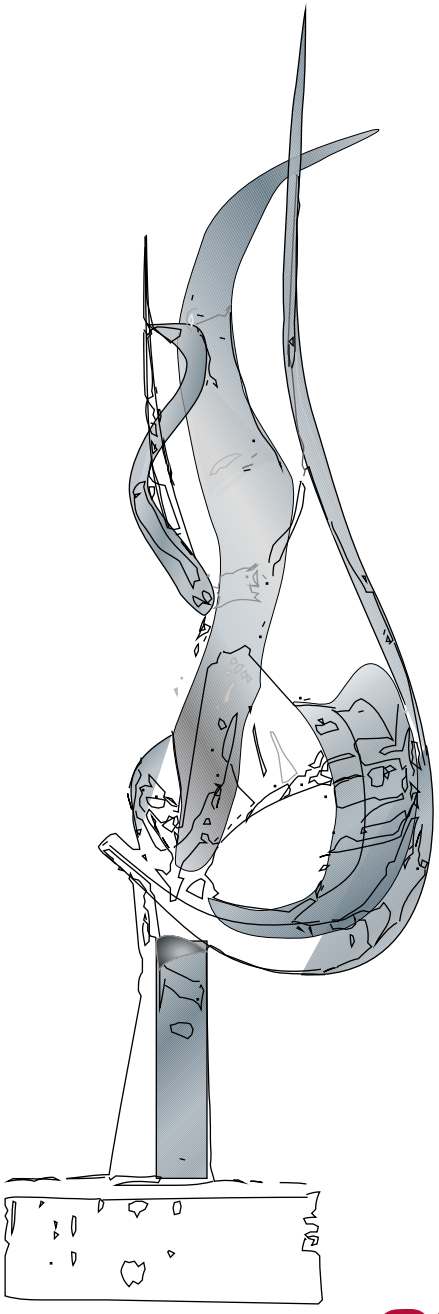
Interdisciplinary Research Collaborative

IRC

Rose-Hulman Institute of Technology



11th Annual IRC Undergraduate Research Symposium

Friday
October 24, 2014

Sponsored by

Edwards Lifesciences

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Welcome to the

11th Annual IRC Undergraduate Research Symposium

Sponsored by

Edwards Lifesciences

Friday, October 24, 2014

We are honored to welcome you to the 11th 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 Edwards Lifesciences, 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 and the Wabash Valley Local Section of the American Chemical Society.

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 some of our colleagues in Indiana.

We are delighted to welcome you to this eleventh in the annual event series. 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

Peter Coppinger
IRC Program Coordinator

ROSE-HULMAN
INSTITUTE OF TECHNOLOGY

Symposium Schedule

Morning Session I (8:30 – 9:45 AM)

Regulation of Estrogen Receptor via Catechin Polyphenols from Green Tea

Abigail Etters and Ross V. Weatherman*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Biologically Plausible Indoor Scene Classification and Vision-based Indoor Robot Localization

Zhihao Li and David Mutchler*
Department of Computer Science & Software Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Metamaterial Inspired Common-Mode Filtering

Sang Goo Kang and Edward Wheeler*
Department of Electrical & Computer Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Brain response to unexpected visual stimuli

Milan Thakker and Alan Chiu*
Department of Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Synthetic Unity

Daniel Griffin, Braxton Carter*, Dani Bauhan*, Wenjun Kong, Michael Riddle, and Briana Harvey*
Rose-Hulman International Genetically Engineered Machine (iGEM) Team, Department of Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Morning Session II (10:00 to 11:00 AM)

Fast Pyrolysis of Lignin using Pd/HZSM-5 Catalyst

Gabriel Seufitelli, Oliver Jan, and Fernando Resende*
School of Environmental and Forest Science, University of Washington

Synthesis and Analysis of Tamoxifen Derivatives

Kent Kraus and Ross V. Weatherman*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

Identification of BARE-1 Retrotransposon in Barley

George Conway and Peter Coppinger
Department of Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

Ionic Liquids as Solvents for Digestion of Biomass for Ethanol Production

Seth Clark, Julia Kubisz, and Rebecca DeVasher*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Keynote Presentation 12:00 to 1:00 PM

Allen White, Ph.D.
Department of Mechanical Engineering, Rose-Hulman Institute of Technology
and
Department of Chemistry, Indiana University

Afternoon Session I (3:00 to 3:45 PM)

Assessing first year student's ability to reflect with video

Chris Gewirtz[1], Kevin Nguyen[2], and Nick Tatar[3]*

[1]Department of Physics and Optical Engineering, Rose-Hulman Institute of Technology, Terre Haute IN 47803, [2]Department of Civil and Environmental Engineering, Texas Tech University, Lubbock, TX, 79409, and [3]Office of Student Life, Franklin W. Olin College of Engineering, Needham MA 02492

Synthesis of Biodegradable Polymers

Mike Yuan Xue and Bruce Allison

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

Ring-Opening Polymerization of Trimethylene Carbonate Using Bimetallic Catalysts

W. Frank Schwandt and Stephanie J. Poland

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

Afternoon Session II (4:00 to 5:00 PM)

Co-Synthesis of Bioenergy Proteins from Thermoacidophilic Microorganisms

Danielle Uchimura Pascoli, Deepak Rudrappa, Tyler Johnson, and Paul Blum*
School of Biological Sciences, E234 Beadle Center, University of Nebraska-Lincoln

Digestion of Corn Husks Using Ionic Liquid

Julia Kubisz, Seth Clark, Anna Weber, and Rebecca DeVasher*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology,

