Summer 2014

Undergraduate Research Poster Symposium

at Washington State University

10 a.m. to 1 p.m., Friday Aug. 1, 2014
Smith CUE Atrium, 2nd Floor

Hosted by the Office of Undergraduate Research. Featuring more than 60 students from WSU and 36 other universities and colleges working with faculty on...

- Plant genomics
- Advanced materials
- Renewable resources/biofuels
- Climate change
- Materials under extreme conditions
- Plant metabolism
- Multi-scale engineering
- Computer systems design

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Washington State University

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Welcome to the WSU Summer 2014 Undergraduate Research Poster Symposium!

This summer Washington State University has been honored to host students from around the world involved in research in various programs across campus. We had **five** Research Experience for Undergraduates (REU) programs funded by the National Science Foundation (NSF), one program funded by the United States Department of Agriculture (USDA), and others supported by private grants and funding. Student participants in these programs represent a wide range of majors, and join us from schools ranging from small colleges that only offer undergraduate degrees to large Tier 1 research universities. More than 55 students from 38 institutions are participating in this August 1st poster event; one fifth of them are from WSU.

The wide range of research done by these students fits the model of undergraduate research: the students take ownership of their projects, which are mentored, unique, and appropriate to the discipline in which they work. Their work is being disseminated at today's symposium. It is quite possible that peer-reviewed journal articles and presentations to national audiences will follow for some.

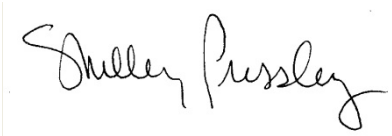
Below is a list of program directors and advisors whose students are showing their work in diverse disciplines. They are:

Amit Dhingra, Plant Genomics and Biotechnology REU
David Field, Materials Science and Engineering REU
Konstantin Matveev and **Cill Richards**, Mechanical Engineering REU
Partha Pande and **Behrooz Shirazi**, Electrical Engineering and Computer Science REU
Shelley Pressley and **Jennifer LeBeau**, Atmospheric Chemistry REU
Michael Wolcott and **Shelley Pressley**, Northwest Advanced Renewables Alliance, USDA
Y.M. Gupta, Institute for Shock Physics Summer Undergraduate Research Experience

Other faculty also work with and mentor undergraduate students in areas including biochemistry, chemical engineering, chemistry, and entomology.

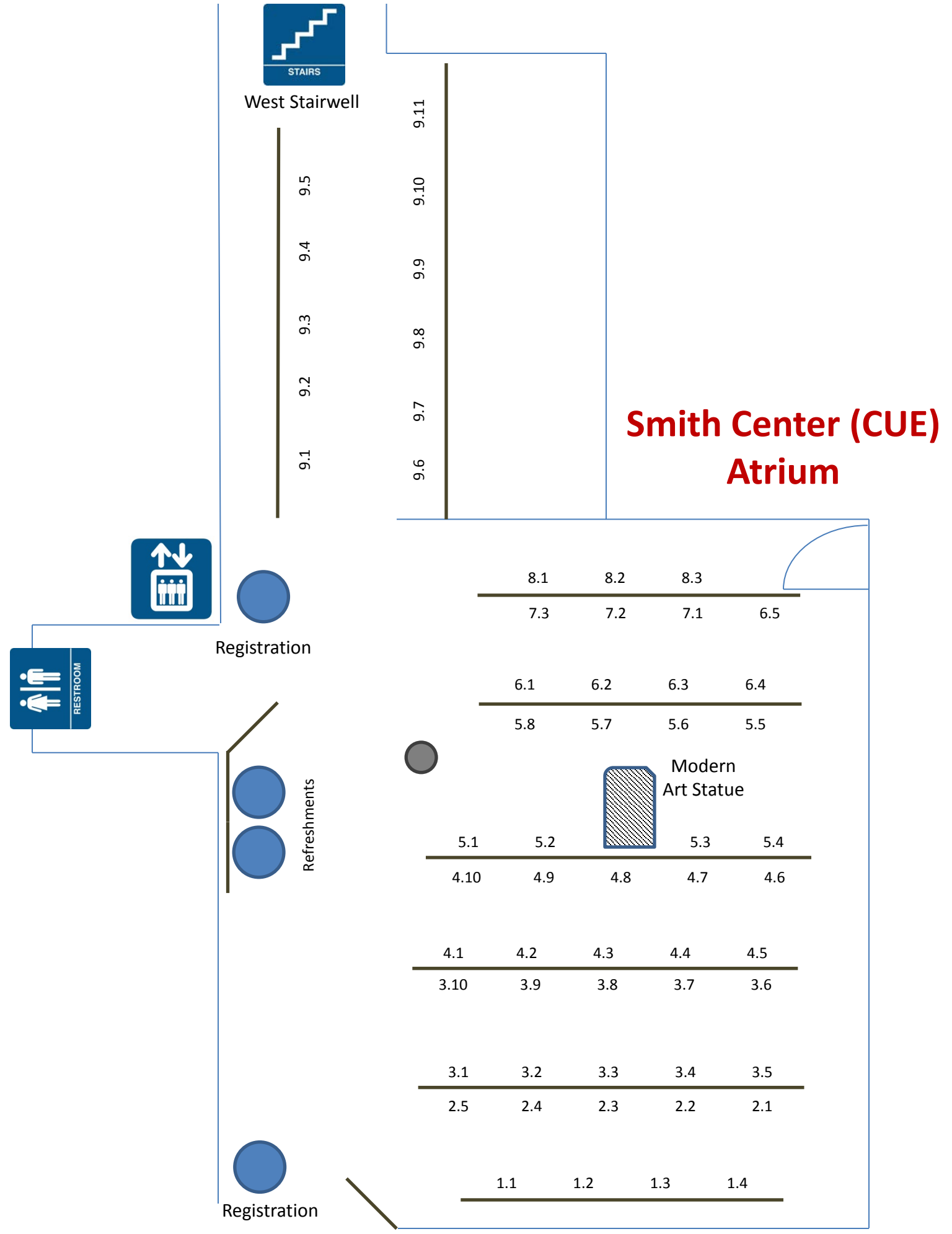
The students' work, of course, would not be possible without faculty advisors participating in the programs, supervising students, and integrating them into their research groups, plus all the staff, graduate students, and other researchers on campus who have fully embraced working with these students. I would also like to note that, in addition to the financial support of the NSF and USDA, the students and programs have had financial support from various departments (and their colleges), and the Office of Undergraduate Research. **In total, more than $300,000 of federal grant money was brought to WSU to support these fine young researchers.**

I hope you enjoy the poster symposium. This abstract book will be online at our website, UndergraduateResearch.wsu.edu.



Shelley Pressley, Ph.D.
Director, Undergraduate Research
Assistant Research Professor, Laboratory for Atmospheric Research, College of Engineering and Architecture

Smith Center (CUE) Atrium



Presenters by Group and Location

Group 1: Institute for Shock Physics (Summer Undergraduate Research Experience)			
Sec.	**Poster Title**	**Author**	**Advisor**
1.1	Experimental Characterization and Numerical Modeling of the Carbon Nanofiber Reinforced High Density Polyethylene under Dynamic Loading	Nathan Briggs	Jow Ding
1.2	Using Laser Interferometry to Measure the Shock Wave Response of 1050 Aluminum	David Mildebrath	Yoshi Toyoda, Y.M. Gupta
1.3	Infrared Spectroscopy of Selenium Dioxide and Mineral Oil under Pressure	Sonal Nanda	Matt McCluskey
1.4	High Pressure Stability of Para-Nitroaniline: Role of Hydrogen Bonding	Paul Somers	Zbigniew Dreger

Group 2: Characterization of Advanced Materials (REU in Materials Science and Engineering)			
Sec.	**Poster Title**	**Author**	**Advisor**
2.1	Carbon Nanotube Growth Through Modification of Catalyst and Heat Treatment Process Parameters	Denise Blohowiak	David Field
2.2	Cryogenic tensile and compressive properties of 3D-printed plastics	Paloma Cruz	Jacob Leachman
2.3	Characterization of Cracks in two Brittle Materials using Nanoindentation	Austin Hurd	Amy Wo
2.4	Determination of chromium behavior in simulated nuclear waste glass	Pablo Moreno	John McCloy
2.5	Photoconductivity of Ionically Self-Assembled Organic Nanorods	Naomi Rosenkranz	K. W. Hipps, Ursula Mazur

Group 3: Introduction to Multiscale Engineering (REU in Mechanical Engineering)			
Sec.	**Poster Title**	**Author**	**Advisor**
3.1	Process development for fabricating polymer biconvex parabolic lenses	Jessica Birmingham	Lei Li
3.2	Venturi Experiment	Christian Carlos	Robert Richards
3.3	Complexity of Assembly/disassembly	Juan Diaz	Gaurav Ameta
3.4	Prototype Design of a Type IV Hydrogen Pressure Vessel with Vapor Cooled Shielding	Gina Georgadarellis	Jacob Leachman
3.5	Electrochemical Stability of Potential Ionic Liquid Electrolytes for Lithium Batteries	Johnathan Gilvey	Soumik Banerjee
3.6	Molecular Simulation of Lipoplex Assembly in a Nano-Droplet	Andrew Gloor	Jin Liu
3.7	The Investigation of Fuel Effects on the Performance and Emissions of a Micro-gasifier Stove	Mariana Perez-Lozano	Cill Richards

3.8	Development of a Remotely Controlled Testing Platform with Low-Drag Air-Ventilated Hull	Nicholaus Perry	Konstantin Matveev
3.9	Particle Size-Based Separation Using DC Dielectrophoresis	Courtney Rouse	Prashanta Dutta
3.10	Micro Gasefiers- Effects of Fuel Type Variation With Respect to Emissions and Efficiency	Josh Steele	Cill Richards

Group 4: New-Generation Power-Efficient Computer Systems Design (REU in Electrical Engineering and Computer Science)			
Sec.	**Poster Title**	**Author**	**Advisor**
4.1	Performance and Power efficient multi-core computation	John Bell	Partha Pande, Behrooz Shirazi
4.2	Evaluation of Rail Voltage Variation on Power Efficiency and Operating Frequency in a FinFET SRAM Cell *(Partners with Trokon Johnson)*	Kristofer Henderson	Jose Delgado-Frias
4.3	Evaluation of Rail Voltage Variation on Power Efficiency and Operating Frequency in a FinFET SRAM Cell *(Partners with Kristofer Henderson)*	Trokon Johnson	Jose Delgado-Frias
4.4	New-generation Power-efficient Computer Systems	Abner Molina	Partha Pande, Behrooz Shirazi
4.5	Optimizing LDO DC-DC Voltage Regulators in 65nm CMOS Technology	Mackenzie Neavor	Deuk Heo
4.6	DVFS and Windowing: Improving the Power Efficiency of Computer Systems	Nicholas Paco	Partha Pande, Behrooz Shirazi
4.7	Develop suitable on-chip voltage regulator as an enabling technology to implement dynamic voltage and frequency scaling (DVFS)	Armin Rahimi	Behrooz Shirazi, Partha Pande
4.8	Analog Circuit Design for Time-Reversal-Division-Multiple-Access Impulse Response Recording	Noel Wang	Benjamin Belzer
4.9	Pulse Shaping Filters for Wireless Communications in Networks on Chip	Evan Wright	Benjamin Belzer
4.10	An Integrated DC-DC Converter in 65nm CMOS	Joshua Zoellick	Deuk Heo

Group 5: Plant Genomics and Biotechnology (REU in Horticulture)			
Sec.	**Poster Title**	**Author**	**Advisor**
5.1	Time-Course Analysis of Genetic Components in Sweet Cherry Fruit-Pedicel Abscission Following Ethylene Treatment	Jonathan Abarca	Amit Dhingra
5.2	Determining sources of genetic resistance to fire blight in apple	Haley Allen	Kate Evans
5.3	Impact of Overhead and Drip Irrigation and Chlorine Dioxide Treatment on Food Safety Indicator Organisms in an Organic Farming System	Isabel Cueva	Karen Killinger
5.4	Seeds to Fuel the Future	Destin Holland	Amit Dhingra

5.5	Screening for Puccinia graminis suppressors of Hypersensitive Response in Tobacco	Andrea Mathis	Scot Hulbert
5.6	Prevalence of ACCase and ALS target-site mutations in PNW Herbicide-resistant Lolium multiflorum	Jeanette Rodriguez	Ian Burke
5.7	Heteromorphic Self-incompability in Primula: Molecular analysis of Pin	Kelli Russell	Andrew McCubbin
5.8	Netting reduces physiological stress in 'Granny Smith' apples	Olivia Schertz	Lee Kalcsits

Group 6: Northwest Advanced Renewables Alliance – NARA (Summer Undergraduate Research Experience)			
Sec.	**Poster Title**	**Author**	**Advisor**
6.1	Mechanistic kinetics study of biomass derived inhibitory compounds on cellulase hydrolysis of biomass substrate	Cassandra Sanders	Xiao Zhang
6.2	Lignin residue as Wood Pellet Binder and Energy Enhancer for Energy Applications	Rodney Seals	Jinwu Wang
6.3	Spatial Distribution of Grain Sizes in Sampling Heterogeneous Stream Beds	Eric Sorensen	John Petrie
6.4	Potential Technological Pathways for the Production of Alternative Jet Fuel	Preenaa Venugopal	Paul M. Smith
6.5	Ball Milling: Effective Pretreatment Leading to A Clean Biomass to Cellulosic Sugar Conversion	Eileen Wu	Michael Wolcott, Jinwu Wang

Group 7: Harnessing Plant Metabolism for Society – Institute of Biological Chemistry			
Sec.	**Poster Title**	**Author**	**Advisor**
7.1	Expression of Formate-tetrahydrofolate Ligase From Arabidopsis Plants in Yeast	Parker Scott	Sanja Roje
7.2	Combating Pollution from Overfertilization: An Analysis of AtCHH6 Hydrolase in Pi Metabolism	Natasha Sioda	Sanja Roje
7.3	Effects of Abiotic Stress Conditions on Arabidopsis HAD Mutants	Alyssa Thomas	Sanja Roje

