To determine additional structural details of this particular conformation, we have obtained two synthetic oligonucleotides in which base C24 or base U25 of the bulge has been replaced by a fluorescent analog, 2-aminopurine. Since this analog will undergo fluorescent quenching if it is in a stacked conformation with any RNA nitrogenous base, we have been able to infer details about how the stacking interactions of bases 24 and 25 are affected by Neomycin-B. Steady-state fluorescent titrations performed with Neomycin-B as the ligand reveal that increasing the Neomycin-B concentration initially causes base 24 to flip out of a stacked conformation, and then causes it to go into an undetermined stacked conformation. In addition, increasing Neomycin-B concentration causes base 25 to assume an undetermined stacked conformation. We have further verified these observations by performing femtosecond time-resolved spectroscopy, which has the additional ability to reveal details on what particular bases the fluorescent analog might stack with, on complexes of TAR RNA with Neomycin-B.
Methane has proven to be a useful precursor for the production of liquid fuels and other value-added chemicals through the Fischer-Tropsch process, but currently its potential is limited since it appears to be too energetically stable to undergo direct conversion to higher hydrocarbons and other liquid fuels. It is believed that more technologically advanced nanoscale catalysts may facilitate more economical and direct methods of production. In this study, the physisorption of methane on a 20-atom tetrahedral platinum nanocluster, and the chemisorption of dehydrogenated methane derivatives have been modeled using density functional theory. These calculations provide a strong base for computing the reaction pathway, using the nudged elastic band and related methods, for catalytic methane dehydrogenation on Pt nanoclusters. Furthermore, the nanoparticle structure, composition and placement on a metal oxide support may be varied to design catalysts with improved yield, selectivity, and stability for the direct synthesis of liquid fuels from methane.
This thesis investigates punishment and overcriminalization in the United States. Specifically, I am interested in the right not to be punished and how that right should translate into our criminal system. Unlike Douglas Husak in his book *Overcriminalization*, I argue that the right not to be punished is a fundamental right and should be treated as such. Also, I explore the possibility that this will lead to a more just criminal justice system. I do not want to argue that treating the right not to be punished as a fundamental right will annihilate our criminal justice system as we know it; rather, I argue that it places the onus on the state to uphold the justice of the system. I also use the proliferation of inefficient and overreaching sexual conduct laws as an example of our bloated criminal justice system.
The term “bike culture” has two related but different meanings. In countries that support, encourage, and have high bicycle usage, it refers to cooperation between government and private organizations to achieve these goals. In countries with relatively low bicycle usage, such as the United States, bike culture refers to a cycling subculture. As the U. S. searches for low carbon solutions to transportation problems, it must pursue the former definition as it attempts to bring cycling from a subculture into the mainstream. To compare these two definitions, I conducted a study which draws on theoretical material from economics, environmental policy, and urban development as it relates to the cities of Amsterdam and Copenhagen. This project evaluates the steps these cities have taken to promote bike use through infrastructural, social, governmental, and market incentives. American bike commuters face several challenges, including strong opposition from small business and car owners. By better understanding the attributes that Amsterdam and Copenhagen have which resulted in a perfect habitat for cyclists and a thriving urban bike culture, I assess which changes can be made to our own active and public transportation networks. In doing so, reasonable solutions to the problems American cyclists face through new technologies and old mechanisms are identified.
Thoughts on the Effectiveness of Foreign Aid

Morgan Grossman-McKee

Mentor: Sebastian Galiani

Since the 1960s, the literature on the effectiveness of foreign aid has struggled to reach robust conclusions. In 2004, Michael Clemens and two coauthors pioneered a new approach to studying foreign aid. Clemens et al isolated components of aid that they believed could realistically promote short-run growth, and found that indeed such aid flows were robustly correlated with GDP growth.

While this new strategy appears promising, it needs to be replicated by outside researchers. The present study attempts to reproduce the results from Clemens et al, using a similar but slightly-updated data set. Unfortunately, the seemingly-stable results from Clemens et al do not appear to survive this attempted replication. Although several factors that could influence the results still need to be investigated, it appears that a robust link between foreign aid and growth remains elusive.
We have monitored [2+2] photocycloadditions in the solid state of both molecular crystals, including cinnamic acid (and its derivatives) and cinnamoyl-substituted polymers. The reaction kinetics can be followed using $^{13}$C NMR due to chemical shift resolution between reactants and products. We have detected a polymorphic phase change in molecular crystals, and single crystal NMR has revealed an unexpected splitting of product resonances, attributable to two magnetically inequivalent sites, while x-ray diffraction suggests a single crystal site. These apparent anomalies will be discussed. This photoreaction is also being studied in other species that will be discussed.
This project investigates the gender segregation of the feminist movement in general and the movement to end domestic violence and sexual assault in particular. Men have been relegated to certain tasks within these movements, often unable to break out of the roles allocated to them by the organizations for which they work. Men in this field usually counsel abusers and batterers instead of working directly with the victims and survivors of the violence while women usually take on the role of helping survivors directly. The aim of my research is to investigate this gender segregation by talking to men and women in the field about their experiences and opinions on male involvement in direct service provision. Interviews are ongoing, but they have shown a wide variety of opinions on male involvement in this field, demonstrating the need for a larger conversation on the topic.
Transcriptional Regulation of FGF1 by PPARγ: Effects on Adipogenesis

Mojibade N. Hassan

Mentor: Ronald M. Evans, Salk Institute

Nuclear receptors (NRs) are a superfamily of ligand activated transcription factors. The Evans laboratory developed a high-throughput screen to determine the regulation of genes by NRs. Recently regulation of Fibroblast Growth Factors (FGFs) by NRs was discovered, so one of these screens done in the lab included testing the entire family of FGFs for regulation by NRs. Of particular interest was the strong and specific transcriptional regulation of FGF1A, one of the alternative splice variants of FGF1, by peroxisome proliferator-activated receptor (PPAR) γ. PPARs are a subgroup of NRs that are involved in lipid metabolism and regulate genes by binding to the PPAR response element (PPRE). In particular, PPARγ is involved in adipogenesis and fat storage. In this project we characterized the FGF1A promoter. First, we identified a putative PPRE and determined its functional activity by mutational analysis. Second, we investigated the evolutionary conservation of the FGF1A promoter, and its regulation by PPARγ. We show that the FGF1A promoter and its regulation by PPARγ is highly conserved in a wide range of mammals suggesting that this regulation is functionally important.
Dr. Seuss’s 1971 children’s story, *The Lorax*, tells the tale of the demise of a Truffula forest because of the greed of a green creature known as the Onceler. Although clearly advocating protection of the environment, this picture book fosters implications targeting a more mature audience. Through the juxtaposition of the Truffula habitat, where creatures live harmoniously and have abundant resources, with the Onceler’s self-advancing world, where natives experience homelessness and starvation for the first time, the text seems to advocate a return to a pre-industrialized past. Dr. Seuss’s drawings (where a funnel shape repeats in the Onceler’s body, his factories, and the Truffula trees) suggest a second interpretation that the Truffula environment symbolizes and warns against an individual’s moral decay. Connecting and clarifying these claims, Amitai Etzioni, John Kavanaugh, and Heinz Hengst offer definitions of morality and explore possible psychological and sociological factors influencing the Onceler’s actions. Research on these articles complicated and led to my final claim that the text calls for the return to a preindustrial community where people are not pressured to impose their wills on others and sink into amorality as a means of achieving individuality in an increasingly mechanized world.
Toward a Better Understanding of...

Spatial Niches in Mixed-Species Exhibits

Erin Kane

Mentor: Robert Sussman

Examining two different mixed-species exhibits of primates at the St. Louis Zoo, this research evaluates whether or not captive primates use spatial arrangement to maintain their distinct niches, and whether the distinctiveness of the niche determines the success of the exhibit. Based particularly on the frequency with which each species used different parts of their exhibit, it was determined that spatial arrangement is distinct between species, and that monkeys arrange themselves non-randomly within their enclosures. I did not find that the more distinct the niches, the lower the rates of agonism (and therefore the more successful). To the contrary, the exhibit with more distinct spatial niches had higher inter-species agonism.
Toward a Better Understanding of...

