

*Interdisciplinary  
Research  
Collaborative*

**IRC**  
Rose-Hulman  
Institute of Technology



**6<sup>th</sup> Annual  
IRC  
Undergraduate  
Research  
Symposium**

**Friday  
October 30, 2009**

Sponsored by



Edwards Lifesciences

**ROSE-HULMAN**  
INSTITUTE OF TECHNOLOGY

**Welcome to the**  
***6<sup>th</sup> Annual IRC Undergraduate Research Symposium***



Friday, October 30, 2009

We are honored to welcome you to the 6<sup>th</sup> Annual IRC Undergraduate Research Symposium and we sincerely appreciate your participation. The symposium is coordinated by the Interdisciplinary Research Collaborative (IRC), which is supported by funding from the Lilly Endowment, the Lilly/Guidant Applied Life Sciences Research Center, and Rose-Hulman Institute of Technology. The IRC would like to express its great appreciation for the Symposium sponsorship of Edwards Lifesciences.

The IRC was created to encourage scientific research by undergraduate students and to help them better understand the exciting educational and research opportunities that exist in science and engineering. An appreciation for laboratory research is central to a working understanding of experimental sciences. By participating in research, students add to current knowledge and, furthermore, they enhance their education and broaden their understanding of the scientific method and its application.

Interdisciplinary research is gaining prominence in both academia and industry, as new techniques from one discipline are applied to problems in other disciplines. By acquiring experience in interdisciplinary research, students become more attractive to potential post-graduate programs and employers. The IRC program specifically fosters such interdisciplinary work, and we are pleased to highlight the research of our students, as well as the research of our colleagues in Indiana.

With this sixth annual event, we are delighted to welcome you. Our intention in hosting this event is to offer students an opportunity to share their research interests and progress with their colleagues in a nurturing and supportive environment, and to encourage celebration of the undergraduate research experience. We hope you enjoy the dynamic program of speakers.

Mark Brandt  
IRC Program Coordinator

J. Peter Coppinger  
IRC Program Coordinator

Rose-Hulman Institute of Technology

## Symposium Schedule

**8:15 AM Registration**

**8:30 AM Welcoming Remarks**

### Morning Session I (8:45 – 10:45 AM)

#### **Examination of Acetabular Cup Insertion Energy and Removal in Total Hip Arthroplasty**

*Leah Howard\**, *Scott Small*, and *Christine Buckley*

Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

#### **Preparation of HA-Pln DIV Conjugates Hydrogel**

*LeMoyne Habimana-Griffin<sup>1\*</sup>*, *Chao Liu<sup>2</sup>*, and *Xinqiao Jia<sup>2</sup>*

<sup>1</sup>Departments of Applied Biology & Biomedical Engineering and Electrical and Computer Engineering, Rose-Hulman Institute of Technology, and <sup>2</sup>Department of Materials Science and Engineering, University of Delaware

#### **Characterization of Non Race-specific Disease Resistance Proteins NDR2 and NDR3 through Epitope Tagging**

*Evan P. Jones\**, *Anita Isch*, and *Peter Coppinger*

Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

#### **A Bayesian Markov Chain Monte Carlo Implementation of Analysis of Molecular Variance**

*Zach Gompert<sup>1</sup>*, *Alex Buerkle<sup>1</sup>*, and *Robert Williamson<sup>2\*</sup>*

<sup>1</sup>Department of Botany and Program in Ecology, University of Wyoming, Laramie, WY 82071, and <sup>2</sup>Department of Applied Biology & Biomedical Engineering and Department of Computer Science & Software Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

#### **Direct and Collisional Excitation of Fuel Components**

*Kyle Wilson\**, *Rebecca B. DeVasher*, and *Allen White*

Department of Mechanical Engineering and Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

#### **Flexibility of Spinal Central Pattern Generators**

*Angelica Patino\*<sup>1</sup>*, *David Klein<sup>2</sup>*, and *Matt Tresch<sup>2</sup>*

<sup>1</sup>Department of Applied Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, Indiana 47803 and <sup>2</sup>Department of Physiology, Northwestern University, Chicago, Illinois 60611

## **Engineering Novel Viral Vectors: Transforming Infectious Agents into Vehicles for Vaccine Delivery**

*Mariya Krisenko<sup>1\*</sup>, Michael Barry<sup>2</sup>, and Eric Weaver<sup>2</sup>*

<sup>1</sup>Department of Applied Biology & Biomedical Engineering Rose-Hulman Institute of Technology, Terre Haute, IN and <sup>2</sup>Department of Virology and Gene Therapy, Mayo Graduate School, Rochester, MN

## **The Effects of Oxidation on Free Fatty Acid Methyl Ester (FAME) Physical Properties**

*Elizabeth H. Malola and Michael Mueller*

Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN

### **Poster Session (10:45 AM – 11:50 AM)**

## **Cloning Of Mouse RON Receptor Tyrosine Kinase Into a Lentiviral Expression Vector**

*Molly Gillam<sup>\*1</sup>, Devikala Gurusamy<sup>2</sup>, and Susan Waltz<sup>2</sup>*

<sup>1</sup>Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN and <sup>2</sup>Department of Cancer and Cell Biology, University of Cincinnati College of Medicine, Cincinnati, Ohio

## **Environmentally Friendly Suzuki Cross Coupling**

*Josh Andreas, Ashley Brockhaus, Stephen Chase, Joseph Barlan, and Rebecca B. DeVasher*

Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

## **Tracing the Journey of Each Footstep**

*Mariya Krisenko<sup>2</sup>, Matthew Moseng<sup>1</sup>, Drew Paine<sup>1</sup>, Robert Williamson<sup>1,2</sup> and Gregory Zynda<sup>1,3</sup>*

<sup>1</sup>Department of Computer Science & Software Engineering, <sup>2</sup>Department of Applied Biology & Biomedical Engineering, and <sup>3</sup>Department of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

## **Utilizing Collaborative Prototyping to Enhance the Usability of Software Products**

*Drew Paine\* and Sriram Mohan*

Department of Computer Science & Software Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

## **Investigation of Changes in the Combustion Process of a Spark Ignition Internal Combustion Engine due to Laser Excitation of Fuel Molecules**