Group 8: Chemical Engineering, Chemistry, and Entomology (Other WSU Projects)			
Sec.	**Poster Title**	**Author**	**Advisor**
8.1	Segregation and Carbon Monoxide Induced Anti-Segregation of a Cu/Co(0001) Catalyst: A DFT Study	Greg Collinge	Jean-Sabin McEwen
8.2	The Effects of Juvenile Hormone and Ecdysone on the Rhinoceros Beetle’s Head Horn	Aurora Kraus	Laura Lavine
8.3	STM Study of Temperature Dependent Adsorption/Desorption Kinetics of Cobalt(II) Octaethylporphyrin and Octaethylporphyrin on Phenyloctane/Au(111) Interface	Kevin Marchbanks-Owens	K. W. Hipps

Group 9: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest (REU in Laboratory for Atmospheric Research / Civil and Environmental Engineering)			
Sec.	**Poster Title**	**Author**	**Advisor**
9.1	The influence of NAO on the near-surface meteorology at Summit, Greenland	Brooke Adams	Von Walden
9.2	NO+ as a PTR-MS Reagent Ion: Improving the detection of long chain alkane molecules	Randy Bartoshevich	Tom Jobson
9.3	Comparing air quality models with observed isoprene emissions to improve air quality forecasting	Dylan Curtis	Alex Gunther
9.4	Analysis of eddy-covariance measurements of the surface energy budget in complex sagebrush terrain	Raleigh Grysko	Heping Liu
9.5	Measurements of Isoprene fluxes at University of Michigan Biological Station during summer	Jinyanzi Luo	Shelley Pressley, Brian Lamb, Tim VanReken
9.6	El Niño and Seasonal Forecasting: Does a Global Climatic Event Impact Accuracy of Climate Models?	Taylor Scott Mandelbaum	Von Walden
9.7	Evaporation and Surface Energy Balance Over a Large Reservoir	Devin Marcy	Heping Liu
9.8	The design and characterization of a chamber to investigate the impacts of TiO2 as an air quality mitigation strategy under ambient conditions	Rebecca McLean	Tom Jobson
9.9	Assessment of Residential Methane Emissions from Natural Gas Usage	Kevin Montalvo	Brian Lamb, Shelley Pressley
9.10	Assessing the Impact of Climate Change on Indoor Air Quality Using CONTAM Software	Colby Sameshima	Brian Lamb, Shelley Pressley Von Walden
9.11	Diesel Exhaust: Flow Tube Experiment	Justin Singleton	Tom Jobson

Group 1: Institute for Shock Physics (Summer Undergraduate Research Experience)

1.1	**Experimental Characterization and Numerical Modeling of the Carbon Nanofiber Reinforced High Density Polyethylene under Dynamic Loading**	1.1

Undergraduate Researcher: Nathan Briggs

Faculty Advisor: Jow Ding

Other Collaborators: Yueqi Hu, Yuanyuan Liu

Home Institution: University of Utah, Mechanical Engineering, Junior

Abstract:

High Density Polyethylene (HDPE) is a widely used material in many applications due to its relatively high strength, light weight and low cost. Carbon Nanofibers (CNFs) and Graphite Nanoplates (GNPs) and their combination present a potentially inexpensive way to improve the strength of HDPE without significant impact on the weight. Using the Split Hopkinson Pressure Bar (SHPB) we investigated and compared the tensile and compressive response of the pure HDPE and its nanocomposites. The composites were reinforced with 0.1 wt%, 0.2 wt%, 0.3 wt% and 0.5 wt% CNF/GNP. All the materials were tested under strain rates of 1000/s, 2000/s and 4000/s. Besides mechanical experiments, Scanning Electron Microscope (SEM) study was also used to gather some physical evidences on the deformation and fracture mechanisms at the microstructural level. To gain insights on the experimentally observed material behavior, numerical simulation using finite element method (FEM) was also conducted. A viscoelastic model was assumed for the HDPE matrix material, and the cohesive zone element was used to numerically investigate the effect of nano-sized reinforcements and their interface with the matrix material on the overall response of the composites.

1.2 Using Laser Interferometry to Measure the Shock Wave Response of 1050 Aluminum 1.2

Undergraduate Researcher: David Mildebrath
Faculty Advisor: Yoshi Toyoda, Y.M. Gupta
Other Collaborators: Celia Faiola and Miao Wen
Home Institution: The University of Alabama, Physics and Mathematics, Junior

Abstract:

Because 1050 aluminum is commonly used as an impactor and as a buffer in shock wave experiments, knowing its shock wave response accurately is useful. To this end, laser interferometry was used to measure wave profiles of propagating shock waves in 1050 aluminum. In laser interferometry, light reflected off the back of the sample undergoes a Doppler shift due to the back surface motion. This Doppler-shifted light is split into two beams. One beam is delayed by a short time relative to the other, and the beams are recombined into one. The difference in optical phase between the two beams is measured, from which the velocity of the back surface of the target is determined. In these experiments, a disc of 1050 aluminum was impacted on another disc of 1050 aluminum, and laser interferometry was used to monitor the back surface motion of the target. The measured velocity agreed with the independently measured impact velocity as predicted by momentum conservation, and also provided the shock wave structure. Similar experiments will be conducted with other 1050 aluminum samples at different impact velocities to determine the shock wave structure at different stresses.

1.3 Infrared Spectroscopy of Selenium Dioxide and Mineral Oil under Pressure 1.3

Undergraduate Researcher: Sonal Nanda
Faculty Advisor: Matt McCluskey
Other Collaborators: Anya Rasmussen, Caleb Corolewski
Home Institution: Carnegie Mellon University, Physics, Senior

Abstract:

Previous studies, using synchrotron radiation, indicated a phase change of selenium dioxide may occur around 0.5 GPa. We investigated selenium dioxide and mineral oil with Fourier transform infrared spectroscopy (FTIR) in order to explore the proposed phase change of selenium dioxide and the effect of pressure on mineral oil. Pressure was applied with a diamond anvil cell (DAC), ranging from 0.1 GPa to 8.0 GPa. Ruby microspheres were included in the DAC for calibrating the pressure. Sample preparation played a role in the FTIR spectra of selenium dioxide. Changes may have occurred due to exposure to the FTIR vacuum chamber or heat, affecting the color of the selenium dioxide and the IR transmission. Two major absorption peaks from mineral oil were observed in the frequency range of 4200-4500 cm-1. These peaks were found to linearly increase in frequency with respect to pressure.

1.4	**High Pressure Stability of Para-Nitroaniline: Role of Hydrogen Bonding**	1.4

Undergraduate Researcher: Paul Somers

Faculty Advisor: Zbigniew Dreger

Other Collaborators: Yuchuan Tao

Home Institution: Missouri University of Science and Technology, Physics, Senior

Abstract:

Hydrogen bonding plays an important role in stabilizing the structure of crystals and therefore determines their properties. Because the strength of hydrogen bonding depends on the distance between donor and acceptor, pressure is a very useful tool for controlling and changing the behavior of hydrogen bonding. The objective of this project is to further understand the role of hydrogen bonding in stability of a crystal structure by examining the effects of high pressure on behavior of hydrogen bonding in molecular crystals of para-nitroaniline (PNA). PNA is an organic crystal known for its attractive nonlinear optical properties and its tendency to polymerize under certain conditions. At ambient conditions, PNA crystallizes in a monoclinic structure in which each molecule is connected via four hydrogen bonds with four adjacent molecules. This arrangement leads to the formation of parallel layers bonded with Van der Waals forces. In this work, the changes in inter- and intra-molecular bonds of PNA are examined with high pressure vibrational spectroscopy (Raman and FT-IR). Experiments are performed on single crystals in a diamond anvil cell under pressures as high as 20 GPa. Hydrostatic pressures are generated by cryogenically loaded nitrogen. In particular, in these studies we will focus on: (1) determination of molecular and crystal changes under pressure in order to examine stability of the ambient structure, (2) monitoring hydrogen bonding through examination of stretching N-H vibrational modes, (3) determination of reversibility of pressure induced changes to gain insight into chemical stability, and (4) addressing the previous suggestion of a phase transition at 4.0 GPa.

Group 2: Characterization of Advanced Materials (REU in Materials Science and Engineering)

2.1	**Carbon Nanotube Growth Through Modification of Catalyst and Heat Treatment Process Parameters**	2.1

Undergraduate Researcher: Denise Blohowiak

Faculty Advisor: David Field

Other Collaborators: Joshah Jennings

Home Institution: Washington State University, Materials Science and Engineering, Junior

Abstract:

Inclusion of nanotechnology into structural materials is an area that has been increasing in interest as a mechanism for strengthening materials. The incorporation of carbon nanotubes (CNTs) into structural materials is of particular interest because of their unique properties and potential for applications from composites to electronics. This project looks at methods to achieve controlled carbon nanotube growth. The first method uses physical vapor deposition, or sputtering, to deposit thin films of iron and carbon onto silicon wafers in order to create the catalyst particles that are needed to achieve the growth of the carbon nanotubes. Once a uniform film has been deposited, the wafers are then annealed at high temperature to create "islands" of iron particles, which are the nucleating sites from which the carbon nanotubes grow. At this point, the wafers with the iron particle islands are placed in a heat treatment chamber under an inert argon atmosphere where the wafers are heat treated for the optimal period of time for carbon nanotube growth. The argon atmosphere is used to prevent oxidation of the iron. An alternative approach for nanotube growth is being assessed where the nanotubes are grown from a sol-gel layer spin-coated onto the silicon wafers to create a thin catalyst layer on the surface. Carbon is subsequently sputtered onto the sol-gel coated silicon wafers and the same chemical vapor deposition process takes place to achieve the growth of the nanotubes. In this project, uniform methods for deposition of the thin film coatings, catalyst particles, and subsequent carbon nanotubes are: 1) defined by parameters including physical vapor deposition rate, catalyst particle, and CNT growth rate, and 2) characterized using analytical tools including Scanning Electron Microscopy (SEM) and Zygo Profilometer.

2.2	**Cryogenic tensile and compressive properties of 3D-printed plastics**	2.2

Undergraduate Researcher: Paloma Cruz

Faculty Advisor: Jacob Leachman

Other Collaborators: Patrick Adam

Home Institution: Gonzaga University, Mechanical Engineering, Senior

Abstract:

The rapid emergence of 3-D printing many engineering-grade plastics is opening new frontiers in cryogenic engineering. However, plastics exhibit unique responses such as creep to thermo-mechanical loading and negligible yielding at cryogenic temperatures, so considerations of cryogenic mechanical and physical properties are essential in dictating design limitations. FDM-printed polyetherimide (PEI) and polyamide (nylon) specimen are used to standardize and study a process to characterize the thermal and print orientation effects on the coefficient of thermal expansion (CTE), tensile strength, compressive strength, and strain rates in liquid nitrogen (77K). The results of these tests are anticipated to directly contribute to the design of next-generation cryogenic dewars and fuel tanks.

2.3	**Characterization of Cracks in two Brittle Materials using Nanoindentation**	2.3

Undergraduate Researcher: Austin Wade Hurd

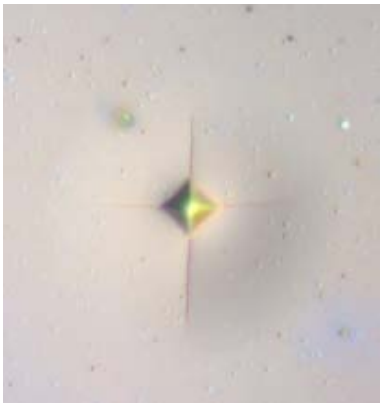
Faculty Advisor: Amy Wo

Home Institution: University of Idaho, Applied Physics, Junior

Abstract:

Brittle materials exhibit high hardness values but low toughness values. Due to low toughness, brittle materials undergo little plastic deformation and primarily deform via fast propagating cracks. Because the majority of deformation for brittle materials happens by the way of cracks, it is important to understand how the cracks propagate through the material. In this study, cracks in Al_2O_3/Mo multilayer thin film and Zircaloy-4 were investigated using nanoindentation.

Studies of thin films have shown multilayer thin films of hard materials alternate with ductile materials improve the overall toughness with a small compromise of hardness. A multilayer interface of hard aluminum oxide and ductile molybdenum was created to analyze the crack propagation of such a composite for potential applications.



An optical image of a 50 g Vicker's indent on multilayer Al_2O_3/Mo thin film

Zircaloy-4 exhibits a hexagonal close-packed (HCP) crystal structure. The low symmetry of the crystal leads to complex deformation mechanisms, including crack formation and propagations. These deformation mechanisms in HCP crystals are not clearly understood. Zircaloy-4 has been utilized as nuclear fuel rod cladding, so it is important to gain better understanding on criteria for cracks formation and propagation.

In this study, micro-cracks and plastic deformation were created by micro-hardness testing. Nanoindentation was performed around these micro-cracks to characterize the local micrometer sized volume hardness and reduced modulus. The results are anticipated to shed light on the cracks propagation mechanism in these brittle materials.

2.4	**Determination of chromium behavior in simulated nuclear waste glass**	2.4

Undergraduate Researcher: Pablo Moreno

Faculty Advisor: John McCloy

Other Collaborators: Jose Marcial

Home Institution: San Jose State University, Materials Science and Engineering, Junior

Abstract:

In the vitrification process, nuclear waste is combined with glass-forming additives and converted to glass. Glass serves as a good storage material for nuclear waste due to its mechanical and chemical durability. After conversion, nuclear waste glass will be poured into a stainless steel canister and stored in a long-term geological repository to prevent contamination with the surrounding environment. However, over hundreds to thousands of years, the metal canisters will corrode and aqueous solutions rich in iron, chromium, or nickel solute will come into contact with the waste glass and may alter the glass dissolution behavior. It is critical to understand the near field effects on the waste storage glass as the surroundings tend to influence the corrosion behavior of the glass. Ultimately, the effects of chromium on glass durabilityare not well understood. Therefore, it is of interest to characterize a standard glass composition doped with chromium (III) oxide. This study focused on the incorporation of chromium in international simple glass (ISG), with composition SiO2-B2O3-Na2O-Al2O3-CaO-ZrO2, using the characterization techniques of X-Ray Diffraction (XRD), Optical Microscopy (OM), and Ultraviolet/Visible Absorption Spectroscopy (UV-Vis).Glasses were prepared by melting batches at 1300-1500^{o}C, air quenching, and annealing at 450^{o}C or 500^{o}C. Samples containing 1,2, and 5 wt% Cr2O3 were prepared in a Pt-Rh crucible while an additional 2 wt% Cr2O3-ISG sample was prepared in a fire clay crucible to test of the effects of crucible composition. XRD analysis showed the 5 wt% Cr2O3-ISG exhibited significant crystallization of eskolaite (Cr2O3). Preliminary UV-Vis data suggested that Cr concentration and crucible choice influences the Cr3+/Cr6+ ratio in this glass. Ultimately, samples similar to these will be used in glass corrosion experiments to study the effect of Cr on dissolution rate, secondary alteration phases, and other aspects of glass chemical durability.