Optimization of Detector Geometry for Balloon-Born GCR Collection

Andrew Kanyer, Jr.

Mentor: Robert Binns

In any satellite or balloon-based experiment, balancing payload size, weight, and cost is a primary concern. Designers strive to produce the most effective detector possible while respecting the various cost, weight, and size restrictions dictated by the balloon in use. While this balance is tedious and difficult to achieve using analytical methods, computer simulation can simplify the process. This work explores the challenges and benefits that developing such a simulation introduces into the design process for a balloon-born galactic cosmic ray detector.
During the past year, whether or not the United States economy is in a recession has been subject to debate. Many economists have questioned whether this debate in itself has contributed to the decline in consumer confidence. This experiment tested whether the media’s framing of an economics article can change a consumer’s decisions, and whether economic literacy can lessen this effect. It examined whether participants who read a fictitious news article with the word recession in it made different economic decisions than a group of participants who read an article that was identical in content, but substituted recession for the formal economics definition, negative real gross domestic product growth for two or more consecutive quarters.
Fibroblast growth factor receptor 2 (FGFR2) plays a critical role in cell growth and signaling. It is abundantly expressed in the adult endometrium and somatic activating mutations in FGFR2 are seen in ~16% of endometrioid endometrial cancers. Two recent genome-wide association studies identified alleles in FGFR2 associated with breast cancer risk. Given the similar role estrogen plays as a risk factor in both breast and endometrial cancers and the involvement of FGFR2 activating mutations in endometrial cancer, we sought to determine whether variation in FGFR2 contributes to endometrial cancer risk.

We examined 14 haplotype tagging SNPs in FGFR2 that capture most of the variation in the gene in 363 well-characterized Caucasian endometrial cancer patients (ages 26 - 92 years at diagnosis) and 336 Caucasian cancer-free controls. SNPs were genotyped using Pyrosequencing™. The rs1219648 allele tagging the LD block previously associated with breast cancer risk showed no evidence for association with endometrial cancer. rs2912760, rs1863741, and rs2981428, however, showed a difference in allele frequency in cases and controls that approached statistical significance. In particular, the rs1863741 minor allele (G) was more common in cases (46%) than controls (37%) (Odds ratio 1.39, 95% CI 1.11-1.73, p=0.004).

The three SNPs that showed a significant difference in allele frequency in cases and controls were genotyped in an additional 376 Caucasian endometrial cancer patients and 188 cancer-free controls in Phase 2 of the study. Data analysis of the combined cases and controls in Phase 1 and Phase 2 showed that there was no longer a significant difference in allele frequency between the cases and controls. Recent data indicate the FGFR2 susceptibility allele(s) associated with breast cancer is unlikely to play a role in endometrial cancer. None of the SNPs from the 14 LD blocks of FGFR2 seems to contribute to risk for endometrioid endometrial cancer.
In previous work we have found that the performance of the 2D position estimation algorithms using two pairs of microphones depends on array variables such as the distances between the individual and pairs of microphones, and also the sampling frequency. Therefore, we propose to build a robotic microphone array with autonomous control of the array geometry and sampling rate for improving the localization performance of an acoustic source in 2D space. In particular, in this project we focus on developing data processing architectures for estimating in real-time the 2D locations of an acoustic source. We implemented our algorithms in Labview combined with Matlab and developed a graphical user interface that allows for easy interaction with the experimental setup. The system allows for tracking a fixed and moving wideband acoustic source.
There is a clear interaction between sleep and metabolism, where insufficient sleep results in metabolic defects such as obesity and endocrine dysfunction. Conversely, recent data from Paul Shaw has shown that mutations in enzymes involved in lipid metabolism change sleep behavior. Unfortunately, the mechanism of how lipids control the regulation of sleep is unknown. The model organism Drosophila melanogaster is used to understand mechanisms underlying sleep. Previous microarray experiments in the lab have identified multiple lipid metabolism genes involved in sleep regulation. One such gene with unknown function but homology to Acyl-CoA synthetases (ACS) is CG9009. Using techniques such as P-element mutagenesis, RNA interference (RNAi), qPCR, and various sleep behavior parameters we hope to elucidate the molecular interaction between sleep and metabolism through understanding the role of this putative metabolic gene, CG9009.
The suprachiasmatic nucleus (SCN) of the mammalian hypothalamus is required for near-24 hour behavioral and physiological rhythms. Individual neurons in the SCN have circadian rhythms in firing rate and clock gene expression. Circadian synchrony between oscillators is critical for coherent output from the SCN, and thus for behavioral rhythmicity. How these neurons remain synchronous is unclear. Here we study the underlying functional connectivity of neurons within synchronized SCN networks to determine which types of communication may be important for synchrony. By cross-correlating neuronal spike trains recorded on multielectrode arrays, we found evidence for significant connectivity between individual neurons. These correlations peaked within 10 ms of firing by a reference neuron, and were classified as excitatory or inhibitory. We found that communication between neuron pairs oscillated over the day, much like their electrical activity. Application of specific receptor antagonists allows us to determine which neurotransmitters mediate these correlations. Furthermore, we can determine whether this millisecond-resolution communication is necessary for circadian synchrony by applying specific receptor antagonists to SCN slices and imaging the expression of a bioluminescent reporter driven by the clock gene *Period2* (*Per2::Luc*). Preliminary results indicated that blockade of GABA signaling by application of 200 µM bicuculline decreased the number of inhibitory correlations by ~90 % and decreased the number of excitatory correlations by ~0 - 50% (n=3 cultures). Bicuculline did not, however, affect circadian synchrony in SCN slices. Blockade of ionotropic glutamate receptors with APV and CNQX also did not affect the *Per2::Luc* rhythm in SCN slices. These results indicate that we can effectively probe the connectivity between individual SCN neurons using spike train analysis and determine how oscillators couple to maintain circadian synchrony.
This work is an analysis of data that was obtained through X-ray scattering of metals by means of Beamline Electrostatic Levitation. The purpose was to glean the structural properties of the metallic liquids. Metallic samples are levitated in electric fields then melted and X-rays scattered through them. Computer programs are used to organize this data into ways that reveal the atomic structure of the metallic liquids. The analysis is intended to fill holes in our knowledge of how the atoms of pure metals and alloys arrange themselves in the liquid. No significant results have been obtained thus far, but further analysis of the data may be done.
The shantytowns of Lima Peru present a unique environment in which the role of community identity and its constructive function in marginal settlements may be studied. Community action and solidarity are at the core of the reason why the shantytowns have experienced such success and permanency since the initial land invasions of the twentieth century. The residents have discovered and proven that their voice, and not their exit, is what will bring improvement to their settlements. In determining the most effective means of interacting with the government, I have explored how these diverse community groups are organized, who organizes them, where the community resources come from, and how resources are distributed within the community. Through a cohesive community and strong-willed actors, the residents of these towns have created a shining example of negotiation for services and amenities from the government, while at the same time created thriving urban centers where once there was only desert sand.
This research was conducted in La Paz, Bolivia where I interviewed women on their experiences and opinions on machismo, male chauvinism. The goal was to conduct enough interviews and take enough video footage and photographs to create a photo documentary. By living with the anarchist-feminist group Mujeres Creando, I gained an insider’s perspective on what would be considered one of the more radical opinions of Bolivian women, as well as connections to the women who were interviewed. Photographing daily life of Bolivian women provided visual evidence for the research. I conclude that there is a huge separation between classes, and ethnicities of women within Bolivia in relation to their opinions, and willingness to talk about their views on the role of men in society. I also conclude that Bolivian women acknowledge that machismo is prevalent in their society and that they view that as negative, but they do not know what to do about it and feel powerless.
Toward a Better Understanding of...