*Stephen S. Sakai<sup>1\*</sup>, Kyle Wilson<sup>1</sup>, Allen R. White<sup>1</sup>, and Rebecca B. DeVasher<sup>2</sup>*

<sup>1</sup>Department of Mechanical Engineering and <sup>2</sup>Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

**The Plant Homologue of EYES ABSENT Retains the Ability to be Potentiated by the SIX family of Transcription Factors**

*Eric A. Smith*<sup>\*1</sup>, *Weiming Bu*<sup>2</sup>, *Naresh Pandey*<sup>2</sup>, and *Rashmi Hegde*<sup>2</sup>

<sup>1</sup>Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803, and <sup>2</sup>Cincinnati Children's Hospital Medical Center, Cincinnati, OH

**The Mathematical *E. coli***

*Kyla Lutz*<sup>1</sup>, *Gregory Zynda*<sup>\*2</sup>, and *Allen Holder*<sup>2</sup>

<sup>1</sup>Department of Applied Biology and Biomedical Engineering and <sup>2</sup>Department of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

**Identifying and Isolating Unknown Iridoviruses in Amphibian Populations**

*Adam Markley*<sup>\*</sup> and *Jennifer O'Connor*

Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

**12:00 PM – 12:50 PM Invited Speaker: Dr. H. Kathleen Dannelly,**  
Associate Professor of Biology  
Indiana State University  
***Emerging Infections: The Rise of the Super Staphs***

**Afternoon Session (2:00 PM – 5:00 PM)**

**Synthesis and Optimization of a High Capacity Carbon Dioxide Absorbent**

*Abigail Switzer*<sup>\*1</sup> and *Genggeng Qi*<sup>2</sup>

<sup>1</sup>Department of Chemical Engineering, Rose-Hulman Institute of Technology, Terre Haute, Indiana, 47803 and <sup>2</sup>Department of Material Science and Engineering, Cornell University, Ithaca, New York, 14853

**Difference in Blood Viscosity between Diabetics and Non-Diabetics Receiving Treatment for Kidney Failure by Dialysis**

*William W. Terrill*<sup>1</sup>, *Kevin Cassel*<sup>2</sup>, *Promila Dhar*<sup>3</sup>, *Michael Boghosian*<sup>2</sup>, and *Mary S. Hammes*<sup>4</sup>

<sup>1</sup>Department of Applied Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, <sup>2</sup>Department of Mechanical, Materials, Aerospace Engineering, Illinois Institute of Technology, <sup>3</sup>Department of Biomedical Engineering, Illinois Institute of Technology, and <sup>4</sup>Section of Nephrology, Department of Medicine, University of Chicago

**Development of a Protocol to Synthesize PLGA Nanospheres**

*Jennifer L. Fischer*<sup>\*</sup> and *Scott J. McClellan*

Department of Chemical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

### **Audio Depth Map as a Replacement for Traditional Vision**

*JP Verkamp\**

Department of Computer Science, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

### **Surfactant-Assisted Aqueous Extraction of Soybean Oil from Soybean and Recovery of Oil from Skim**

*Jordan Milligan\*<sup>1</sup>, Kerry A. Campbell<sup>2</sup>, and Charles E. Glatz<sup>2</sup>*

<sup>1</sup>Department of Chemical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803, and <sup>2</sup>Department of Chemical and Biological Engineering, Iowa State University, Ames, IA 50011

### **In-Vitro Generation of Amebocytes from the American Horseshoe Crab, *Limulus Polyphemus***

*Kirk Thompson\*, Amber Brannan, and William Weiner*

Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

### **Evaluation of Descriptors Used in Sexual Selection Research**

*Jeanie Sozansky\* and Ella Ingram*

Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

### **Examining the Effects of Ligands and Alcohols on Dimer Exchange in the Human Estrogen Receptor**

*Carly Baehr\* and Mark E. Brandt*

Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

### **Molecular Dynamics Simulations of the Estrogen Receptor- $\alpha$**

*David Cooper\*<sup>1,2</sup>, Yosi Shibberu<sup>2</sup>, and Mark E. Brandt<sup>1</sup>*

<sup>1</sup>Department of Chemistry & Biochemistry and <sup>2</sup>Department of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

### **Developing a Fluorescence Lifetime-based Assay for Ligand Binding**

*Sarah Erhart and Mark E. Brandt*

Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

### **Ion-Current Rectification in Conical Nanopores**

*Ted Frater\*, Kaimeng Zhou, Brett Hildenbrand, Michelle Kovarik, and Stephen C. Jacobson*

Department of Chemistry, Indiana University Bloomington, Bloomington, IN 47405

## **Examination of Acetabular Cup Insertion Energy and Removal in Total Hip Arthroplasty**

Leah Howard\*, Scott Small, and Christine Buckley

Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

It is unknown whether certain designs of acetabular cups need more energy than others for implantation by an orthopaedic surgeon. The purpose of this study is to examine the energy required to fully seat and fully remove an acetabular cup in four cup designs of varying materials, wall thicknesses, and porous coatings. Replicate cancellous bone test blocks of two densities; one representing healthy bone, and the other with properties of osteoporotic bone were used as the test medium. Each test block was reamed to a 57mm diameter and press-fit with a 58 mm acetabular cup. Both the insertion and removal tests were performed using a servohydraulic materials testing machine.

Our results suggest that cup design plays no significant role in insertion energy for the acetabular cups ( $p$ -value  $\geq 0.05$ ). Higher insertion energy was required for the healthy bone compared to the less dense osteoporotic bone, by an average of 544 Newtons ( $p$ -value  $\leq 0.001$ ). Cup design and density of testing blocks were highly significant in the force required to remove the acetabular cups in our lever out tests. The highest average in cup design for lever out force was 3085 N, while the lowest was 1886 N. Between the two different bone densities, the healthy bone saw an average of 2538 N, and 2268 N for the osteoporotic bone .

In summary, while a difference was not detected in insertion energy between the four cup types, cup design did make a difference in the removal force required for the cups in the lever out tests. Block density significantly changed the insertion and removal forces required for the acetabular cups. Healthy bone requires more force to insert and remove the cups than osteoporotic bone. With this knowledge, it is suggested that cup design and bone health plays an important role in areas such as implanted cup stability, and micro-motion inhibiting bone ingrowth.