2.5	**Photoconductivity of Ionically Self-Assembled Organic Nanorods**	2.5

Undergraduate Researcher: Naomi Rosenkranz

Faculty Advisor: K. W. Hipps, Ursula Mazur

Other Collaborators: Bryan C. Borders, Jeremy R. Eskelsen

Home Institution: Barnard College, Physics, Senior

Abstract:

The photoconductive properties of ionically self-assembled binary porphyrin nanorods of meso-tetra(4-pyridyl)porphyrin (TPyP) and meso-tetra(sulfonatophenyl)porphyrin (TSPP) have great potential for various optoelectronic and sensor applications. Upon illumination, the nanorods exhibit time- and temperature-dependent conductive behavior, and the photoconductivity decays with time once the illumination is terminated. This persistent photocurrent decay of the TSPP:TPyP nanorods occurs with either a 405 nm or 633 nm laser irradiation and can be modeled using the Kohlrausch (stretched exponential) function. Temperature-dependent determination of the Kohlrausch parameters provides insight into the electron transport process and can be related to the structure of these nanorods. Furthermore, the type of charge carrier (electron or hole) can be determined by observing the effect of an applied gate voltage on the conductivity of the nanorods.

Group 3: Introduction to Multiscale Engineering (REU in Mechanical Engineering)

3.1	**Process development for fabricating polymer biconvex parabolic lenses**	3.1

Undergraduate Researcher: Jessica Birmingham

Faculty Advisor: Lei Li

Other Collaborators: Rongrong Sun

Home Institution: Gonzaga University, Mechanical Engineering, Sophomore

Abstract:

Micro lenses have a variety of applications such as optical sensors, displays, and cameras. They are more cost-effective and compact than conventional lenses. Micro lenses have been manufactured using molding, photolithography, or laser cutting, which are costly and limit lens shape. Our project has been to find ways of manufacturing biconvex micro lenses that will be cost effective and produce lenses comparable in quality to conventional lenses. In the past our team has based our study on a method called partial wetting which uses the interactions between gravity, surface tension, and buoyancy to create a biconvex lens from a polymer droplet on the surface of water.

In this project, we investigated the partial wetting process and also worked on developing new methods to improve the quality of the fabricated lenses. Our team looked into how the lenses' shape is influenced by conditions such as the height from which the droplet falls and the surface tension of the solution on which the droplets are formed. Through this process study, we have established a relationship between the process parameters and the shape of the lenses. This relationship can be used to optimize the manufacturing process and also help to establish a theoretical model. We also attempted to develop a new process to control refractive index distribution inside a lens for better imaging quality. Changing variables such as the diffusion time and the solvent in which the lenses diffuse will influence the final quality of the lenses and the refractive index at various points throughout each lens. By better understanding the manufacturing process and the effects of these parameters, we are determining how best to create lenses, which we can control the shape, refractive index, and surface texture of, all of which greatly impact the imaging quality of the lenses.

3.2	**Venturi Experiment**	3.2

Undergraduate Researcher: Christian Carlos
Faculty Advisor: Robert Richards
Other Collaborators: Shamus Meng
Home Institution: Washington State University, Mechanical Engineering, Sophomore

Abstract:

Our work involves developing a Venturi nozzle to help students learn fluid mechanics. The Venturi nozzle should enable students to understand the fundamentals of fluid mechanics, in particular to understand concepts of Conservation of Mass and Energy. As a fluid like water or air flows through a pipe, the Mass and Energy of the fluid remains constant. If the pipe diameter does not change, this means that the fluid's velocity also does not change. However, if the pipe does change in diameter, the velocity of the fluid will change. For a student, the questions to answer are: "What exactly changes?" and "How can we determine the changes?" With the Venturi nozzle we are developing, students should be able to use Bernoulli's equation to calculate the flow rate, pressure difference, velocity, and head loss. The goal for our work is to create an inexpensive Venturi nozzle so they can understand what is happening to the fluid within the nozzle, and apply Bernoulli's equation to solve for the velocity , pressure differences and head loss of the Venturi pipe. Solving problems like this is expected to help students gain knowledge of an experimental methods and using Conservation of Mass, and Energy.

3.3	**Complexity of Assembly/disassembly**	3.3

Undergraduate Researcher: Juan Diaz
Faculty Advisor: Gaurav Ameta
Other Collaborators: Yang Hu
Home Institution: Washington State University, Mechanical Engineering, Junior

Abstract:

The purpose of this study was to develop a grading scale that will alleviate the process of assembly and disassembly for a given part in three projects that were explored. This grading scale, which is still in its early stage, will note the most difficult and time consuming part for assembly and disassembly. To get to this process, we explored the complexity of assembly and disassembly in three projects: a toy monkey, a yellow toy, and a printer tray. Two methods were used to calculate the assembly time: Boothroyd and Dewhurst's assembly chart (1980) and Mathieson, Wallace, and Summer's (2012) formula. The methods were carried out separately for the three projects. We compared the results of both processes and concluded that they have a similar assembly time. A modeling chart was made for each of the products, which show the relationship between parts. These model charts were used to figure out the number of parts connecting to other parts of each of the projects. In addition, they were used to examine the difficulty and time that each part took to assemble. Upon the completion of this grading scale, manufacturers interested in using parts from these three products could use the results of this study to have an idea of how long it would take to assemble and/or disassemble some of the parts used here.

3.4	**Prototype Design of a Type IV Hydrogen Pressure Vessel with Vapor Cooled Shielding**	3.4

Undergraduate Researcher: Gina Georgadarellis

Faculty Advisor: Jacob Leachman

Other Collaborators: Patrick Adam

Home Institution: University of Massachusetts Amherst, Mechanical Engineering, Junior

Abstract:

The utilization of hydrogen as a fuel source requires solving the issue of containment. Hydrogen stores 2.8 times more energy per weight than gasoline but more than three times as much volume is typically required, making it difficult for gasoline-powered vehicles to convert to hydrogen power. To resolve this issue, hydrogen can be liquefied to increase the density to four times that of room temperature gas at 700 bar (10,000 psi). The new issue created with the use of liquid hydrogen is the low temperature (-431°F, 21 K) needed for hydrogen to maintain the liquid state. A Type IV pressure vessel made of polymeric liner and wrapped in a fiber-resin composite may be used to meet such requirements. Our goal is to develop prototype designs of a Type IV hydrogen pressure vessel with vapor cooled shielding that contains liquid hydrogen while withstanding the cryogenic temperatures associated with it. Two steps are required in order to validate this concept: an iterative design process using SolidWorks 3D CAD software and a testing process of prototypes printed with the uPrint SE by Stratasys. Prototypes composed of ABSplus and lined with polystyrene are tested using liquid nitrogen and their boil off mass flow rate calculated. The additional use of Mylar as an insulation is also tested. Based on the performance of the prototypes, the concept of our Type IV pressure vessel was successful in comparison to single shelled Type IV pressure vessels and has the potential to be scaled for commercial development.

3.5	**Electrochemical Stability of Potential Ionic Liquid Electrolytes for Lithium Batteries**	3.5

Undergraduate Researcher: Jonathan Gilvey

Faculty Advisor: Soumik Banerjee

Home Institution: Washington State University, Mechanical Engineering, Senior

Abstract:

Ionic liquids have excellent potential for use as electrolytes in advanced lithium batteries due to their tunable electrochemical properties. Ionic liquids have extremely low vapor pressure, which makes them practically non-inflammable leading to safe operation of the batteries. However, enhanced cyclic performance of lithium batteries require that ionic liquid electrolytes are stable towards oxidation and reduction when exposed to a large enough electric potential. Such reactions lead to the formation of free radicals in the electrolyte solution and deterioration of the electrolyte, accompanied with significant reduction in performance over repeated charge-discharge cycles. Therefore, the electrical stability windows of potential ionic liquid electrolytes need to be evaluated in order to select the most suitable electrolyte. Ab initio quantum mechanical calculations provide a cost effective means to determine the electrical stability windows as to screen from a large variety of species of ionic liquids. In this project we employed density functional theory to investigate the electrochemical stability of ionic liquids based on the pyrrolidinium cation. We investigated the effect of the length of side alkyl chains on the electrochemical stability with respect to lithium. The electrochemical stability window was determined using relevant free-energy cycle which traces changes in free-energy between molecular species. The results from this study provide a better understanding of how molecular structure of the ionic liquid affects their electrochemical stability.

3.6	**Molecular Simulation of Lipoplex Assembly in a Nano-Droplet**	3.6

Undergraduate Researcher: Andrew Gloor

Faculty Advisor: Jin Liu

Other Collaborators: Yead Jewel

Home Institution: University of Colorado, Mechanical Engineering, Senior

Abstract:

Lipoplex nanoparticles have shown extraordinary properties and enormous potential for biomedical applications. However, conventional methods for producing these particles, such as bulk mixing, are problematic in controlling particle quality and uniformity. It has been found that electrospray methods can be used to produce a much narrower particle size distribution as well as a higher drug encapsulation efficiency by creating micro/nano droplets in which the assembly of lipoplex particles take place. Although this greater repeatability is known, little is known about the fundamental mechanisms that result in this consistency. In this research, we simulate lipoplex assembly in nano-sized water droplets by coarse-grained molecular dynamics to investigate the kinetics and dynamics involved in the assembly process. The coarse grained MARTINI force field is adopted to explore the molecular mechanisms and effects of droplet size, lipid concentration and drug molecule properties, which may provide invaluable information for efficient production of lipoplex nanoparticles.

3.7	**The Investigation of Fuel Effects on the Performance and Emissions of a Micro-gasifier Stove**	3.7

Undergraduate Researcher: Mariana Pérez-Lozano

Faculty Advisor: Cill Richards

Other Collaborators: Kyle Saari and Josh Steele

Home Institution: Carnegie Mellon University, Mechanical Engineering, Junior

Abstract:

Almost half of the world's population, roughly 3 billion people, still cook their meals over a fire. In addition to polluting and burning fuel inefficiently, the World Health Organization estimates there are 4 million deaths each year due to exposure to smoke from indoor cooking. In order to design an efficient and low emissions micro-gasifier cookstove, it is essential to understand the impact of fuel characteristics on stove performance. In this project, we used a top-lit updraft (TLUD) wood gasifying stove to test how different sizes of fuel affect the time it takes to boil a pot of water as well as the time it takes for the flame to extinguish. A TLUD stove utilizes pyrolysis to gasify biomass and produce a flame. The design of the stove starves the fuel of oxygen as the secondary air inlet helps to ignite the wood gas. Once the wood gas is ignited, the upward draft coming through the primary air inlet helps to transport the wood gas to the top of the stove until all the biomass has been burned. This work is focused on the experimental characterization of the impact of fuel characteristics on top lit updraft (TLUD) micro-gasifier performance. Two stove designs are tested with three different types of fuel. The standard water boil test for cookstoves is used to assess performance. The time required to reach boiling and simmer time achieved for a single batch of fuel are measured. In addition, measurements of the fuel consumption, air flow, CO concentration, CO2 concentration, and mass of soot produced are acquired during the water boil test. These data are used to map the performance of the cookstove, describing the relationship between the fuel characteristics and the micro-gasifier cookstove design.

3.8	**Development of a Remotely Controlled Testing Platform with Low-Drag Air-Ventilated Hull**	3.8

Undergraduate Researcher: Nicholaus Perry
Faculty Advisor: Konstantin Matveev
Other Collaborators: Alexander Mattson, Christopher Chaney
Home Institution: Washington State University, Mechanical Engineering, Sophomore

Abstract:

The focus of this research is the development and testing of a remotely controlled boat platform with an innovative air-ventilated hull. The application of air cavities on the hull bottom is a promising means for reducing hydrodynamic drag and pollutant emissions of ships and increasing marine transportation efficiency. This involves utilization of air-ventilated cavities on the hull bottom for reducing the wetted surface area of a ship and consequently its skin-friction resistance. This leads to reductions of required propulsive power, consumed fuel, and pollutant emissions. The main objective of this work is to develop a small-scale model of an air-cavity hull that can be easily modified and tested in outdoor environment at a relatively low cost. The secondary goal is to create of a remotely controlled, self-propelled and instrumented boat platform that can be further developed into a high-performance unmanned boat. The boat is constructed from foam and fiberglass with carbon fiber and plywood panels. The boat is powered by an electric outboard marine motor attached to a thrust cell with a custom designed and manufactured mounting system. The boat is controlled remotely via a radio system. Results of initial tests are reported, including thrust, speed, and airflow rate in several loading conditions. The constructed platform can be used for optimizing air-cavity systems and testing other innovative hull designs. This system can be also developed into a high-performance unmanned boat.