CASPASE-9: A Candidate Susceptibility Factor for Murine Alkylator-induced Leukemia

Yedda Li

Mentor: Timothy A. Graubert

Therapy-related acute myeloid leukemia (tAML) is caused by exposure to chemotherapies and radiotherapies and has a poor prognosis. To better understand the genetic factors involved in secondary leukemogenesis, we performed murine genome-wide mRNA profiling and found that differential expression of apoptosis-related genes was correlated with strain-dependent differences in tAML susceptibility. We identified a 1,725-bp copy number variant (CNV) loss on chromosome 4 of the DBA/2J and PL/J strains that correlates with altered Caspase-9 (Casp9) expression levels in hematopoietic stem/progenitor cells. Casp9 is a gene downstream from extrinsic and intrinsic death-inducing signals crucial for the initiation of cellular apoptosis, and we propose that it may be an important factor influencing tAML susceptibility. In these strains, Casp9 expression is undetectable in flow sorted kit+/lineage- (KL) hematopoietic stem/progenitor cells as measured by microarray profiling, and confirmed in independent qRT-PCR assays. Full-length Casp9 cDNA clones could be isolated from mRNA libraries prepared from DBA/2J and PL/J KL cells, but 35% of the transcripts were a novel isoform lacking exon 2 that results in a frameshift and an early stop codon in exon 4. This premature termination codon is predicted to trigger nonsense-mediated mRNA decay, leading to the degradation of the novel isoform and thus accounting for the low Casp9 expression levels in DBA/2J and PL/J. We hypothesize that cells with relatively low Casp9 expression would be more resistant to alkylator-induced apoptosis and more likely to accumulate mutations that initiate leukemias. Preliminary data from flow cytometric apoptosis assays in KL cells after treatment with ENU show a 45.4%±1.4% and 72.61%±2.6% decrease in AnnexinV+ cells in PL/J and DBA/2J, respectively, compared to C57BL/6J cells with normal Casp9 expression. This shows that PL/J and DBA/2J cells are more resistant to ENU-induced apoptosis, suggesting that differences in Casp9 expression levels may indeed play a role in influencing individual susceptibility to tAML.
Due to the negative effects that soot has on health and the environment there is significant interest in reducing or eliminating its production during the combustion of carbon-based fuels. Soot-free flames, known as permanently blue flames, have been observed experimentally; however there is debate regarding the physical explanation of these flames. Previously conducted computational work suggests that these flames result from a change in the activation energy of a key soot formation reaction during oxygen enhanced combustion. This work uses a one-dimensional gaseous laminar diffusion flame to study the experimental phenomena correlated with the computational results. The data show that in oxygen-rich environments the activation energy associated the formation reaction drops to zero. This is an important result because it implies that the formation of soot is independent of temperature under these conditions. For a flame burning in air conditions, soot formation increases as the temperature increases; however in the oxygen-rich environment the temperature can be increased without the onset of soot inception.
Mechanical processes are at the basis of development, shaping the embryo and organs in order to give rise to the organisms we see today. Yet, the physics behind these processes remains largely uncertain. Biomechanics has focused on the mechanics of sub-cellular structures and of the mechanical properties of adult tissues but has largely passed over embryonic tissue-scale mechanics. In large part this overlook is due to the fact that only a few devices have been designed to investigate the delicacy of embryonic tissues. We have used micro-indentation experiments to examine the mechanical properties of the early stage chick embryo. In particular, we have examined HH stage 5 and 6 embryos paying particular interest to Hensen’s node, regions within the neural plate and regions just outside the neural plate, anterior to the headfold formation. Knowledge of applied forces and deformation allows us to quantify the viscous and elastic properties of these tissues. Results indicate regional variations in stiffness evolve over time.
Capcom’s promotional trailer for their 2009 video game Resident Evil 5 prominently features racially-charged imagery: black children leering from the shadows of a shantytown; a small gang of black men chasing a terrified white woman; a crowd of black men and women working itself into a riot, communicating in barks and grunts. The game attributes the increased aggression of the black villagers to a viral infection, but the imagery hews so closely to a Colonial tradition of negative stereotypes that many critics wondered: does the game encourage a fear of black people? The philosophical approach produces mixed results: Plato, Aristotle, and contemporary philosophers disagree on the cathartic potential of art depicting negative images to enlighten. The empirical approach, tracking consumption of violent games against commission of violent acts, suggests that the game encourages compassion—or at least placation. This project’s examination of the cathartic value of games informs the critics’ approach to the medium, as well as the responsibility of a producer in the medium.
Atmospheric scientists have calculated that just 1% of the energy stored in high altitude winds could provide enough energy to power the entire Earth. One technology that may be used to harvest this energy is autogyros. An autogyro, first successfully flown in 1923, is a rotorcraft similar to a helicopter that uses the upwards flow of air created during flight to turn its free-spinning rotors to provide lift for the vehicle. I worked on a system of four autogyros attached to a frame that can be flown like a kite, 10,000 feet in the air. Not only is this system designed to operate at higher efficiency levels than other windmills, but it will also cause significantly less environmental damage. Design graphs to determine the optimum efficiency of different systems were produced in this work.
Ephrin genes encode for proteins that guide retinal axons to their final locations in the brain. Three Ephrin genes from the IMAGE consortium, a cDNA library, were cloned from mice. The expressed proteins will be placed in gradients on self-assembled monolayers (SAMs). Neurons will then be cultured on these SAMs, with the intent of studying how neural growth is influenced by the Ephrin guidance cues.

The size of a DNA vector insert plays an important role in the cloning method used. During transformation, the vector inserts must find both ends of the cut vector and be correctly attached. As insert size increases, the DNA experiences more difficulty circularizing. This process becomes extremely difficult when using ligation methods.

In order to alleviate the difficulties associated with ligation, the Ek-LIC cloning method was utilized to clone the Ephrin genes. The Ek-LIC cloning method should be an efficient and high-yielding method, even for large inserts. The pTriEx-5 vector was chosen for its many advantages, including triple protein expression capabilities (bacterial, insect, and mammalian) that allow us to study the post-translational modifications of mammalian proteins, as well as the ability to use multiple purification tags.
A set of incubation experiments with deep saline aquifer field site rock samples and acidified saline solutions was conducted at atmospheric pressure and a temperature of 80 °C. The field site rock samples, a shale cap rock and a coarse sandstone, are intrinsic to the makeup of deep saline aquifers and require study for carbon sequestration to be a viable option. These saline solutions, intended to mimic aquifer fluids after CO₂ injection, varied in ionic strength of NaCl and in pH. After incubations of the rock samples with the simulated solutions for durations that ranged from fifteen minutes to two weeks, the solutions were measured using inductively-coupled plasma mass spectrometry. Results showed that concentrations of potassium and calcium ions increased over time for incubated cap rock samples, representing an ion exchange between K⁺, Ca²⁺, and Na⁺ ions and an alteration of the cap rock chemistry. The cap rock and sandstone samples were also analyzed post-incubation using the BET gas adsorption method and x-ray diffraction. These analyses indicated changes in the reactive surface area of the cap rock sample and elucidated potential formation of secondary minerals. Further research is required to improve understanding of the dissolution and precipitation reactions innate to CO₂ injection into deep saline aquifers and these reactions’ effects on the cap rock chemistry and mineralogy. This work provided fundamental information regarding the reactions at mineral-carbonated saline water interfaces at high temperatures and helped lay the groundwork for continued investigation.
Measuring neutron polarization to a high degree of precision is critical for the next generation of neutron decay correlation experiments. Polarized neutrons are also used in experiments to probe the hadronic weak interaction which contributes a small portion (~$10^{-7}$) of the force between nucleons. Using a beam of cold neutrons at Los Alamos Neutron Science Center (LANSCE), we polarized neutrons and measured their absolute polarization to ~0.1%. Neutrons were polarized by passing them through a $^3$He spin filter, relying on the maximally spin-dependent $^3$He neutron absorption cross section. The neutron polarization can be determined by measuring the wavelength-dependent neutron transmission through the $^3$He cell. An independent measurement of the neutron polarization was also obtained by passing the polarized beam through an RF spin flipper and a second polarized $^3$He cell, used as an analyzer. To measure the efficiency of the spin flipper, the same measurements were made after reversing the $^3$He polarization in the polarizer by using NMR techniques (adiabatic fast passage). We will show the consistency of these two measurements and the resulting precision of neutron polarimetry using these techniques.
Photosynthetic light harvesting antennas function to collect light and transfer energy to a reaction center for photochemistry. Phototrophs evolved large antennas to compete for photons in natural environments where light is scarce. Consequently, cells at the surface of photobioreactors over-absorb light, leading to attenuated photobioreactor light penetration and starving cells on the interior of photons. This reduction of photosynthetic productivity has been identified as the primary impediment to improving photobioreactor efficiency. While reduction of antenna size improves photosynthetic productivity, current approaches to this end uniformly truncate antennas and are difficult to manipulate from the perspective of bioengineering. We aim to create a modifiable system to optimize antenna size throughout the bioreactor by utilizing a synthetic regulatory mechanism that correlates expression of the pucB/A LH2 antenna genes with incident light intensity. This new application of synthetic biology serves to transform the science of antenna reduction into the engineering of antenna optimization.
Toward a Better Understanding of…