Clinical studies have found that stress shielding following total hip arthroplasty could lead to significant loss of periacetabular bone density with press-fit acetabular cups. If the effects of acetabular cup design and position on loading are examined, the results could potentially influence the surgical alignment of the acetabular components during total hip arthroplasty. The next stage of our study will provide an independent comparison of the four acetabular cup designs and their loading on the pelvis in varying degrees of surgical alignment.

We hypothesize that the stiffest acetabular component design will produce the highest strain concentrations, and that the cup position will significantly affect the location of the maximum strains on the pelvis.

This work was funded in part by the Lilly Endowment under the auspices of the IRC.

## **Preparation of HA-Pln DIV Conjugates Hydrogel**

LeMoyne Habimana-Griffin<sup>1\*</sup>, Chao Liu<sup>2</sup>, and Xinqiao Jia<sup>2</sup>

<sup>1</sup>Departments of Applied Biology & Biomedical Engineering and Electrical and Computer Engineering, Rose-Hulman Institute of Technology, and <sup>2</sup>Department of Materials Science and Engineering, University of Delaware

Although synthetic polymers can produce tissue engineering matrices with desirable material properties, most lack the facility to promote biological activity. Synthetic polymer-protein hybrid gels combine both modular material and biological functionality. In particular, glycidyl methacrylate (GMA) functionalized hyaluronic acid (HA)-based hydrogels have shown great potential as tissue scaffolds. However, without infrastructure within the gel to support cell adhesion, the cells will merely fall of the gel. But the incorporation of an immunoglobulin sequence in perlecan domain IV (Pln DIV), which has recently been found to support cell adherence, will allow the cells to stick to the gel. Nevertheless, highly toxic catalysts used in the synthesis of the gel, such as dimethylaminopyridine (DMAP), can interact with the HA-GMA and become trapped in the polymer during precipitation. We present a novel method to purify the HA-Pln DIV hydrogel. Using this method we were able to purge the gel of the DMAP, as confirmed by nuclear magnetic resonance spectroscopy and finally get the Pln DIV imbedded hydrogel.

## **Characterization of Non Race-specific Disease Resistance Proteins NDR2 and NDR3 through Epitope Tagging**

Evan P. Jones\*, Anita Isch, and Peter Coppinger

Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Previous studies have established that the plasma membrane-localized NDR1 (non race-specific disease resistance-1) protein results in enhanced bacterial disease resistance in *Arabidopsis thaliana*. Conserved sequence similarity between NDR1 and previously uncharacterized NDR2 and NDR3 genes suggest that NDR2 and NDR3 may play a role in disease resistance of plants. RT-PCR has demonstrated that NDR2 and NDR3 are transcribed *in planta*. The focus of this ongoing project is to determine whether these transcripts produce functional proteins, and whether over-expression of these genes alters wild-type resistance. Towards this end, we are in the process of cloning and tagging NDR2 and NDR3 with hemagglutinin (HA) epitope tags to allow detection and characterization of translation products *in planta*. Upon successful addition of the epitope tags, *Agrobacterium tumefaciens* will be used to transiently express these constructs in the host plant *Nicotiana benthamiana* to observe biochemical properties of the proteins. Concomitantly, these constructs will be stably transformed and over-expressed in *Arabidopsis* to test for effects on pathogen resistance.

This work was funded in part by the Lilly Endowment under the auspices of the IRC.

## **A Bayesian Markov Chain Monte Carlo Implementation of Analysis of Molecular Variance**

Zach Gompert<sup>1</sup>, Alex Buerkle<sup>1</sup>, and Robert Williamson<sup>2\*</sup>

<sup>1</sup>Department of Botany and Program in Ecology, University of Wyoming, Laramie, WY 82071, and <sup>2</sup>Department of Applied Biology & Biomedical Engineering and Department of Computer Science & Software Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

As technologies have improved, the availability of genetic data has increased rapidly. Yet many population genetics studies still use the statistics developed fifty years ago. For example, simple F statistics are inappropriate for loci with many alleles. Without additional calculation there is no way to reflect confidence (*i.e.* via a confidence interval) in the result. We have developed a Bayesian Markov Chain Monte Carlo implementation of AMOVA (Analysis of Molecular Variance), for many loci and alleles. The AMOVA yields  $\Phi$ -statistics describing population differentiation, a parameter analogous to the F-statistic. The method also gives confidence intervals for the statistics, which incorporate various sources of error in the data. The Bayesian AMOVA technique gives similar results to other programs for individual loci, but can utilize genetic data in which populations rather than individuals are the unit of sampling. This technique results in a better global estimate of the  $\Phi$ -statistics across loci than that of the weighted mean that has been used in the past. We test BAMOVA (Bayesian AMOVA) using a set of previously published STR data. The procedure continues to be tested for robustness using multiple datasets.

## **Direct and Collisional Excitation of Fuel Components**

Kyle Wilson\*, Rebecca B. DeVasher, and Allen White

Department of Mechanical Engineering and Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

The infrared excitation of automotive fuel components is of interest for decreasing engine emissions at low combustion chamber temperatures. Adding energy directly into the vibrational modes of the fuel may reduce the threshold energy required for combustion, without raising the combustion chamber temperature. This energy can be supplied either directly, via incident radiation, or indirectly, through collision with directly excited molecules. Although it is of greatest interest to the combustion process, isooctane does not absorb infrared radiation well at any wavelength for which a laser is readily available. However, CO<sub>2</sub> lasers are relatively cheap, and are available at wavelengths which are absorbed by ethanol, which is a component of commercial gasoline. In this study, the infrared absorption of isopropanol, ethanol, and isooctane under three wavelengths (10.6 μm, 10.2 μm, and 9.3 μm) of CO<sub>2</sub> laser excitation was studied. Additionally, this data was supplemented by time-resolved emissions measurements which indicate the speed at which excitation and subsequent decay occur. Finally, mixtures of these three fuel components were tested. The data support the existence of the proposed collisional pathway for energy transfer from ethanol to isooctane.