Development and Optimization of a Method for Producing Undenatured Type II Chicken Collagen and Hydrolyzed Chicken Collagen

Christopher Lippelt and Mark E. Brandt
Departments of Chemical Engineering and Chemistry & Molecular Biology, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Quantification of Glycerol Monostearate through HPLC paired with ELS detector

Amanda Kelley and Jared A. Tatum*
Department of Chemical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803 and Ampacet Corporation R&D Center, Terre Haute, IN 47804

Poster Presentations

Large Hadron Collider beauty Particle Analysis

Theodore Baker (Walnut Hills High School), Kyle Debry (Anderson High School), Brenda Shen (Sycamore High School), Rebecca Swertfeger (Turpin High School), David Whittington (Fairfield High School), and Michael Sokoloff (University of Cincinnati)*
Department of Physics, University of Cincinnati, Cincinnati, OH 45220

Development of Lab-on-a-Chip Microfluidic Capillary Electrochromatography Techniques

Bennett Chappell, and Daniel Morris*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Antioxidant Mechanisms of Glutathione against Metal-Initiated Oxidative DNA Damage

Elias Eteshola and Daniel Morris*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Evaluation of Acetabular Cup Deformation Using Digital Image Correlation

Danielle Gehron, Katie Lakstins, Scott Small, Renee Rogge, Jordan Oja, Christine Buckley, and John Meding*
Department of Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803 and Joint Replacement Surgeons of Indiana Research Foundation, Mooresville, IN 46158

Monitoring Road Health with Mobile Smartphones

Sijun He and Matthew Lovell*
Department of Civil Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Measuring the Binding Affinity of Estradiol to the Human Estrogen Receptor

Mark Lasher and Mark E. Brandt*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Overview of Air Quality Regulations in South America

André Henrique Pereira de Freitas Leal[1] and Lupita Montoya*[2]
[1] Sanitary and Environmental Engineering, Federal University of Bahia, Salvador, Bahia, Brazil, and [2] Civil, Environmental & Architectural Engineering Department, University of Colorado Boulder, Boulder, CO, USA

Spectrally-resolved Imaging of the Transverse Modes in Multimode VCSELs

Stephen Misak, Dan Dugmore, Kirsten Middleton, Evan Hale, Kelly Farner, Daniel Thul, Kent Choquette, and Paul Leisher*

Department of Physics & Optical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803, and University of Illinois at Urbana-Champaign, 208 N. Wright St., Urbana, IL 61801

Reserve Capacity in New and Existing Low-Ductility Steel Braced Frames

Milton Sanders Park, Eric Hines, Joshua Sizemore, Cameron Bradley, and Larry Fahnestock

Department of Civil Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803, University of Illinois, Urbana-Champaign, and Tufts University

Effects of Glutathione Disulfide in Site-Specific Metal-Mediated Oxidative DNA Damage

Lee Anne Siemer and Daniel Morris*

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

Homogenizing Biomass for Conversion of Ethanol by Fermentation

Anna Weber, Julia Kubisz, Seth Clark, and Rebecca DeVasher*

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

Regulation of Estrogen Receptor via Catechin Polyphenols from Green Tea

Abigail Etters* and Ross V. Weatherman
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

It has long been suggested that green tea could aid in preventing breast cancer. Green tea is rich in catechin polyphenols that have been associated with bioactive properties, such as anti-proliferative effects on antiestrogen resistant breast cancer cells. There is currently no consensus mechanism for how catechins work. Proposed mechanisms include both estrogen receptor dependent and independent pathways. Studies in Weatherman Lab conclude that green tea catechin polyphenols, particularly catechin gallates, exhibit weak estrogenic effects on estrogen receptor(ER)-mediated transcription. The catechins tested were (-)-Epicatechin gallate, (-)-Gallocatechin gallate, (-)-Epigallocatechin, and (-)-Gallocatechin. This research determined the antiestrogen strength of these catechins relative to prominent antiestrogens, and tested them in antiestrogen sensitive and resistant cell lines to determine catechin polyphenol behavior as agonistic or antagonistic. This was accomplished via fluorescent polarization binding assay and luciferase assay. The FP binding assay results showed that catechins do indeed demonstrate successful binding to ER at high concentration doses, but they are weaker than prominent antiestrogens. The luciferase assay data demonstrated that catechins are able to stimulate ER-mediated transcription, but at levels lower than those observed with estradiol. However, the extent of catechin ER-mediated transcription activation does not seem to correlate with binding affinity. This suggests a more complicated mechanism to be analyzed in the future. Further studies will also dissect whether these catechin polyphenols, particularly the catechin gallates, are low potency full agonists or high potency partial agonists.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC and by an Eli Lilly, Co. Undergraduate Research Grant.

Biologically Plausible Indoor Scene Classification and Vision-based Indoor Robot Localization

Zhihao Li* and David Mutchler
Department of Computer Science & Software Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Indoor scene classification is a high-level vision problem that exploits both local and global spatial discriminative information. Unlike outdoor environments such as beaches, parking lots, or woods, which are easier to discriminate, the large variability of indoor scenes makes the classification task more difficult.

Despite the recent advances of computer vision technologies, human still remains the gold standard for the task of indoor scene classification and low-level human vision mechanisms of visual attention and visual gist have been demonstrated to contribute to the outdoor scene classification task. This fact inspires us to examine the low-level vision mechanisms of human and make use of it to perform indoor task.