3.9	**Particle Size-Based Separation Using DC Dielectrophoresis**	3.9

Undergraduate Researcher: Courtney Rouse
Faculty Advisor: Prashanta Dutta
Other Collaborators: Walid Rezanoor
Home Institution: Illinois Institute of Technology, Mechanical Engineering, Senior

Abstract:

Dielectrophoresis, the phenomenon of separation caused by a force acting on a dielectric particle due to a nonuniform electric field, has been used in many applications to separate particles submerged in a flowing fluid. Particles with different properties can be separated from one another using dielectrophoresis (DEP) due to the fact that the direction and strength of the DEP force depend on the relative permittivities of the particle and the surrounding fluid, the size of the particle, and the position of the particle. A micro device design was studied numerically for separation of particles of different sizes by keeping fluid flow, electric field and initial location of the particle constant. The permittivity of the particle was less than that of the fluid so negative DEP occurred and the DEP force pushed the particle towards lower electric field strength. Results showed that larger particles had a stronger DEP force that overcame the opposing fluid force whereas the DEP force on smaller particles did not have as big an impact so the smaller particles followed the fluid stream.

3.10	**Micro Gasefiers- Effects of Fuel Type Variation With Respect to Emissions and Efficiency**	3.10

Undergraduate Researcher: Josh Steele

Faculty Advisor: Cill Richards

Other Collaborators: Kyle Saari, Mariana Perez-Lozano

Home Institution: Washington State University, Mechanical Engineering, Senior

Abstract:

Almost half of the world's population, roughly 3 billion people, cook their meals over an open indoor fire. The World Health Organization estimates that there are 4 million deaths each year due to exposure to smoke from this type of food preparation. In addition, cooking fires produce a substantial amount of green house gas emissions and black carbon. The use of clean and efficient cookstoves can maximize fuel, reduce exposure to toxic smoke, and decrease the emissions contributing to climate change. The Top Light Up Draft (TLUD), type stove is a viable option for this type of food preparation. These batch type stoves require a finite amount of biomass which is placed within the stove, lit from the top, and supplied with an updraft of air from vents on the stove. The biomass (wood) is heated to the point of gasification which produces flammable wood gas. Emissions and stove performance may be highly dependent upon fuel characteristics. To analyze a micro-gasifier cookstove for efficiency and emissions the impact of fuel characteristics must be well understood. This study focuses on the effect of fuel size on TLUD stove performance. Three sizes of fuel are tested: 8 mm pellets, 1 cm x 1.5 cm x 2 cm chunks, and 1.5 cm x 2.25 cm x 3 cm chunks. Performance is evaluated using a standard water boil test procedure. Evaluation of the ignition-to-boil efficiency is performed using a gravimetric analysis of burned and unburned fuel. The mass of fuel is determined before ignition. When the water reaches the boiling point the flame is extinguished and the mass of burned and unburned fuel is measured. These data can be used to determine the heat released and thus the efficiency of the ignition-to-boil process. In addition, the CO, black carbon, and CO2 emissions are measured.

Group 4: New-Generation Power-Efficient Computer Systems Design (REU in Electrical Engineering and Computer Science)

4.1	**Performance and Power efficient multi-core computation**	4.1

Undergraduate Researcher: John Bell

Faculty Advisor: Partha Pande, Behrooz Shirazi

Other Collaborators: Ehsan Mohandesi, Abner Molina

Home Institution: Southern University at Shreveport, Computer Science, Junior

Abstract:

One of the major concerns today surrounding chip technology is power dissipation. The power of the chip has been increasing by a factor of 4 every 3 years. Typically high-speed means high power. Power is consumed as chip gates switch during logic operations. Simply the faster and more gates switch the more power it takes. Our focus is to find ways to minimize power consumption during logic operations.

The goal is to achieve a power-performance tradeoff aimed at decreasing power with minimum speed required. Power-related tradeoffs can be focused into three main areas: timing, power and surface area. Power and timing are the two most important specifications for design and the areas that we are focusing.
Both dynamic and short-circuit power consumption are dependent on the clock frequency, while the leakage current is dependent on the CPU supply voltage. According to a recent paper by K. De Vogeleer, ”It has been shown that the energy consumption of a program shows convex energy behavior, meaning that there exists an optimal CPU frequency at which energy consumption is minimal.” Building upon Vogeleer's statement, we are reducing power consumption by focusing on voltage reduction and frequency reduction.

There has been work recently published that consider network-on-chip (NoC) architectures partitioned into several voltage-frequency islands (VFIs) which propose design methodologies for runtime energy management. Their proposed approach minimizes the energy consumption by subjecting the chips to performance constraints.

While De Vogeleer's work focuses on mobile devices and the more recent study shifts to chip architecture our work looks at multicore processors using GEM5. GEM5 is the latest computer simulation modeling program and we use it to captures computer processing time with VFIs.

Using GEM5 we are able to capture runtime data from multiple CPUs and use that information to determine optimal conditions to save energy. We run five established benchmarks: Bodytrack, Canneal, FFT, LU Contiguous, and Radix. Using detailed CPU set up in full system simulations, we measured the benchmarks’ idle times and busy times for each of the 64-Core CPUs, varying their voltage and frequency to determine optimal performance under new conditions and compare with the 2.5GHz case.

The results show improvement and although they are primarily and too early to tell it does look promising.

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4.2	**Evaluation of Rail Voltage Variation on Power Efficiency and Operating Frequency in a FinFET SRAM Cell**	4.2

Undergraduate Researcher: Kristofer Henderson

Faculty Advisor: Jose Delgado-Frias

Other Collaborators: Trokon Johnson, Mike Turi

Home Institution: Gonzaga University, Electrical Engineering, Senior

Abstract:

Most modern digital systems utilize Static Random Access Memory (SRAM) to access data at high speeds. SRAM cells have traditionally been implemented using CMOS transistors technology. However, due to the growing need for power efficient computing, alternatives to the CMOS-based SRAM cell are being developed and explored. The FinFET, a novel double-gate transistor, is being developed as an alternative to the bulk CMOS transistor. FinFET technology allows for greater power efficiency because its second gate can be biased to restrict leakage current. In some cases, leakage current accounts for up to 40% of CPU power consumption; thus, reducing leakage current is an approach to increase power efficiency.

Power efficiency may also be improved by decreasing the operating voltage of the SRAM cells in a device. While these techniques can lower power consumption, they also limit the current flow through the transistors, causing the read and write delays of the SRAM cell to increase. In response to increasing delay time, experiments were carried out by adding multiple FinFETs in parallel to compensate for the decrease in current. These parallel transistors effectively increased the flow of operational current and decreased delay time.

Our research involved establishing a range of SRAM operating voltages and frequencies to allow a wide range of power-performance tradeoffs. We will use a technique called Dynamic Voltage and Frequency Scaling (DVFS), which helps regulate power consumption by modifying the SRAM operating voltage and consequently scaling read and write delays. This in turn will help adjust memory operating frequency and power to the application demands, optimizing for speed or power as needed. Our early results show that as the operating voltage decreases past a 0.6V, the delay time becomes too great to be viable, placing what seems to be a practical limit on the lower operating voltage limit.

4.3	**Evaluation of Rail Voltage Variation on Power Efficiency and Operating Frequency in a FinFET SRAM Cell**	4.3

Student Name: Trokon Johnson

Faculty Advisor: Jose Delgado-Frias

Other Collaborators: Kristofer Henderson, Mike Turi

Home Institution: University of Tulsa, Electrical and Computer Engineering, Senior

Abstract:

Most modern digital systems utilize Static Random Access Memory (SRAM) to access data at high speeds. SRAM cells have traditionally been implemented using CMOS transistors technology. However, due to the growing need for power efficient computing, alternatives to the CMOS-based SRAM cell are being developed and explored. The FinFET, a novel double-gate transistor, is being developed as an alternative to the bulk CMOS transistor. FinFET technology allows for greater power efficiency because its second gate can be biased to restrict leakage current. In some cases, leakage current accounts for up to 40% of CPU power consumption; thus, reducing leakage current is an approach to increase power efficiency.

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4.4	**New-generation Power-efficient Computer Systems**	4.4

Undergraduate Researcher: Abner Molina

Faculty Advisor: Partha Pande, Behrooz Shirazi

Other Collaborators: Ehsan Mohandesi, John Bell

Home Institution: NYU Poly, Electrical Engineering, Senior

Abstract:

To produce the most efficient hardware designs, it is crucial to have a good knowledge of application behavior. Without this knowledge it can be quite difficult to properly partition resources between communication and computation. Our research group focuses on understanding the behavior of applications in multi-core processors by running simulations on GEM5, which is a full system simulator platform designed for the use in computer architecture research, in order to be able to develop more power-efficient computers.

To understand in more detail the behavior of applications, we run simulations using different benchmarks, or applications, from two benchmark suites: Parsec and Plash-2. The Splash-2 benchmarks suite contains a variety of high performance computing (HPC) and graphic applications. The Splash-2 benchmarks that we are currently studying are FFT, LU, and RADIX. Parsec benchmarks offer a wider variety of applications rather than focusing on HPC. The Parsec benchmarks that we are currently studying are BODYTRACK and CANNEAL.

By running these simulations on GEM5, we are able to know the run-time of each benchmark, the total number of cycles each of the 64-Core CPU were on during each simulation, and the number of busy and idle cycles for each CPU. With this information we are able to find the busy percentage for each CPU for different configurations and run time penalty of each configuration, which is crucial to our research since this help us determine the most power-efficient configuration. We compare the default CPU configuration with VFI CPU configuration. In the default mode, all the 64-Core CPUs run at a frequency of 2.5GHz and a voltage of 1.0 Volt. In the VFI mode, we change the frequency and voltage of the CPUs in order to decrease power consumption of the CPUs without compromising their overall performance.

4.5	**Optimizing LDO DC-DC Voltage Regulators in 65nm CMOS Technology**	4.5

Undergraduate Researcher: Mackenzie Neavor

Faculty Advisor: Deuk Heo

Other Collaborators: Joshua Zoellick, Zhiyuan Zhou

Home Institution: Washington State University, Electrical Engineering, Senior

Abstract:

The low dropout (LDO) DC-DC voltage regulator scheme utilizes a feedback system to maintain a constant output voltage despite changes in input voltage and load current. Due to high demand for smaller and more power efficient integrated circuits, research in LDO design has lead to new ways of increasing stability, accuracy, and power efficiency while maintaining a low amount of chip surface area. Despite numerous LDO schemes already having been created, many times the feedback system for each LDO only tolerates a specific range of voltage and current demand before the LDO either becomes too inefficient to meet a current load's demand or the system becomes unstable. By utilizing tsmc 65nm CMOS technology and simulating circuit performance in Cadence, an LDO can be engineered to fit a specific margin of stability and power efficiency by having the control of each system parameter value in order to maximize power efficiency while also maintaining stability. A PMOS transistor behaving similar to a variable resistor controlled by a negative feedback system sets up the circuit as a varying voltage divider. By utilizing a large gain two-stage CMOS error amplifier the PMOS transistor's resistance can be carefully controlled based off the value of the output voltage. However, a two-stage error amplifier introduces two poles into the system that can cause instability if their location is not properly chosen. The system will be designed to receive an unregulated input voltage of 1.1V to be stabilized at a constant 850mV over a load range of 0-20mA. By analyzing line/load regulation, power supply rejection ratios, line/load transients, noise, and quiescent power consumption the efficiency of my design can be compared and contrasted with existing solutions in order to further improve LDO design.

4.6	**DVFS and Windowing: Improving the Power Efficiency of Computer Systems**	4.6

Undergraduate Researcher: Nicholas Paco

Faculty Advisor: Partha Pande, Behrooz Shirazi

Other Collaborators: Shervin Hajiamini, Armin Rahimi

Home Institution: University of Arizona, Electrical Engineering, Junior

Abstract:

The need for more power efficient computer systems is becoming more and more necessary as the demand for such machines increases. According to ieee.org, nearly half the energy consumed by high performance computers goes to cooling its infrastructure. In order to try and tackle this ever-growing issue, we focus our attention to the actual runtime of those computer systems when running certain computation and communication extensive benchmarks (applications). We use gem5, a full system simulator, to run simulations of various benchmarks and use DVFS and windowing to decrease power consumption during runtime. Using DVFS (Dynamic Voltage Frequency Scaling), we strive to find the appropriate instances where the power consumption of the CPU (affected by the operating voltage and frequency) can be lowered, specifically, in the idle times (when the CPU is not performing computations), without negatively effecting the performance of the computer system. If this is done successfully, the computer will consume less power while still completing the computations with little to no time penalty (extra runtime). In order to accomplish this, we use the Viterbi algorithm as an AI-based algorithm to predict the idle and busy periods of the CPUs so that the voltage and frequency of the system can be adjusted accordingly. In order to understand the behavior of the benchmark in terms of computation and communication periods, we use windowing which divides a simulation into windows, or time frames. This helps the Viterbi algorithm determine the performance level of each CPU (voltage and frequency) for the following window using the analysis of the current window's busy/idle times. Using these tools, we collected data for the computation intensive benchmarks (fft, lu, radix) and communication intensive benchmarks (canneal), and had calculated energy savings ranging from 3% with lu to 28% with canneal.

4.7	**Develop suitable on-chip voltage regulator as an enabling technology to implement dynamic voltage and frequency scaling (DVFS)**	4.7

Undergraduate Researcher: Armin Rahimi

Faculty Advisor: Behrooz Shirazi, Partha Pande

Other Collaborators: Shervin Hajiamini

Home Institution: Washington State University, Computer Science, Junior

Abstract:

Computers that run high intensity calculations or algorithms consume very large amounts of power. This results in the parts heating up, and consuming higher amounts of power than they need to. Every processor that is busy performing a task will have idle cycles during its computations. These are cycles during which the processor is not doing anything. We are finding a way to allocate dynamic voltage and frequency scaling to the processors, so that we can reduce the amount of power used by the processors during the idle periods. To do this we use a simulation program called gem5 which allows us to simulate a full computer with many cores, and an operating system. To be able to assign the voltage and frequency dynamically, we use a method called windowing. Windowing is a way of knowing the CPUs' idle/busy periods during the execution time This method helps us in identifying the behavior of each benchmark in terms of communicational and computational characteristic. We use an algorithm, called viterbi, that records the number of busy cycles and idle cycles, and based on the number of busy cycles in the previous window, it allocates a certain voltage and frequency for the next window. Some of the benchmarks that we use, like fft, are computation intensive, and others are communication intensive. Our best results so far for fft is 14 percent energy savings and five percent time penalty. For canneal we have achieved 32 percent energy savings at the cost of nine percent time penalty. We are evaluating the viterbi algorithm with other DVFS optimization mechanisms, and examining how well it performs.

