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# Berea College

## Undergraduate Research Abstract Journal

2013

*Elizabeth  
Hawley*

# INTRODUCTION

*Editors: Ericka Berg (Senior Biology Major) and Ronald B. Rosen (Professor of Biology)*

This eighth issue of the “Berea College Journal of Undergraduate Research Abstracts” contains 48 different abstracts (52 total projects) representing majors from 7 different academic programs. The common theme to the research presented in these abstracts is that the: (1) original proposal was peer-reviewed and (2) work was subsequently presented by undergraduates at meetings on- and/or off campus. These abstracts represent research completed on-campus with funds provided by Berea College’s Undergraduate Research and Creative Projects Program (URCCP; 15 reporting), Center for Transformative Learning and non-funded class or independent projects. Off-campus projects were funded by the Kentucky Biomedical Research Infrastructure Network (KBRIN) at the Universities of Kentucky and Louisville, and by other universities and colleges throughout the country. Much of this collaborative work was presented at off-campus meetings including the 99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science (44 presentations and 16 rewards received), the Bluegrass Undergraduate Math Symposium at Centre College, and at undergraduate research symposiums at the sponsoring universities. It should also be noted that many projects were presented on campus during the 14<sup>th</sup> Berea Undergraduate Research Symposium (BURS) on October 18<sup>th</sup>, 2013. Presentations and awards received are noted below each abstract where appropriate.

## ACKNOWLEDGEMENTS

This publication would not have been possible without the support of many people. We would like to thank Chad Berry, Academic Vice President and Dean of the Faculty, for providing funds to print hard copies of these abstracts and Sarah Broomfield for coordinating the URCCP initiative on campus. Gratitude is extended to Berea College faculty for their mentorship, and of course to students whose hard work is reflected in this journal. Additionally, we would like to acknowledge former student, Elizabeth Fleming, for the cover art. Finally, I would like to thank all the off-campus mentors at the following universities, colleges and non-profit organizations for supporting Berea students during the summer of 2013 (number of Berea students in brackets): Alta Bates Summit Medical Hospital {1}, Cleveland Clinic {1}, Cincinnati Children’s Hospital {1}, Massachusetts Institute of Technology {1}, Mayo Clinic {2}, Morehouse School of Medicine {1}, Nevada Terawatt Facility {1}, Ohio State University {2}, Southern Polytechnic University {1}, University of Colorado {2}, University of Kentucky {2}, University of Louisville {1}, University of Wisconsin {1}, and Vanderbilt University {7}.

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**Directly following is the Undergraduate Research and Creative Projects Program (URCPP) summer assessment for 2013.**

## **AGRICULTURE AND NATURAL RESOURCES PROGRAM**

Nucleus Hive Production as a Microenterprise of the Berea College Farm. CAITLIN THOMAS and SEAN CLARK, Agriculture and Natural Resources Program, Berea College, Berea, Kentucky 40404.

A decline in both honeybees and beekeepers has deemed it imperative to find solutions in once unconventional beekeeping practices. Until recently, beekeeping was thought to be a mostly rural practice, allowing the bees to forage and prosper in their “natural” environment. With increasing pesticide use and monoculture, attention is being paid to the ever-expanding urban environment as a new, healthy foraging region. Urban beekeeping allows people who are concerned for bee health to become educated and to participate while also allowing a reprieve for honey bees exposed to the harmful pesticides believed to be causing Colony Collapse Disorder. The students at Berea College assessed the capacity of the college farm apiary to produce nucleus hives to sell to the public. This was accomplished by analyzing the five- year growth projection of the apiary and determining production costs and product value through research. It was found that splits could be made each spring as necessary hive maintenance, and a limited number of nucleus hives made from these splits could be sold to the public. Consumer demand was evaluated at the Madison County Extension Beekeeping Meeting and was found to be significant enough to generate profit.

*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Poster Presentation – Agricultural Science Section: 1<sup>st</sup> Place Undergraduate Research Competition)*

## **AGRICULTURE AND NATURAL RESOURCES PROGRAM**

Soil microbial analysis of differing spoil types from Bent Mountain surface mine in Pike Co., Kentucky. REENA MARTIN, YOSHUA REECE, and SARAH HALL, Agriculture and Natural Resources Program, Berea College, Berea, Kentucky 40404.

Current regulations for the reclamation of surface mined lands in do not specify the type of spoil to serve as a rooting medium for developing forest vegetation. It is common for coal companies to use the most abundant and readily available spoil type, which may not be the best for restoring forest. While data exists for vegetation, physical, and chemical differences for spoil types common to the Appalachian coalfields, soil biological activity had not yet been quantified. In this study we examined microbial communities of brown (weathered sandstone), gray (un-weathered sandstone), and mixed (weathered sandstone, un-weathered sandstone, and shale) spoil from the Bent Mountain surface mine in Pike County, Kentucky. We took four samples from each of six plots (two replicates of each spoil type) established in 2005. We prepared soil solutions from the 24 samples and inoculated Biolog EcoPlates that were read in 24-hour intervals over a 168-hour time period. We analyzed these readings based on the Average Well Color Development (AWCD). We also analyzed the microbial and vegetative diversity of the spoils using the Shannon Diversity Index (SDI). We found that the brown spoil showed significantly higher AWCD than the gray and mixed spoils. Additionally, we found that vegetative SDI and microbial SDI (by plot) were significantly positively correlated ( $P = 0.0415$  and  $R^2 = 0.6868$ ). Our results add to the evidence that brown weathered sandstone is of better quality when choosing an adequate rooting medium for vegetative recovery to forest on surface-mined sites in Central Appalachia.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Poster Presentation)*

*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Poster Presentation – Ecology and Environmental Science Section)*

**Funded by Berea College URCP**

## **BIOLOGY PROGRAM**

An Innovative Approach to Teaching Cellular Respiration in Introductory Biology. MELANIE KEIL, JOSHUA WEDDING, and MEGAN HOFFMAN, Biology Program, Berea College, Berea, Kentucky 40404.

This poster summarizes both the development of a learning activity, using the pedagogical framework of Process Oriented Guided Inquiry Learning (POGIL), and the plan to test the activity in introductory college biology courses at Berea College. The activity approaches cellular respiration from a different direction than traditional models in an attempt to first familiarize students with the essential energy producing force in the process, before requiring the type of rote memorization of equations, reactants and products, which can stymie a thorough understanding and conceal possible student misconceptions. In contrast to traditional learning models that start at the beginning with a single glucose molecule and follow its transformations through glycolysis, the link reaction, Krebs cycle, the electron transport chain, and chemiosmosis, this activity introduces the concept of aerobic respiration from the establishment of the proton gradient across the inner mitochondrial membrane, and focuses on guiding student understanding of the forces made possible through this gradient by encouraging simple real life connections through the use of models and guided inquiry. Once students have an understanding of the forces and components of the gradient that drives the synthesis of ATP they are then directed to inquire about the origin of the protons in the gradient and the equations, products and reactants can be introduced with a greater understanding of their relevance. The activity will be tested in introductory biology courses: in one course aerobic respiration will be taught using the activity and in another, the control, aerobic respiration will be taught in the traditional sequence, also using POGIL activities. Students from both classes will take the same test, and scores will be compared.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Poster Presentation)*

*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Poster Presentation –Science Education Section)*

**Funded by Berea College URCP**

## BIOLOGY PROGRAM

Comparative analysis of different types of colorectal cancer surgeries. DIPENDRA SHARMA CHAPAGAIN<sup>1</sup>, GIOVANNI BEGOSSI<sup>2</sup>, and AJAYA UPADHYA<sup>2</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Alta Bates Summit Medical Hospital, Oakland, California 94705.

Colorectal cancer is the third most common cancer diagnosed in both men and women in United States. Most colorectal cancers start as a polyp and grow towards the center. But only certain types of polyps which are called adenomas can turn into cancer. Colectomy is a surgical procedure used to treat ulcerative colitis, Crohn's disease, and diverticulitis and colorectal cancer. Colectomy can be segmental (left, right or sigmoid) or subtotal depending on the complexity of the case. Techniques involved in colectomy include laparoscopic, robotic, lap-rob and open type. The main purpose of this research was to analyze the long term effect of different type of colectomy performed on colorectal cancer patient by analyzing the clinical history database from 2004 - 2013. Fifty-three different parameters (such as time difference between biopsy and date of surgery, time difference between surgery and readmission, complication and status upon latest consultation etc) concerning individual cases were collected. The project is still in progress and specific conclusions have yet to be reached. Here we present the preliminary data.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Poster Presentation)*

*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Poster Presentation – Health Sciences Section)*

## BIOLOGY PROGRAM

Cordon-Bleu and IRTKS protein interaction in microvillar brush border formation. WILLIAM ASSAN<sup>1</sup> and MATTHEW J. TYSKA<sup>2</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Department of Cell and Developmental Biology, Vanderbilt University, Nashville, Tennessee 37232.

The microvillar brush border lines the intestinal tract, interfaces with the gut lumen and is the sole site of nutrient absorption in mammals. Microvilli are supported by f-actin filaments, but how they are formed is unknown. Following the elucidation of the intestinal brush border proteome, investigations of the cytoskeletal proteins Cordon-Bleu (Cobl) and insulin receptor tyrosine kinase substrate (IRTKS) have been conducted. Cobl has been shown to possess actin nucleating, severing and elongating activity, while IRTKS is an I-BAR domain-containing protein that can sense and induce plasma membrane curvature. The hypothesis of our study is that a polyproline (PXXP) domain of Cobl interacts with the SH3 domain of IRTKS to couple f-actin assembly to membrane deformation during brush border assembly. In a previous pull-down assay, interaction between the two proteins was observed in vitro. Imaging from confocal and super-resolution microscopy was performed which showed Cobl localizing at the base of the microvillar brush border in doxycycline-induced W4 cells and IRTKS localizing at the tips of microvilli—thus suggesting no direct co-localization.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Poster Presentation)*

*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Poster Presentation – Cellular and Molecular Biology Section: 1<sup>st</sup> Place Undergraduate Research Competition)*

## BIOLOGY PROGRAM

Dietary Immunomodulation: Examining the Effect of Conjugated Linoleic Acid Treatment on Dendritic Cell Cytokine Production. HSUAN PENG<sup>1</sup>, XUE QUN XU<sup>2</sup>, and JENNY GUMPERZ<sup>2</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Department of Medical Microbiology and Immunology, School of Medicine and Public Health, University of Wisconsin, Madison, Wisconsin 53706.

Previous studies on conjugated linoleic acid (CLA), a dietary polyunsaturated fatty acid, have revealed a wide range of immunomodulatory function in both human subjects and animal models. Of 28 known CLA isomers, cis-9, trans-11 (c9, t11-CLA) and trans-10, cis-12 (t10, c12-CLA) account for over 90% of total CLA found in dietary source, and are thought to be responsible for the beneficial health effects. This study investigated the impact of CLA isomers on human monocyte-derived dendritic cells in vitro. Based on previous data, we hypothesized that CLA alters the inflammatory response via modulating dendritic cell (DC) cytokine profile. As CLA was previously identified as having an anti-inflammatory effect on animals, we anticipated that DCs pre-treated with CLA and challenged with an inflammatory stimulus (lipopolysaccharide, or LPS) would show reduction of TH1 and increase of TH2 cytokine secretion. As the effect of CLAs seems to depend on the specific isomer, it is possible that only one isomer has an immunomodulatory effect. As a result, we cultured DCs with purified CLA isomers. The results confirmed our hypothesis that CLA treatments can influence DC cytokine secretion in response to LPS. After CLA treatment and LPS stimulation, reduce in TNF- $\alpha$ , IL-1  $\beta$ , IL-6, and IL-12 secretion by DCs was observed.