## **Flexibility of Spinal Central Pattern Generators**

Angelica Patino\*<sup>1</sup>, David Klein<sup>2</sup>, and Matt Tresch<sup>2</sup>

<sup>1</sup>Department of Applied Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, Indiana 47803 and <sup>2</sup>Department of Physiology, Northwestern University, Chicago, Illinois 60611

To better understand the coordination of movement by spinal motor systems, the evoked locomotion and rhythmic muscle patterns induced by spinal cord stimulation are studied. Using a neonatal rat in vitro preparation with the spinal cord and attached hind limb, the spinal cord is stimulated electrically at the substrates cauda equina and L5 dorsal root as well as pharmacologically with doses of 5-HT and NMDA. Experimental results demonstrate varied rhythmic patterns with the muscles semitendinosus and rectus femoris, reflecting the structured architecture of the spinal cord. Further implications of these studies will be directed toward detecting signals from spinal interneurons, eventually mapping the central pattern generator neural networks existing in the neonatal rat model.

## **Engineering Novel Viral Vectors: Transforming Infectious Agents into Vehicles for Vaccine Delivery**

Mariya Krisenko<sup>1\*</sup>, Michael Barry<sup>2</sup>, and Eric Weaver<sup>2</sup>

<sup>1</sup>Department of Applied Biology & Biomedical Engineering Rose-Hulman Institute of Technology, Terre Haute, IN and <sup>2</sup>Department of Virology and Gene Therapy, Mayo Graduate School, Rochester, MN

One approach to ameliorating the worldwide human immunodeficiency virus (HIV) epidemic involves the development of effective vaccines. One advantage of using Adenoviruses (Ads) is that in mammalian hosts they are able to activate both innate and adaptive immune responses. The objective of this study was to develop two new Ad vectors, Ad5 and Ad7, for HIV vaccine delivery. The first viral vector developed was an Ad5 virus expressing the SIV envelope gene. The vector was constructed by cloning a codon-optimized gp140 form, which is an ectodomain region of the SIV envelop glycoprotein, into a carrier plasmid. This plasmid was then recombined with the rest of the Ad5 genome in bacteria. To generate virus particles, the recombinant Ad plasmid was linearized and transfected into the 293 mammalian cell line. The formation of plaques indicated the production of the virus. Although Ad5 vaccine will be tested in macaques, about 50% of the humans are immune to Ad5 viruses resulting in short term expression of a transgene and a limited application in vivo. However, by understanding how the vector performs in vivo, we will be able to understand the mechanism of other serotypes. The next vector developed was Ad7. An advantage to using Ad7 is that the human population is not immune to the virus. The vector was developed by capturing the 5' and 3' ends of the Ad7 genome via overlapping polymerase chain reaction and cloning the genome into a low copy plasmid which contains a kanamycin resistance gene as a selectable marker. This plasmid bears unique restriction sites allowing the rest of the 36 kb viral genome to be directly cloned into the plasmid. We captured the Ad7 genome, and testing of the vaccine is underway in mouse and non-human primate models. Testing of the vaccine is under way in mouse and non-human primate models.

## **The Effects of Oxidation on Free Fatty Acid Methyl Ester (FAME) Physical Properties**

Elizabeth H. Malola and Michael Mueller

Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology,  
Terre Haute, IN

Through the experimentation of lipid oxidation techniques, the epoxidation of unsaturated free fatty acid methyl esters (FAME) and its effect on physical properties have been studied. Forming an epoxy group, hydroxyl group, and/or hydroperoxy group onto the site of the double bond of a free fatty acid alters parameters such as viscosity, cloud point, pour point, and flash point. The ability of a variety of oxidizing agents to oxidize the double bond can be confirmed through spectral analysis and then tested for physical values. Hydrogen peroxide and acetic acid form peracetic acid, and has been shown to successfully oxidize the free fatty acid double bond site. In order to determine the physical properties, the FAME is purified for spectral analysis, cloud point test, flash point test, and a viscosity test. Our hypothesis is that oxidation of the FAME double bonds will result in lower cloud flow properties, lower viscosity, and an ideal flash point. Further research must be performed, however; to examine alternative oxidative chemicals that lead to a decrease in cloud point and are more sustainable to the lab environment. In addition, by analyzing the effect of different oxidation techniques on FAME, further research can be done on the effects of various oils, both pristine and waste. It appears that peracetic acid is the most effective oxidizing agent with slightly beneficial results on the physical properties of FAME.

This project was funded by Hoosier Biodiesel, LLC

## **Cloning Of Mouse RON Receptor Tyrosine Kinase Into a Lentiviral Expression Vector**

Molly Gillam\*<sup>1</sup>, Devikala Gurusamy<sup>2</sup>, and Susan Waltz<sup>2</sup>

<sup>1</sup>Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN and <sup>2</sup>Department of Cancer and Cell Biology, University of Cincinnati College of Medicine, Cincinnati, Ohio

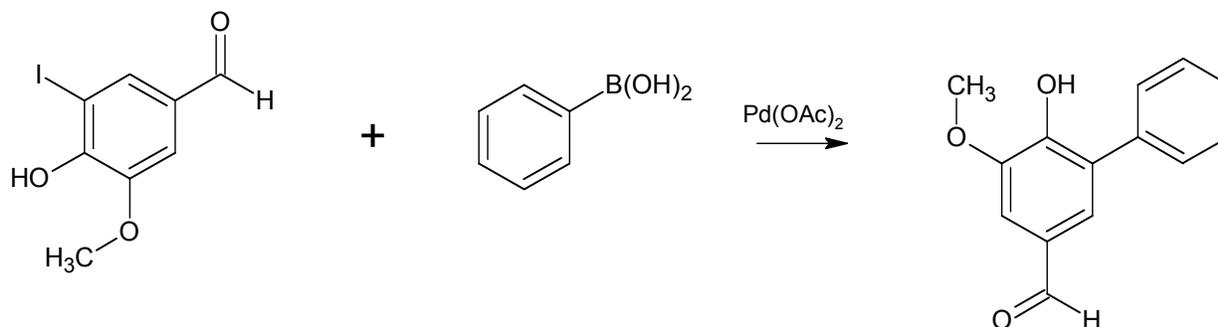
The RON receptor is a transmembrane receptor tyrosine kinase expressed on epithelial cells, macrophages, and hematopoietic cells, and has been shown to have an active role in cell growth and invasion leading to cancer. To aid the research in our laboratory, the full length cDNA of mouse RON (mRON) was cloned into the pCDH lentiviral expression vector. The lentiviral expression vector aids in the efficient transduction of the cDNA to the target cells. To generate the lentiviral expression construct, mRON cDNA was excised from a pcDNA3.1 construct at the *Xba* I and *Not* I restriction sites. RON was then ligated into the multiple cloning site (MCS) of pCDH using *Xba* I and *Not* I restriction enzymes. The ligated DNA was transformed into competent *E. coli* DH5 $\alpha$  cells, and colonies were collected for plasmid purification. The colonies were screened by PCR using primers for RON to verify the presence of the insert. The positive clone was further confirmed by restriction digestions using *Xba* I and *Not* I. A digest using BamHI was also used to cut RON and verify the ligation. The clone will be sent to be sequenced for confirmation. The lentiviral expression vector encoding full length mRON will be packaged into a virus which can be used to transduce cells, causing the cells to overexpress RON. In the future, we plan to perform *in vivo* studies by investigating tumor burden and size in mice injected with cells that overexpress RON.