4.8	**Analog Circuit Design for Time-Reversal-Division-Multiple-Access Impulse Response Recording**	4.8

Undergraduate Researcher: Noel Wang

Faculty Advisor: Benjamin Belzer

Other Collaborators: Joe Baylon

Home Institution: Washington State University, Electrical Engineering, Senior

Abstract:

A Network-on-Chip (NoC) system that employs Time-Reversal-Division-Multiple-Access (TRDMA), which utilizes the multi-path nature of wireless communication to spatially and temporally focus a signal's energy between transmitting and receiving antennas, may reduce latency and power consumptions over architectures that rely on omni-directional antennas with token-passing wireless medium access control protocols. TRDMA takes advantage of channel reciprocity to focus a signal's energy on the desired receiver, thereby reducing the power needed to transmit signals between nodes, decreasing intersymbol interference, and eliminating the need for nodes to wait for tokens to transmit. However, in order to implement TRDMA, the impulse response between potential transmitting and receiving antennas must be learned and stored. At NoC and indoor cellular communication scales, it may not be currently practical or possible to digitally record impulse responses between antennas. However the impulse response can be approximated with analog circuits.

Using Matlab, we show that a 60th order Fourier Series approximation can adequately approximate an indoor cellular impulse response. A time-reversed impulse is easily realized by inverting the sine components of the series expansion. The analog circuit used to model the Fourier Series approximation in this research consists of a network of high Q band pass filters. Active high Q band pass filters are used as opposed to passive resonator filters in this research due to circuit size considerations. Common resonator filter designs rely on inductors. However, the performance of inductors degrades at higher frequencies, and inductors are significantly larger than other circuit components. Therefore inductorless high Q band pass filters are used to reduce the overall footprint of the analog circuit while maintaining reasonable performance. The analog circuit was simulated using LTSPICE to test the analog circuit performance for NoC TRDMA applications.

4.9	**Pulse Shaping Filters for Wireless Communications in Networks on Chip**	4.9

Undergraduate Researcher: Evan Wright

Faculty Advisor: Benjamin Belzer

Other Collaborators: Joe Baylon

Home Institution: Embry-Riddle Aeronautical University, Electrical Engineering – Aerospace Systems, Senior

Abstract:

As newer microprocessors are developed with a higher number of cores to improve performance, the efficiency of the overall process must be kept in mind in regards to power and speed. In order to reduce communication latency and power dissipation between large numbers of cores, the Network-on-Chip (NoC) concept has been proposed. By having the cores communicate wirelessly, wireless NoCs will reduce communication times compared to having wires connecting tens and even hundreds of cores, as the signal in a wired NoC must pass through every single core along the way to its destination. This paper describes design of efficient shaping filters for the wireless communication across the chip in order to reduce Bit Error Rate (BER) due to noise and intersymbol interference (ISI). Using Matlab's Simulink software, multiple simulations of different shaping filters for On-Off-Keying (OOK) communication, such as root raised cosine and rectangular filters, were used to test which shaping filter had the highest gain regarding energy per transmitted bit versus spectral noise density (Eb/No gain) that exists across all electrical communications systems. The hypothesis is that a unique root raised cosine filter that is compensated and scaled for the antenna loss will be the most efficient in terms of limiting the BER to a minimum.

4.10	**An Integrated DC-DC Converter in 65nm CMOS**	4.10

Undergraduate Researcher: Joshua Zoellick

Faculty Advisor: Deuk Heo

Other Collaborators: Zhiyuan Zhou, Bai N. Nguyen, Mackenzie Neavor

Home Institution: Washington State University, Electrical Engineering

Abstract:

The goal of this project is to design (in Cadence) and optimize the performance of an integrated DC-DC converter (switching regulator) implemented in 65nm CMOS. The overall system uses the Buck converter methodology to down-convert a varying DC input battery/supply (application specific) voltage. Some of the advantages of using CMOS converters are: high efficiency, constant output voltage, fast response to load and line transients, long life-time/high reliability, and minimum off-chip components.

The system is designed to down-convert about a 2V input to a range of desired output voltages based on the feedback system's variable reference voltage. The feedback system consists of a compensated error amplifier, comparator with a sawtooth input, and non-overlapping gate drivers. For all load currents, fixed-frequency pulse width modulation feedback is used with type III compensation feedback, and is most efficient in high and medium load systems. The compensation network provides the ability to adjust and maintain a steady output voltage during changes in Vin or load perturbations. The system operates in constant conduction mode which improves the efficiency as power is always delivered to the load.

The final design of output filter and feedback component values are selected to optimize the switching regulator for a steady 2V input and a 1V output. There is always a demand for increased performance in power management applications. The end goal is to reach peak performance of the Converter through parasitic and parametric analysis.

Group 5: Plant Genomics and Biotechnology (REU in Horticulture)

5.1	**Time-Course Analysis of Genetic Components in Sweet Cherry Fruit-Pedicel Abscission Following Ethylene Treatment**	5.1

Undergraduate Researcher: Jonathan Abarca

Faculty Advisor: Amit Dhingra

Other Collaborators: Benjamin Kilian

Home Institution: Washington State University, Fruit and Vegetable Management, Junior

Abstract:

Along with current harvest methods, an increase in labor costs and a decline in workforce can adversely affect sweet cherry production. However, the sweet cherry industry would benefit from an alternative harvest method such as mechanical harvest. For mechanical harvest to be possible a better understanding of gene expression involved in the development of the stem/fruit abscission zone is required. In certain cherry varieties, an ethylene-induced abscission pathway results in the development of a clearly defined abscission zone between the fruit and pedicel of the cherry. The aim of this project is to identify and analyze the genetic components of fruit-pedicel abscission in sweet cherry. A time-course transcriptome analysis of fruit-pedicel abscission zone was performed following an ethephon (ethylene releasing) treatment. Three genotypes were used, Chelan, Bing, and Skeena representing the range of phenotypes and expected alleles in response to ethylene. Previously, RNA-Seq was used to generate transcriptomic data in similarly designed experiments. Physiological data and abscission zone samples were collected May-July, 2014 in the Roza Orchards at the WSU Prosser Irrigated Agriculture Research and Extension Center (IAREC). Ethephon (240ppm) was applied at 80% maturation of each genotype. Gene expression of the abscission zone and genes related to the production and response to ethylene will be measured via qRT-PCR. These data will lead to functional characterization studies of specific genes shown to be involved with the development of the stem/fruit abscission zone. These in turn will aid breeding programs in the development of novel varieties that exhibit desired traits amenable to new and developing harvest technologies.

5.2	**Determining sources of genetic resistance to fire blight in apple**	5.2

Undergraduate Researcher: Haley Allen

Faculty Advisor: Kate Evans

Other Collaborators: Julia Harshman, Jay Norelli (USDA-ARS Kearneysville)

Home Institution: University of Wisconsin – La Crosse, Biochemistry/Biology, Senior

Abstract:

Fire blight is a bacterial disease caused by Erwinia amylovora that affects many members of the Rosaceae family all over the world. When apple (Malus × domestica Borkh.) trees become infected, blossoms wilt and turn brown and branches shrivel, tips curl over, and become black. Tree death may result in infected trees. The Washington apple breeding program (WABP) would like to incorporate resistance to fire blight in future varieties, as current treatments for the disease are costly and largely ineffective.

To identify new sources of fire blight resistance to use in the breeding program, seedlings of the wild progenitor species Malus sieversii grafted onto M.7 rootstock (3 reps per accession) were inoculated with fire blight in a field study. M. sieversii was chosen because of its broad range of genetic diversity. 'Delicious' and 'Empire' were used as resistant controls and 'Gala' and 'Jonathan' were used as susceptible controls. The level of resistance in the various accessions was determined by measuring the amount of infected tissue. This study was conducted in 2013 and repeated in 2014. Future studies will include association mapping to locate genes implicated in the resistance.

To determine the presence of fire blight resistance in the current WABP, 43 elite apple breeding selections were inoculated with fire blight in a replicated greenhouse study. 'Gala' and 'Delicious' were used as controls in the greenhouse study. The level of resistance in the selections was determined by measuring the amount of infected tissue. In 2013, two different inoculum preparations (freeze dried and fresh) were used and no significant differences were found. Therefore, in the second year of this study, only freeze-dried inoculum was used. Selections that were found to be highly susceptible were removed from the study in the second year.

5.3	**Impact of Overhead and Drip Irrigation and Chlorine Dioxide Treatment on Food Safety Indicator Organisms in an Organic Farming System**	5.3

Undergraduate Researcher: Isabel Cueva

Faculty Advisor: Karen Killinger

Other Collaborators: YenTe Liao

Home Institution: Heritage University, Biomedical Science, Junior

Abstract:

Contaminated irrigation water has been linked to several outbreaks associated with E. coli O157:H7 and Salmonella in commercial produce. Investigating practices that can reduce risk for irrigation water are important due to proposed regulatory requirements through the Food Safety Modernization Act. This study evaluated irrigation delivery (overhead and drip) and water treatment (with or without chlorine dioxide) on indicator organism levels within an organic farming system. Water samples were collected from the irrigation water source and 4 plots per treatment (overhead and drip untreated, overhead and drip with chlorine dioxide) for four irrigation events. For treated plots, chlorine dioxide (ClO_2) was applied in the water system prior to irrigation. Samples were subjected to the most probable number (MPN) method for quantification of total coliforms, fecal coliforms and generic Escherichia coli, and examined for detection of E. coli O157 and Salmonella. MPN of the indicator microorganisms was based on proportion of observed positive samples. Creek water total coliform, fecal coliform, and generic E. coli levels ranged from 3.3 - 3.5 log cfu/100ml, 2.3 - 3.0 log cfu/100ml, and <1.2 - 2.5 log cfu/100ml, respectively. Treated plots had lower levels of indicator organisms as compared to the untreated plots. For both treated overhead and drip irrigation, the indicator organism of all water samples were <1.2 log cfu/100ml. For untreated overhead irrigation water, total coliforms, fecal coliforms and generic E. coli ranged from 2.52 to 3.41 log cfu/100ml, 1.89 to 3.23 log cfu/100ml, and <1.25 to 1.97 log cfu/100ml respectively. The drip irrigation, untreated water samples ranged from 3.0 - 4.2 log cfu/100ml, 2.3 - 3.5 log cfu/100ml, and <1.2 - 2.1 log cfu/100 ml for total coliforms, fecal coliforms and generic E. coli. Treated irrigation water (with chlorine dioxide) yielded lower levels of total coliform, fecal coliform and generic E. coli than untreated water.

5.4	**Seeds to Fuel the Future**	5.4

Undergraduate Researcher: Destin Holland

Faculty Advisor: Amit Dhingra

Other Collaborators: Ryan Christian, Benjamin Kilian

Home Institution: North Florida University, Physics, Junior

Abstract:

With the increasing realization of human's contribution to climate change, it is becoming increasingly important to find more sustainable methods for producing necessities such as food and energy with the smallest carbon footprint. Cultivation of bioenergy crops typically creates competition for land resources between plants produced to make biofuel and plants used to produce food products. However, in the case of Camelina sativa, this competition is lessened due to its high performance on marginal lands with fewer water and fertilizer inputs. Camelina is also considered carbon neutral because it captures as much carbon as it releases while producing biodiesel, and is thus more attractive than fossil fuels as an energy source. As an oil-seed crop, Camelina has an inherently high oil content, making it an attractive biodiesel feedstock. However, there is widespread interest in the prospects of genetic engineering for improving Camelina yields and growth characteristics. Current research is concerned with identifying the most viable method of chloroplast transformation in Camelina using biolistic particle bombardment on leaf explants. Chloroplast transformation is attractive compared to floral dip-based nuclear transformations due to containment of the transgene in a field setting and because of extremely high expression with up to 10,000 chloroplast genome copies per cell. We have optimized the process of leaf-based organogenesis using varying concentrations and ratios of plant growth hormones BAP and NAA with respect to genetic variability. Our research indicates that overexposure of Camelina to growth hormones in MS media seems to be fatal to the plant tissue so as research continues, we are limiting the time that the leaf explants are being cultured on media with exogenous hormones. Once a suitable chloroplast transformation procedure is found for Camelina, work can be done to increase the appeal of the plant with regard to cost and energy efficiency.

5.5	**Screening for Puccinia graminis suppressors of Hypersensitive Response in Tobacco**	5.5

Undergraduate Researcher: Andrea Mathis

Faculty Advisor: Scot Hulbert

Other Collaborators: Sowmya Ramachandran

Home Institution: Fort Valley State University, Plant Science Biotechnology, Sophomore

Abstract:

Stem rust has emerged as a catastrophic fungal disease threatening cereal crops in vast regions throughout the world. Puccinia, the genus of the fungi, is a major pathogen of the wheat plant, which contains over 4.000 species. Puccinia graminis is the first sequenced representative of the wheat rust fungi, and is an epidemic spreading across Africa, Asia, and the Middle East which has risen concerns for the extensive amount of people in these areas depending on wheat productions for means of sustaining life. In this study, the goal is to screen for suppressor genes of HR in tobacco plants. Suppressors are vital because they help the infection take place. When the fungus infects the plant it puts out a haustorium, which serves to acquire nutrition from the plant and put out distinct effector proteins that mediate infection. Primers were designed for genes that are highly expressed in the haustorium of these fungi. These genes would be cloned into an Agrobacterium based vector and expressed to produce proteins in tobacco. The identification of suppressor genes would help to understand the biology of the disease and management systems in the future.