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## BIOLOGY PROGRAM

Host HLA Haplotype May Predict the Effect of Cigarette Smoke in Arthritis. SHANEQUA ROSCOE<sup>1,2</sup>, DAVID LUCKEY<sup>3</sup>, MICHELE SMART<sup>3</sup>, CHELLA DAVID<sup>3</sup>, and VEENA TANEJA<sup>3,4</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Mayo Clinic Undergraduate Research Employment Program, <sup>3</sup>Department of Immunology and <sup>4</sup>Department of Rheumatology, Mayo Clinic College of Medicine, Rochester, Minnesota 55905.

Rheumatoid arthritis (RA) is a systemic autoimmune disease characterized by chronic inflammation of the joints as well as the presence of anti-citrullinated peptide antibodies (ACPAs) directed against synovial proteins including collagen and vimentin. RA is a multifactorial disease. Certain HLA class II molecules, DRB1\*0401/DQ8, are associated with predisposition to RA while DRB1\*402 provides resistance. Cigarette smoking has been identified as a strong environmental risk factor for the development of RA. The purpose of this research is to study interaction between genetic and environmental factors to understand the role of vimentin in elicitation and progression of collagen induced arthritis, an animal model of RA, and to determine the role of cigarette smoking on immune response to vimentin-derived peptides in genetically susceptible, AEO DQ8 and AE.DRB1\*0401/DQ8, and resistant, AEO DRB1\*0402/DQ8 transgenic mice. Arthritis was induced by immunizing mice with type II collagen and mice were exposed to cigarette smoke for three weeks. At the termination of the experiment, mice were then sacrificed, and their splenocytes were isolated to determine changes in immune cell profile by fluorescence-activated cell sorting (FACS). *In vitro* T cell response to vimentin-derived peptides was done by challenging T cells to various peptides. Our data showed that vimentin may be involved later in epitope spreading during the course of the disease but may not be the initiating antigen for arthritis as resistant mice generated a good response to vimentin and peptides. Additionally, short term duration of cigarette smoking does not seem to enhance immune response in transgenic mice to vimentin-derived peptides.

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## BIOLOGY PROGRAM

Inverted Formin 2(INF2), A Fetal Risk Gene for Preterm Birth, is Highly Expressed in Mouse and Human Placentas. AMBER BOOTHE<sup>1</sup> and LOUIS J. MUGLIA<sup>2</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Center for Prevention of Preterm Birth, Cincinnati Children's Hospital, Cincinnati, Ohio 45229.

Disorders associated with short gestational age are the leading cause of infant mortality worldwide. The action of giving birth, or parturition, is a poorly understood mechanism that complicates our ability to understand why preterm birth, defined as birth at less than 37 weeks of completed gestation, occurs. The rate of preterm birth in the United States is 11.7% having declined from its peak in 2006. Although we are seeing this decline, effective preventive treatment options are lacking. Several risk factors for preterm birth have been identified including maternal health and age, ethnic classification and a previous history of preterm birth which may suggest a genetic contribution to preterm birth. Evidence suggests that genetics is playing a role in preterm birth but no direct link has been established. In order to discover a genetic link between the fetal genome and prematurity, we compared the presence and frequency of 2.5 million single nucleotide polymorphisms (SNPs) in term and preterm Finnish infants. We identified a single nucleotide polymorphism that is significantly associated with preterm birth that is located upstream of and in linkage disequilibrium with Inverted Formin 2 (INF2). Mutations in INF2 are the primary cause for focal segmental glomerulosclerosis (FSGS) and Charcot-Marie Tooth Neuropathy associated with nephropathy. The level of expression of INF2 in the human placenta is greater than that seen in the kidney suggesting that INF2 mutations can lead to preterm birth.

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## BIOLOGY PROGRAM

In-Vitro Egg Development in the Trematode, *Cotylaspis insignis* (Subclass Aspidogastrea). ERICKA BERG, LIN PENG, and RON ROSEN, Biology Program, Berea College, Berea, Kentucky 40404.

*Cotylaspis insignis* belongs to the Subclass Aspidogastrea, which consists of a minor group of loosely parasitic trematodes. The adult of *C. insignis* is found in freshwater mussels and resides externally at the gill and visceral mass junction. This worm produces unembryonated, ectolecithal eggs which contain a large number of vitelline cells surrounding the nucleus. The development of the embryo within the egg has not been previously described and was the objective of this study. Mussels, *Lampsilis siliquoidea*, were collected from North Elkhorn Creek in Scott County, Kentucky. Adult worms were dissected from *L. siliquoidea*, isolated in plastic jars containing 6.0 ml of spring water, monitored for 48 h and then removed. The number of eggs shed by each adult was recorded. Over 36 days at 20° C, developing embryos within these eggs were photographed using interference contrast microscopy. Between 0-6 eggs were released from each adult worm. On day 0, eggs showed a large, centrally located nucleus surrounded by vitelline cells. By day 7, a small embryo was visible among the vitelline cells and was surrounded by an embryonic membrane. By day 28, a pair of eyespots was present within an elongated embryonic body. A ventral sucker and mouth (located at the opercular end) were clearly visible by day 32, and the vitelline cells were noticeably reduced in number. On days 34 and 36, significant larval movement was observed inside the egg, and on day 36, a portion of the eggs hatched, leaving empty shells with detached opercula. The released cotylocidium larvae had two visible eyespots and three patches of posterior cilia—two lateral patches and one abopercular patch. The cotylocidium was propelled forward by its cilia but was also capable of movement by expansion and contraction. Though many hatched eggs were observed, only three cotylocidia were found, likely attesting to a brief longevity of these larvae. A future project will draw from the timeline of embryonic development established in this study to address whether some unembryonated eggs are retained and develop in the gill/visceral mass junction where adults reside or simply pass into the water column. In addition, developmental rates in artificial pond water vs. artificial snail water will be assessed to further clarify the preferred osmotic environment for *C. insignis* embryo development within these eggs.

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## **BIOLOGY PROGRAM**

Isolation and characterization of non- virulent plasmids. RAY ISINGA MIREMBO, MAHLON KIRK, and DAWN ANDERSON, Biology Program, Berea College, Berea, Kentucky 40404.

Over 100 trillion microbes inhabit the human gastrointestinal tract. This microbial community forms a dynamic ecosystem that plays a key role in host metabolism, cell growth and differentiation, immune system homeostasis and pathogen protection. *Escherichia coli* is an important component of the normal gut microbiota. Some strains of *E. coli* are, however, pathogens, so-called “bad bugs,” and are responsible for a variety of gastrointestinal diseases. Many of the genes that code for the various virulence factors or antibiotic resistances of *E. coli* are located on extra-chromosomal plasmid molecules. While the virulence and drug resistance plasmids have been well studied, less attention has been focused on those *E. coli* plasmids not associated with disease. A lot of research has focused on the negative effects of plasmids and their associated virulence factors such as toxins, adherence factors and drug resistance. There have, however, been some plasmids found in normal flora *E. coli* that do not appear code for any major virulence factor. Not much research has focused on the structure and function of these DNA molecules or on the role that these plasmids may play in the human gut bacterial ecosystem. The purpose of this research project was to identify, isolate and characterize naturally-occurring *E. coli* non-virulence plasmids in order to gain a better insight into their structure and function within the human gut flora ecosystem and a better understanding of these energetically expensive DNA molecules.

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**Funded by Berea College URCP**

## BIOLOGY PROGRAM

Obesity Induced Leptin Mediated Notch Signaling in Breast Cancer. KAAMILAH WILSON<sup>1</sup> and DR. RUBEN R. GONZALEZ-PEREZ<sup>2</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Morehouse School of Medicine, Atlanta, Georgia 30310.

Breast cancer is currently the most common cancer amongst women worldwide. Obesity, characterized by high levels of leptin, has consistently been associated with higher incidence of breast cancer. Leptin signaling regulates angiogenesis, stimulates survival, proliferation, and migration of Breast Cancer (BC) cells. Notch, another known angiogenic factor, is associated with aggressive BC and poor prognosis. We have found that Leptin can induce the expression and activation of Notch in Breast Cancer cells. This investigation will determine whether obesity induces a functional Leptin-Notch signaling crosstalk that stimulates Breast Cancer progression. Western blot (WB) analysis was used to investigate the expression levels of Notch receptors and targeted proteins in cell lysates and in tumors derived from mouse mammary cancer cells (E0771). Tumors were dissected from lean and DIO-mice (diet-induced-obesity) C57BL/6J female mice. Mice were inoculated with E0771 cells then treated with leptin inhibitor (PEG-LPrA2). Real-time PCR (Polymerase Chain Reaction) was used to measure relative Notch gene expression in E0771 tumors; cDNA was synthesized from total RNA by reverse transcription and used as a template for real-time PCR amplification of Notch ligands/receptors. WB analysis revealed that leptin induced the expression of several Notch receptors and activated molecules in E0771-BC cells. Western Blot and RT-PCR further revealed that LPrA2 abrogated leptin-specific Notch signaling. Data suggest that leptin contributes to Breast Cancer (BC) development through the activation of the Notch signaling pathway. Thus, inhibition of leptin signaling may significantly decrease the high incidence, aggressiveness and poor prognosis of BC in obese patients.

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## **BIOLOGY PROGRAM**

POGIL in General Biology: Introduction and Analysis of Process Oriented Guided Inquiry Learning. JOSHUA WEDDING, MELANIE KEIL, and MEGAN HOFFMAN, Biology Program, Berea College, Berea, Kentucky 40404.

This study evaluated whether or not introductory biology courses that incorporate cooperative guided inquiry are more effective in students' learning than lecture-based courses. The POGIL approach (Process Oriented Guided Inquiry Learning) was compared to lecture, looking at grade distribution as well as students' ability to answer higher-order questions on the Bloom's Taxonomy scale. The results indicated that POGIL-based learning raised the number of ABC grades and decreased DFW (withdrawal) grades. Not only were students earning better grades, but they were answering higher-order questions as well. This study is being continued by varying the teaching approach in parallel sections of an introductory biology course. Students will be evaluated by a variety of means, including the ability to explain complex concepts, metacognitive measures, and exam and course grades.

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**Funded by Berea College URCP**

## BIOLOGY PROGRAM

Porosity change after aging high-copper dental amalgams for 19 years. LIN PENG<sup>1</sup> and DR. RICHARD MITCHELL<sup>2</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Department of Oral Health Practice, College of Dentistry, University of Kentucky, Lexington, Kentucky 40536-0297.

Dental amalgam is made by mixing mercury with a powder that consists of particles made of Ag-Sn, Ag-Cu, and/or Ag-Cu-Sn alloys. After amalgam has set, the partially dissolved alloy particles are found to be surrounded by a metallic matrix that is composed of the intermetallic compound  $\gamma_1$  (gamma-one) Ag-Hg. During aging,  $\gamma_1$  may decompose by either one or by both of two processes: 1) Hg evaporation or 2) Hg diffusion into alloy particles. During both process,  $\gamma_1$  decomposition is likely to be accompanied by an increase in porosity. The preliminary result suggested both amalgam samples will exhibit a significantly greater volume percentage of porosity after storage in air at 37°C for 19 years than after storage for two weeks under the same conditions. In this study, two types of high-copper amalgam are studied. For each type of amalgam, three amalgam cylinders (8 mm long x 4 mm in diameter) were aged for two weeks and three others were aged for 19 years. Cross sectional surfaces were relief polished to bring out the microstructure. Digital micrographs will be analyzed with an image analysis program. The volume percentages of alloy particles and porosity will be measured and, using t-tests, the volume percentages at two weeks and 19 years will be compared. Key point: If porosity increases,  $\gamma_1$  is decomposing.