In the research, we will try to extract visual saliency map and gist features from the input image and do multiclass classification. Then we will compare our work with state-of-art indoor classification models. After that, we will apply our model to a real robot with vision sensor and do localization tasks. Currently, we have developed a fully functional gist-extracting algorithm based on Siagian&Itti2007. We will try to develop a method to combine saliency map with gist features to compose the full feature vector for the next step.

Metamaterial Inspired Common-Mode Filtering

Sang Goo Kang* and Edward Wheeler
Department of Electrical & Computer Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

The internet, social media, high-performance computing and smart phones all depend on dependable high-speed communications. Differential signaling has become a norm in many high-speed data transmission protocols due to its ability to transfer information at very high frequencies and its relative immunity to electromagnetic interference. Differential signaling has been implemented in current revisions of Serial ATA, PCI Express, HDMI, and 10-Gigabit Ethernet. All these technologies work at over one billion bits per second (Gigabit/s), speeds at which more conventional signaling methods become ineffective. When implemented in printed circuit boards and integrated circuits, differential signaling channels are most often formed by combining two conventional channels having opposite polarity and must maintain perfect symmetry for ideal operation, a goal typically not achievable in practice due to the size and complexity of modern electronic systems. When this symmetry is broken, the signal energy is partially converted into common-mode (CM), which degrades the original differential signal and results in unintentional electromagnetic radiation. This can be avoided through common mode filtering, which prevents transmission of common-mode signals while allowing differential signals to propagate. Metamaterial-inspired structures such as Complementary Split-Ring Resonators (CSRRs) have been shown to be effective in filtering out such common mode signals in simple two layer printed circuit boards (PCBs) but their implementations in previous work have lost their effectiveness when used in complex multilayer structures, an important point since many high-speed data applications involve such multilayer boards. This problem was previously shown to be counteracted through the use of via cages. Research done at Rose-Hulman also suggests that alternate structures derived from the CSRR circuit model such as composite right/left handed (CRLH) transmission lines can also prove to be effective in filtering out the common mode signals in a multi-layer environment. Another problem existed in the testing phase, where due to the imperfect nature of connectors, an unwanted differential mode attenuation occurred at high frequencies. Evidence show that TRL Calibrations help fix this problem by de-embeding the connectors through matrix mathematics.

Brain response to unexpected visual stimuli

Milan Thakker* and Alan Chiu
Department of Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

In cognitive psychology studies, if the subject is presented with a stimulus that violates the expectation dictated by the subject's internal model, a strong neural response called P300 is elicited. In this project we test the P300 response by giving false answers to a small percentage of the math problems given to the subject, testing whether the violation of a subject's internal model in the form of performing and expressing numerical solutions to mental math problems will produce a P300 wave.

First, positive control experiments are performed in order to evaluate whether each subject is able to generate P300, given an unexpected visual stimulus. In the positive control experiment, white X and O characters are shown on the computer monitor on a black background. The X is the standard stimulus, and the O is the target stimulus.

Next, standard and target stimuli are given in the form of numbers and written out words (*i.e*. twenty-two), with a randomized problem, and a slim chance of being shown a wrong answer, in order to violate the subject's internal model. Though there is not enough data for a definite conclusion, the early data suggests that there is in fact a strong difference in brain wave reaction to an unexpected visual stimulus as compared to the standard stimulus.

Synthetic Unity

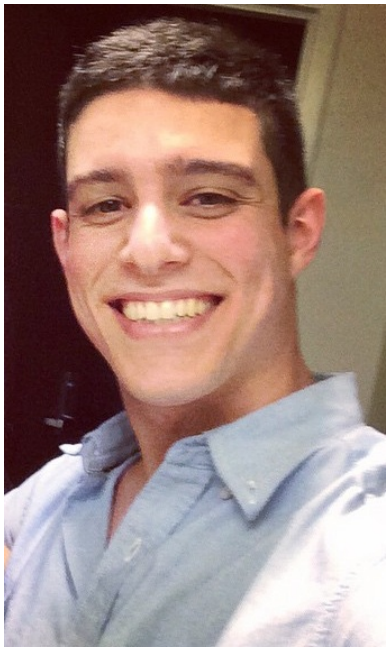
Daniel Griffin*, Braxton Carter*, Dani Bauhan*, Wenjun Kong, Michael Riddle, and Briana Harvey
Rose-Hulman International Genetically Engineered Machine (iGEM) Team, Department of Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Our project explores synthetic obligate mutualism as a means to produce novel, multi-species chassis as foundations for innovative synthetic biological applications. These applications could exploit unique biochemical potentials emerging within chimeric systems. Here we explore the pairing of *Saccharomyces cerevisiae* and *Escherichia coli* by constructing genetic circuits for reciprocal induction of essential histidine biosynthetic genes. Since one species relies on the other for induction of their own essential gene, mutualism is obligatory. Another key component of our efforts addresses the need for effective interactive models to facilitate teaching and understanding of synthetic biology concepts. Victor the Vector is an electromechanical device, which combines circuits and software to not only model components of our project, but to facilitate understanding of gene regulation and the synthesis of genetic circuits. In toto, Team RHIT strives to stimulate innovation and education in synthetic biology.