5.6	**Prevalence of ACCase and ALS target-site mutations in PNW Herbicide-resistant Lolium multiflorum**	5.6

Undergraduate Researcher: Jeanette Rodriguez

Faculty Advisor: Ian Burke

Other Collaborators: Caleb Squires

Home Institution: Heritage University, Clinical Lab Science, Junior

Abstract:

In the Pacific North West (PNW) Lolium moltiflorum, also known as Italian ryegrass, is common and troublesome weed species in wheat fields due to rapid development of herbicide resistance in the species. Italian ryegrass has developed resistance to Acetyl-CoA carboxylase (ACCase) inhibitors, an important class of herbicides used to manage grass weeds in wheat. It is import to detect herbicide resistance early to enable a rapid response by crop managers to manage Italian ryegrass effectively. To identify herbicide target-site resistance in ryegrass, DNA was extracted from known Italian ryegrass resistant samples. Using Polymerase Chain Reaction (PCR) and Sanger Sequencing from both 5' and 3' ends, ALS and ACCase DNA sequences were determined for the enzyme active sites known to have possible mutations. The resulting five 365 to 720 base pair sequences were then analyzed for mutations known to cause resistance to specific types of herbicides. Several samples had a I2041N substitution. This mutation confers resistance to the aryoxyphenoxy propionate ACCase herbicides, but the samples are still sensitive to the cyclohexanedione ACCase inhibiting herbicides. Knowledge of which mutations are prevalent in Italian ryegrass from the inland PNW will be critical for crop managers to effectively manage herbicide resistant Italian ryegrass.

5.7	**Heteromorphic Self-incompability in Primula: Molecular analysis of Pin**	5.7

Undergraduate Researcher: Kelli Russell

Faculty Advisor: Andrew McCubbin

Other Collaborators: Benjamin A. Burrows

Home Institution: Fort Valley State University, Plant Biotechnology, Junior

Abstract:

Plant breeding systems are biologically important, but are often overlooked. Without knowing the different components that make up the system, we cannot fully understand how plant reproduction takes place. In this study, the plant species that was focused on was Primula vulgaris, a common primrose which results in plant heteromorphy producing two types of flowers, pin and thrum. These two types of flowers are part of the heteromorphic self-incompatibility system where self self-pollination is prevented due to the positioning of the male and female structures located in pin and thrum.

This project is part of a larger study to differentiate the genes expressed in pin and thrum plants, which are morphologically distinct mating types controlled by a single multi-gene linkage group known as the S-locus, where pin is homozygous recessive (ss) and thrum is heterozygous (Ss); it was intended to look for genes that regulate stigma and style positioning. Very rarely recombination can occur within the S-locus, generating “homostyle” plants with a flower phenotype that is intermediate between those of pin and thrum. In pin, the style is long and the anthers are located at the bottom, where as in thrum the style is shortened and the anthers are located at the top. The goal of this project was to examine the expression of a number of genes which have been shown to be differentially regulated between pin and thrum flowers and determine whether their expression in homostyle flowers correlates with their morphological phenotypes of the male and female organs in respect to pin and thrum mating types.

5.8	**Netting reduces physiological stress in 'Granny Smith' apples**	5.8

Undergraduate Researcher: Olivia Schertz

Faculty Advisor: Lee Kalcsits

Home Institution: Clemson University, Food Science and Technology, Sophomore

Abstract:

Washington State is the number one apple producer in the United States. However, climate affects apples in a way that may decrease total yields for Washington producers. During the summer, the critical time for apples as the fruit is developing, the average air temperature at Sunrise Orchard near Wenatchee, WA was 21.29^{0}C, there was low precipitation with wind speeds averaging 2.47 m/sec (5.53 mph), and light levels fluctuating around 270.66 W/m2, and average humidity of 36.78%. These extreme weather conditions may cause increased stress on the apple trees and when heat and light intensity is too high, sunburn can occur and the affected fruit becomes unmarketable. The use of netting in apple orchards could decrease this stress and, therefore, increase the overall yield and fruit quality for apple producers. Carbon isotope values are one way to determine stress levels in a plant and act as time-averaged proxy indicators of stomatal conductance and photosynthetic activity. Leaves were collected at Sunrise Orchard near Wenatchee, WA and Washington Fruit Company's Plymouth Orchard near Kennewick, WA. Hole-punch samples were taken from two sun exposed leaves and then the leaves and hole punches were dried and weighed to determine the leaf mass area (LMA) of each treatment. The dried whole leaves were crushed and analyzed for carbon isotope values using an isotope ratio mass spectrometer at the University of British Columbia. For both sites, the LMA of the trees under the net (0.0559 mg/mm2) was smaller than the LMA for the trees grown without the netting (0.0696 mg/mm2). The carbon isotope values for the trees under the netting (-27.19‰) were more negative than those without netting (-26.23‰). With the more negative carbon isotope values, the trees underneath the netting were more photosynthetically active and less stressed and as such, may have increased carbon available to allocate to developing fruit.

Group 6: Northwest Advanced Renewables Alliance – NARA (Summer Undergraduate Research Experience)

6.1	**Mechanistic kinetics study of biomass derived inhibitory compounds on cellulase hydrolysis of biomass substrate**	6.1

Undergraduate Researcher: Cassandra Sanders

Faculty Advisor: Xiao Zhang

Other Collaborators: Elvie Brown

Home Institution: Washington State University, Environmental and Biological Sciences, Senior

Abstract:

With the increase in demands and the dwindling reserves; as well as, increases in environmental concerns, there is an urgent need to find alternative fuel sources. Washington State University is leading a major effort to evaluate the feasibility to convert forest and agricultural residues into biofuels (USDA NARA). Several pre-treatments and processes are used to break down renewable plant biomass to generate platform molecules for biofuel and biochemical production. One of the processes is the enzymatic hydrolysis of substrate to break down cellulose into biofuel precursors. In this process, substances are formed that inhibit hydrolysis activities. Such inhibition lowers the yield of desired products and represents a high cost. A detailed understanding of the kinetic mechanisms of these inhibitors and their interaction with cellulase enzymes will help identify highly efficient enzymes and design better processes to significantly reduce enzyme cost. Research conducted at the Bioproducts, Science and Engineering Laboratory has developed a set of biomass reference substrates with controlled physical and chemical properties which can be used to identify specific deficiencies of cellulase enzymes in breaking down carbohydrate polymers into sugars. My SURE work focuses on investigating the effects of several representative inhibitory compounds including phenol, vanillin, levulinic acid, maleic acid, furfural and xylan to determine their impact on the reaction kinetics of the enzyme Celluclast. A significant amount of enzyme kinetics data was collected and applied to elucidate the inhibition mechanism and compare the degree of inhibition among different inhibitors. We hope this study will provide useful insight for finding suitable enzymes and better process design for biomass conversion.

6.2	**Lignin residue as Wood Pellet Binder and Energy Enhancer for Energy Applications**	6.2

Undergraduate Researcher: Rodney Seals

Faculty Advisor: Jinwu Wang

Other Collaborators: Jinxue Jiang, Yalan Liu, Huinan Liu, Michael Wolcott

Home Institution: University of Arkansas at Fayetteville, Freshman

Abstract:

The United States Environmental Protection Agency (US EPA) has set a new regulation to reduce our greenhouse gas emissions by 25 percent by 2020. Greenhouse gas emissions are one of the biggest contributing factors to global warming. Reducing these emissions will greatly help the longevity of the planet. Increased usage of renewable energy and a switch from coal-fired to biomass-fired power in heat generation will help in reducing greenhouse gas emissions. 60 percent of the carbohydrates in the walls of a plant cell is already used and converted into biofuels where 25 percent lignin is yet without any obvious benefits. The goal of this research is to bond leftover Douglass Fir lignin residues from various methods of enzymatic hydrolysis with wooden particles in order to create wooden pellets for use in residential heating or in co-fired boilers. These wooden pellets were tested for their breakage strength and calorific value. The higher the lignin content, the stronger the pellets were while having little effect on its heating value. My hopes are that future researchers will use this information and consider lignin bonded pellets as a possible alternative to coal in the production of power.

6.3	**Spatial Distribution of Grain Sizes in Sampling Heterogeneous Stream Beds**	6.3

Undergraduate Researcher: Eric Sorensen

Faculty Advisor: John Petrie

Other Collaborators: Ross Wickham

Home Institution: Humboldt State University, Environmental Resources Engineering, Senior

Abstract:

Erosion and deposition of sediment into headwater stream beds is a well-known result of logging activities that impacts the geomorphology and ecology of streams. However, the distribution of grain-sizes is difficult to quantify due to the inherent error in standard bed material sampling techniques. Furthermore, standard sampling techniques do not consider the spatial distribution of grain-sizes over a reach. In this study, the spatial distribution of grain-sizes over the cat spur creek was determined by dividing the examined reach into zones based off of the dominant bed material grain-sizes. Grain-size distributions in each zone were then estimated using grid sampling techniques. The technique of breaking up the reach into zones allowed for increased resolution of channel roughness values used in geomorphological models. This is especially important in streams such the one examined due to the heterogeneous makeup of the stream bed. Furthermore, the incorporation of grid sampling techniques into the pebbled count reduced the operator error. Due to the variability of watershed characteristics, environmental impact in headwater streams can only be determined by observing the changes in a given watershed over time. The purpose of this study was to therefore provide a more comprehensive bed material sampling method whose results can be used to accurately track geomorphological changes over time.

6.4	**Potential Technological Pathways for the Production of Alternative Jet Fuel**	6.4

Undergraduate Researcher: Preenaa Venugopal

Faculty Advisor: Paul M. Smith

Other Collaborators: Min Chen

Home Institution: Pennsylvania State University, Chemical Engineering, Senior

Abstract:

High oil prices have led to developments in first generation biofuels that are mainly made from starch, sugars, animal fats and vegetable oils. However, there has been much debate and speculation on how these feedstocks contribute to problems such as accelerated deforestation and rising food prices among others. This has given rise to second and third generation biofuels derived from agricultural residues and microalgae respectively. Various U.S companies are deploying technology pathways to convert these feedstocks to biofuels, in which some of the pathways are ASTM D7566 approved. As of 2014, the approved pathways are ASTM D7566 Annex 1 (Fischer-Tropsch), Annex 2 (Hydroprocessed Esters and Fatty Acids (HEFA)) and Annex A3 (Direct Sugars to Hydrocarbon (DSHC)) whereas the current ASTM approval pending pathway is Alcohol to Jet (ATJ). The possible approval of ATJ in the near future extends pre-existing information provided by The Commercial Aviation Alternative Fuels Initiative (CAAFI) and The Federal Aviation Administration (FAA).

Biorefineries (BR) in the U.S are divided into four clusters, namely, 1st generation biofuel BR, 2nd generation biofuel BR, 3rd generation biofuel BR and the fourth being 1st and 2nd generation non-fuel BR. Based on our initial identification and analysis of 77 advanced biorefineries in the U.S moving toward commercialization, 63 refineries produce 2nd generation biofuels and 14 produce 3rd generation biofuels. Due to time constraints of this project, the examination of U.S biorefineries is limited to only 2nd generation biorefineries (n=63). This NARA SURE research project includes the following objectives:

i) Identifying U.S 2nd generation biorefineries by location and technology platform.

ii) Categorizing 2nd generation biorefineries that currently deploy ASTM approved pathways.

iii) A brief comparison of Fischer-Tropsch, HEFA and DSHC and the factors that contribute to the possibility of ATJ being the next approved technology pathway.

6.5	**Ball Milling: Effective Pretreatment Leading to A Clean Biomass to Cellulosic Sugar Conversion**	6.5

Undergraduate Researcher: Eileen Wu

Faculty Advisor: Michael Wolcott, Jinwu Wang

Other Collaborators: Yalan Liu, Jinxue Jiang, Huinan Liu

Home Institution: University of California Berkeley, Chemical Engineering, Sophomore

Abstract:

Biofuels have the potential to replace fossil fuels due to its environmental friendliness and sustainability. The process to convert biomass to biofuels includes pretreatment, enzymatic hydrolysis, and fermentation. By doing so, biomass is broken down into sugars and then converted to hydrocarbons. The goal of this project is to study the effect of ball milling on final sugar yields of Douglas-fir (softwood). The wood pieces were grinded to 20-mesh small wood particles using the Wiley Mill and then ball-milled for 60 minutes. 105 g of the dry wood was mixed with 0.5% NaOH, 0.5% H2SO4, or water for the autoclave treatment at 121°C for 3 hours. Then, enzymes (CTec/HTec) and 50 mM citrate buffer were added to the mixtures for the enzymatic hydrolysis. A blank solution with the same condition was also prepared as the control. The four flasks were placed in the shaking incubator at 180 rpm and 50°C for 72 hours. The glucose yields for the blank, water, NaOH, and H2SO4 were 64.9%, 59.4%, 44.9%, and 48.0%, respectively, and the xylose/mannose yields were 25.9%, 31.24%, 35.7%, and 86.2%. The autoclave treatment was not effective in achieving high glucose yields, but it should be employed when the goal was to get high xylose/mannose yields. In particular, the dilute strong acid autoclave treatment would achieve very high xylose/mannose yields. Uv-Vis spectra shows that the cellulosic sugars obtained from the mechanical pretreatment contained less impurities (aromatics and furans) than those obtained by alkaline, acid and hot water treatments, which will translate into better performance of downstream fermentation. Considering higher glucose yield and purer product, this project demonstrated that the mechanical pretreatment without involving any chemical is very promising.

Group 7: Harnessing Plant Metabolism for Society – Institute of Biological Chemistry

7.1	**Expression of Formate-tetrahydrofolate Ligase From Arabidopsis Plants in Yeast**	7.1

Undergraduate Researcher: Parker Scott

Faculty Advisor: Sanja Roje

Home Institution: Washington State University, Chemical Engineering, Senior

Abstract:

Photosynthesis occurs in all terrestrial plants, however, it uses only a small percentage of the total Sun radiation available to plants. This inefficiency can be attributed to the competitive inhibition by O2 of the CO2 uptake by the bifunctional enzyme Rubisco. The process of one carbon (C1) metabolism in mitochondria has long been known to affect photorespiration, but recent publications suggest that under conditions of high rates of Rubisco oxygenation, cytosolic enzymes of the C1 metabolism can affect photorespiration as well. Formate-tetrahydofolate ligase (FTHFL) is an enzyme involved in the processing of formate in the C1 metabolism pathway, and its effect on photorespiration is not completely understood. In order to characterize FTHFL, the full-length cDNA from Arabidopsis thaliana was ordered, and was recombinantly expressed in the yeast Saccharomyces cerevisiae (vector pYES). The recombinant protein was analyzed in the crude extract from yeast through a western blot to verify that the protein was expressed. The recombinant protein from the crude extract was purified through a process known as His Tag purification, which utilizes a column with an affinity matrix and fast protein liquid chromatography (FPLC), and allows for further study of the enzyme. The FPLC fractions were submitted to a western blot to verify which fractions from the FPLC contain the recombinant protein. Those fractions will be submitted to an assay, which characterizes the activity of FTHFL with respect to products within the C1 metabolism. The biochemical characterization of FTHFL will be in the future linked with analyses of the transgenic plants with impaired FTHFL gene expression to reveal the role of this enzyme in photorespiration.