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## BIOLOGY PROGRAM

Screening for new prions in wild yeasts. AUNG S. LIN<sup>1</sup>, PETER TSVETKOV<sup>2</sup> and SUSAN LINDQUIST<sup>3,4,5</sup>, <sup>1</sup>Department of Biology, Berea College, Berea, Kentucky 40404, <sup>2,3</sup>Whitehead Institute for Biochemical Research, <sup>4</sup>Howard Hughes Medical Institute, <sup>5</sup>Department of Biology, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

Prions are proteins that can acquire a self-perpetuating conformation, thereby resulting in a loss or gain of functions relative to the original non-prion state of the prion. They can trigger non-prion conformation of a protein into prion conformation by serving as a template, resulting in formation of amyloid fibers/aggregates. The original definition of prion was based on disease-associated prion proteins (PrP). However, over the years, there has been an accumulation of examples of proteins which have prion-like characteristics, yet are not associated with pathology. The best characterized prion biology was described in yeast where several proteins including Sup35, Rnq1 and Mot3 were characterized as prions. Their prion natures give rise to the observed prion phenotypes, [PSI+], [PIN+] and [MOT3+] respectively. These proteins in the prion conformation were shown to be beneficial to the cell under different conditions. Recently, it was shown that the most well characterized prion states were also observed in a large collection of wild yeast strains. Transient inhibition of one of the chaperones, Hsp104 with guanidine hydrochloride (GndHCl), results in the loss of the amyloid form of the characterized prions in yeast (Sup35, Rnq1, Mot3). This inhibition is termed as curing of the prion. The research has shown that transient inhibition of Hsp104 in the wild strains resulted in numerous sustained phenotypes. It implies that a prion based mechanism is regulating these observed changes. Less than a quarter of these phenotypes could only be explained by known prions, suggesting there might be many key regulatory prion based proteins in the yeast that have not been characterized yet. Furthermore, bioinformatics algorithms analysis has shown that approximately 30% prion forming domains (PrD) are present in proteins with RNA binding domains, whereas in yeast proteome, around 4% present. It indicates that there might be RNA binding proteins that exist as prion states and that have not been characterized yet. Hence, in this work, we set out to characterize potential new prions in the proteins with RNA binding domains- HRP1, PUB1, NRP1, NGR1 and PBP1 in the wild yeast strains. In order to screen for potential new prions in around 300 wild yeast strains, two biochemical assays are being utilized- dot blotting and SDD AGE. Prions assemble into self-propagating amyloid fibers both in vivo and in vitro. The amyloids are resistant to protease and insoluble in sodium dodecyl sulfate (SDS). Due to these characteristics, the above biochemical assays are very effective for screening new prion like proteins because both assays involve using SDS to detect for protein aggregates. From analysis of dot blotting in every two biological replicates, we observed that approximately a quarter of the wild strains have SDS-resistant aggregates. Further analysis of SDD AGE has shown that even less than a quarter of the wild strains have SDS-resistant aggregates. Taking the hit wild strains from analyses of two biochemical approaches, we are further analyzing whether those protein aggregates observed are actually prion forms in the wild yeasts by inhibiting Hsp104 with GndHCl (curing of a prion).

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## BIOLOGY PROGRAM

Seed germination ecology and seedling survivorship of the endangered cream gentian *Gentiana flavida*. A. Gray (Gentianaceae). SOPHIA AL-MAAMARY, LAUREN A. BALLOU, JOHN F. DARLING, ALANNA M. WENTWORTH, and CHRISTOPHER A. ADAMS, Biology Program, Berea College, Berea, Kentucky 40404.

*Gentiana flavida* is an endangered species in Kentucky, with populations known from only five counties. Little is known about the life history of this species. The purpose of this project was to examine the initial stages of the species' life history: seed germination and seedling survivorship. Initial tests determined that the seeds are dormant at maturity. This study attempted to discover the proper dormancy-breaking conditions for maximum seed germination and to determine the necessary growth medium for maximum seedling establishment. Mature seeds were placed in a 5°C incubator for varying time periods (0-12 weeks), simulating the cold stratification that seeds would receive in the field during winter. Next, each group of seeds was moved to a 25° C incubator and germination was monitored. To determine ideal growth medium conditions, *G. flavida* seedlings were placed in three different soil treatments (mycorrhizal inoculated, non-mycorrhizal, and soil from the field site) and then monitored over time for survivorship. Results indicated that the 12 week cold stratification treatment produced a significantly higher percent germination (68%) than stratification at 8 (59%), 4 (8%), or 0 (0%) weeks. Among the growth medium treatments, soil collected from the field site contained seedlings with the highest seedling survivorship (67%), significantly higher than the other two treatments. Potting media that contained mycorrhizal inoculants showed higher survivorship (38%) than media that was not inoculated (2%). In conclusion, for maximum germination and survivorship, seeds should receive 12 weeks of cold stratification and have exposure to mycorrhizal soil microbes.

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**Funded by Berea College URCP**



## BIOLOGY PROGRAM

Standardizing cellular analysis: establishing an ASTM standard through the application of Colonyze™. WENDELL BLISS and DR. GEORGE MUSCHLER, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Orthopedic Surgery, The Cleveland Clinic, Cleveland, Ohio 44195.

Cell and colony enumerations (CFU assays) are becoming significantly important in the manufacturing, quality assurance and development of cell-based regenerative medicine and cellular therapies. Traditional methods of CFU assays involve manual quantification of cell cultures based on observer-dependent criteria. Because each user has their own unique criteria for determining cell and colony counts, the same observer is often required to perform all assays in an entire study to maintain consistency. This can result in both reduced accuracy and reproducibility. When multiple observers are used to reduce fatigue significant intra- and inter-observer variability can affect the consistency of the assays. Implementation of a quantitative automated image analysis system would not only provide a reproducible and consistent analysis, but it would also reduce the time and resources devoted to manual assays. Developing a series of protocol linking automated image capturing and the use of Colonyze™ our lab was able to achieve an ASTM standard for automated colony forming unit assays. Colonyze™ has been used successfully to study human adult Connective Tissue Progenitor (CTP) cells and the effects of Wnt signaling, hypoxia, magnetic cell-selection, and CTP homing to a defect site in a parabiotic mouse model. The automated CFU assays provided by Colonyze™ produced data on individual colonies that was agreeable with manual researchers 85% of the time. Colony numbers obtained using automated method demonstrated a correlation coefficient of 0.99 with data from observers.

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## BIOLOGY PROGRAM

The role of residue K752 in  $\beta 1$  integrin homodimerization. KAITLYN REASONER<sup>1</sup>, JOHN CHEN<sup>2,3</sup>, ROY ZENT<sup>4</sup> and CHARLES R. SANDERS<sup>2,3</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Center for Structural Biology, <sup>3</sup>Department of Biochemistry, <sup>4</sup>Department of Medicine, Vanderbilt University Medical Center, Nashville, Tennessee 37232.

Integrins are heterodimeric, transmembrane cell adhesion receptors involved in cellular signaling. At the interface of the cytoplasmic tail (CT) and the transmembrane region (TM) is the membrane proximal region (MPR). Highly conserved lysine and arginine in the MPR appear to be significant in activation. In a previous study of the  $\alpha \text{IIb}\beta 3$  integrin, researchers found that mutating the lysine (K) in the MPR led to increased ligand binding. Mutations of the lysine at residue 752 in the MPR also differentially affect  $\alpha 1\beta 1$  and  $\alpha 2\beta 1$  binding affinity to collagens in the different integrins. Although integrins are heterodimers, we investigated whether they also have homodimeric properties.  $\beta 1$  TM-CT fragments were expressed and purified. Tryptophan fluoroscopy was used to investigate  $\beta 1$  homodimeric properties. The wild type and all mutants exhibit strong homodimerization. Lysine, glutamine and arginine had the smallest dissociation constant values, indicating tighter homodimerization. The polarity and charge of these amino acids indicates that polarity and charge in the MPR may be important. However, glutamine exhibited the strongest homodimerization, likely due to the strong hydrogen bond-donor capabilities of its side chain. The polarity, charge and other side chain properties at residue K752 appear to influence integrin homodimerization.

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## BIOLOGY PROGRAM

Toward defining the oncogenic activities in Aurora Kinase A that transform pre-malignant keratinocytes. JENNA RUFER<sup>1</sup>, DR. ENRIQUE TORCHIA<sup>2</sup>, DR. DENNIS ROOP, and DR. RON ROSEN<sup>1</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Charles C. Gates Center for Regenerative Medicine and Stem Cell Biology, Anschutz Medical Campus, University of Colorado, Denver, Colorado 80202.

The proto-oncogene Aurora Kinase-A (Aurora-A) is implicated in numerous epithelial cancers. It has key roles in mitotic division, promoting the timely entry into mitosis, the maturation of centrosomes and the establishment of bipolar spindles. Little is known how mechanistically Aurora-A contributes to the transformation of epithelial cells. Animal models have shown that abnormal expression of Aurora-A in premalignant skin cells can lead to genomic instability and cellular transformation. To define the critical oncogenic activities of Aurora-A, we sought out to test if mutants of Aurora-A deficient in their ability to phosphorylate targets or induced centrosome amplification could co-operate with activated Ras to fully transform premalignant keratinocytes. Aurora-A mutants were cloned into the pInducer Lentiviral system using gateway cloning. To test the functionality of the Aurora-A Lenti-constructs, we co-transfected individual plasmids and a GFP control with packaging vectors into 293FT cells. The conditioned media was then collected and used to transduce naïve 293FT cells or primary keratinocytes. To establish initiated, but pre-malignant epithelial cell cultures, we isolated skin keratinocytes from P2 pups carrying K14CreER (T), KrasLSLG12D, and p53floxed alleles. In this pre-cancer model, the p53 gene is deleted and the constitutively active form of Ras (RasG12D) expressed after incubation with the CreER ligand, 4Hydroxytamoxifen. Titers of the GFP Lentivirus were low until the production protocol had been further refined. Nevertheless, we successfully cultured and transduced primary cultures of p53<sup>-/-</sup>;KrasG12D keratinocytes. In summary, we have established the experimental approach to express mutant forms of Aurora-A in premalignant epithelial cells.

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## BIOLOGY PROGRAM

Variation in Diversity and Abundance of Salamanders in Relation to Human Development in Six Selected Stream Habitats in Central Kentucky. LEIF VAN LAAR, CHRISTINA BENEDICT, ALYSSA HUBBARD, REBECCA JEONG, MICHON MARTIN, and DR. ROY SCUDDER-DAVIS, Biology Program, Berea College, Berea, Kentucky 40404.