Are Natural States Less Resilient?
A Test of the North, Wallis and Weingast Thesis

Jon Millis

Mentor: Lee Benham

In their book *Violence and Social Orders*, North, Wallace and Weingast propose a new theory of economic development. Central to their argument is the classification of countries into “natural states” and “open access orders.” One important implication of their theory is that open access orders are more resilient than natural states. This work examines this thesis for the 2008-2009 episode of financial shock by tracing the volatility of currencies over the period. Implementing the Euro as a benchmark, I examine currency fluctuations in 102 different countries. Open access orders should exhibit greater financial stability, as measured by the annualized standard deviation of percent change in daily price of a currency. Low values suggest low volatility—and hence, high resilience—to economic shock.
The fourth chromosome of Drosophila melanogaster is unique in that it possesses a high gene density within a heterochromatic chromatin structure, simultaneously exhibiting features of euchromatin and heterochromatin. If the chromatin structure of the fourth chromosome is assayed with transgene reporters, lines with fully active reporter genes and lines with variegating (partially silenced) reporter genes are recovered, implying a difference in chromosomal packaging at the insertion site. Simplistically, one could expect that when the host gene is being actively transcribed, the reporter should also be transcribed; similarly, silencing might be correlated. By analyzing the fourth chromosome reporters, we can determine how the expression of the host gene influences reporter expression. Quantitative-PCR was used to assay the expression levels of the host gene and the reporter in five fly lines at different developmental stages. As expected, lines with active reporters showed significantly more transcription of the reporter than variegating lines; however, the results show only a weak correlation between the expression level of the reporter and the host gene. This implies a chromatin environment that silences the reporter, yet allows for fourth chromosome host gene expression, suggesting special properties of the latter genes.
Individuals discount probabilistic rewards according to the hyperboloid function: $V = A/(1 + bX)^s$, where $V$ is the present, subjective value of a reward of amount $A$, $X$ is the odds against it being received, $b$ is a parameter that determines the rate at which the subjective value decreases, and $s$ represents the non-linear scaling of amount or probability. The subjective value of a probabilistic reward is typically measured by finding the indifferent point between the larger probabilistic reward and a smaller certain reward. The goal of the current study was to add a common ratio to the probability of receiving the larger reward and to the probability of receiving the smaller reward. In essence, indifference points were now found for the larger probabilistic rewards in terms of a “less probabilistic” valuation. In two studies, participants discounted several probabilistic amounts ranging from $250$ to $2$ million, several probabilities ranging from $.8$ to $.05$, and several common ratios ranging from $1.0$ to $.05$. Magnitude effects were evident for the discounting functions of the highest common ratios, but were not apparent at the extreme low common ratios. Furthermore, the inclusion of common ratios led to decreases in the rate of discounting at the extreme low common ratios, but had little effect on the rate of discounting at the medium to high common ratios.
Isonitrile hydratase (INH) is an enzyme found in the soil degrading bacteria, *Pseudomonas putida*. It catalyzes the hydration of isonitrile to the corresponding N-substituted formamide, degrading the N≡C triple bond of isonitriles. The main role of INH in *P. putida* seems to be detoxification—the isocyanide reacts completely to yield formamide. Isonitriles are highly toxic, and some organisms produce isocyanocompounds which are used to protect them from their enemies. It has been previously shown by UV spectroscopy that INH catalyzes the formation of naphthyl formamide from naphthyl isocyanide. Fluorescence spectrophotometry confirmed this reaction and showed that the reverse rate of INH is negligible.

The enzymatic activity of INH was confirmed and the catalytic rate determined. The function of the water molecule at the active site between the cysteine and the aspartic acid residue on the enzyme was tested by making a D17E mutation, converting the aspartic acid, D, into a glutamic acid, E, residue. Since glutamic acid is larger than aspartic acid by one methyl group, the mutation did not leave sufficient space for a water molecule at the active site and deactivated INH, revealing that the mechanism for catalyzing the decomposition of isonitriles requires the particular water molecule seen in the active site.
In an intersection of the humanities and public health, journalist Michael Pollan shows us how effective nutrition behavior change communication can stem from a written format. Using mantras like: “Eat food. Not too much. Mostly Plants,” Pollan creatively uses rhetorical writing tools to incite healthy decision-making among his readers. In his essay entitled “Unhappy Meals” that appeared in the January 28, 2007, Sunday *New York Times Magazine*, Pollan uses devices like conversational tone and repetitive conclusive reasoning to allow readers to use what they know to be true to make consistent healthy decisions. With ever-prevalent nutritional messages conveying contradictory suggestions, Pollan’s essay proves valuable with its unique style and integration of the social, historical, and political factors contributing to a reader’s need to convert knowledge to wisdom. The demonstrated efficacy of devices used in “Unhappy Meals” can serve as a basis for other health behavior change communication appearing as a written work, including works that cater to diversified audiences, as it appears audiences can be unified by their intent in reading a piece.
Toward a Better Understanding of…

NRF Technical Core: Controlled Synthesis of Metallic Nanostructures

Landon Kyle Oetjen

Mentor: Yujie Xiong

Over the past decade, metallic nanostructures have been widely used not only for fundamental research but also for practical uses in our lives. The research community has yet to unlock the huge potential in these nanostructures with reliable and precise controlling means in their production process. At the Washington University Nano Research Facility (NRF), we are able to control the shape, size, structure, composition, surface group, and surface charge of metallic nanostructures, leading to the feasibility of finely controlling their properties and functions and fully exploiting their applications or investigating their implications.
Analysis of WM Tract Integrity Associated with the Ventromedial Prefrontal Cortex in Children with Major Depression

Neil O’Kelly

Mentor: Kelly Botteron

This project is an extension of a previous investigation involving early onset major depression in children and adolescents. In that study the volume of gray matter in several regions of the brain including the ventromedial prefrontal cortex (VMPFC) were measured. There were two alterations in this project. Here we analyzed the white matter (WM) tracts rather than gray matter of the ventromedial prefrontal cortex, and measured properties reflecting the integrity of the white matter: fractional anisotropy and mean diffusivity (obtained from diffusion tensor imaging (DTI) scans) rather than volume. We hypothesize that early onset major depression affects white matter connections near the ventromedial prefrontal cortex, a known region of interest.
The synthesis of radiometal-based Positron Emission Tomography (PET) imaging agents occurs through (a) the binding of a bifunctional chelator to a biomolecule that targets cancer antigens, and (b) the chelation reaction of a radioactive metal ion by the bifunctional chelator. Currently, inefficient mixing and the use of large volumes results in waste products and inefficient production of agents. Micoreactors, systems of micron(sub-millimeter)-scale channels into which liquid reagents are introduced and allowed to react, have been used to improve mixing of reagents. A system utilizing a LabVIEW VI, automated pumps, and syringes, was developed to produce PET imaging agents in a microreactor. Upon entering the buffer, radiometal, and ligand required to complete the second reaction into a microreactor, improved mixing was observed through Thin Layer Chromatography. These results will elucidate methods of producing radiometal PET agents on a small and efficient scale.
This project explores the intragroup conflicts and eventual decline of the Student Nonviolent Coordinating Committee (SNCC), the “shock troops of the Civil Rights Movement.” The focus is on SNCC’s relationship with an informal support network in the North, characterized by “Friends of SNCC” groups. I hypothesize that SNCC’s increasingly caustic public persona and separatism impaired Friends of SNCC groups’ ability to effectively fundraise, hastening the abrupt decline and disappearance of SNCC.
This research seeks to analyze the impact of microhydropower installations in Iceland based on economic and environmental costs and benefits. Using a methodology similar to that applied in cost-benefit analysis, a case study in Ísafjörður demonstrates how residents can project the overall impact of building a microhydropower installation and how the benefits of doing so compare to the costs. Based on the data available and following several assumptions, a microhydropower installation modeled after an existing one in Ísafjörður would require a large initial capital cost that eventually pays for itself over the course of the lifetime of the system. This research project was part of a larger study in which each project focused on a different way that renewable energy technology could be applied in Ísafjörður based on local resources.
Toward a Better Understanding of...