Fast Pyrolysis of Lignin using Pd/HZSM-5 Catalyst

Gabriel Seufitelli*, Oliver Jan, and Fernando Resende
School of Environmental and Forest Science, University of Washington

Biotechnology is becoming an important field with several technological implications for biobased products and fuels. Biofuels are of economical and environmental importance because they replace nonrenewable fuels, which are a major contributor to the greenhouse effect. The feedstock for biofuels production is denominated biomass. However, processes to convert biomass to biofuels are still in their infancy. Fast pyrolysis is a process in which biomass is thermally decomposed at high temperature and pressure in the presence of a selective catalyst. The reaction is carried out in a fixed-bed reactor, and the products may vary according to the process temperature. The objective of this project is to optimize the production of aviation fuels by finding the optimum temperature that results in high yield of naphthenic and aromatics produced. In order to obtain these high yields, fast pyrolysis was performed in a packed-bed reactor using lignin and Pd/HZSM-5 catalyst. The pyrolysis was performed in-situ and ex-situ with a catalyst ratio of 20 to 1 of lignin. The products were analyzed and compared with each other, aiming to find the conditions in which yields of naphthenic and aromatics were higher. According to the results, temperatures ranging between 400 and 600 oC led to higher concentrations than those higher than 700 oC, but it was not satisfactory enough. Also, this reaction was not determined to be economically viable as it requires a large amount of catalyst, which is extremely expensive. In conclusion, the production of jet-fuels from biomass is a potential process, but there are still technical and catalytic challenges to be thoroughly explored before the process can be commercially viable.



Synthesis and Analysis of Tamoxifen Derivatives

Kent Kraus* and Ross V. Weatherman
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

Tamoxifen is a breast cancer drug that works through inhibiting transcription of Estrogen Receptor α (ERα). Tamoxifen has proven to be an effective drug against ERα positive breast cancers, but over time, the cancer can become immune to tamoxifen. Previous research has proven that tamoxifen derivatives with large, linked groups can still permeate the cell membrane with some properties superior to the original tamoxifen with regards to resistance. The role of the extra attachment in the overall activity of the conjugate is unknown. To that end, this project focused on making biodegradable linkers between the drug and the large attachment. In these new conjugates, the bond between the linked group and tamoxifen hydrolyzes upon entry into the cell; the drug is released, permeates the nuclear envelope and inhibits transcription. Tamoxifen derivatives were synthesized with linkers containing aldehydes and carboxylic acids of varying carbon chain length. The various tamoxifen derivatives were tested for binding affinity to ERα via fluorescent spectroscopy and for inhibitory potency via cell-based assays. The results from this research discovered that using an aldehyde at the end of the linker moiety as an attachment point resulted in a compound with decent binding affinity for the receptor in vitro and modest inhibitory potency in cells. The main limitation in trying to optimize this functionality is a significant decrease in water solubility that prevents the drug from reaching sufficient concentrations for full activity. The carboxylic acid functionality was more promising, but needs to be researched further.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC and by an Eli Lilly, Co. Undergraduate Research Grant.

Identification of BARE-1 Retrotransposon in Barley

George Conway and Peter Coppinger
Department of Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

Retrotransposons are mobile genetic elements that copy and paste themselves around the genome. One retrotransposon, BARE-1, is present in barley in copies upwards of 10,000. Copy number in barley is maintained by methylation to prevent potential deleterious insertions into genes. Methylation is a common epigenetic mechanism of gene regulation where the cytosines in DNA have a methyl group attached. Under varying temperatures the number of retrotransposons can fluctuate and while the mechanism behind this is not well understood, methylation of the long terminal repeats (LTRS) is thought to play a part. Previous literature has shown that the methylation of retrotransposons change under heat, pH, and salinity. I am investigating the effect of colder temperatures on methylation levels. My current research is to clone and sequence the BARE-1 retrotransposon in barley to verify its presence, then after growing the plants under varying temperatures perform bisulfite converted PCR (BSP) to quantify the change in methylation levels. This summer I successfully designed primers to amplify the 5' LTR region of the BARE-1, current attempts to sequence and investigate methylation is ongoing.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

Ionic Liquids as Solvents for Digestion of Biomass for Ethanol Production

Seth Clark*, Julia Kubisz, and Rebecca DeVasher
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

There is more energy stored in the amount of biomass produced in ten years than the total energy stored in the Earth's entire supply of crude oil. Several processes have been developed for processing this biomass into usable sugars; however, these methods employ hazardous solvents and require complex recycling efforts. Ionic Liquids show great promise as more benign and potentially more efficient cellulose solvents. Various Ionic Liquids were synthesized and used to digest corn husks; the digested solutions were then fermented and analyzed for ethanol content via fractional distillation. Traditional methods were also employed to digest the corn husks; the digested solutions were then fermented and analyzed for ethanol content via fractional distillation. The fermented ionic liquid solution was found to contain high amounts of ethanol. This indicates that the ionic liquids were effective solvents in digesting the corn husks, producing adequate amounts of fermentable sugars for fuel production. Further experiments will be performed using different ionic liquids, as well as developing a method of solvent recycling.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

Assessing first year student's ability to reflect with video

Chris Gewirtz[1]*, Kevin Nguyen[2], and Nick Tatar[3]
[1]Department of Physics and Optical Engineering, Rose-Hulman Institute of Technology, Terre Haute IN 47803, [2]Department of Civil and Environmental Engineering, Texas Tech University, Lubbock, TX, 79409, and [3]Office of Student Life, Franklin W. Olin College of Engineering, Needham MA 02492

At a small East-Coast undergraduate engineering college, first year students recorded videos of team meetings while they worked on a design project. After recording the meeting, students were asked to watch themselves and their team and write a self-reflection essay that provided evidence based feedback for themselves and their team. To scaffold the self-reflection exercise, students were given the choice of five different methods to analyze the recorded video

A pedagogical shift toward project based team learning environments has raised a number of questions for first year teaching faculty. When asked to reflect on their own team experience, what kinds of insight do first year students put forward about their team experience? How do students leverage those insights to improve their learning and their team's overall performance?