The diversity and abundance of salamanders in six streams in Central Kentucky was monitored during the summer of 2013. The habitat surrounding four of the streams showed various amounts of human development, while two were relatively undisturbed habitats. In two of the disturbed habitat streams, human development took the form of the north and south bound lanes of Interstate 75 which passed on both sides of the streams forming “habitat islands.” In the other two disturbed habitat streams, human development took the form of nearby roads, bridges, culverts and dwellings. Two, ten-meter long transects were established within each stream, and each stream was sampled five times during the study. Sampling sessions involved turning over objects in the stream bed, collecting the salamanders encountered, and photographing each specimen to determine maturity and for identification purposes. The number of objects turned and the time spent sampling were recorded for each sampling session. Salamander diversity was higher in the two undisturbed habitat streams than in the disturbed habitat streams. While it was postulated that the isolation of the I-75 streams would decrease diversity more than in the non-isolated disturbed habitat streams, both kinds of habitat streams were dominated by a single species, the southern two-lined salamander, *Eurycea cirrigera*. Abundance of salamanders showed no consistent pattern among the types of stream habitats. One each of the undisturbed, disturbed isolated, and disturbed non-isolated stream habitats had relatively high abundance of salamanders and one each had relatively low salamander abundance.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Oral Presentation)*

*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Oral Presentation – Ecology and Environmental Science Section: 1<sup>st</sup> Place Undergraduate Research Competition)*

**Funded by Berea College URCP**

## BIOLOGY PROGRAM

A putative antimicrobial defense mechanism in basement membranes. PHILIP PALUMBO<sup>1</sup>, CHRISTOPHER F. CUMMINGS<sup>2</sup>, and BILLY HUDSON<sup>3</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404; <sup>2</sup>Aspirnaut Program, Department of Nephrology and Hypertension, Vanderbilt University Medical Center, Nashville, Tennessee 37232.

Expression and Modulation of Lysyl Oxidase-Like 2 in PFHR9 Mouse Endodermal Cell Line. AMBER CRABTREE<sup>1</sup>, CAROLINA AÑAZCO<sup>2</sup>, and ROBERTO VANACORE<sup>2</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Department of Medicine/Division of Nephrology, Vanderbilt University Medical Center, Nashville, Tennessee 37232.

Proprotein Convertase Processing of Peroxidase. ERICKA L. BERG<sup>1</sup>, BILLY HUDSON<sup>2</sup>, and GAUTAM BHAVE<sup>2</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404; <sup>2</sup>Division of Nephrology, Vanderbilt University Medical Center, Nashville, Tennessee 37232.

Pyridoxamine Protects Collagen IV from Damage by Hypochlorous Acid. JOSHUA AVANCE<sup>1</sup>, CARL DARRIS<sup>2,3</sup>, BILLY HUDSON<sup>2,3</sup>, and PAUL VOZIYAN<sup>2,3</sup>, <sup>1</sup>Biology Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Division of Nephrology, <sup>3</sup>Center for Matrix Biology, Vanderbilt University, Nashville, Tennessee 37232.

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Research performed at Vanderbilt University

**Funding provided by the Aspirnaut Program, Vanderbilt Medical Center, and the Berea College Internship Office**

## CHEMISTRY PROGRAM

Analysis of soil lead in Berea, Kentucky derived from leaded paint. PHYO PHYO KYAW ZIN, CHRISTINA KOLSTO, and PAUL C. SMITHSON, Chemistry Program, Berea College, Berea, Kentucky 40404.

Lead (Pb) is a potent neurotoxin, and exposure early in life can result in permanent learning deficits and violent behavior. The major sources of environmental Pb are leaded paint and soil impacted by auto exhaust from leaded gasoline. Some older Berea College campus buildings still contain leaded exterior paint (1 to 15 wt% Pb). We sampled the top 2.5 cm of soil at the base of several campus buildings, both on the side facing the road and the opposite side, as well as in two urban gardens with possible lead contamination. We extracted 2.0 g air-dried, sieved (2 mm) soil for 1 hour with 20 mL 1M HNO<sub>3</sub>, filtered and analyzed the extracts for Pb by atomic absorption spectroscopy. We found elevated Pb levels at the base of buildings, with no significant difference between the road side and back side (paired t-test, P = 0.336), from which we conclude that leaded paint was the likely source of the elevated Pb. Only a few samples exceeded the US EPA “urban background” level of 400 mg/kg, but the mean Pb was significantly higher than background (taken to be average Pb in samples taken well away from roads and buildings) (t-test, P = 0.03). Both urban gardens had significantly higher Pb than background (P = 0.02), likely due to a 1930s-era dwelling that had suffered fire damage. Lead levels in Berea soils are lower than is common in dense urban settings, but high enough to be of some concern around older buildings.

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**Funded by Berea College URCP**

## CHEMISTRY PROGRAM

Asymmetric Catalytic Synthesis of  $\beta$ -Ketoesters through Ketene Intermediation. MICHAEL MCCANN and DR. MARY ROBERT GARRETT, Chemistry Program, Berea College, Berea, Kentucky 40404.

$\beta$ -Ketoesters are used as building blocks for natural products and pharmaceuticals. The current synthesis of  $\beta$ -ketoesters is wasteful, toxic, and expensive with almost no stereospecificity. Ketenes can be generated at such low costs, but have never been used to synthesize  $\beta$ -ketoesters. Reactions of ketenes and cinchona alkaloid derivatives form zwitterionic enolates that are could potentially attack an ester in a Claisen-like condensation yielding the desired  $\beta$ -ketoester. This method can lead to enantioselectivity depending on the ketene starting material.

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**Funded by Berea College URCP**

## CHEMISTRY PROGRAM

Characterization of Magnesium Stearate. DANIEL PARDUE<sup>1</sup>, ERIC MUNSON<sup>2</sup> and MATTHEW J. NETHERCOTT<sup>2</sup>, <sup>1</sup>Chemistry Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Department of Pharmaceutical Sciences, University of Kentucky, Lexington, Kentucky 40536.

Magnesium stearate (MgSt) is the most commonly used excipient in drug formulations in the pharmaceutical industry and it is poorly understood. Pharmaceutical MgSt is composed of a blend of magnesium stearate and magnesium palmitate. An excipient is an inactive ingredient used in a drug formulation. MgSt is not well characterized, which results in many problems such as multiple states (anhydrous, hydrous, amorphous), changes in solid state induced by manufacturing process of tablets, and dissolution problems of tablets. The purpose of this project was to characterize the molecular properties of MgSt by <sup>13</sup>C Solid State Nuclear Magnetic Resonance (SSNMR), Differential Scanning Calorimetry (DSC), and Thermo-Gravimetric Analysis (TGA). Seven commercial samples were characterized, as well as stearic acid, palmitic acid, and synthetically prepared magnesium stearate and magnesium palmitate. The synthesized samples were crystalline but the commercial samples were both crystalline and amorphous. From the characterization, a correlation can be made between the SSNMR carbonyl region and DSC thermogram. The TGA of the commercial samples showed an average weight loss of about 3%, whereas, the synthesized MgSt showed a weight loss of about 6%.

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## CHEMISTRY PROGRAM

Coherence Pathways for CPMG and PIETA NMR Experiments. ANNA TRIBBLE and DR. JAY BALTISBERGER, Chemistry Program, Berea College, Berea, Kentucky 40404.

The use of Carr-Purcell-Meiboom-Gill (CPMG) echo sequences in NMR spectroscopy has grown substantially in the last ten years. In particular CPMG is used for imaging, wideline spectra, relaxation dispersion, and well-logging/core analysis. In all of these experiments the sequence is assumed to generate a series of spin-echoes that decay in time according to a transverse relaxation rate. With the discovery of the Phase Incremented Echo Train Acquisition (PIETA) approach we are now able to analyze the coherence transfer pathways occurring within a CPMG echo train. We have shown that when RF offset effects are large, the CPMG sequence leads to significant numbers of stimulated echoes instead of the spin-echoes. The CPMG echoes follow a coherence pathway that spends considerable time in a zero-coherence state that decays with the longitudinal relaxation time rather than the transverse relaxation time. This means that in most of these applications where the results depend on the echo decay dimension, the offsets can lead to seemingly unpredictable results. PIETA offers a partial solution to the problem by guaranteeing a coherence pathway, though it still has significant signal loss due to offset effects.

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**Funded by Berea College URCP**

## CHEMISTRY PROGRAM

Integrin subunits  $\alpha 3$  and  $\alpha 6$  are essential for collecting duct cells functions regulated by binding to LM-511. FRANCESKA MEHMETI<sup>1</sup> and DR. ROY ZENT<sup>2</sup>, <sup>1</sup>Chemistry Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Department of Nephrology, Vanderbilt University, Nashville, Tennessee 37232.

Integrins are transmembrane glycoprotein heterodimers formed by  $\alpha$  and  $\beta$  subunits. Laminin-binding integrins  $\alpha 3\beta 1$ ,  $\alpha 6\beta 1$  and  $\alpha 6\beta 4$  play critical role in branching morphogenesis of the collecting duct during kidney development. By knocking-out integrin subunits  $\alpha 3$  and  $\alpha 6$  in the inner-medullary collecting duct (IMCD) cells, we study the role of laminin-binding integrins in adhesion, migration and proliferation. Our results demonstrate that adhesion, migration and proliferation of Itg  $\alpha 3\alpha 6$ -knockout (KO) IMCD cells on LM-511 are significantly lower as compared to Itg  $\alpha 3\alpha 6$ -wild-type (WT) IMCD cells suggesting that laminin-binding integrins are essential for major functions of IMCD cells. To address the role of laminin-binding integrins in signal transduction pathways triggered by interaction of IMCD cells with LM-511 and by growth factors (glial cell line neurotrophic factor (GDNF) and fibroblast growth factor 10 (FGF 10)), we studied time-dependent changes in activation of focal adhesion kinase (FAK), Src, Akt, glycogen synthase kinase  $\beta$  (GSK-3 $\beta$ ) and p38 after plating IMCD cells on LM-511 and after treatment with GDNF or FGF10. Higher and more sustained activating phosphorylation of FAK, Src, p38 and Akt was observed in Itg  $\alpha 3\alpha 6$ -WT compared to Itg  $\alpha 3\alpha 6$ -KO IMCD cells plated on LM-511 or treated with FGF10. However, no differences were observed when cells were treated with GDNF. Therefore, we conclude that integrins  $\alpha 3\beta 1$ ,  $\alpha 6\beta 1$  and  $\alpha 6\beta 4$  regulate activation of FAK, Src and Akt and p38 signaling in IMCD cells triggered by interaction with LM-511 or FGF10.

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## CHEMISTRY PROGRAM

Lead levels in soils of Berea, Kentucky attributed to roadside gasoline exhaust and pesticide usage. CHRISTINA KOLSTO, PHYO PHYO ZIN, and PAUL C. SMITHSON, Chemistry Program, Berea College, Berea, Kentucky 40404.

Lead (Pb) exposure at an early age can cause neurological damage and has been linked to criminal behavior as an adolescent. This study was conducted to analyze the lead content of roadside soils suspected of containing leaded gasoline deposits, as well as farm fields suspected of containing lead arsenate pesticide residues. Two hundred two surface soil samples (top 2.5 cm) were collected for lead analysis in Berea, Kentucky. Samples were collected near roads and in farm fields, as well as away from roads to establish background lead levels. Soils were sieved (2 mm), 2.0 g of each sample was shaken in 20 mL 1M HNO<sub>3</sub> for one hour, filtered and the extracts analyzed for Pb by atomic absorption spectroscopy. Using log transformed data, samples near roadways had a mean  $\pm$  SD of 40 $\pm$ 27 mg Pb/kg (antilog of log mean), slightly but significantly higher than background levels (t-test, P = 0.03). Samples in farm fields had a mean of 27 $\pm$ 19 ppm Pb (antilog of log mean), slightly lower than but not significantly different from background (t-test, P = 0.07). We conclude that roadside lead contamination of Berea soils is less severe than is common in dense urban settings, but is high enough to be of some environmental and health concern in a few locations. There was no evidence of lead arsenate pesticide residues in farm fields.

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**Funded by Berea College URCP**

## CHEMISTRY PROGRAM

Optimization of Synthesis of Internally-Quenched Fluorescent Peptides. GARRETT CAIRO, ANDREW NORRIS, CORY PAYTON, and DR. MATTHEW SADERHOLM, Chemistry Program, Berea College, Berea, Kentucky 40404.