The Relation of VMPFC and Insular Cortex to the Longitudinal Course of Illness in Early Onset Major Depression

Eric Potter

Mentor: Kelly Botteron

Changes in volumes of cortical structures, like the Ventra Medial Prefrontal Cortex and the Insular Cortex, have been implicated in Major Depressive Disorder. The results of Magnetic Resonance Imaging (MRI) illustrate a possible correlation between cortical structure and specific disorders or symptom cluster. The Insular Cortex is highly effective in maintaining sustainable emotion and sensory processes. Damaged or impaired Insula have been shown to contribute to or allow MDD to occur. The goal of this work was to document the change in regional cortical structure from the subject’s first baseline scans compared with periodic scans taken during the longitudinal course of the study.

The Botteron lab has recruited a sample population of 95 female, right-handed, monozygotic and dizygotic twin pairs between the ages of 13 and 23 where at least one twin meets diagnostic criteria for MDD according to the DSM-IV. Established diagnostic interviews have been administered to the subjects to ascertain Axis I diagnoses. The insular cortex has been isolated in the averaged 3D T1-weighted MPRAGE (1 mm isotropic voxels) MRI images using the image processing program ANALYZE that compiles 3D renderings of the Insula from the segmentations for volumetric analysis. The boundaries of the Insular Cortex are defined with frequent reference to axial and coronal images.
This research focuses on the demonology of Justin Martyr’s *1 Apology*. The work displays Justin’s complex take on the presence and activity of demons within the cosmological hierarchy. Throughout *1 Apology*, Justin invokes the demons both as inspirations for evil activity and as explanations for the hindering of the Gospel. The research explores the sources for 2nd Century conceptions of demons and Justin’s application of his demonology in his apologetic agenda. Through this research, I examine 2nd Century Christian cosmology and how the fledgling religion fits into the “locative” and “utopian” frameworks as defined by Peter Brown and J.Z. Smith in their respective works, *The Making of Late Antiquity* and *Map is Not Territory*. 
In a nuclear magnetic resonance (NMR) experiment or imaging session, a short radio-frequency electromagnetic pulse causes the precession that produces the information or image. The device that creates this wave pulse is called an NMR “coil,” a series of one or many circuits tuned to a specific frequency depending on the particular sample to be imaged. Researchers at Washington University Medical School needed a coil for imaging experiments on ex vivo human brains. This project was to build a specific type of coil design, called a birdcage coil, which could accommodate an entire brain at one time for these experiments. It needed to be large enough to fit the whole brain and able to create a pulse field homogeneous enough to produce a high-resolution image. A coil consisting of 24 tuned circuits arranged around the circumference of an eighteen-inch-long, eight-inch diameter Plexiglas tube was constructed. This coil could create an image with good enough resolution for the imaging experiments; it is now being used to image and study the brains of U.S. soldiers who died of massive head traumas.
One of the most interesting and pertinent areas of study in neuroscience is the ability to perceive spatial orientation, a multisensory task that requires integration from many sensory systems. It is of special interest to study how the brain integrates multisensory information when different senses provide conflicting information. For example, in an airplane that is pitched and accelerating upward, conflicting vestibular and visual information must be resolved by the brain, resulting in a weighted compromise based on the reliability of each input. These “compromises” are not always accurate to life and the need to consider them has been implicated when developing new technology, particularly regarding flight.

Previous experiments have shown that when a bar of light is enclosed in a visual frame, subjects make consistent errors when trying to set the bar vertically. This effect demonstrates the effect of our visual surroundings on our visually perceived vertical (VPV) and is called the Rod and Frame Effect. Additionally, subjects have been observed to make similar mistakes when the same bar is presented to a tilted subject against no backdrop. This demonstrates the variability in our vestibular estimations and has been attributed to the effect of a “prior,” a tendency in our estimates based on intrinsic or acquired knowledge about the world. A rich body of knowledge has been developed describing these two effects and their interactions with each other, but no inquiry has yet been made as to the effect of the stimulus itself. The present research aims to study the ability of subjects to align full visual scenes, rather than a bar, to the vertical and ultimately will be the groundwork for single unit recording experiments which will help identify the exact regions in the brain responsible for spatial orientation and perception.
G-protein coupled receptors (GPCRs) comprise a large protein family that plays an important role in many physiological and pathological processes. Modulation of the interaction between activated GPCRs and their respective G-proteins is an attractive paradigm for the treatment of certain congenital diseases that cause constitutive activation. Typically, the interaction between a GPCR and its respective G-protein is modulated by blocking agonist binding to the extracellular region of the GPCR. A relatively unexplored method is to block the G-protein from binding to the GPCR on the intracellular side. A ligand-based approach was used to find compounds that modulate the interaction between rhodopsin, a GPCR involved in vision, and transducin, its G-protein. A pharmacophore was generated from a tetrazole peptidomimetic designed to stabilize the photoactivated state of rhodopsin. The Maybridge Hitfinder and National Cancer Institute (NCI) Diversity small molecule libraries were screened for compounds containing the pharmacophore using UNITY, a search program in SYBYL. Forty-seven compounds resulted from the Maybridge library, and none resulted from the NCI library. These compounds were tested experimentally for their ability to stabilize Meta II (MII), one of the photoactivated states of rhodopsin. Five of these compounds were found to stabilize the MII state (an 11% hit rate), with EC50 values ranging from 0.593 to 1.8 mM. Four of these confirmed MII stabilization with acid trapping assays. Binding and release assays were performed to determine if the small molecules inhibited transducin from binding to photoactivated rhodopsin. The compounds found in this study are promising starting points for subsequent optimization for possible therapeutics to treat congenital retinal diseases, such as retinitis pigmentosa.
On February 15, 2009 the Venezuelan people voted on a referendum to end Presidential term limits, thereby making it possible for current Venezuelan President Hugo Chávez to run for re-election indefinitely. Inspired by this event, this study focuses on two aspects of Chávez’s career. Firstly, it investigates the shift in Chavismo, which is a socio-political movement that revolves around Chávez’s political positions. This portion of the study explores the transition from the idealistic, Simón Bolívar-focused phenomenon to twenty-first century socialism. Secondly, the study examines the impact that Chavismo and twenty-first century socialism have had on the rest of Latin America. This researched showed that Chávez has greatly influenced other Latin American leaders by providing an alternative to the unsuccessful neo-liberal policies that have plagued Latin America. Chávez’s twenty-first century socialism represents a Latin American solution. Furthermore, Chávez has also become a ringleader for leaders around the world. Chávez has become the symbol of anti-globalization and anti-U.S. sentiments. Despite his controversial persona and his distaste for political niceties, Chávez continues to be politically successful in Venezuela. Ultimately, the passing of the re-election referendum has solidified Chávez’s power while bringing Chávez one step closer to successfully implementing twenty-first century socialism.
Are men sexually satisfied with woman’s expression of the ideal female physique? Do their opinions matter? How do certain style trends work for or against this topical ideal? Much of this research stems from an extremely explorative and theoretical approach. Gender issues, the fashion industry, and Vladimir Nabokov’s *Lolita* were three somewhat disparate modes of intrigue that came to reveal something about the sexual relationship between men and women. For many years, women have been cast as subservient in our hierarchical culture and, even today, there exists a kind of asymmetry in which the idea of female independence is subverted. Is this idea of dependence beginning to change? John Berger’s *Ways of Seeing* and numerous psychological studies on body type preference served as lenses for this analysis and helped unveil an interesting contradiction—on the average, men like women to be larger than women want to be.
The goal of this project is to prepare a comprehensive critical edition of *Brittain’s Ida* along with an accompanying essay on attribution in early modern English literature using scans and collations of the six remaining printed witnesses of the work. The poem *Brittain’s Ida*, once considered to be the writing of Edmond Spenser, has been attributed to Phineas Fletcher since the 19th century. This edition will become part of the larger Spenser Edition prepared by the Spenser Project.
Toward a Better Understanding of...