## Environmentally Friendly Suzuki Cross Coupling

Josh Andreas, Ashley Brockhaus, Stephen Chase, Joseph Barlan, and Rebecca B. DeVasher

Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

The goal of this research was to use greener reagents to successfully complete a chemical reaction that can be implemented into the Organic Chemistry laboratory. In this research we focused on Suzuki Cross Coupling in order to obtain a biphenyl product. We confirmed the production of 6-hydroxy-5-methoxy-1,1'-biphenyl-3-carbaldehyde with <sup>1</sup>H NMR Spectroscopy, melting point, and Gas Chromatograph/Mass Spectrometry. We will report optimal conditions for the reaction using phenylboronic acid, 5-iodovanillin, and Amberlite IRA-400(OH) resin in the presence of a palladium catalyst. The reaction occurred on a 1 mmol and a 5 mmol preparatory scale. In addition to the presentation of our successful results, we will also present alternative methods used to produce our desired product that were not favorable including microwave reaction methods. Additionally, we will focus on the identity and type of reaction conditions needed to achieve a reasonable reaction yield and discuss the effects on each variable on the outcome of the reaction. Of particular interest is the ion exchange resin, Amberlite IRA-400(OH), and its analog, Amberlyst IRA-basic, which result in completely different pH values, although both are associated hydroxide ion exchange resins. We will also discuss the differences between these two resins as it pertains to our research.



## **Tracing the Journey of Each Footstep**

Mariya Krisenko<sup>2</sup>, Matthew Moseng<sup>1</sup>, Drew Paine<sup>1</sup>, Robert Williamson<sup>1,2</sup> and Gregory Zynda<sup>1,3</sup>

<sup>1</sup>Department of Computer Science & Software Engineering, <sup>2</sup>Department of Applied Biology & Biomedical Engineering, and <sup>3</sup>Department of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Walking as we know it is an essential part of most individual's daily life. Around the world walking is an environmentally friendly, cheap, and essential form of transportation. The overall goal of our research is to design a user friendly software system that would encourage users to take a walk. We will employ user centered techniques design and ethnography to understand the factors that motivate and hinder individuals' ability to take a walk.

One hundred and fifty-six individuals responded to a survey conducted regarding demographic information and walking habits. Our results show that there is a decline in the amount of time spent walking in the 26-60 age range, followed by an increase in the 60 plus age range. When comparing our walking data between males and females, we found that while women walk more than men, women feel that they walk less than the average person. The results also indicate that the size of an individual's town has an impact on their walking habits.

We are now in the process of conducting a follow-up study which aims at identifying specific factors that influence an individual's walking behavior. A few of the factors we are exploring include personal safety, sense of community, aesthetics, and access to walking areas. The results of this survey will also help us create profiles of potential users that we will use to tailor our solution to a specific demographic. After we have identified the relevant factors for our chosen demographic, we will develop a system to encourage people to take a walk. The results of this work will then be submitted to the Association of Computing Machinery's Computer Human Interaction (CHI) conference as part of the Student Design Competition.

## **Utilizing Collaborative Prototyping to Enhance the Usability of Software Products**

Drew Paine\* and Sriram Mohan

Department of Computer Science & Software Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Human-Computer Interaction (HCI) paradigms have revolved around the familiar Window-Icon-Menu- Pointer (WIMP) concept since the inception of graphical user interfaces. Today HCI is migrating away from WIMP towards an alternative paradigm, centering on multi-touch (MT) interaction. Multi-touch enhances the experience afforded to users of computing devices and enables them to fully interact with their machine and the data stored within. Software development, like many engineering disciplines, begins with a prototyping phase to a) clarify requirements and to b) assist the customer and developer in obtaining a common vision of the product. Current prototyping strategies typically reside within the confines of the WIMP paradigm. This inhibits collaboration, as the customer is generally resigned to a passive interaction form (verbal feedback) and unable to directly manipulate the look and feel of the software product in conjunction with the developer. We posit that the multi-touch paradigm will increase collaboration between the end user and the developer, and improve the overall usability of the software product. We are in the process of developing a multi-touch prototyping tool, for the Microsoft Surface, a multi-touch interaction device, and plan to evaluate the effectiveness of this multi-touch prototyping process through usability testing. Towards this end, we are developing a protocol to look at usability from the perspective of multi-touch interaction. Standard usability factors/metrics will be evaluated to gauge their applicability to the multi-touch paradigm. To test the effectiveness of the prototyping tool, we envision the use of students in developer and customer roles to collaboratively develop a solution using a) multi-touch prototyping process, as well as b) standard WIMP prototyping processes. We plan to usability test each prototyping process along with the developed products. This will help determine whether the multi-touch paradigm can increase the quality of a product's user interface. The effectiveness of the process will be further tested by conducting a heuristic evaluation with industry professionals. Feedback from industry professionals will then be used to further refine the processes and guidelines with the hope that better software may be developed.

The results of this research shall be submitted for the Association of Computing Machinery's Student Research Competition.