Procedures for synthesizing internally-quenched, fluorescently-labeled peptide substrates for the neuropeptidase neurolysin were optimized. First, the synthesis of Fmoc-Lys(DNP)-OH, used to fluorescently label peptides was improved both in terms of yield and purity. Secondly, methods for a range of solid-phase peptide synthesis methods (deprotection, resin loading, amino-acid coupling, and peptide cleavage) were analyzed and improved.

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**Funded by Berea College URCP**

## CHEMISTRY PROGRAM

Second distinct Q(3) site observed in Cs<sub>2</sub>O•2SiO<sub>2</sub> glass using <sup>29</sup>Si Two-Dimensional MAF-PIETA NMR. KEVIN J. SANDERS<sup>1</sup>, PYAE PHYO<sup>2</sup>, PHILIP J. GRANDINETTI<sup>1</sup>, and JAY BALTISBERGER<sup>2</sup>, <sup>1</sup>Department of Chemistry, The Ohio State University, Columbus, Ohio 43210, <sup>2</sup>Division of Natural Science, Mathematics and Nursing, Berea College, Berea, Kentucky 40404.

Using the 2D Magic Angle Flipping (MAF) [1] experiment with PIETA acquisition [2] on the <sup>29</sup>Si nucleus at natural abundance, we have observed two distinctly unique Q(3) environments in a Cs<sub>2</sub>O•2SiO<sub>2</sub> glass. The <sup>29</sup>Si 2D MAF spectrum in Figure 1 shows a clear discontinuous change in the shielding anisotropy in the region normally associated with the Q(3) environment. Both Q(3) environments are also clearly resolved in the isotropic projection. This discontinuity suggests that the cesium disilicate sample does not follow the conventional disproportionation model, which predicts only one unique Q(3) site. Malfait [4] showed that cesium glasses follow a very binary distribution, but the two Q(3) sites were not clearly resolved in his Raman experiments. Such a discontinuous change in the Q(3) pattern is not observed in the 2D MAF spectrum of other alkali-modified silicate glasses, such as K<sub>2</sub>O•2SiO<sub>2</sub> [3].

Interestingly, Kroeker et al. [5] observed multiple 11B peaks in the [4]B region of cesium borate glasses where lighter alkali modifiers (Li, Na) produced only one peak on the [4]B region. Kroeker suggested different clustering of cesium cations around the [4]B as a possible explanation. The basis for this explanation could be modifier packing constraints or modifier field strength effects on network polymerization or some combination of these and other factors. Based on this preliminary observation on the Cs<sub>2</sub>O•2SiO<sub>2</sub> glass system, we propose different cation clustering schemes around the non-bridging oxygen (NBO) as the most likely reason for observing two different Q(3) peaks. Based on our preliminary observations, it is clear that further studies are required. Experiments on more compositions of cesium-silicate glasses will be performed to discern trends in the proportions of different Q(3) sites observed; experiments like DAS [6] on <sup>17</sup>O may also be beneficial to perform to try to identify the coordination environment of the NBOs in the different Q(3) sites.

The cesium disilicate sample was chosen for this study because it very closely follows the binary disproportionation model of silicate glasses and should contain mostly the Q(3) environment. The sample was prepared using reagent grade Cs<sub>2</sub>CO<sub>3</sub> and amorphous SiO<sub>2</sub>. To aid in spin-lattice relaxation, CuO (containing the paramagnetic Cu<sup>2+</sup> ion) was added at a level of 0.5% w/w. The sample was rotated at approximately 12 kHz, resulting in sidebands with very minimal intensity, so the data was treated in the infinite-spinning limit. During the t<sub>1</sub> evolution period, the rotor was oriented at an angle of 80° to B<sub>0</sub> to evolve shielding anisotropy. It is worth noting that an angle of 90° is preferable to use during anisotropic evolution; however, the rotor did not spin stably below 80°, so this angle was used. The rotor was then hopped to the magic angle using a solid-state stepper motor. It is also prudent to note that PIETA acquisition is identical to CPMG acquisition for amplitude-modulated experiments if the excitation and refocusing pulses are perfect; however, the possibility of having some spins evolve at p=0 during the anisotropic evolution period due to imperfect excitation led us to choose PIETA since this acquisition scheme allows for separation of all four possible pathways, eliminating this possibility.

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*Presented in a poster presentation at the 54th Experimental NMR Conference in Asilomar, California from April 14<sup>th</sup> – 19<sup>th</sup> in 2013.*

## CHEMISTRY PROGRAM

Spinning Sideband Analysis of Phosphate Glasses using scaled and unscaled correlation experiments. MIKIYAS ASSEFA<sup>1</sup>, DR. JAY BALTISBERGER<sup>1</sup> and DR. PHILIP GRANDINETTI<sup>2</sup>, <sup>1</sup>Chemistry Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Department of Chemistry and Biochemistry, Ohio State University, Columbus, Ohio 43210.

The use of chemical shift anisotropy (CSA) correlation experiments in solid-state nuclear magnetic resonance (NMR) spectroscopy has gained increasing popularity in the study of amorphous materials, particularly as new slow spinning and high sensitivity approaches have been developed. The majority of this work has been done using a slow spinning method called magic-angle turning (MAT) or phase adjusted spinning sidebands (PASS) or some combination of the two (MAT/PASS). However in the case of an amorphous material where a distribution of CSA tensor elements exists at every isotropic slice, the mapping of the spinning sideband data back onto the CSA distribution is quite difficult. The most popular model used in these situations is a Gaussian random field model created by Czjek to model Mössbauer spectra of disordered metal alloys containing iron. We are adapting this same model to convert our sideband patterns from various MAT/PASS experiments into CSA distributions. Once these distributions are determined, we may begin to look for correlations between them and macroscopic glass properties.

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## CHEMISTRY PROGRAM

Synthesis of Beta-ketoesters via ketene intermediate. TRAVIS CLAY, CHYNA JOHNSON, and DR. MARY ROBERT GARRETT, Chemistry Program, Berea College, Berea, Kentucky 40404.

Studies show  $\beta$ -ketoesters as critical intermediates for the synthesis of many important natural products, pharmaceuticals, and photographic chemicals. Through a proposed ketene-Claisen condensation reaction, an acid chloride can provide a ketene precursor that when reacted with an ester could potentially yield  $\beta$ -ketoesters. This method offers a more green technique than previously proposed methods in the since that it is very atom economical. This research project aimed to synthesis novel  $\beta$ -ketoesters in high enantiomeric excess.

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**Funded by Berea College URCP**

## CHEMISTRY PROGRAM

Using Phase Incremented Echo Train Acquisition (PIETA) Experiment to Measure Homonuclear  $^{31}\text{P}$  J-Couplings in Phosphate Glasses. PYAE PHYO<sup>1</sup>, DR. JAY BALTISBERGER<sup>1</sup> and DR. PHILIP GRANDINETTI<sup>2</sup>, <sup>1</sup>Chemistry Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Ohio State University, Columbus, Ohio 43210.

By studying the local structures in amorphous materials we may attempt to understand how microscopic properties control bulk properties. Phosphate glasses are used in a variety of applications similar to silicate glasses including biocompatible materials and radioactive waste confinement. Using two-dimensional Phase Incremented Echo Train Acquisition (PIETA) nuclear magnetic resonance under fast magic-angle spinning (MAS) conditions, we measured the homonuclear  $^{31}\text{P}$  two-bond J-couplings in various phosphate glasses modified by zinc, barium, and lead. These PIETA measured J-coupling distributions were compared with the traditional Hahn-echo and Carr-Purcell-Meiboom-Gill (CPMG) methods. It was seen that PIETA is equal in speed and sensitivity to CPMG but without the zero-frequency artifact that obscures the J-couplings under CPMG conditions. The PIETA method is fully equivalent to the traditionally used Hahn-echo method but sixty-four times faster for the same sensitivity. Our observations suggest that the modifier cation has a significant impact on the measured range of J-couplings across the P–O–P bonds and we are investigating how to map this distribution of J-couplings into a distribution of bond-angles in these glasses, acting as a direct measure of medium range order in these samples. Also by using a two-dimensional approach we are able to separate overlapping sites in a glass using the J-resolved dimension (such as distinguishing between closed-ring and open-chain structures that overlap in a standard MAS experiment). There are no other techniques able to give this level of detailed local structural distribution information in these kinds of systems.

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## CHEMISTRY PROGRAM

USING PHASE INCREMENTED ECHO TRAIN ACQUISITION (PIETA) EXPERIMENT TO MEASURE HOMONUCLEAR  $^{31}\text{P}$  J-COUPPLINGS IN PHOSPHATE GLASSES. PYAE PHYO<sup>1</sup>, JAY BALTISBERGER<sup>1</sup>, BRENNAN WALDER<sup>2</sup>, and PHILIP GRANDINETTI<sup>2</sup>, <sup>1</sup>Chemistry Program, Berea College Berea, Kentucky 40404, <sup>2</sup>Department of Biochemistry and Chemistry, The Ohio State University, Columbus, Ohio 43210.

By studying the local structures in amorphous materials we may attempt to understand how microscopic properties control bulk properties. Phosphate glasses are used in a variety of applications similar to silicate glasses including biocompatible materials and radioactive waste confinement. Using the newly invented two-dimensional Phase Incremented Echo Train Acquisition (PIETA) nuclear magnetic resonance experiment under fast magic-angle spinning (MAS) conditions, we measured the homonuclear  $^{31}\text{P}$  two-bond J-couplings in various phosphate glasses modified by zinc, barium, and lead (see fig. 1 below). These PIETA measured J-coupling distributions were compared with the traditional Hahn-echo and Carr-Purcell-Meiboom-Gill (CPMG) methods. It was seen that PIETA is equal in speed and sensitivity to CPMG but without the zero-frequency artifact that obscures the J-couplings under CPMG conditions. The PIETA method is fully equivalent to the traditionally used Hahn-echo method but much

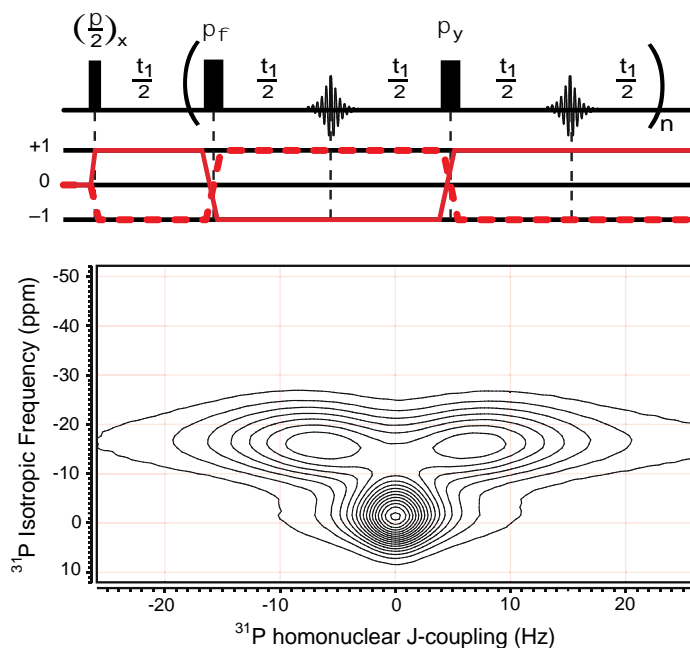


Fig. 1: Pulse sequence (top) and  $^{31}\text{P}$  two-dimensional NMR spectrum (bottom) for  $\text{Zn}_2\text{P}_2\text{O}_7$  glass. A clear doublet is seen in the  $-18$  ppm region for pyrophosphate units and a singlet near 0 ppm for the orthophosphate.

faster for the same sensitivity. Our observations suggest that the modifier cation has a significant impact on the measured range of J-couplings across the P–O–P bonds and we are investigating how to map this distribution of J-couplings into a distribution of bond-angles in these glasses, acting as a direct measure of medium range order in these samples. Also by using a two-dimensional approach we are able to separate overlapping sites in a glass using the J-resolved dimension (such as distinguishing between closed-ring and open-chain structures that overlap in a standard MAS experiment). There are no other techniques able to give this level of detailed local structural distribution information in these kinds of systems.