Researchers used a rubric developed by Kember (2008) for nursing education, based on Mezirow's (1990) theory of reflection. Mezirow describes many levels of reflection, which are interpreted into four levels of assessed reflection by Kember. The first level, Non-Reflection, is attributed to papers that describe situations but do not attempt to interpret them. The second level, Understanding, is attributed to a paper wherein a student tries to understand the events they are describing, but the knowledge they gain from the experience is theoretical or impersonal, and does not have implications for changes in the student's behavior. Reflection is attributed to student papers that use their return to an experience as a learning opportunity. In this case, part a student's system of knowledge is examined and challenged or reinforced. The final level of reflection, Critical Reflection, is reserved for student who reflect on the premises or precedents for their actions within the scope of the assignment. Critical reflection essays demonstrate changes in beliefs and perspectives as a result of the learning experience.

Using Kember's (2008) rubric for evaluating self-reflection, 6% (n=3) of the papers were evaluated as non-neflective, 29% (15) were assessed as understanding, 58% (30) were assessed reflective and 8% (4) were assessed as Critically Reflective. Researchers also found gender differences within the levels of reflection with women more likely to submit essays that were reflective and critically reflective, and men more likely to submit papers that were assessed as non-reflective and understanding. When assigning a single category to non-reflection and understanding, and another category to reflection and critical reflection, a two-sample Wilcoxon test yielded a value of $p = 0.05458$, which suggests a trend but is not statistically significant.

Reliability of assessment, differences between prompts, qualities of critical reflectors and improvements to the assignment are also discussed.

Synthesis of Biodegradable Polymers

Mike Yuan Xue and Bruce Allison
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Biodegradable polymers have found a variety of applications from medical devices to environmentally friendly grocery bags. They are widely used in biomedical applications due to their biodegradability and biocompatibility. For example, poly(lactic-co-glycolic acid) is a one of the most popular biodegradable polymers for therapeutic devices. This research was undertaken in order to easily synthesize and purify this material with the goal of incorporating new co- or ter-monomers that may enhance physical properties and broaden the range of applications for these materials. By running ring-opening reactions using organometallic catalysts, the co-polymer was synthesized. Progress on this research will be reported. Several tests such as optical analysis (IR spectra) and other chemical and mechanical property measurements were performed to identify the products.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

Ring-Opening Polymerization of Trimethylene Carbonate Using Bimetallic Catalysts

W. Frank Schwandt and Stephanie J. Poland
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Due to the numerous applications of polytrimethylene carbonate (polyTMC), especially in the medical field, devising an effective and cost effective method for the synthesis of polyTMC is an important area of research. In this study, two previously reported bimetallic zinc and magnesium catalysts were synthesized used for the catalytic ring opening polymerization of trimethylene carbonate (TMC). Primarily, the effect of temperature on catalyst activity was examined, with a maximum percent conversion of about 67% at 90°C using the bimetallic magnesium catalyst. In addition to studying the temperature effect, the polymerizations were performed both with and without solvent in order to assess the prospect of implementing a more environmentally neat polymerization.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

Co-Synthesis of Bioenergy Proteins from Thermoacidophilic Microorganisms

Danielle Uchimura Pascoli*, Deepak Rudrappa, Tyler Johnson, and Paul Blum
School of Biological Sciences, E234 Beadle Center, University of Nebraska-Lincoln

For many decades, people have used fossil fuels as their main energy source. With over use of fossil fuels, we are facing the greenhouse effect and climate changes. Consequently, many countries are investing in research to find different cost-effective alternatives, such as biofuels. Cellulosic ethanol is a new energy source that is gaining attention due to its capacity for partially substituting fossil fuels and contributing to the growing energy needs. Among the main raw materials used in ethanol production, the lignocellulosic biomass do not compete with food production and has great potential for application as a carbon source in fermentation processes. In order to release all the carbohydrates present in its cell wall, biomass is pretreated and followed by enzymatic saccharification. The pretreatment consists of acid hydrolysis and it occurs inside a reactor at high temperature and pressure in the presence of concentrated acid. At the end of this process the hydrolysate will be at low pH and high temperature, which is inappropriate for the enzymatic saccharification since enzymes currently in use do not tolerate hot acid conditions. The current industrial practice of neutralization and cooling of this hydrolysate increases the costs during large scale ethanol production, denoting an extra expense.

Hence, this study focuses on the development of a thermoacidophilic enzyme, resulting in an economically viable large-scale ethanol production. The *Crenarchaeote Sulfolobus solfataricus* (Sso) is an extreme thermoacidophile and its gene Sso1354 encodes the production of an endoglucanase that has the ability to hydrolyze wide range of oligosaccharides. In this project, it is proposed: to express the gene Sso354 in yeast *Saccharomyces cerevisiae* in a way that it would be able to produce and secrete large amounts of endoglucanase; and to combine this enzyme with LacS as a cocktail in order to obtain more fermentable sugars. Consequently, this practice would increase the ethanol production and allow the possibility of integrating hot acid biomass pretreatment with subsequent enzymatic saccharification.