7.2	**Combating Pollution from Overfertilization: An Analysis of AtCHH6 Hydrolase in Pi Metabolism**	7.2

Undergraduate Researcher: Natasha Sioda

Faculty Advisor: Sanja Roje

Other Collaborators: Chijun Li, Victoria Bolton

Home Institution: Washington State University, Biology, Junior

Abstract:

Inorganic phosphate is largely prevalent in soil and is an essential structural component in organisms; yet only a small amount is available for plant root uptake. In order to combat low inorganic phosphate (Pi) accessibility, fertilization of plants has served as a solution. However, overfertilization has caused significant amounts of water pollution. Therefore, to reduce pollutants, researching the specific enzymes and processes involved in Pi metabolism will provide crucial information to increase the efficiency of plant Pi utilization. The HAD-like hydrolase, AtCHH6, was analyzed within this study in order to determine its biological and biochemical functions in Pi metabolism in Arabidopsis thaliana. The enzyme was predicted to be located in the cytosol of pollen, indicating its possible role in reproduction and Pi regulation. In order to identify the specific function of AtCHH6, the substrates utilized by this enzyme were identified by in vitro assays after the enzyme was expressed and purified from Escherchia coli. Phenotypic analysis was also conducted on screened homozygous plants with t-DNA insertional mutants as well as on plants with overexpressed AtCHH6 to assist in identifying the enzyme's function. Results show that (conclusion)…

7.3	**Effects of Abiotic Stress Conditions on Arabidopsis HAD Mutants**	7.3

Undergraduate Researcher: Alyssa Thomas

Faculty Advisor: Sanja Roje

Other Collaborators: Na Sa

Home Institution: Pacific Lutheran University, Biology, Senior

Abstract:

Plant response to stress is a complex and multifaceted process currently the subject of much investigation. Factors involved in this process include proteins of the Haloacid dehalogenase-like hydrolase (HAD) superfamily, which have a range of hydrolytic enzyme functions. We investigated three of the HAD-like phosphatases found in Arabidopsis thaliana; AtCHH5 (At2g38740), a cytosolic sugar phosphatase, AtPyrP1 (At1g79790) and AtPyrP2 (At4g11570), two plastidal pyrimidinedione phosphatases in the riboflavin biosynthesis pathway. In silico expression studies of these three HADs have indicated their involvement in abiotic stress responses, however a lack of phenotype studies has left their biological effects unknown. To better understand the function of these HAD-Like phosphatases we altered the expression of AtPyrP1, AtPyrP2, and AtCHH5 in A. thaliana, and observed the effect of these alterations on the plant's response to abiotic stress conditions. We investigated changes in root and seedling growth caused by salt, osmotic, and low phosphate stress conditions, as well as changes in germination caused by salt and osmotic stress conditions. We predict that genes previously determined to be upregulated under a particular stress condition are necessary for growth under this condition. Accordingly, we expect mutants with upregulated genes silenced to grow poorly under stress. Testing the response of HAD mutants to stress conditions will clearly link genetic changes to their phenotypic results and allow us to extrapolate our new understanding of HAD-like phosphatase function to other plants beyond A. thaliana.

Group 8: Chemical Engineering, Chemistry, and Entomology (Other WSU Projects)

8.1	**Segregation and Carbon Monoxide Induced Anti-Segregation of a Cu/Co(0001) Catalyst: A DFT Study**	8.1

Undergraduate Researcher: Gregory Collinge

Faculty Advisor: Jean-Sabin McEwen

Other Collaborators: Norbert Kruse

Home Institution: Washington State University , Chemical Engineering, Graduate Student in the Fall

Abstract:

The Fischer-Tropsch reaction provides a viable means of producing long-chain alcohols from carbon monoxide (CO) and hydrogen (H2), but the reaction mechanism is little understood and product selectivity is hindered. However, recent work has suggested that a ternary cobalt/copper/manganese catalyst might allow for high selectivity. Therefore, the atomic-scale metal-metal and metal-adsorbate interactions, along with the subsequent effect on the reaction mechanism, must be completely understood. To begin this investigation, density functional theory calculations were performed on a copper/cobalt, Cu/Co(0001), molecular model of the proposed catalyst.

First calculations revealed that the Cu/Co(0001) catalyst will tend to segregate completely into a copper shell atop the cobalt slab, in agreement with literature. CO was added to this surface at different surface sites and the site preference was found to be the fcc hollow site. The surface of the model was then altered through permutations of the surface copper and subsurface cobalt in order to investigate the possibility of anti-segregation due to the presence of CO; that is, whether the CO itself could cause the subsurface Co to migrate to the surface and force a Cu below the surface layer. Interestingly, this study found that anti-segregation does indeed occur upon CO adsorption. At ¼ monolayer (ML) coverage of CO, the CO was able to induce ¼ ML Cu anti-segregation while further anti-segregation of Cu to ½ ML was found to be as energetically favorable as CO's adsorption on the original surface. This leads to the hypothesis that CO induced anti-segregation of this catalyst is 1-to-1; that is, increasing CO coverage may induce further anti-segregation of Cu to below the surface. Future work will investigate this possibility as well as CO lateral interactions since anti-segregation and co-adsorption interactions could play a critical role in the Fischer-Tropsch reaction mechanism on Cu/Co(0001).

8.2	**The Effects of Juvenile Hormone and Ecdysone on the Rhinoceros Beetle's Head Horn**	8.2

Undergraduate Researcher: Aurora Krauss

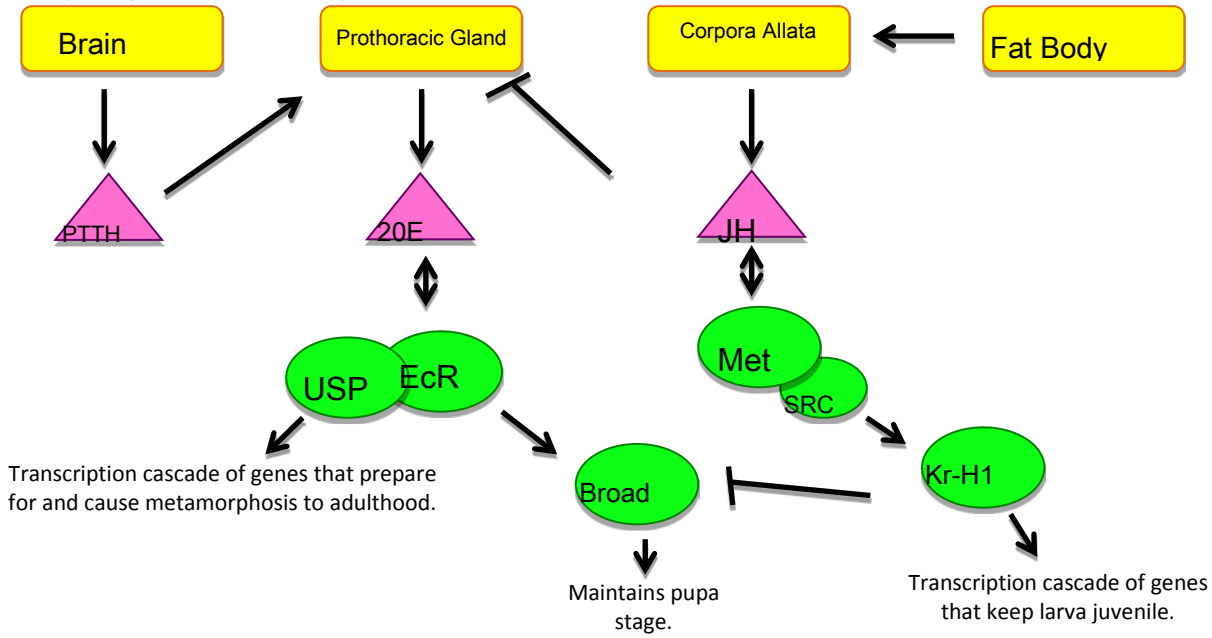
Faculty Advisor: Laura Lavine

Other Collaborators: Robert Zinna, James Hust

Home Institution: Gonzaga University, Biology, Junior

Abstract:

The male Asian Rhinoceros Beetle, Trypoxylus dichotomus, grows mammoth head horns in comparison to their body size. The mechanisms by which extreme traits develop and scale are important to understanding animal body growth in general. The juvenile hormone and ecdysone pathways' antagonistic growth activities have been shown to orchestrate the growth of several exaggerated traits such as dung beetle horns, flour beetle Gnatocerus cornutus mandibles, and stag beetle mandibles. To better understand how the juvenile hormone and ecdysone pathways contribute to head horn size in rhino beetles, we conducted RNA interference (RNAi) knockdown experiments. RNAi knockdown of ultraspiracle (USP), which heterodimerizes with ecdysone receptor to transduce the ecdysone hormone signal, was predicted to truncate the ecdysone pathway and lead to a truncated horn in relation to body size. Some of my USP knockdowns show evidence that ecdysone contributes to large head horns; however validation of knockdown remains to be conducted. In addition, we experimented with the juvenile hormone pathway by RNAi of Krüppel like homolog (Kr-H1), a transcription factor downstream of juvenile hormone, to silence juvenile hormone's growth signal, and anticipated decreased growth of the head horn relative to body size. Also, we ectopically applied juvenile hormone analog to create a heightened titer of juvenile hormone, and expected to increase growth of the horn in relation to body size. Neither decreasing juvenile hormone signal with RNAi of Kr-H1 nor increasing juvenile hormone signal through ectopic application of juvenile hormone analog affected the growth of the head horn in comparison to body size, surprising us because previous research illuminates juvenile hormone as being important for the exaggerated growth of body parts in other insects. Now that we have found that juvenile hormone is not important to rhino beetle head horn growth, we plan to to study other potentially influential pathways in growth such as ecdysone.



8.3	**STM Study of Temperature Dependent Adsorption/Desorption Kinetics of Cobalt(II) Octaethylporphyrin and Octaethylporphyrin on Phenyloctane/Au(111) Interface**	8.3

Undergraduate Researcher: Kevin Marchbanks-Owens

Faculty Advisor: K. W. Hipps

Other Collaborators: Ashish Bhattarai

Home Institution: Alabama A&M University, Chemistry, Junior

Abstract:

Scanning Tunneling Microscopy (STM) is used to study the temperature dependent adsorption and desorption kinetics of cobalt(II) octaethylporphyrin (CoOEP) and free base octaethylporphyrin (H2OEP) at the phenyloctane/Au(111) interface. At temperatures close to room temperature, the rate of desorption is so slow that the monolayer composition of the mixture of CoOEP and H2OEP doesn't change on a time scale greater than 10 to 15 minutes. We conclusively demonstrate that the metal free porphyrin i.e. H2OEP desorbs at significantly lower temperature (above 80°C) compared to that of metalloporphyrin, CoOEP which desorbs extremely slow even at 135°C. Even at 100°C, a solution mixture of CoOEP and H2OEP is not in equilibrium with the gold surface.

Group 9: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest (REU in Laboratory for Atmospheric Research / Civil and Environmental Engineering)

9.1	**The influence of NAO on the near-surface meteorology at Summit, Greenland**	9.1

Undergraduate Researcher: Brooke Adams

Faculty Advisor: Von Walden

Home Institution: Hobart and William Smith Colleges, Geoscience, Junior

Abstract:

Summit Station, located on the high plateau of central Greenland, is currently facing climatic changes. In July 2012, Summit hit a record high temperature (3.60C) and experienced an extreme melting event. In the summer of 2010, the ICECAPS project deployed a suite of instruments in Greenland, allowing for the examination of meteorological patterns at Summit. In this study, the correlations that emerged from comparing the melt event of 2012 to the conditions in 2013 and 2014 were used to decode the dynamic climate of Summit, Greenland. North Atlantic Oscillation (NAO) indices from NCEP archives, Summit Station surface based meteorology data, and ceilometer data were statistically and graphically analyzed from 2012 to 2014. The NAO index, which is based upon upper-level pressure anomalies, was used to quantitatively classify the synoptic scale patterns over Greenland. Surface-based meteorology data was examined to determine the linear correlation between variables such as ten and two-meter air temperatures, temperature inversion strength (between 2 and 10 m), barometric pressure and relative humidity. The ceilometer data was used to determine the percentage sky cover over the time periods studied. This study examined the comprehensive picture of the atmospheric conditions over the Greenland Ice Sheet during the 2012-2014 period in order to identify the connection between the large-scale circulation over the Greenland and local processes at Summit.