*Oral presentation at the Southern Undergraduate Research Conference hosted at the University of Tennessee in Knoxville Tennessee from January 30<sup>th</sup> – 31<sup>st</sup> in 2014.*

## CHEMISTRY PROGRAM

Using PIETA to Map Echo Train Coherence Pathways. PYAE PHYO<sup>1</sup>, ANNA TRIBBLE<sup>1</sup>, JAY BALTISBERGER<sup>1</sup>, THOMAS POUMEYROL<sup>3</sup>, FRANCK FAYON<sup>3</sup>, BRENNAN WALDER<sup>2</sup>, and PHILIP GRANDINETTI<sup>2</sup>, <sup>1</sup>Division of Natural Science, Mathematics and Nursing, Berea College, Berea, Kentucky 40404, <sup>2</sup>Department of Chemistry, The Ohio State University, 100 West 18<sup>th</sup> Avenue, Columbus, Ohio 43210-1173, <sup>3</sup>CEMHTI, CNRS UPR 3079, Orleans Cedex 2, France.

Using the Phase Incremented Echo Train Acquisition (PIETA) approach [1], we have studied the coherence pathways generated by this experiment as a function of pulse length and offset errors. There seems to be a general misconception that experiments like CPMG [2,3] are highly effective at creating a train of Hahn echoes. This is only true if the offset is small and the  $\pi$ -pulse time is close to the ideal. Using PIETA, we show that as pulses are applied with improper length and/or off-resonance, the coherence pathway deviates significantly from an expected Hahn echo path ( $\pm 2$  coherence change at each  $\pi$  pulse) to one that includes stimulated echoes. This has significant implications when you are relying on the echo train to measure properties such as J-coupling,  $T_2$  relaxation, or diffusion.

The fundamental problem with CPMG lies in the hope that the coherence pathway will change by  $\pm 2$  with each  $\pi$  pulse and this is reinforced by the belief that the phases of the CPMG pulses help correct any coherence transfer errors. In truth, when the  $\pi$ -pulse is off-resonance or of the wrong length, the coherence pathway will split into many additional paths at each pulse with  $\Delta p = 0, \pm 1, \pm 2$  and even higher transitions if multiple quantum possibilities exist due to multiple spin couplings. When applying the PIETA approach (where every other  $\pi$ -pulse is phase incremented), we examine the Fourier transform at the echo top as a function of echo number and we produce the plots seen in figure 1. The  $\Delta p$  dimension gives the sum of the coherence transfer steps for each  $\pi$ -pulse multiplied by a factor coming from the phase increment of each pulse with PIETA leading to a  $\Delta p_n$  of  $+1$  for the odd  $n$  and  $0$  for even  $n$  values.

$$Dp(N_{echo}) = \sum_n^{N_{echo}} Dp_n f_n \quad \text{and} \quad -1 = \sum_n^{N_{echo}} Dp_n$$

This means if you want a proper Hahn echo pathway you would need to have a  $\pm 1$  coherence after the  $\pi/2$  pulse and  $\pm 2$  after each  $\pi$ -pulse. Putting this pathway into these equations gives the coherence map position for the 6<sup>th</sup> and 7<sup>th</sup> echo.

$$Dp(6) = -1(0) + 2(1) - 2(0) + 2(1) - 2(0) + 2(1) - 2(0) = +6$$

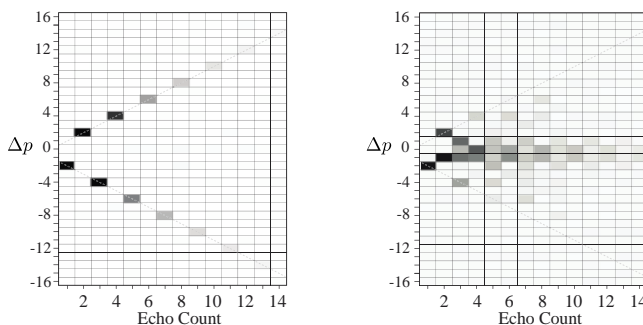
$$Dp(7) = +1(0) - 2(1) + 2(0) - 2(1) + 2(0) - 2(1) + 2(0) - 2(1) = -8$$

You can do similar calculations for the other Hahn echoes and find they form the two diagonals (arrowhead shape) leading away from the center of the spectrum in figure 1. If you look at pathways that meet the detection requirement but follow other pathways, including some time spent as a 0-order coherence forming at least some stimulated echoes, you get many coherences that map near the center (the shaft) such as this example for the 6<sup>th</sup> echo (the first of these is a pure stimulated echo and the second has both stimulated and Hahn echoes).

$$Dp(6) = +1(0) - 1(1) + 0(0) + 0(1) + 0(0) + 0(1) - 0(0) = -1$$

$$Dp(6) = +1(0) - 2(1) + 1(0) + 1(1) - 1(0) + 0(1) - 1(0) = -1$$

The problem with these sorts of pathways is that they spend considerable time evolving as a 0-order coherence (which would relax with  $T_1$  instead of  $T_2$  and show no diffusion or couplings during these periods) instead of  $\pm 1$ -order coherences. We will show how using popular broadband pulses in sequences like WURST-QCMPG leads to non-exponential echo decay trains that fail to give proper measurements of parameters like  $T_2$  or J-coupling constants. Using PIETA can partially alleviate these problems but still requires a correction factor to scale observed parameters appropriately. References: [1] J.H. Baltisberger, B.J. Walder, E.G. Keeler, D.C. Kaseman, K.J. Sanders, and P.J. Grandinetti, J. Chem. Phys. **136**, 211104 (2012), [2] H.Y. Carr and E.M. Purcell, Phys. Rev. **94**, 630-638 (1954), [3] S. Meiboom and D. Gill, Rev. Sci. Instrum. **29**, 688 (1958)



**Fig. 1.** PIETA Coherence map collected for carbonyl peak in fully <sup>13</sup>C labeled zinc acetate with proper  $\pi$  pulse width (left) and improper  $\pi$  pulse width (right).

## CHEMISTRY PROGRAM

Using 2D-PIETA to Measure Homonuclear  $^{31}\text{P}$  J-Couplings in  $\text{Zn}_{2.25}\text{P}_2\text{O}_{7.25}$  Glass. PYAE PHYO<sup>1</sup>, JAY BALTISBERGER<sup>1</sup>, BRENNAN WALDER<sup>2</sup>, and PHILIP GRANDINETTI<sup>2</sup>, <sup>1</sup>Division of Natural Science, Mathematics and Nursing, Berea College, Berea, Kentucky 40404, <sup>2</sup>Department of Chemistry, The Ohio State University, 100 West 18<sup>th</sup> Avenue, Columbus, Ohio 43210-1173.

Using two-dimensional Phase Incremented Echo Train Acquisition (2D – PIETA, [4]), we studied  $^{31}\text{P}$  homonuclear two bond (P-O-P) J-couplings and compared these results to similar experiments conducted using both traditional Hahn echo J-resolved spectroscopy [3] as well as CPMG [1,2] for  $\text{Zn}_{2.25}\text{P}_2\text{O}_{7.25}$  glasses. This glass consists of a mixture of orthophosphate ( $\text{PO}_4^{3-}$ ,  $Q^{(0)}$ ) and pyrophosphate ( $\text{P}_2\text{O}_7^{4-}$ ,  $Q^{(1)}$ ) sites. There is some evidence that there may also be a small fraction of both linear and/or cyclic  $Q^{(2)}$  polyphosphate sites. The 2D-PIETA [4] and Hahn echo [3] experiments produced identical J-coupling distributions while the CPMG failed to exhibit the actual splittings. Copper (II) oxide was added to reduce the  $T_1$  relaxation time in these samples from 300s when undoped to less than 5s with 1% CuO. This doping had a minimal impact on the overall lineshape of the spectrum with the lower doped sample having only slightly longer  $T_2^*$ . Studies were also conducted spinning at both 12.5 kHz and 25.0 kHz with the faster speed only slightly reducing the  $T_2^*$ , indicating that dipolar contributions to the linewidth in both dimensions were minimal.

The J-resolved dimension was simulated using a continuous distribution of J-coupling values using the following equation

$$S(f) = \int_0^\infty I(J) \left[ \frac{1}{(f-J)^2 + a^2} + \frac{1}{(f+J)^2 + a^2} \right] dJ$$

where we assume the inhomogeneous lineshape is comprised of pairs of J-split Lorentzian lines with intensity of each being  $I(J)$  and a width (parameterized by  $a$ ) comparable to the non-coupled  $Q^{(0)}$  site (7 Hz pure Lorentzian). Investigations are underway to determine if measured J-coupling distributions (between 8 and 24 Hz) are related to the P-O-P bond angle distribution for the pyrophosphate units in this glass. A similar analysis has been conducted on  $^{29}\text{Si}$  labeled wollastonite data by Florian and co-workers using J-resolved Hahn echo and INADEQUATE pulse sequences [5,6].

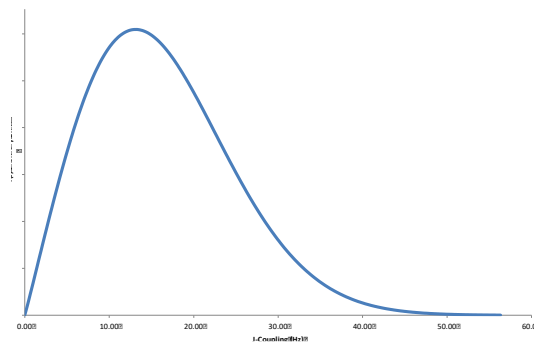


Figure 2. Best fit J-coupling distribution,  $I(J)$ , for a slice at 20 ppm showing a maximum probability near 15 Hz of J-coupling but a full range from 0 to beyond 30 Hz, indicating that there are a range of P-O-P bond angles present for even a single isotropic slice.

### References:

- [1] H.Y. Carr and E.M. Purcell, “Effects of diffusion on free precession in nuclear magnetic resonance experiments,” *Phys. Rev.* 94, 630-638 (1954), [2] S. Meiboom and D. Gill, “Modified spin-echo method for measuring nuclear relaxation times,” *Rev. Sci. Instrum.* 29, 688 (1958), [3] R. Freeman and H.D.W. Hill, “High-resolution study of nmr spin echoes: “J spectra”,” *J. Chem. Phys.* 54, 301-313 (1971), [4] J.H. Baltisberger, B.J. Walder, E.G. Keeler, D.C. Kaseman, K.J. Sanders, and P.J. Grandinetti, “Phase incremented echo train acquisitions in NMR spectroscopy,” *J. Chem. Phys.* 136, 211104-1-4 (2012), [5] P. Florian, F. Fayon, and D. Massiot, “ $^{29}\text{Si}$  Si–O–Si Scalar spin-spin coupling in the solid state: crystalline and glassy wollastonite  $\text{CaSiO}_3$ ,” *J. Phys. Chem. C*, 113, 2562-2572 (2009), [6] D. Massiot, F. Fayon, M. Deschamps, S. Cadars, P. Florian, V. Montouillout, N. Pellerin, J. Hiet, A. Rakhmatullin, C. Bessada, “Detection and use of small J coupling in solid state NMR experiments,” *C.R. Chimie*, 13, 117-129 (2010).