**Identification of PA3920 as the Primary sil-like Silver Resistance Determinant in Pseudomonas aeruginosa, MPAO1**

*Adam J. Salazar*

**Mentor: Carolyn Cannon**

The *sil* operon consists of seven genetic determinants capable of conferring plasmid-based resistance to silver antimicrobials on otherwise susceptible gram negative, enteric species. To assess the role chromosomal *sil* homologues play in modulating silver sensitivity in the gram negative, non-enteric pathogen, *Pseudomonas aeruginosa* MPAO1, single gene MPAO1 transposon insertion mutants (sgTIMs) corresponding to pBLAST identified *sil* homologues were tested for silver sensitivity by observing culture density in the presence and absence of silver nitrate. Most sgTIMs showed nominal deviation from wild type sensitivity. However, a high sensitivity elevation phenotype was found for the *silP* homologue, PA3920, sgTIM. *In trans* recovery of wild type sensitivity via the generation of a plasmid expressing PA3920 and its transformation into the PA3920 sgTIM demonstrates that PA3920, which encodes a known copper efflux, P-type metal binding ATPase, is the primary *sil*-like mitigator of silver toxicity in *P. aeruginosa*. In order to establish that the *Salmonella PA3920* homologue, *silP*, is similarly capable of recovering wild type MPAO1 silver sensitivity, a plasmid was constructed expressing *silP* and transformed into the PA3920 sgTIM. It was found that *silP* is unable to restore wild type sensitivity, suggesting that *silP* does not have native silver efflux activity in Pseudomonas.
Moroccan Street Performers: Renovators of Past Traditions

Stefan Santiago

Mentor: Younasse Tarbouni

Moroccan music has captured the minds of Europeans and Americans alike. Thanks to famous musicologists like Paul Bowles and Phillip D. Schuyler, there has been extensive documentation of the traditional styles that occur across the country. In recent years within this vast tradition, there has been a movement towards individualism and in surroundings where much of the music has occurred in a collective manner, this is reason to investigate. I chose to look at the sphere of street musicians within Moroccan music as a whole. On one hand these performers are adhering to traditions that have lasted for centuries, but on the other, they are breaking out of the molds of space and sound. Through interviews with musicians and consultation on pre-written sources, I sought information on traditional music, recent trends in Moroccan music, and general perceptions toward street performers. Though the trade is not exactly appreciated, it remains an important part of the preservation of Moroccan folk music, while demonstrating the lasting effects of significant musical trends in modern years. The mix between traditional setting and modern music, or vice-versa, is interesting and can illuminate the subsistence of folk music or acquiescence of new music thanks to tourist industries and human ingenuity.
Some international opinion surveys rank Belarusians as among the most committed democrats in the former Soviet Union. At the same time the current Belarusian regime has been labeled “the last dictatorship of Europe” and “an outpost of tyranny.” For many scholars Belarus remains a puzzle: after the break-up of the USSR, despite the optimistic predictions and existing necessary preconditions, such as tolerance, trust, political activism and post-materialist values, Belarus has rejected democracy and market reforms, submitting to the authoritative rule of a charismatic populist leader A. Lukashenka. It stands in sharp contrast to its politically and economically prospering neighbors that have joined the West through NATO and EU: Poland, Ukraine, and especially the Baltic States. So what has caused Belarus to “deviate” from the promising path of democratic transition without any major opposition from its citizens and what are the prospects for democracy in the future? Current democratization literature fails to explain this failure of democratic transition. I build a most-likely case study and show that Belarus has failed to democratize due to interaction of economic and cultural factors, such as economic development and urbanization, factors that have been previously thought to promote democratization.
Rising atmospheric levels of carbon dioxide and methane contribute to global warming. While sequestration would reduce these levels, turning the unwanted gases into a valuable product would be better. The direct conversion of carbon dioxide and methane to liquid fuels using an integrated nanocatalyst of platinum on cerium oxide is the focus of this research. Using computer modeling, the nanocatalyst will be designed.

Preliminary results indicate strong chemisorption of methane onto platinum and weak physisorption of carbon dioxide onto stoichiometric ceria. Previous work indicates that carbon dioxide will be strongly chemisorbed onto a reduced ceria surface, thus activating it for the desired reaction.
The thesis is an analysis of how Louise Bourgeois’ thirty-foot tall, bronze sculpture of a mother spider titled, *Maman* (1999) operates within the context of the Louvre in Paris, France; The Guggenheim in Bilbao, Spain; The National Gallery of Art in Ottawa, Canada; and The Tate Modern in London, England. Surveying these four locations, I took photographic and video documentation of their varying aesthetic components, in addition to researching the cultural history of each respective museum and city. As can be expected, due to the differences in appearance and social context of these sites, the viewer’s interaction with the sculpture is significantly altered. For example, the unique, domineering, contemporary design of the Guggenheim juxtaposed with *Maman*’s bronze material and sculpted musculature highlights its classic and traditional background. By comparison, *Maman*’s large scale and abstract representation of such alternative subject matter as a mother spider feels highly current in context with the neat, symmetrical, classic architecture of the Louvre. It is my intent to discuss the ways in which *Maman* interacts with each site in its exhibition of the timeless, universal and complex theme of motherhood.
Globalization and capitalism have had obvious impacts throughout the world. An increase in immigration between countries along with an increase in immigrant laborers working in the informal sector of the economy is one such impact. While this phenomenon is not limited to any single area of the world, it is clearly seen in Argentina, where there has been an influx of migrant workers from neighboring countries. In the largest city in Argentina, Buenos Aires, Bolivian immigrants have created an economic niche working informally in the garment industry; they have not only provided cheap labor for many garment sweatshop owners and for many well-known clothing manufacturers, but have also taken advantage of the flexibility and informality of the industry to start their own small clothing factories, called *talleres*.

Through analyzing the personal narratives of a group Bolivian immigrants, this study tries to understand why these immigrants decided to leave their home country of Bolivia and what processes they had to go through in order to find work in the garment industry in Buenos Aires. This study concludes that migrant social networks play a crucial role in connecting immigrant laborers with jobs in the informal sector of the economy. It also concludes that while these networks help to unify Bolivian immigrants culturally, they fall short of unifying them economically or politically. Social networks help to form the foundation of migratory movements, but they do not necessarily have the power to confront larger socioeconomic problems, such as a lack of regulation within the garment industry and an absence of labor rights for Bolivian workers.
The mammalian suprachiasmatic nuclei (SCN), located in the anterior hypothalamus, are a master circadian pacemaker. These 20,000 heterogeneous neurons synchronize with each other to regulate daily rhythms in physiology and behavior. Elucidating the mechanisms behind rhythm generation and synchrony between oscillators in the SCN is a crucial step in the study of disorders related to circadian dysfunction, such as major depressive disorder and advanced phase sleep syndrome.