Digestion of Corn Husks Using Ionic Liquid

Julia Kubisz*, Seth Clark, Anna Weber, and Rebecca DeVasher
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

My project focuses on the conversion of biomass waste into ethanol, an attractive fuel alternative to petrochemical resources. One of the most practical and attractive elements of this research is the apparent solution to the food versus fuel debate. Instead of using the corn itself, we use the husk of the corn instead as the biomass. This uses a material that would have been disposed of anyway. The corn husk contains cellulose and lignin polymers that can be broken down into monomeric units that are digestible by certain yeast strains. The digested, or broken down cellulose and lignin monomers, are then fermented to produce ethanol. Traditionally, harmful chemicals like nitric acid and hydrochloric acid have been used to digest the biopolymers in the corn husk. Ionic liquids represent an environmentally friendly alternative to harsh acids in the digestion process. The digestion is a microwave-assisted process, using the CEM Microwave system. Using the microwave reactor reduces the time of not only the traditional digestion, but the alternative digestion with the ionic liquids. Additional the ionic liquids can possibly be recycled unlike the strong acids, therefore making it a sustainable alternative.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

Development and Optimization of a Method for Producing Undenatured Type II Chicken Collagen and Hydrolyzed Chicken Collagen

Christopher Lippelt and Mark E. Brandt
Departments of Chemical Engineering and Chemistry & Molecular Biology, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Chicken collagen is believed by many to reduce or eliminate the pain associated with rheumatoid arthritis. While these statements have not been evaluated by the FDA, this has created a substantial market for both undenatured type II chicken collagen and hydrolyzed chicken collagen. However, some packaging companies have worries that collagen obtained from overseas producers is low in purity. Therefore, the scope of our work is to develop a method for producing high purity undenatured and hydrolyzed collagen and to maximize efficiency of said method. Our results are confirmed mainly using SDS-PAGE in addition to HPLC gel filtration and basic characterization such as solubility. The purified material appears to substantially free of major contaminants.

Quantification of Glycerol Monostearate through HPLC paired with ELS detector

Amanda Kelley* and Jared A. Tatum
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Glycerol monostearate is commonly used as an anti-static plastic additive within the polymer/plastic industry. The ability to quantify this additive enables better quality control analysis of consumer products. However the current quantification of glycerol monostearate (GMS) consisted of a mathematical derivation in which more than one peak average within the chromatogram was utilized causing more error to propagate within the derived value. Through use of a Waters Alliance 2695 HPLC device with Empower 3 software coupled with Waters C18 5μm column paired with a Waters 2424 ELS (evaporative light scattering) detector an instrument, processing, and quantification method for the additive was developed. By testing the instrument parameters, mobile-phase solvents and flow rates, and the maximum concentration that could be held within solution, standard curves consisting of multiple data points from resulting chromatograms were developed. Standards of GMS, pressed master batches samples, and films consisting of three different additives at varying concentration levels of GMS were produced in order to test the standard curves and the quantification method that it yielded. After the injections were processed by the method an ANOVA statistical analysis was conducted to ensure the validity of the results and the applicability of the process. The quantification method developed can accurately detect and quantify levels, on the ppm scale, of glycerol monostearate within various mediums produced by the industry.

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Large Hadron Collider beauty Particle Analysis

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The Standard Model of the atom is a fundamental part of modern physics and we are striving to learn more about it in order to unlock the mysteries of the physical world. The main topic of this Standard Model conversation is quarks. Quarks are the building blocks of everything that makes up this world, so it is important that we learn everything there is to know about them. The purpose of our research was to identify signal and background ranges of particle masses in high energy decays from the Large Hadron Collider beauty (LHCb) at European Laboratory for Particle Physics (CERN), to compare these masses to those recorded by the Particle Data Group (PDG) in order to confirm particle identification, and to search for evidence of unobserved particles. We studied Ω_b^- to J/Ψ Ω^-, Ω_b^- to Ξ^- D^0, and Ξ_b^0 to J/Ψ $\Xi^0(1530)$ decay channels by plotting particle properties such as momentum, probability of particle, lifetime, energy, mass, and invariant mass using 1D and 2D histograms. A Linux terminal and ROOT program to write code in C++ that enabled us to graph and manipulate the large amount of data we were given. We applied many cuts on variables such as decay time and mass, fit the peaks with a Gaussian fit, and compared the peaks to the mass values given by PDG. Our Ω_b^- mass was slightly different from that of LHCb's recent studies, and should be further explored. We searched for the Ξ_b^0 to J/Ψ Ξ^0 (1530) decay through invariant mass plots. The Ξ_b^0 particle is composed of an up quark, a down quark, and a bottom quark. The Ξ_b^0 particle has not been observed before, however evidence of it was found in our research. We determined the mass of the Ξ_b^0 particle to be 5786 MeV. The decay time was observed to be 1.474 ps. Additional research should be completed to confirm these measurements.

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Development of Lab-on-a-Chip Microfluidic Capillary Electro-chromatography Techniques

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Capillary chromatography and capillary electrophoresis, separately, are generally accepted as well understood separation techniques for analytical chemistry applications. Additionally, a "soda" sample mixture of benzoic acid, aspartame, and caffeine can be clearly and easily separated with either of these techniques. These two methods, when combined, form a capillary electrochromatography (CEC) system. This project investigates the best method of altering a standalone CE system, with the use a packed acrylic device and fused silica capillaries, to form this CEC system. The acrylic microfluidic devices were cut and etched using a CO_2 laser. The etched channel was packed with an octadecylsilane (ODS) stationary phase and sealed by low-temperature thermal bonding (~ 120° C) of an acrylic cover plate to the etched plate. The low temperatures required for sealing the channel with an acrylic cover plate do not damage the ODS stationary phase as evidenced by the ability to perform separations of several text mixtures. These CEC systems were tested by separating the components of a "soda" mix as well as a caffeine/ASA mixture. A CEC separation of a mixture of mononucleosides from a DNA digest was also attempted on this device. The results demonstrate that open-face acrylic microfluidic channels can be packed easily with ODS stationary phase without the need for high pressures and retaining frits.