*Presented in a poster presentation at the 54th Experimental NMR Conference in Asilomar, California from April 14<sup>th</sup> – 19<sup>th</sup> in 2013.*

## MATHEMATICS PROGRAM

Modeling a Pinhole Camera with Projective Geometry. CODY GRINNELL, JASON BENTLEY, LARRY GRATTON and JAMES BLACKBURN-LYNCH, Mathematics Program, Berea College, Berea, Kentucky 40404.

Our research focused on three-dimensional reconstruction of an object using a camera and projector along with the Phase Measuring Profilometry process. We used the pinhole model of the camera as well. To better understand this process we investigated the pinhole model and projective geometry. Projective geometry gave us insight into how the pinhole camera maps the object onto the camera image.

*Presented at the Bluegrass Undergraduate Math Symposium at Centre College, Danville, Kentucky on September 28<sup>th</sup> 2013.*

**Funded by Berea College URCP**

## MATHEMATICS PROGRAM

A slice of projective geometry: lines projecting to lines. JASON BENTLY, CODY GRINNELL, LARRY GRATTON and JAMES BLACKBURN-LYNCH, Mathematics Program, Berea College, Berea, Kentucky 40404.

Our research for the summer was centered around 3D reconstruction of an object using a camera and projector, along with using the PMP process. Because this overall reconstruction process involves using cameras and projectors, knowing the relationship between the 3D coordinates (where the object exists) and the 2D camera coordinates (where the object's image lies) was necessary. This relationship is explained by the pinhole model, which involves using projective geometry. Thus, many principles of projective geometry were revisited and discussed in an effort to better understand the pinhole model and the 3D reconstruction process. One result which was useful for this connection was the idea that lines are projected to lines. For example, a photograph of a rectangular box will have the edges mapped to some line segments on the camera image.

*Presented at the Bluegrass Undergraduate Math Symposium at Centre College, Danville, Kentucky on September 28<sup>th</sup> 2013.*

**Funded by Berea College URCP**

## PHYSICS PROGRAM

Analyzing Topological Defects in Disordered Charge Density Waves in Transition-Metal Dichalcogenides. DANIELLE SCHAPER<sup>1</sup> and KYLE MCELROY<sup>2</sup>, <sup>1</sup>Physics Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Department of Physics, University of Colorado Boulder, Boulder, Colorado 80309.

Doping materials can lead to interesting, new phenomena. Many of the most striking examples of such new properties have been found at the boundary where one ordered state is ‘melted’ or destroyed. An interesting test case for study is the ordered 2D charge density wave (CDW) found in the transition metal dichalcogenides. We performed an analytical study on the dichalcogenides tantalum disulfide (TaS<sub>2</sub>) and tantalum diselenide (TaSe<sub>2</sub>) to observe how CDWs present in the material can be ‘melted’ as disorder is introduced into the system via copper doping. Data was taken using a scanning tunneling microscope (STM) below the transition to the CDW state, both with and without dopants added. The resulting topographs were then analyzed. Fourier analysis was used to investigate the relationship between the phase and the amplitude of the disordered CDW. We found that the copper doping caused disorder in the CDW state characterized by phase wanderings and  $2\pi$  phase winding ‘point defects’ in the CDW not present in the undoped parent compound. The locations of these point defects and windings were, in turn, found to have the characteristics of topological defects, occurring in locations where the magnitude of the phase gradient was the highest. The results of this analysis are being compared to a modified expression for Ginzburg-Landau free energy as theorized for these materials. Tentative correlations which show some of the predicted behavior have been found, pointing to an explanation behind some of the previously phenomenological understandings of CDWs.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Oral Presentation)*

*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Oral Presentation – Physics and Astronomy Section: 1<sup>st</sup> Place Undergraduate Research Competition)*

## PHYSICS PROGRAM

Bistable pneumatic actuators for soft robotics. FIDEL TEWOLDE<sup>1</sup> and DR. CINDY HARNETTE<sup>2</sup>, <sup>1</sup>Physics Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>University of Louisville, Louisville, Kentucky 40202.

We developed bistable pneumatic actuators for soft robot systems. Soft actuators are elastic and more importantly, a step forward towards bridging the gap between machines and their biological counterparts so that robots might work more effectively alongside people. Flexible tactile actuators can wrap around curved surfaces, and they could enhance gripping by cushioning impacts and increasing the effective contact area during acts such as grasping. However, flexible microfabricated devices that use thin film or solid electrical components are susceptible to failure due to cracking and fatigue. To address this point, soft materials and conductive fluids have recently been used as transduction media, electrical connections, and in resistance based pressure and bend sensors. In this work, we developed soft actuators fabricated from stiff silicone rubber (a mixture of Dragon Skin 10, DS-10; and Ecoflex 00-30; Smooth-on, Inc.) with embedded air channels. Two inflatable chambers were attached to a bistable beam so that the actuator would maintain its position even without air pressure. This approach could improve power efficiency for mobile systems that have a limited energy source. The goal of the project was to find actuator materials and designs compatible with the switching force of the beam. The actuator used an electrical control circuit for control of air pressure and duration of the air filling time. The pressure channels are connected to an external air tank on the other end of system. In the future the actuator could be connected using pressure created from a chemical reaction instead of the pressure from external tank and also microfabricated using a PDMS microchannel skin filled with air or liquid material.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Poster Presentation)*

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## PHYSICS PROGRAM

Boron Fullerenes: Laser Ablation of Boron crystals mixed with Carbon. MACKENZIE ENDRES and DR. AMER LAHAMER, Physics Program, Berea College, Berea, Kentucky 40404.

Since their discovery, Carbon caged fullerenes have been widely observed and studied. Similarly, theory predicts that boron caged clusters have high stability and conductivity, and there is a high potential for their use. An Nd: YAG 532 nm laser was used to ablate several samples of pure boron crystal samples and compounds containing various ratios of boron crystals and carbon under slow flow of Argon. The results were analyzed using a Linear Time of Flight mass spectrometer in the positive ion mode. The results of this research over last summer period will be presented.

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**Funded by Berea College URCP**



## PHYSICS PROGRAM

Creating a cooling chamber to reduce noise on a CCD chip in a DSLR camera. ANTONIO BILL and DR. TRACY HODGE, Physics Program, Berea College, Berea, Kentucky 40404.

Charged-Coupled Device (CCD) cameras are utilized by astronomers to capture images of stars and galaxies in order to obtain unique information about the star such as the elements that comprises the star. We constructed an aluminum housing for a Canon Rebel Xsi camera and attached a thermoelectric cooler (TEC) directly to the aluminum box so that the camera can be cooled by conduction. Using just one TEC, we were able to decrease the temperature of the camera down to about a steady sixty-five degrees Fahrenheit with a surrounding temperature of seventy-two degrees Fahrenheit. We hope to improve its design and effectiveness in the near future. Our ultimate goal is to produce a low-cost cooled camera for undergraduate research or amateur use for observing and photographing stars and galaxies while maintaining relative clarity and accuracy in our photographs.

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**Funded by Berea College URCP**

## PHYSICS PROGRAM

Development of Low Cost, Efficient CZTS Thin Films and Solar Cells. DENZELL BARNETT<sup>1</sup> and DIEDRA HODGES<sup>2</sup>, <sup>1</sup>Physics Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>Southern Polytechnic State University, Marietta, Georgia 30060.

Cu<sub>2</sub>ZnSnS<sub>4</sub> (CZTS) thin-film photovoltaic cells have gained attention in solar cell research as a non-toxic, inexpensive, and efficient alternative in renewable energy. The cell operates as a diode in an electrical circuit by converting electromagnetic radiation to electrical energy in a current. These thin films have been popularized due to their potential to compete with other contending thin-film compositions such as Copper Indium Gallium Diselenide (CIGS) and Cadmium Telluride (CdTe). CZTS thin-films have attractive properties, such as rare-metal free composition, low toxicity, and potential to compete with efficiencies produced from these other models. This study investigates the parameters of CZTS fabrication that affect the stoichiometric properties of the thin-film photovoltaic cell. Copper zinc tin sulfur (Cu<sub>2</sub>ZnSnS<sub>4</sub>) CZTS polycrystalline thin films were prepared by a non-vacuum liquid-based coating method enabling the fabrication of high efficiency, low cost and toxicity solar cell devices. A particle solution (slurry) was developed using the CZTS constituents, varying the range of composition ratios to achieve a stable stoichiometric kesterite CZTS crystal lattice structure. Preliminary data suggests that specific annealing temperatures directly correlate to ideal lattice structures.

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*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Poster Presentation – Engineering Section: 1<sup>st</sup> Place Undergraduate Research Competition)*

## PHYSICS PROGRAM

Equivalent Dosage from Neutron Radiation Produced by Deuterium-Palladium Plasma in the NTF Zebra Chamber. BRANDON SCHURTER<sup>1</sup>, TOM KVALE RICK IRVING<sup>2</sup>, ERIK MCKEE<sup>3</sup> and TIM DARLING<sup>3</sup>, <sup>1</sup>Physics Program, Berea College, Berea, Kentucky 40404, <sup>2</sup>University of Toledo, Toledo, Ohio 43606, <sup>3</sup>Nevada Terawatt Facility, Reno, Nevada 89506.

In this project, the radiation shielding for the console and safety rooms in the NTF (Nevada Terawatt Facility) Zebra bay was tested against neutron radiation by computer simulation. The radiation dose received by a model person in the console and safety rooms was simulated using the MCNP (Monte Carlo N-Particle) code. The results from the MCNP deck used the flux-to-dose-rate conversion standards established by the American Nuclear Society. The calculated dosage received by the model person was compared to national standards for equivalent radiation dosage to determine if the console and safety rooms for the Zebra bay were safe from typical neutron irradiation produced on Zebra.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Poster Presentation)*

## PHYSICS PROGRAM

Implementation of New DSLR Camera at the Berea College Observatory for Use in Variable Star Observations. PRESTON TUCKER, TAYLOR MYNHIER, and TRACY HODGE, Physics Program, Berea College, Berea, Kentucky 40404.

In the summer of 2013 we tested a new camera system for the Berea College 16" observatory. We tested the sensitivity and field of view of the new Apogee Ultra-U6 CCD USB camera with standard UBVRI filter wheel. Light pollution from nearby campus floodlights significantly contaminated images taken from either West or South-East directions. Future plans include further system calibration and observation of short-term variable stars.

*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Poster Presentation – Physics and Astronomy Section: 3<sup>rd</sup> Place Undergraduate Research Competition)*

**Funded by Berea College URCP**

## PHYSICS PROGRAM

Raven Rocks Visitors Center Construction Internship. KARLA SOPHIA ROBINSON and DR. MARTIN VEILLETTE, Physics Program, Berea College, Berea, Kentucky 40404.