## **Investigation of Changes in the Combustion Process of a Spark Ignition Internal Combustion Engine due to Laser Excitation of Fuel Molecules**

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Today, engine emissions are of increasing concern for engine and automobile manufacturers. By improving the efficiency of combustion, especially during the time in which the engine is cold (cold start), harmful exhaust emissions can be reduced. If fuel could be excited to maintain vaporization in air, engine emissions would be greatly reduced. Previous work has shown that the fuel components of Isopropyl Alcohol and Ethanol can be excited by a 10.2  $\mu\text{m}$  and 9.3  $\mu\text{m}$  CO<sub>2</sub> lasers respectively. Through the use of a monochromator and an Indium Antimonide detector, the decay time of the excited molecules was measured and found to be significantly long enough to allow for the possibility of experimentation in an internal combustion (IC) engine. In order to pursue In Situ measurements in an internal combustion engine, a Megatech Mark III transparent engine was fitted with a sapphire combustion chamber. This modification allows the transmission of infrared radiation for time-resolved spectroscopic measurements by an infrared spectrometer. By using a Telops FIRST-MWE imaging Fourier transform spectrometer, temporally and spatially resolved infrared spectral data can be acquired and compared for combustion in the engine both with and without laser excitation. Additionally, an IC engine was fitted to an engine dynamometer in preparation for measurement of the impact of direct fuel excitation in a production engine.

## **The Plant Homologue of EYES ABSENT Retains the Ability to be Potentiated by the SIX family of Transcription Factors**

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In humans and other animals, the conserved Retinal Determination Cascade (RDC) is important for the correct development of renal, otic, optic, muscle, and other tissues. Mutations in this pathway result in debilitating phenotypes such as Brachio-oto-renal syndrome. Of the enzymes and transcription factors involved in the RDC, only Eyes Absent (EYA) has been found to have a homologue in a non-animal species. Considering the unique evolutionary position of EYA, a comparison of these homologues may illuminate what aspects of EYA were essential to its adoption into the RDC. In this study, the *Arabidopsis thaliana* Eyes Absent (AtEYA) homologue's ability to interact with mammalian SIX transcription factors is compared to mammalian EYA3. Using the standard para-nitrophenyl phosphate Tyr-phosphatase activity assay, AtEYA's Tyr-phosphatase activity was found to be potentiated in the presence of SIX2 in a manner similar to mammalian EYA3. This result supports the hypothesis that EYA's ability to bind to the RDC's SIX family of transcription factors was present before the plant-animal split in evolution. A second study examined the homology between the Tyr-phosphatase active site environments of AtEYA and mammalian EYA3. Fifty-six compounds experimentally determined to inhibit the Tyr-phosphatase activity of AtEYA were modeled in Autodock using a Lamarckian Genetic Algorithm with a rigid protein model. Preliminary results show that 84% of the compounds bound to both AtEYA and mammalian EYA3 within the associated error, indicating a conserved active site environment. Future studies are aimed at determining what evolutionary steps were required for the co-opting of EYA into the RDC.

### **The Mathematical *E. coli***

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Currently in the Biological world, scores of people are spending countless hours in wet-labs eliminating, or “knocking out”, single genes in populations of organisms and observing the effects each knockout has on the population of cells. This process is slow and tedious, involving a high degree of manual labor. Because these populations are incredibly delicate, there is almost no room for error, so research is very costly and does not yield the most reliable results. Today, however, there is currently a more efficient way to perform these tests on organisms in the virtual world: by modeling systems biology with linear models on optimization software. *E. coli* is a useful organism to work with in this manner. Almost all of their biological processes are known, but they are not necessarily understood. Modeling their metabolic systems allows the researcher to control the virtual environment, what processes are working, and any other constraints on the population. Modeling metabolic capabilities of cellular systems is called Flux Balance Analysis (FBA). An organism strives to grow at the maximum rate possible with the resources available to it, so the internal chemical reactions (metabolism) will optimize growth for whatever environment the organism currently inhabits. The purpose of FBA is to solve the optimization problem of the metabolic processes of a cell given a certain environment. This research takes aim at a long term goal of building a large “macro” model of an entire cell where all genes, proteins, and metabolic activities are mapped and held in a steady state for observation and experimentation. The short term research was to identify reactions not used in optimal growth states. This will eventually lead to determining if these reactions are ever used as backups for the more efficient reactions or if they are obsolete, but not yet eliminated through evolution.

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## **Identifying and Isolating Unknown Iridoviruses in Amphibian Populations**

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Over the past five years, amphibian species have experienced a dramatic decline in species population. The reduction in population has previously been associated with an increase in the prevalence of members of the Iridoviridae family of viruses. These viruses have adapted icosahedral nucleocapsids, which contain double-stranded DNA and replicate within the host genome, killing the infected cell by lysis after replication is complete. To investigate the prevalence of Iridoviruses in local amphibian populations, a PCR-based detection assay was used. Nucleic acids were extracted from the samples taken from captured frogs and subjected to this PCR assay. A positive control of frog virus 3 was used to make sure our protocol was sufficient. These samples are currently being tested for the presence of Iridoviruses using the PCR assay.

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## **Synthesis and Optimization of a High Capacity Carbon Dioxide Absorbent**

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In recent decades, there has been much discussion in the scientific community on environmental and climate change, and the primary focus of this debate is the amount of carbon dioxide that is being released in the atmosphere. Many methods are currently being investigated and implemented in an attempt to reduce that amount, and to remove carbon dioxide from the atmosphere. One promising process for sequestering carbon dioxide is the use of mesoporous silica nanoparticles, which is the focus of the present work. These silica particles are hollow spheres 45-1000 nm in diameter with a high density of pores 2-5 nm in diameter. These attributes give the particles incredibly high surface area to volume ratios, which makes them ideal for absorbing gases and addresses material and energy problems that arise in other current methods. The present work focused on optimizing of the synthesis of mesoporous silica particles to control the pore size and outer diameter by varying preparation amounts and techniques. Mesoporous silica particles prepared in this project have shown an absorbance of carbon dioxide of approximately 4.5 mmol CO<sub>2</sub>/g silica and an overall improvement in the absorbance of a factor of 2250, from initial experimentation.