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Antioxidant Mechanisms of Glutathione against Metal-Initiated Oxidative DNA Damage

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The main focus of this research project involves elucidating the mechanism of antioxidant sulfur compounds against metal-mediated oxidative DNA damage. Under oxidative stress conditions, such as in intercellular reactions involving hydrogen peroxide, metals such as Cu^{2+}, Cu^{+} and Fe^{2+} have been shown to increase the generation of site-specific base modifications through their formation of reactive oxygen species (ROS). The specific damage markers that have been measured via HPLC are the 8-hydroxy-2´-deoxyguanosine (8-OH-dG) and the dA-N^1-oxide markers. The current project deals with the reduced form of the sulfur antioxidant Glutathione (GSH) and its minimizing effects against ROS formation. Comparative studies with known radical-scavenging sulfur antioxidant Dimethyl Sulfoxide (DMSO) have also been performed. Future aspects of the project will include the measurement of the ROS formation using the fluorescent probe Dichlorofluorescein (DCF) for both GSH and DMSO. Oxidative damage of DNA strands has been strongly linked with the development of serious diseases, such as certain cancers, cystic fibrosis and Parkinson's, as well as aging. A better understanding of antioxidant mechanisms against oxidative DNA damage will eventually lead to the development of better therapeutics and treatment options against the aforementioned ailments and conditions in the future.

Evaluation of Acetabular Cup Deformation Using Digital Image Correlation

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Press-fit acetabular cups experience pinching between the ilial and ischial columns, which may result in significant rim deformation. In an attempt to provide a high stability and low wear option, mobile bearing hip systems have been recently introduced in the USA. There is no current published data documenting component deformation and implantation characteristics in these new cups designed specifically for mobile bearing total hip arthroplasty (THA). The purpose of this study was to analyze the insertion and deformation characteristics of a new generation of mobile bearing acetabular components. To assess the rim deformation of press-fit mobile bearing acetabular components, a foam deformation model for component pinching was used for the comparison of modular and one piece dual mobility cups. Solid polyurethane foam blocks with compressive zones and relief wells were used as the media for the implantation and deformation testing. The blocks had reamed centers of various diameters of one millimeter smaller, one millimeter larger and exactly reamed to the diameter of the acetabular cups. The largest cup tested in reaming one millimeter smaller than cup diameter, 64 mm, exhibited the most deformation in all of the categories and also was not fully seated in the reamed hole with the 10kN force. The lowest deformation was the smallest cup, 46 mm. Cup deformation was decreased in all cup sizes when blocks were over-reamed. Modular components exhibited lower deformation in both cup and liner than one-piece components following liner insertion.

Monitoring Road Health with Mobile Smartphones

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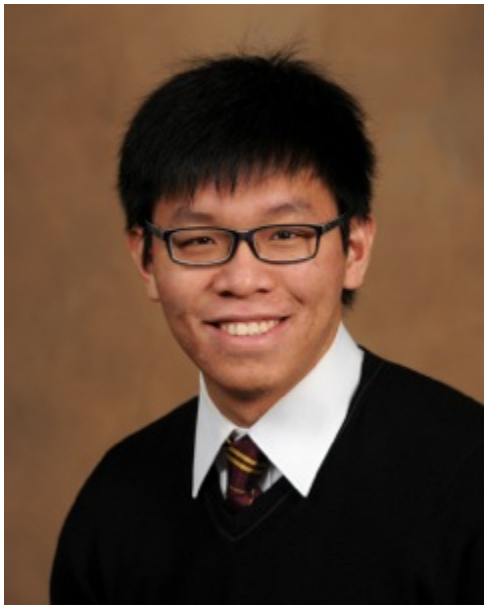
Every year, state highway agencies spend millions of dollars to monitor the condition of pavement structures. Much work has been done in order to provide an affordable system that continuously monitors the road network so that road surface damage can be detected as soon as it occurs. This study implements an innovative system process in which mobile phones are leveraged as road health monitoring sensors. The process utilizes the accelerometer within smartphones for motion sensing and GPS receiver for location sensing. Analysis is run on the compiled data to determine locations for potential road damage. This presentation will include a description of the application on iOS to collect the data, an example data set from Terre Haute, IN, and an evaluation of the system performance. The presentation will also include the development of a "reorienting" process for when the smartphone is disoriented.



Measuring the Binding Affinity of Estradiol to the Human Estrogen Receptor

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It has been established that the estrogen receptor protein plays a major role in the both the normal growth and development of breast cancer. Our purpose was to understand more of the interaction of the estrogen receptor by attempting to determine the binding of estradiol and other small molecules to the human estrogen receptor ligand binding domain (LBD).
Isothermal titration calorimetry, a sensitive technique for measuring molecular interactions, is one method for assaying binding interactions. The ITC is comprised of two cells: a sample cell and a reference cell. As a titration is performed the temperature in the sample cell will change based off whether the reaction is endothermic or exothermic. The instruments records the energy required to maintain the sample and reference cell at the same temperature. The experimental data consists of peaks where the injections happen and show the amount of energy needed to equilibrate the two cells. The ITC would be appropriate because it is one of the latest methods that is being used to measure the binding affinity of ligands for proteins. We used a TA Instruments Nano Isothermal Titration Calorimeter for our experiments.
We used the ITC to measure the heat changes when Estradiol was titrated into a 300uL sample of LBD. In our experiments, we encountered a significant level of denaturation and aggregation of the protein during the titration. This denaturation phenomenon interfered with our ability to obtain reproducible data. We intend to continue to evaluate methods for preventing denaturation and for generating interpretable binding data, in order to be able to evaluate the effects of other small molecule additives on the binding of estradiol to the estrogen receptor.