Recent studies implicate vasoactive intestinal polypeptide (VIP) as a candidate for generating and coordinating circadian rhythms in the SCN. We hypothesized that VIP-expressing neurons are a class of pacemaking cells which drive and synchronize rhythms for the entire SCN. To test this hypothesis, we generated a transgenic mouse model to specifically delete VIP neurons in the SCN upon exposure to the steroid hormone, tamoxifen. This project involves (1) verifying that our transgenic model deletes VIP neurons in the SCN using immunohistochemistry, and (2) analyzing locomotor data of VIP-cell-less mice. In our preliminary work, we have confirmed that VIP neurons die upon exposure to tamoxifen in vitro and that our transgenic mice exhibit normal circadian behavior in the absence of tamoxifen. In future experiments, we plan to delete VIP neurons of mice in vivo and analyze their changes in running wheel behavior.
Soon after infection, HIV enters the central nervous system by a so-called “Trojan horse” method. Previous cerebral perfusion studies have shown that HIV causes lowered blood flow in specific cortical and subcortical regions in HIV positive (HIV+) individuals undergoing highly active antiretroviral therapy (HAART) compared to non-infected (HIV-) controls. We hypothesized that, in a longitudinal and crosssectional study of HIV+ (naive), HIV+ (on HAART) and HIV- controls, HAART would lead to normalization in global resting cerebral blood flow (rCBF) measures.

rCBF measures were acquired from 26 controls and 39 HIV+ subjects using an arterial spin labeling technique on a Siemens 3T scanner. HIV+ subjects were subdivided into those who were naive to medications (n=19) and those undergoing HAART (n=20). Nine HIV+ naive subjects were studied 3-5 months after starting medications.

No significant differences existed between groups in age, sex, or education. HIV+ individuals had a significantly higher viral load than HIV- controls (p=.001). Overall, HIV- controls had a significantly higher global rCBF (61.7 ± 1.7 ml/100gm/min) compared to HIV+ participants (48.4 ± 1.9 ml/100gm/min). Global rCBF was significantly diminished in HIV+ naive patients (44.8 ± 1.9 ml/100gm/min) compared to HIV+ subjects on HAART (52.6 ± 2.0 ml/100gm/min). Longitudinally, every HIV+ naive subject had a decrease in viral load and an increase in rCBF after starting HAART.
To address future water supply shortage due to climate changes, development of effective conservation strategies of sustainable water supplies are required. A potential promising solution to prevent water shortage is the aquifer recharge with wastewater effluents. However, to perform a more effective and safe operation of this process, a better understanding of the fate and transport of remaining pollutants, such as pharmaceuticals or pesticides in the effluent is necessary. Aldicarb, a carbamate insecticide used on a wide range of crops, needs to be removed from wastewater, if this is to be used to recharge fresh water aquifers. Our research project investigates the adsorption of aldicarb onto soil as it flows through it, as it would in the recharging process. We aimed to identify which soil mineral components are most responsible for aldicarb adsorption. We studied the interaction between aldicarb and different model minerals (which could be present in soil) individually—aluminum oxide, iron oxide, manganese dioxide, calcite, and quartz—and field-collected soils. Using Diffuse Reflectance Fourier Transform Spectroscopy to study the forming or breaking of bonds between aldicarb and model and field soils, we concluded that calcite and quartz are responsible for aldicarb binding to soils. We also investigated the effect of humic and fulvic acids, naturally occurring organic matter found in soil, on aldicarb adsorption. For this, we coated calcite and quartz with fulvic acid and humic acid and let the coated samples react with aldicarb in a batch equilibrium experiment. Using the results of these experiments, we determined a quantitative contribution from quartz and calcite to overall aldicarb adsorption and identified the functional groups of aldicarb responsible for binding to soil.
Investigating Effects of Isoflurane on Tracer Binding

Iboro Umana

Mentor: Joel Perlmutter

Parkinson disease (PD) is a neurodegenerative disorder characterized by loss of dopaminergic neurons in the substantia nigra. Currently, PD research is actively focused on pathology of PD. To learn more about PD pathways, we need to have a research tool that allows us to study PD progression. In our lab, we utilize PET radiotracers (FDOPA, DTBZ, and CFT) to accomplish this objective. Their binding potential (BP) to striatal binding sites serves as an indicator of neurodegeneration in PD.

Recently, we have noticed that BP values appeared to be variable across baseline scans for several monkeys that we have studied. We hypothesized that isoflurane, a general anesthetic, could be a contributing factor to BP variability. To test this hypothesis, we calculated isoflurane exposure via several methods to determine if there was any relationship between isoflurane exposure and BP potential.

We found that isoflurane had a differential effect on PET radiotracers. FDOPA BP strongly correlated with isoflurane calculated from time of injection and during scan time of interest. DTBZ and CFT BP did not demonstrate any relationship with isoflurane, but the power of the sample needs to be increased to add further support to this claim.
The use of the Prandtl tip-loss correction is quite common in the analysis of rotating wings. It is a correction factor between blade loading (i.e., circulation) and the induced flow near the blade tip that accounts for the effects of a finite number of blades. This factor is placed on the loading-to-inflow theory before it is coupled with blade-element theory in order to find the final inflow and loading distributions. With proper correction, the inflow should be such that the loading goes to zero at the blade tip. However, sometimes it is useful to correct a loading distribution after the fact (that is, after an inflow theory and lifting theory have been already coupled). Often the Prandtl correction factor is used as the means to correct the blade loading and to insure that it goes to zero at the blade tip; but direct application of the factor is not appropriate for such an application. In this project, we show how to make lift corrections to account for blade number after the coupled lift-inflow distribution has been computed without the effect the blade number.
Epidermal growth factor (EGF) is a cytoprotective peptide that improves survival and decreases intestinal injury in non-infectious intestinal injury models and in peritonitis-induced sepsis. The aim of this study was to determine if systemic administration of EGF following pneumonia-induced sepsis improved gut integrity and survival. Pneumonia was induced by intratracheal injection of 40μL of *Pseudomonas aeruginosa* (2-4 × 10⁸ colony-forming units (CFU)) followed immediately by intraperitoneal injections of 150 μg/kg/day EGF or an equivalent volume of saline for controls. At 24 hours, lung histology was scored in H&E slides, and apoptosis was determined by active caspase-3 staining. Neutrophil activation was measured by myeloperoxidase assay of both lung tissue and Broncho Alveolar Lung Fluid. Intestines were evaluated for changes in villus length, apoptosis by active caspase-3 and H&E staining, and proliferation by BrdU staining. Systemic cytokines were measured in serum by multiplex array. EGF had no significant effects on lung histology and systemic cytokines. However, EGF did return gut apoptosis and proliferation to sham levels. A separate group of mice were followed for survival. When given immediately after surgery, EGF treatment improved survival from 35% in untreated septic mice to 90% in EGF-treated septic mice. When delayed 24 hours, EGF treatment still provided a survival advantage of 73%. These results suggest there is an association between improved gut integrity and survival in pneumonia-induced sepsis.
Toward a Better Understanding of...