## **Difference in Blood Viscosity between Diabetics and Non-Diabetics Receiving Treatment for Kidney Failure by Dialysis**

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In the treatment of kidney failure by the use of a brachiocephalic fistula and dialysis, complications arise in the cephalic arch due to the high velocity of the blood. Patients with diabetes mellitus have been observed to have significantly healthier fistulas than patients without diabetes mellitus. This may occur due to differences in fluid dynamics between the two patient populations. A higher blood viscosity in people with diabetes could explain the differences as it would decrease the Reynolds,  $\text{Re}$  number giving the blood stream a more laminar flow and also keeping the shear stress on the vein wall closer to the normal shear stress. In the present investigation, a literature study was performed which suggested that diabetics have on average a 10.4% higher blood viscosity and a 9.9% higher plasma viscosity. A percent difference of that amount could very likely cause the prolonged health of the diabetics,  $\text{Re}$  fistulas. The present investigation involves analyzing differences in blood and plasma viscosity between diabetics and non-diabetics receiving treatment for kidney failure by dialysis. Samples will be taken from patients of a dialysis clinic and viscosity measurements will be made over various shear rates using a cone and plate viscometer.

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## Development of a Protocol to Synthesize PLGA Nanospheres

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There have been an abundance of research studies over the last decade focusing on the development of polymer microspheres for use as vehicles in the controlled release of drugs. These microspheres were designed with the intention to treat diseases caused by intracellular pathogens. Though these studies have shown promise in their methodologies as far as particle formation and drug loading efficiency, implementation has been challenging. It was hypothesized that scaling the polymer microspheres down to nano-sized particles would aide in the uptake of these spheres through the plasma membrane, which is also on the nano-scale. The objectives of this study were to determine the effects of several process variables on nanospheres fabrication including: amount of surfactant, type of surfactant, concentration of polymer, concentration of surfactant, as well as polymer to surfactant ratio.

In order to prepare a base trial for synthesis, a modified emulsification-diffusion technique similar to Leroux et. al was utilized. In that method, an o/w emulsion of polylactic acid (PLA) and benzyl alcohol was formed in the presence of the stabilizer polyvinyl alcohol (PVA). Nanopure water was added in excess to induce the diffusion of the solvent as well as the precipitation of polymer nanospheres. For the base trial of this study, poly(DL-lactide-co-glycolide) (PLGA) was dissolved in an 80:20 mixture of dichloromethane and acetone with PVA used as a stabilizer.

The base trial resulted in non-uniform spheres that ranged from approximately 1-30 microns in diameter. Doubling the amount of surfactant used generally resulted in a higher yield of spheres with diameters in the 1-10 micron range, as expected. Utilizing hexadecylpyridinium chloride monohydrate in place of PVA as the surfactant resulted in non-uniform spheres as well that were larger than those resulting from the base trial. Doubling the amount of polymer used typically resulted in larger particles, while doubling the concentration of surfactant used generally resulted in smaller, more uniform spheres. Again, these results align with what one would expect based on the method of formation. Finally, decreasing the volumetric ratio of the polymer:surfactant solutions from 2:1 to 1:1 resulted in only a few larger spheres. The majority of the product resulting from this change did not precipitate out into individual spheres.

In summation, while this method of synthesis reduced the size of spheres that had been generated in previous studies by one to two orders of magnitude, the alterations to the process variables studied did not result in uniform spheres on the nano-scale. A more comprehensive study of experimental factors including duration of sonication and rate of addition of nanopure water is recommended.

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## **Audio Depth Map as a Replacement for Traditional Vision**

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In the past, each of the traditional five senses has been used with some success to help with the loss of another. For example, Braille makes use of touch to replace lost sight while sign language allows for the sense of sign to be used in place of hearing in communication. Quite simply, the goal of the AudioVision project was to perform a similar function by mapping the visual world to an audio representation using computer vision and surround sound techniques in real-time. To this end, three separate software components were necessary: First, some method of collecting visual data in real time was necessary involving either a single camera for monocular vision algorithms or two or more for more traditional stereo vision. Next, a depth map had to be calculated from the visual information at a resolution that was capable of being translated into sound. Finally, it was necessary to convert the depth map into a three-dimensional audio representation to be played through a standard pair of headphones. While a number of problems became apparent during the implementation of AudioVision, the final results are promising. With some amount of training and acclimating oneself to the program, it should be entirely possible to navigate the visual world using only your sense of hearing.

## **Surfactant-Assisted Aqueous Extraction of Soybean Oil from Soybean and Recovery of Oil from Skim**

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Aqueous extraction processing (AEP) is a safer and more environmentally friendly oil extraction method than conventional solvent extraction. SDS and phospholipid were added as emulsifiers to the extraction mixture to test their effect on extraction yield of protein and oil during AEP. It was found that the addition of SDS to the extraction increased the amount of oil released from the insoluble fraction of the soybean; however, this was not true for phospholipid. A protein-rich skim fraction resulting from AEP was isolated and analyzed by differential scanning calorimetry to determine the effect of the emulsifiers on the native protein conformation. The addition of phospholipid did not affect the native conformation of either glycinin or  $\beta$ -conglycinin; however, SDS-assisted extraction resulted in the denaturation of  $\beta$ -conglycinin. Efforts to break the skim emulsion and induce aggregation of oil droplets to form a cream via electrostatic shielding with electrolyte, exclusion aggregation with a polyelectrolyte, a secondary extraction performed on the skim fraction were unsuccessful.

### ***In-Vitro* Generation of Amebocytes from the American Horseshoe Crab, *Limulus Polyphemus***

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Bacterial pyrogens such as lipopolysaccharides (LPS) are found on the outer membrane of gram negative bacteria. When these contaminants come into contact with the mammalian blood stream, an immune response, which can result in fatal shock, occurs. Therefore, all implantable devices and most injectable drugs require tests for endotoxin contamination. The test currently employed is derived from amebocytes which are present in the blood of horseshoe crabs. Since these crabs are in danger of being placed on the endangered species list, researchers are experimenting with generating these amebocytes in-vitro by utilizing tissue cultures. By simulating the interstitial environment of these crabs, I have attempted to stimulate the release of amebocytes from tissue dissected from the American horseshoe crab, *Limulus polyphemus*. By using nuclear fluorescent staining protocols, I have evidence that supports the presence of amebocytes in the tissue five weeks after the culture was initiated.