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Overview of Air Quality Regulations in South America

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In the US, the Environmental Protection Agency (EPA) established the National Ambient Air Quality Standards (NAAQS) selecting six pollutants as indicators: particulate matter, carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone and lead. The transportation growth and accelerated urban development in developing countries are a threat to air quality worldwide. In Latin America, most of the air quality regulations established are based on EPA regulations. Previous efforts to determine the state of ambient air quality regulations in Latin America have been performed but that information is limited and hard to access. Indoor air quality regulations are even more scant. The main objectives of this project are to:
1) Determine and compare outdoor air quality regulations existing in South America countries with those of the US EPA and WHO guidelines.
2) Identify indoor air quality studies and regulations from countries in South America and assess that information.
3) Discuss the quality of the information available and prepare recommendations.

Spectrally-resolved Imaging of the Transverse Modes in Multimode VCSELs

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Vertical-cavity surface-emitting lasers (VCSELs) enable a range of applications such as data transmission, trace sensing, atomic clocks, and optical mice. For many of these applications, the output power and beam quality are both critical (i.e. high output power with good beam quality is desired). Multi-mode VCSELs offer much higher power than single-mode devices, but this comes at the expense of lower beam quality. Directly observing the resolved mode structure of multi-mode VCSELs would enable engineers to better understand the underlying physics and help them to develop multi-mode devices with improved beam quality. In this work, a low-cost, high-resolution (<3 pm) Echelle grating spectrometer system is used to map the two-dimensional VCSEL near-field emission profile. In order to image the beam, the system magnifies and collimates it before the grating. The Echelle grating spectrally disperses the collimated VCSEL beam while in the Littrow configuration, and the system images with high magnification onto a CMOS camera. The narrow spectral content of each LP (linear polarization) mode allows direct observation of the modal content of the VCSEL with minimal modal overlap.

Keywords: multi-mode VCSEL, Echelle grating spectrometer, Littrow condition, LP mode

Reserve Capacity in New and Existing Low-Ductility Steel Braced Frames

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The study, Reserve Capacity in New and Existing Low-Ductility Steel Braced Frames, investigated how structural systems without seismic detailing and having an R = 3 value according to ASCE 7-10 Table 12.2-1 behave under seismic loading. The study looked specifically at how sources of reserve capacity affect an entire structural system in terms of collapse performance. Reserve capacity allows a structural system to deform plastically after one or many of its members become fully yielded. By better understanding how sources of reserve capacity affect the collapse performance of a structural system, such systems will be able to be designed for safer, more economical, and more efficient use.
For this study, two full scale, two-story low-ductility concentrically braced steel frames were constructed and tested in the Advanced Technology for Large Structural Systems (ATLSS) Laboratory at Lehigh University, one of the 14 laboratory facilities in the George E, Brown, Jr. Network for Earthquake Engineering Simulation (NEES). The test of the first, chevron configured frame took place from July 28 to July 31, 2014. The frame was subjected to horizontal quasi-static cyclic loading applied by two actuators. Critical areas of investigation included the beam-column connections, brace-gusset plate connections, and column bases. Data was obtained via strain gauges, inclinometers, LVDTs, and string potentiometers. The data obtained from the test is currently being processed. A hysteresis of Total Drift vs Base Shear has been processed showing buckling of the top story braces during testing. No conclusions have been made thus far.

Effects of Glutathione Disulfide in Site-Specific Metal-Mediated Oxidative DNA Damage

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The breakage and damage of DNA strands is strongly linked to the development of several serious diseases, including cancers, Parkinson's, AIDS, and cystic fibrosis. Under the right conditions, certain metals have been shown to cause formation of "reactive oxygen species", radical oxygen compounds that readily react with DNA to cause strand breakage, and modifications to individual bases. One antioxidant compound, glutathione, is known to act as a radical scavenger in cells. However, current studies suggest that glutathione (and its oxidized form, glutathione disulfide) may work by some additional mechanism when present in metal-mediated radical formation.
Oxidative reactions were performed with DNA in the presence of Cu^{+}, Cu^{2+}, and Fe^{2+} ions with and without glutathione disulfide. HPLC was to monitor the formation of 8-hydroxy-2´-deoxyguanosine (8-OH-dG), a site-specific marker that is a commonly accepted indicator of oxidative DNA damage. The amount of 2´-deoxyadenosine N-1 oxide (dA-N^1-oxide) formed was also measured as an indicator of whether DNA damage is occurring through a non-radical mechanism. The reactions were also performed in the presence of a fluorescent indicator, dihydrodichlorofluorescein diacetate (DCF-DA), as an additional method to explore the formation of radical oxygen species.

Homogenizing Biomass for Conversion of Ethanol by Fermentation

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With a focus in converting biomass into ethanol, corn husks were digested utilizing various methods. The corn husks themselves are composed of cellulose and several lignin polymers that were able to be broken down into monomers. These monomers were able to be fermented by several strains of yeast, both baker's and brewer's strains. An optimal pH range of 5.3-5.9 was determined for the fermentation process, according to literature standard. The amount of ethanol distilled after fermentation was determined by density and IR measurements. The variability in the amount of ethanol distilled from this conversion remains the subject of further research.

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