9.2	**NO+ as a PTR-MS Reagent Ion: Improving the detection of long chain alkane molecules**	9.2

Undergraduate Researcher: Randy Bartoshevich

Faculty Advisor: Tom Jobson

Other Collaborators: Graham Vanderschelden

Home Institution: Washington State University Tri-Cities, Sophomore, Civil Engineering

Abstract:

The Proton Transfer Reaction – Mass Spectrometer (PTR-MS) is most commonly used with H3O+ as the reagent ion, but is also capable of using NO+ and O2+. The focus of this study will be on adapting the current PTR-MS system to employ NO+ as a reagent ion. This will enhance the ability of the PTR-MS to identify longer chain alkanes and other organic molecules that are common aerosol precursors in urban air. Utilizing NO+ as a reagent ion is expected to expand the analytical product of the PTR-MS by reducing molecular dissociation of certain organic compounds in the reaction chamber, such as alkanes, and thereby simplifying the PTR-MS mass spectrum and making individual compounds easier to identify. The experimental plan will include the ion source optimization to create NO+ with the least amount of impurities, followed by a comparison of observed instrument sensitivities to a variety of compounds from a compressed gas standard between NO+ and H3O+ as reagent ions, and a comparison of the mass spectrum of diesel exhaust using both reagent ions. Preliminary results indicate that the optimal settings are a source voltage of 50 to 100 V, a source current of 8 to 10 mA, an air flow rate of 10 to 15 SCCM, and a source out voltage of 40 to 60 V. From further experiments using NO+ as a reagent ion, it will be demonstrated that the NO+ approach is a viable way of identifying organic compounds that are common in diesel exhaust. In addition, NO+ will be used to identify specific compounds in the diesel exhaust mass spectrum that are not easily identifiable using H3O+, such as n-alkanes.

9.3	**Comparing air quality models with observed isoprene emissions to improve air quality forecasting**	9.3

Student Name: Dylan Curtis

Faculty Advisor: Alex Gunther

Other Collaborators: Dasa Gu

Home Institution: Washington State University, Junior

Abstract:

Biogenic volatile organic compounds (BVOCs), including isoprene and monoterpene, plays important role in photochemical reactions, and have further impacts on regional air quality and global climate change. It is important to accurately estimate the emissions of BVOCs, in order to predict their impacts on the environment. To do this a model has been created to estimate the emission of BVOCs, which can provide necessary information for in-site observations. If we are able to know when and where air quality will be poor we can improve worldwide respiratory health.

Currently I am graphing and comparing predicted isoprene emissions to those observed in 2005. To do this I have converted units and time in order to see a pattern in the data sets. I then ran the predicted emissions through MEGAN, a model that is designed to predict isoprene emissions based on temperature, solar radiation, humidity, and wind. Along with this MEGAN model compared the observed with two other forms of the model, both of which assume different initial conditions. I created regression lines to show the trends between the different models and the observed data so I can see which of the models is more capable at predicting the observed data.

9.4	**Analysis of eddy-covariance measurements of the surface energy budget in complex sagebrush terrain**	9.4

Undergraduate Researcher: Raleigh Grysko

Faculty Advisor: Heping Liu

Other Collaborators: Eric Russell, Zhongming Gao

Home Institution: Hobart and William Smith Colleges, Senior

Abstract:

The eddy-covariance technique was used to measure the components of the surface energy budget at 30-minute means for two eddy covariance tower sites located in Birch Creek Valley, Idaho from June 24, 2013 to September 15, 2013. The two towers were located eight miles apart north-south on opposite sides of the valley. The differing factors between the two sites were the distributions and concentrations of the sagebrush in each area, the elevation above sea level of the towers, and the terrain undulations. The surface energy budget consists of four main components: latent heat flux (LE), sensible heat flux (H), ground heat flux (G), and net radiation (Rn). In ideal situations net radiation equals the sum of the latent, sensible, and ground heat flux values causing the energy budget to "close" (i.e., Rn=H+LE+G). When calculating the ground heat flux, corrections were made to account for needing to bury soil sensors at a deep enough depth so they are not significantly disturbed and the absolute depth in the soil is not significantly altered due to erosion, compaction or expansion of the soil layer. Meteorological and turbulent variables were analyzed during periods where the surface energy budget was closed in an attempt to determine the main factors that contributed to surface energy budget closure. Meteorological and turbulent variables were also analyzed in instances where the surface energy budget was not closed. One instance of particularly high closure rates was identified from August 15, 2013 to August 19, 2013 and analyzed extensively.

9.5	**Measurements of Isoprene fluxes at University of Michigan Biological Station during summer**	9.5

Undergraduate Researcher: Jinyanzi Luo

Faculty Advisor: Shelley Pressley, Brian Lamb, Tim VanReken

Other Collaborators: Anyone Collaborating on the Project

Home Institution: Bellevue College, Electrical Engineering, Sophomore

Abstract:

Isoprene (C5H8) is produced and emitted by many plants, and it is one of the more reactive biogenic volatile organic compounds (BVOCs). Its oxidation products are precursors to aerosols and haze, and they will preferentially react with anthropogenic nitric oxides leading to increased levels of regional ozone. Previous measurements show isoprene emissions increase throughout a typical day with increasing temperature and light levels, peak at midafternoon, and decline to zero by night. Strong daily correlations between isoprene fluxes and associated energy fluxes (sensible and latent heat) were also noted in previous measurements. Isoprene fluxes are currently (since late May) being measured continuously using eddy covariance techniques at a mixed hardwood forest in northern lower MI. Seasonal isoprene flux measurements have been conducted yearly at this sight between 2000 and 2007. Calculating isoprene fluxes requires post-processing 10 Hz data and applying multiple correction factors. Objectives for this research project are to process and analyze flux data for the first half of the summer and compare results to previous flux data, to see how these emissions have changed in the last decade. Anticipated results will include a time series of isoprene and associated energy fluxes, along with local meteorological variables for the month of June.

9.6	**El Niño and Seasonal Forecasting: Does a Global Climatic Event Impact Accuracy of Climate Models?**	9.6

Undergraduate Researcher: Taylor Scott Mandelbaum

Faculty Advisor: Von Walden

Home Institution: Stony Brook University, Atmospheric Science, Junior

Abstract:

In recent years, climate modeling has received increased attention from policymakers, researchers, and the general public. In particular the need for better seasonal forecasts has become apparent. These models can benefit not only government but also industries to increase productivity, provide early warning systems, and aid in mitigation efforts. In the Pacific Northwest, the El Nino/Southern Oscillation (ENSO) phenomenon has a strong impact on seasonal forecasting. An El Niño event occurs when sea surface temperature (SST) in the Eastern Pacific becomes anomalously warm for an extended period of time. The change in SST modifies meteorology in the Pacific Northwest. The goal of this project is to determine the accuracy of a climate model during extreme ENSO conditions. We will use the National Oceanic and Atmospheric Administration Climate Forecast System, version 2 (CFSv2) to evaluate the accuracy of climate forecasts during an ENSO positive season (defined as >0.5° C SST anomaly >6 months) compared to ENSO neutral and ENSO negative (La Niña) events (<-0.5° C SST anomaly >6 months). Using variables that have relevance to agriculture, such as surface temperature, total precipitation and soil moisture, we will compare the CFSv2 Reforecast to an appropriate observational dataset to determine which events were forecasted most accurately. We expect to find that extreme El Niño events will be more accurate in comparison to ENSO neutral conditions.

9.7	**Evaporation and Surface Energy Balance Over a Large Reservoir**	9.7

Undergraduate Researcher: Devin Marcy

Faculty Advisor: Heping Liu

Other Collaborators: Zhongming Gao, Eric Russell

Home Institution: Washington State University, Civil and Environmental Engineering, Sophomore

Abstract:

Understanding water-air interactions of inland water bodies (e.g., lakes, reservoirs, etc.) are important in analyzing the role they have in affecting local and regional weather and climates, as well as the impact on hydrological balance. Eddy covariance data and other meteorological datasets from the Ross Barnett Reservoir (32° 26'N, 90° 02'W) in central Mississippi for the year 2008 were analyzed to better understand how meteorological variables affect evaporation and surface energy balance. To understand the surface energy budget, heat storage in water is a key component in regulating energy in and out of the reservoir. Our analysis showed that the time lag for energy transferred between different layers of water was not a matter of minutes or hours, but rather, weeks, months, or intraseasonal. Analysis of net radiation (Rn), sensible heat (H) fluxes, and latent heat (λE) fluxes showed that the reservoir stored energy during the warmer seasons (Feb- August) and released energy during the colder seasons (Sept-Jan). An in-depth analysis of heat storage and surface energy balance closure results for 2008 will be presented. Flux data and other meteorological datasets were also analyzed for days with wind speeds above 5 meters per second ($m\ s^{-1}$) and days with wind speed closer to $1m\ s^{-1}$ to study how different variables regulated evaporation and energy fluxes for these two cases.

9.8	**The design and characterization of a chamber to investigate the impacts of TiO2 as an air quality mitigation strategy under ambient conditions**	9.8

Undergraduate Researcher: Rebecca McLean

Faculty Advisor: Tom Jobson

Other Collaborators: Claudia Toro

Home Institution: University of Central Florida, Environmental Engineering, Junior

Abstract:

TiO2 treated roadway surfaces are being investigated by the engineering community as air pollution mitigation strategy. These surfaces are photocatlitic in sunlight and remove nitrates (NOx) and volatile organic compounds (VOCs) emitted from vehicles. The aim of this experiment is to modify and characterize a chamber that will be able to sample ambient air and allow TiO2-coated surfaces to undergo photolysis from direct sunlight in order to simulate real-world conditions. Several tests were run to characterize chamber dynamics to ensure optimal mixing. This data was then compared to the expected values generated by a box-model equation. Additional experiments were conducted to determine the firsts-order loss coefficient, k, and as well as the transport limited deposition velocity (vt). This was done by measuring ozone uptake to potassium iodide (KI) coated sample surfaces. The preliminary results of this experiment indicate that the chamber will be suitable for further experiments to test the reaction probabilities of NOx and VOCs, the nature of TiO2- coated asphalt, and the yield of hazardous byproducts such as nitrous acid (HONO) and aldehydes —which are a concern for public health as well as the environment. The implications of these studies will allow scientists and engineers to better understand the effectiveness of TiO2 as an air pollution mitigation strategy in a variety of scenarios.

9.9	**Assessment of Residential Methane Emissions from Natural Gas Usage**	9.9

Undergraduate Researcher: Kevin Montalvo

Faculty Advisor: Brian Lamb, Shelley Pressley

Home Institution: Stony Brook University, Environmental Studies, Senior

Abstract:

Natural gas is being used at increasing rates as an energy source in the US. There are significant uncertainties in the amount of methane, the major component of natural gas, lost to the atmosphere as a result of increasing natural gas production and use. Methane is a major greenhouse gas. This project focuses on methane emissions from natural gas usage within residential homes. Although the Environmental Protection Agency has various emission factors for furnaces and appliances used in residential structures, there are no recent measurements of emissions. Therefore, the inefficiency of combustion from methane sources within residential structures is unknown. We developed a measurement approach to measure methane emissions from natural gas sources such as gas stoves, gas dryers, gas furnaces and gas fireplaces to acquire a preliminary data set for methane emissions downstream of customer meters in residential structures. The measurement approach employed a combination of measuring methane concentrations using a small portable methane sensor and syringe grab samples analyzed using flame ionization gas chromatography, and measuring exhaust airflow rates using a portable hot-film anemometer. The results from this work are compared to existing emission factors and are used to inform local emission inventories for methane losses from natural gas distribution systems.

9.10	**Assessing the Impact of Climate Change on Indoor Air Quality Using CONTAM Software**	9.10

Undergraduate Researcher: Colby Sameshima

Faculty Advisor: Brian Lamb, Shelley Pressley, Von Walden

Other Collaborators: Amy Musser

Home Institution: Tufts University, Environmental Science and Geology, Junior

Abstract:

Climate change affects indoor air quality, and consequently, human health, in a multitude of ways. It affects outdoor pollutant levels, which can increase contaminants transported indoors. It affects indoor human behavior, such as potential increased usage of air-conditioning and more time spent indoors due to heat waves. It also calls for tighter building restrictions to save energy, which can reduce airflow and ventilation. Overall, it impacts the properties of pollutants affecting the average building occupant, future building characteristics, and human behavior.

The goal of this study is to use modeling software CONTAM to assess how the indoor air quality of a home may change with future climate change. CONTAM is well-suited to assess many factors that affect indoor air quality, as it requires a schematic representation of a building, and input data for each building component and each airflow path (pressure drop, flow rate, leakage type, flow exponent and discharge coefficient). We first ran a simulation of a pre-existing CONTAM file that models a 3-bedroom, single family home, built in the time period 1940-1969, under current weather conditions in the Pacific Northwest. Then, we created a simulation of the building with the addition of a gas-fired stove, and its corresponding contaminant, NOx. Third, using future climate conditions, we created a different weather file to generate a future climate simulation on the same building. CONTAM generated airflow rates and contaminant concentrations for each simulation. Results are presented in terms of how sensitive indoor air quality is to the change in climate and to the change in contaminant concentration.

9.11	**Diesel Exhaust: Flow Tube Experiment**	9.11

Undergraduate Researcher: Justin Singleton

Faculty Advisor: Tom Jobson

Other Collaborators: Madeline Fuchs

Home Institution: Hampshire College, Environmental Studies, Senior

Abstract:

Diesel exhaust lacks sufficient study of its impact on the earth's atmosphere. Using an experimental flow tube photochemical reactor, exhaust processing in the atmosphere was simulated. Measurements of NO, Nox, CO, CO2 and Ozone were made to determine engine emissions and chemical transformation rates of these pollutants in the photo-reactor. Two engine types were compared: a 5.5 kW diesel generator operated with no electrical load, and a 2004 Chevy Silverado truck operating without a catalytic converter. We began measuring NOx, CO, and CO2 from the chamber's ejector dilutor that is contained in the exhaust. Next, we took measurements from the middle section of the tube that measures Nox and Ozone levels as the exhaust pass through the chamber. The preliminary results shows that the truck emitted a substantial amount of NOx, CO and CO2 , but oxidizes with the ozone as the artificial lights were activate to simulate the photochemical reaction in the atmosphere. The NOx in particular went from a steady concentration and then rapidly decreased when the lights were turned on in our flow tube. Ozone seemed to climb as it also made its way through the chamber as CO2 levels slowly decreased in the same time period. We then compared those results to what the generator produces and we found that the exhaust contained much less pollutants, roughly a couple hundred parts per million/billion of NOx, CO CO2, and Ozone. Each of these gases has had increases and decreases throughout the flow tube more so when the lights were turned on. We understand that both sources of exhaust produced different amounts of pollutants and each had a different rate of reaction throughout its lifetime in the chamber. Our results concluded that the Silverado can be seen as more of an atmospheric problem than the generator according to our study.

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