**Activated Astrocytes Modulate Microglial Activation in APP/PS1 Mice**

**Yan Wang**

_Mentor: Jin-Moo Lee_

Following amyloid plaque formation, reactive microglia and astrocytes accumulate around plaques. However, the role of reactive gliosis in Alzheimer’s disease pathogenesis is poorly understood. We have recently found that deletion of reactive astrocyte genes, glial fibrillary protein (gfap) and vimentin (vim) results in increased amyloid plaque load in APP/PS1 mice, suggesting that astrocyte activation may limit amyloid plaque growth. Deletion of _gfap_ and _vim_ result in astrocytes which demonstrate attenuated activation in response to stress. In this study, we sought to examine the interaction between activated astrocytes and microglia in this AD mouse model. Total microglia counts (using Iba-1 immunohistochemistry) in APP/PS1 _gfap<sup>+/−</sup> vim<sup>+/−</sup> (APP gv+) compared to APP/PS1 _gfap<sup>−/−</sup> vim<sup>−/−</sup> (APP gv-) mice was not different (63,758 microglia per mm<sup>2</sup> in APP gv+ vs. 58,451 microglia per mm<sup>2</sup> in APP gv-, _p_ =0.28). However, the number of microglia adjacent to plaques was higher in APP gv- mice compared to APP gv+ mice (1210 microglia per mm<sup>2</sup> vs. 1780 microglia per mm<sup>2</sup>, _p_ =0.0003), suggesting that activated astrocytes regulate microglial redistribution. This redistribution was evident even when correcting for difference in plaque load between the two genotypes (28,107 microglia per mm<sup>2</sup> vs. 34,931 microglia per mm<sup>2</sup>, _p_ =0.035). Conversely, the number of microglia distant from plaques showed a trend for decrease (1,299 microglia per mm<sup>2</sup> vs. 1,119 microglia per mm<sup>2</sup>, _p_ =0.056). These data suggest that activated astrocytes surrounding amyloid plaques may regulate the distribution of microglia during amyloid plaque pathogenesis.
In broad terms, this project considers the socio-religious continuity between the pre- and early Islamic communities on the Arabian Peninsula. At first glance, the rise of Islam very obviously carved out a great many changes in the Arabian socio-religious landscape. As is concluded in this research, however, the majority of these changes were of an outward rather than paradigmatic nature. They were the sort of changes wrought by a modification of how one acts, but not by the modification of how one thinks about those actions. Thus, by extension, the study maintains that this is precisely the way in which the continuity between the pre- and early Islamic communities should be viewed. In the face of a high degree of external change—modifications in ritual, name, custom and the like—there was an equally palpable degree of continuity in perspective. To make a wildly anachronistic analogy, the rise of Islam didn’t erase what came before it; rather it cut, pasted and ultimately reformatted it.
This project aims to investigate the difference between evolved fears, or fears that humans are programmed with at birth, and learned fears, or fears that are adapted through experience and teaching. To do this I am working with children between the ages of three and five. The assumption is that any fears found in the youngest children will be evolved, and any changes that are observed over the age span will be the result of learning. These fears will be assessed through an indirect storybook method that has been originally designed for this project. I will be looking at two fears: that of animals and that of social exclusion. For each fear two children’s books have been written, one that is meant to tap into the fear and one that is meant to be relatively neutral. I read the stories to the children individually and then go back the next day and ask them to tell the story back to me. The critical variable is the difference in memory between the two versions of the same story. I expect to find a decrease in fear for the animal story and an increase in fear for the social exclusion story. If this is the case, it will suggest that fear for animals is innate but declines with lack of experience, and that fear of being excluded is not innate and increases with more exposure to school and other social activities.
Toward a Better Understanding of...

Magnitude of T-wave Alternans on Post MI Holter Recordings as a Predictor of Cardiac Death in the ENRICHD Trial

Austin Wilmot

Mentor: Phyllis Stein

T-wave alternans (TWA) is a beat-to-beat variation in the T wave of an electrocardiogram (ECG) linked to cardiac death. TWA is subtle therefore computer analysis is required for measurement. In 120 patients taken from the ENRICHD (Enhancing Recovery in Coronary Heart Disease) trial database, the relationship of TWA on Holters and subsequent cardiac death will be examined by level of depression at the time of the recording (non-depressed, mild/moderately depressed, severely depressed). ENRICHD examined the effect of treatment of depression on a combined endpoint of all cause mortality and nonfatal infarction in patients with recently diagnosed acute MI (myocardial infarction). Cases and controls for our sub-study had Holter recordings in ENRICHD and were matched on age, gender and depression status. All patients who died were included. Examining TWA will involve reloading 2-Channel Holter ECG recordings, performing Holter analysis and TWA analysis via GE MARS software. Other questions to be explored include whether TWA is more common in people with depression. If so, does it help explain increased cardiac death among depression patients? Our novel findings may include a connection between TWA post-MI and cardiac death, as well as a mechanism to explain excess mortality among depressed post-MI patients.
Toward a Better Understanding of...

Regulation of Dopamine Release by the Endocannabinoid System in the Nucleus Accumbens Core

Maxim Wolfson

Mentor: Margaret E. Rice, New York University

This work examined the regulation of locally evoked dopamine (DA) release by type 1 cannabinoid receptors (CB1Rs) in a forebrain region important in reward processing, the nucleus accumbens (NAc) core. Using fast-scan cyclic voltammetry with carbon-fiber microelectrodes in coronal slices of guinea pig striatum, stimulated increases in extracellular DA concentrations ([DA]\textsubscript{o}) could be directly monitored in the presence of various pharmacological agents. Findings show a significant decrease in pulse-train evoked [DA]\textsubscript{o} with application of a CB1R agonist WIN55,212-2. This decrease is abolished in the presence of a GABA\textsubscript{A} receptor (GABA\textsubscript{A}R) antagonist picrotoxin (PTX) suggesting a regulatory mechanism in which CB1R activation decreases [DA]\textsubscript{o} via suppression of GABA release in the NAc core. Interestingly, pulse-train evoked [DA]\textsubscript{o} increased with blockade of CB1Rs by an inverse agonist AM251. This result suggests DA release-suppressing endocannabinoids are generated with our stimulation protocol.
Comparative Analysis of the Wanderer Genes between the *D. melanogaster* and *D. virilis* Dot Chromosomes

Jeannette Wong

Mentor: Sarah Elgin

The fourth, or “dot,” chromosome of *Drosophila melanogaster* exhibits an amalgam of chromatin properties: it has a gene density similar to other euchromatic regions but has the typically high levels of association with heterochromatin protein 1 (HP1) seen in heterochromatic regions. However, the dot chromosome of *Drosophila virilis* appears to be more euchromatic based on its lower levels of association with HP1. Finishing and annotating the *D. virilis* dot chromosome has allowed comparison of DNA sequence properties (e.g. repeat density, gene size, codon bias) between the two species. By these measures, the *D. virilis* dot is most like the *D. melanogaster* dot, and does not resemble euchromatin. Comparative analysis between the *D. melanogaster* and *D. virilis* dot chromosomes reveals a small subset of “wanderer” genes that have migrated on or off the dot. Analysis shows that the wanderer genes exhibit euchromatic characteristics when in non-dot locations, but have adopted dot chromosome gene characteristics (greater length, low codon bias) when on the dot. These features may simply reflect the different chromatin environments, or may contribute to the ability of the gene to be expressed in a domain that otherwise appears heterochromatic.
Effect of Inhibition of Hedgehog Pathway on Bone Metastasis of Breast Cancer

Ceren Yalaz

Mentor: Katherine Weilbaecher

Cellular signal transduction components involved in embryonic and postnatal development may function as oncogenes, which cause cancer. The Hedgehog (Hh) gene that plays crucial roles in cell proliferation, differentiation, pattern formation and maintenance is one of them. The topic of this research was how the Hedgehog inhibitors decreased breast cancer growth and bone metastasis through direct anti-tumor effects as well as indirect effects on the tumor microenvironment. Mice with osteoclasts with blocked Hh pathways were grown to analyze the bone-tumor signaling in comparison to normal mice. The osteoclasts were observed in vitro for the production of osteoblast and osteoclast growth signals. Also, mice were imaged for tumor growth and metastasis. It has not been observed that the Hh mediated orthoclase signaling had no direct effect on tumor growth. Future direction of the research includes working on tumor/metastatic microenvironment to understand the impact of cellular microenvironment on metastasis.
Heterochromatin, the condensed regions of a genome, plays a critical role in regulating gene expression. Position Effect Variegation (PEV) is a phenomenon where partial silencing is observed when a euchromatic gene is juxtaposed to heterochromatin. PEV of the hsp70-white reporter in Drosophila melanogaster is correlated with its distance to a DNA transposable element, 1360. This suggests the presence of a sequence element in 1360 that is responsible for such dependence. A useful tool to test for such sequences is phiC31-mediated site-specific recombination, wherein candidate 1360 sequence features can be tested at any PEV site dependent on 1360. To develop this tool, a P-element mobilization of frt-1360-frt-hsp70-white flanked by phage attachment sites has been carried out. The desired sites were identified by screening for male flies exhibiting PEV. DNA insertion sites were mapped by inverse PCR. The effect of 1360 on the reporter was tested in PEV lines with pigment assays of sans 1360 versus 1360 containing flies. Forty-three lines of PEV flies were recovered from the screen. Results from the pigment assays indicate that multiple lines displaying dependence on 1360 for gene silencing have been recovered, setting the ground for testing various candidate 1360 features at these sites.
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The logo for the Office of Undergraduate Research, on the front cover of this publication, consists of an “impossible triangle” within a starburst. To some, the triangle evokes the challenge of puzzles to be solved or the eternal research question “How does that work?” To others, the triangle represents the Greek letter Δ, the mathematical symbol for change.
Modeling of InP OPNMR Signals  Michal Hyrc

Laboratory Study of Presolar Carbonaceous Stardust  Emily K. Lebsack

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