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## **Evaluation of Descriptors Used in Sexual Selection Research**

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Sexual selection is the practice of choosing a mate based on reproductive fitness. Reproductive fitness can be assessed by physical features and by characteristics likely to lead to well-provisioned offspring. Research in sexual selection is often based on surveys that depend on a respondent's interpretation of specific descriptors or phrases meant to individually correlate with a particular set of physical or personality characteristics. However, the use of select descriptors in these surveys is not substantiated; researchers assume that respondents interpret the descriptors in the same way that they themselves do. We examined descriptor interpretation by having respondents categorize descriptors generally used in sexual selection research. Respondents placed four hundred different descriptors into one of three categories: genetic quality (GQ), parental investment (PI), or interpersonal relationship (IPR). Our study showed that respondents and researchers interpret descriptors of GQ in the same way (only 2% disagreement) but disagree in their interpretations of supposed descriptors of PI and IPR (9% disagreement for PI and 53% disagreement for IPR). Overall, 33.6% of the descriptors explicitly categorized by respondents disagreed with our categorizations. We found that males and females interpreted descriptors in the same way. Based on disagreement and the content of the explicit descriptors analyzed, we concluded that words frequently used in survey-based sexual selection research should be re-evaluated in order to verify that researchers and respondents have the same baseline understanding.

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## **Examining the Effects of Ligands and Alcohols on Dimer Exchange in the Human Estrogen Receptor**

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The human estrogen receptor (ER), a nuclear hormone receptor, exists as a dimer in solution. High-performance liquid chromatography (HPLC) can be used to study the binding and dissociation kinetics of the protein, and to probe the effect of different solvent additives, such as alcohols, ethers and ligands, on the dimer exchange rate. In this assay, ER ligand binding domain (LBD) and a larger form of the protein comprised of LBD bound to maltose binding protein (Fusion protein) are combined in equal concentrations and the dimers are allowed to exchange until an equilibrium state is reached. 50  $\mu$ L aliquots are taken at known times, and analyzed using HPLC gel filtration chromatography to determine the relative amounts of each species over the course of 20 to 30 hours. With no solvent added, the observed dimer exchange half-life is approximately 2 hours at 20°C. The physiological ligand estradiol increased the half-life of dimer exchange to roughly 7 hours. Small alcohols decrease the half-life; among C1 through C4 alcohols, the degree of effect is correlated with boiling point, with butanol exhibiting the greatest effect among this series of compounds. To evaluate the types of functional properties of the molecules able to elicit a change in the dimer exchange process, a variety of molecules that contained other functional groups in addition to alcohols were tested. Of these, ethylene glycol butyl ether resulted in the greatest decrease in half-life of all substances tested. In contrast, amines such as N,N-diethyl-3-amino-1-propanol appear to induce increases in the exchange half-life. Further experiments will be required to determine the mechanism by which the small organic molecules alter the properties of the estrogen receptor, and whether these perturbations have physiological effects in humans.

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## **Molecular Dynamics Simulations of the Estrogen Receptor- $\alpha$**

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In order to understand the role that ligands play in the dimerization and subsequent function of the ligand binding domain of the estrogen receptor- $\alpha$  (ER $\alpha$ ) we first need to be able to understand the intricacies of the dimerization process. Because current experimental methods have limited ability to monitor the specific details of the dimerization process, we have begun to use molecular dynamics computer simulations for the ER $\alpha$  to examine the dimerization process. Using NAMD, a widely available molecular dynamics program, to perform the simulation, we are able to compute the trajectory of the ER $\alpha$  in a vacuum in under a single day, and the trajectory for the ER $\alpha$  in water in a couple of weeks. Because dimer dissociation is a relatively rare event, we added force vectors to portions of individual monomers to induce dimer dissociation. The results of this approach suggest that, at least in vacuum simulations, the simulated forces required introduce unrealistic perturbations in the protein structure. We therefore began to simulate the dimer association process, by introducing a spatial separation between the monomers, followed by molecular dynamics to observe the re-association of the monomers. The rapidity in which the dimer reformed suggests that this approach may offer promise in evaluating protein-protein interactions for the ER $\alpha$  and other proteins. Because dimerization plays an important role in the function of the ER $\alpha$  and one of the suspected areas of dimer perturbation via alcohols and other small molecules, these computer simulations offer an improved understanding of an important aspect of ER $\alpha$  function.

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## **Developing a Fluorescence Lifetime-based Assay for Ligand Binding**

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Breast cancer claims over 40,000 lives each year and is the second most prominent cancer in women. It is known that estrogens play a critical role in induction and growth of breast cancer, and that the majority of estrogen actions are mediated by the estrogen receptor. The estrogen receptor binds to estrogens such as estradiol, to drugs such as tamoxifen, and to environmental compounds. In addition, other small molecules such as ethanol appear to perturb some aspects of estrogen receptor structure and function. Because binding of ligands is an important aspect of estrogen receptor function, a reliable, reproducible ligand binding assay is important for characterizing the effects of mutations and other perturbations of the protein. In any binding assay, it must be possible to detect the bound and/or the unbound state. Because fluorescence spectroscopy is sensitive to local environment, it is potentially useful for detecting bound and unbound ligands. One possible approach to this is to measure the lifetime of the excited state of a fluorescent ligand; if the fluorescent lifetime is sufficiently different for bound and unbound forms of the ligand, the amount of each form could be used to measure the thermodynamics of binding. For one fluorescent estrogen receptor ligand, coumestrol, initial trials show promise for such an assay.

## **Ion-Current Rectification in Conical Nanopores**

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Similar to many things studied on the nanoscale, nanopores exhibit properties that can not be explained well with traditional mechanics. This talk focuses on the rectification of ion-current exhibited by conical nanopores and interesting results contrary to previously published reports. Nanopores are track etched in a polyethylene terephthalate membrane and sandwiched between polydimethylsiloxane substrate microchannels, making microfluidic „Äúchips,Äù that facilitate single nanopore isolation and characterization. Our results indicate that rectification, seen as nonlinearity in a current versus voltage plot during polarized DC sweeps, arises from a preferred direction of ion transport through the pore despite identical buffer conditions before and after the pore. Including polyvinylpyrrolidone in the buffer to eliminate pore surface charge produces reversed rectification ratios that increase with ion concentration. Our results show rectification in pores with diameters too large to allow the overlap of the electric double layer contrary to previous experimental studies that state the electric double layer must overlap to exhibit rectification.