Raven Rocks is a non-profit organization in an area where the majority of the land has been leased or sold to stripping agencies. The aim of this organization was to dedicate 900 acres of land to be a permanent preserved area, removed from sale on the speculative market. Forty years later they have had minimal alterations to this land and have hiking trails available to the public. For this reason they are currently building a visitors center and wilderness education center which I was a part of during the summer term of 2013 due to my interest in engineering. This building is an earth sheltered structure, made primarily of reinforced concrete. During the ten weeks I spent there we poured a reinforced hanging ceiling, footer for one wing of the building, an outer support wall and a retaining wall. Each pour involved building the forms to hold the wet concrete, building the steel support structure, placing devices necessary to later install plumbing and electrical wiring, as well as, installing plumbing and electrical wiring. Other processes included waterproofing, insulating, and general material prepping through various procedures. During this internship I was provided with the opportunity to master a variety of tools such as a sand blaster, rotary hammer drill, masonry drill, and cutting torch, in addition to basic tools of construction. There was also research regarding adhesives, lubricants and other protective materials. My involvement in this project gave me basic construction experience, comprehensive understanding of concrete, increased understanding of blueprints and building plans, exposure to construction manager decision making and problem solving, and instruction and evaluation from senior engineers.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Poster Presentation)*

## PHYSICS PROGRAM

Synthesis and exploration of Half-Metallic Heusler Alloys. KYLE GODBEY and DR. AMER LAHAMER, Physics Program, Berea College, Berea, Kentucky 40404.

Potential half-metallic Heusler alloys of the forms  $\text{Co}_{2-x}\text{Fe}_{1+x}\text{Z}$ , where Z is silicon, germanium, or tin, were pursued. The samples were synthesized using the solid state method using an arc discharge furnace. These samples were analyzed with x-ray diffraction to determine the crystal structure and lattice constant. The samples all exhibit the characteristic L21 structure with slight B2 phase disorder in  $\text{Co}_2\text{FeSi}$  before annealing. The lattice constant was found to vary with the changing of the Z site atom, increasing with the larger atomic radius in Si, Ge, and Sn.  $\text{Co}_{2-x}\text{Fe}_{1+x}\text{Sn}$  was found to be unstable, so a tin doped germanium series was pursued. This series suggests a stabilization of the L21 phase in  $\text{Co}_2\text{FeGe}_{1-x}\text{Sn}_x$  until  $x=0.3$ , at which point the disorder in the tin becomes prominent.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Oral Presentation)*

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**Funded by Berea College URCP**

## PSYCHOLOGY PROGRAM

Evolutionary Influences on the Face-in-the-Crowd Effect: Interactions Between Race and Emotion. PRIYANKA SHRESTHA and DR. DAVE PORTER, Psychology Program, Berea College, Berea, Kentucky 40404.

Much of human behavior relates to evolution; features of unconscious cognitive processing often reflect the prior success of our ancestors. This experiment examined the effects of race and emotion on the “face-in-the-crowd” effect. Caucasian female Berea College students (N=31) were asked to decide whether or not a pale blue dot was present on a matrix of 9 faces of mixed races and genders presented for 700 msec. Signal Detection Theory was used to adjust hit rate information to compute subject sensitivity. Results showed that subjects could more readily identify the target when it was located on a black face. Identification was also greater when the dot was on an emotional white face than on a neutral white face and happy white faces appeared to attract more attention than angry white faces. When emotional faces were used as distracters and the target dots appeared on neutral faces, the results generally reflected the pattern predicted by the face-in-the-crowd effect with happy white faces being the most distracting.

*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Oral Presentation – Psychology Section: 1<sup>st</sup> Place Undergraduate Research Competition)*

## PSYCHOLOGY PROGRAM

Motivational disposition, priming and congruency effects on EEG anterior frontal asymmetry and perceived stress. RACHELE JOHNSON, DR. DAVE PORTER, and DR. ROB SMITH, Psychology Program, Berea College, Berea, Kentucky 40404.

The current study examined Self-Determination Theory's (SDT) intrinsic and extrinsic motivational dispositions, priming, and congruency on subject's perceived and physiological cognitive stress using EEG. Previous research has shown that right frontal alpha (8-13 Hz) suppression is indicative of cognitive stress. Using a within-subjects design, participants performed a Stroop Task Paradigm and completed pre- and post-test stress surveys. Before each task session, participants were given implicit primes. Participants with low intrinsic disposition perceived more anxiety than those with high intrinsic disposition. Physiological evidence of increased alpha asymmetry was found in association with incongruent Stroop trials, not congruent trials. No significant findings were demonstrated between neuro-physiological measurements and SDT. Future research should examine differences between perceived and neuro-physiological stress responses.

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## PSYCHOLOGY PROGRAM

The Effect of Locus of Control and Situation on Self Efficacy: Self Efficacy After the Fact.  
SHONDEL YOUNGER, Psychology Program, Berea College, Berea, Kentucky 40404.

This current experiment's focus was to test the effect of Locus of Control (Internal or External) and situation on an individual's self efficacy. Locus of Control and self efficacy are only two parts of core self evaluation and were quasi-experimental and independent variables. Does self efficacy stand alone or can it be affected by other factors such as situation and self appraisal? Situation was used as a second independent variable; upon manipulating the situation of an individual by using bogus positive or negative feedback after a performance task. Self efficacy was the dependent variable and an interaction between Situation and Locus of Control was found to make up 33.9% of the variance in self efficacy. Individuals with an External Locus of Control were found to be the most affected by situation. When a positive situation was presented individuals with an External Locus of Control rated their self efficacy higher. In a negative situation individuals with an External Locus of Control rated their self efficacy lower. Individuals with a Internal Locus of Control rated their self efficacy more positively whether in a positive or negative situation.

*99<sup>th</sup> Annual Meeting of the Kentucky Academy of Science, November 8<sup>th</sup> - 9<sup>th</sup> 2013, Morehead State University, Morehead, Kentucky (Oral Presentation – Psychology Section)*

## **TECHNOLOGY AND APPLIED DESIGN PROGRAM**

Home Health Sensing and Automation. NAMUKABA HICHILO, HATINAWEDU MUPIWA, LOGAN RAY, DR. MATT JADUD and DR. MARK MAHONEY, Technology and Applied Design Program, Berea College, Berea, Kentucky 40404.

The focus of this creative research project was to design and produce an indoor air quality sensing system that could test for a variety of pollutants while remaining substantially less expensive than commercial off-the-shelf systems. The three identified objectives for this project were comprised of health, cost, and community. To attain these measures, the project team designed an affordable system capable of monitoring indoor air quality using readily accessible sensing components. The system is also capable of communicating home health data to residents through a user-friendly interface that is web accessible. Lastly, the project designs are to be shared with the open source community to foster the availability and development of such projects. Initial testing of the sensing system will be conducted throughout the 2013 and 2014 academic terms.

*14<sup>th</sup> Annual Berea College Undergraduate Research Symposium, October 18<sup>th</sup> 2013, Berea College, Berea, Kentucky (Poster Presentation)*

**Funded by Berea College URCP**

## APPENDIX

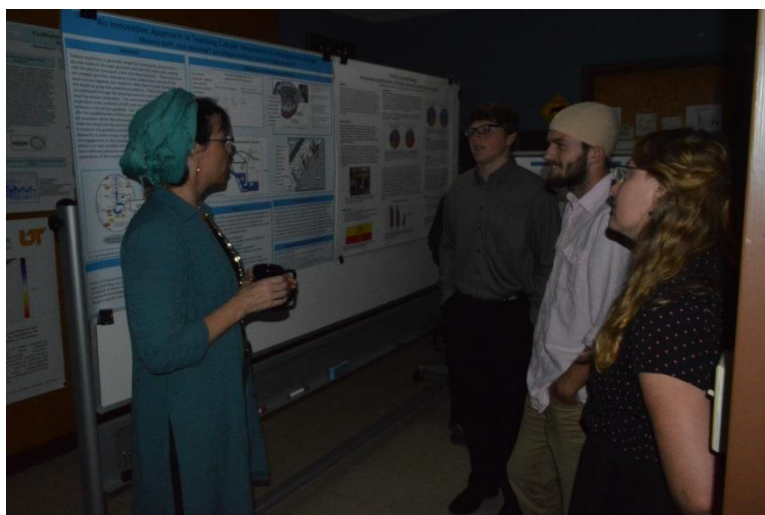
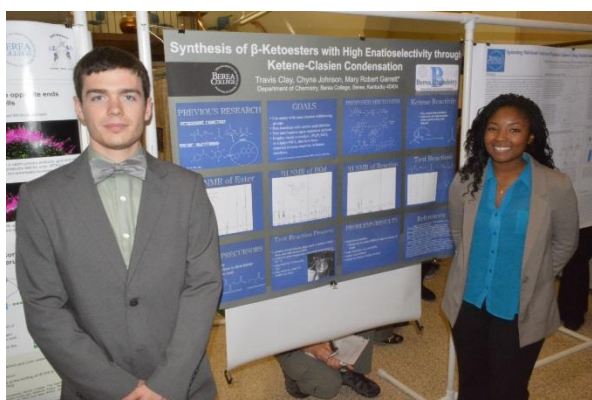
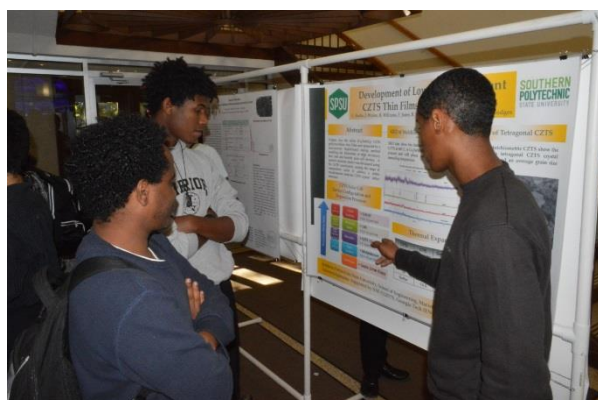
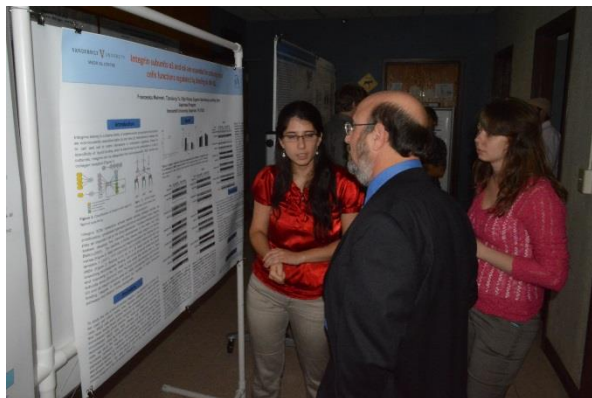


Figure 1. Berea College students and faculty at the Berea Undergraduate Research Symposium on October 18<sup>th</sup> 2013.



Figure 2. Berea College students and faculty at the Kentucky Academy of Science dinner banquet on November 9<sup>th</sup> 2013.



Figure 3. Berea College students and faculty at the Kentucky Academy of Science meeting on November 9<sup>th</sup> 2013.

# Undergraduate Research and Creative Projects Program (URCPP)

Summer 2013 Assessment

All Respondents

Division One and Other than Division One Breakdowns



**PRE-SURVEY, ALL RESPONDENTS. Response Rate: 85.2% or 52/61.**

How did you first hear about the undergraduate research opportunity?

	All Respondents
Announcement on the URCPD website	0 0.0%
Poster/flyer	3 5.8%
A faculty member told me about it	24 46.2%
A former participant told me about it	12 23.1%
My academic advisor told me about it	7 13.5%
Other, please list	6 11.5%
Missing	0 0.0%

Please indicate if each of the following was a major reason, a minor reason, or not a reason in your decision to apply.

	Major Reason (3)	Minor Reason (2)	Not a reason (1)	Missing	Mean
To gain experience doing research or a creative project.	46 88.5%	6 11.5%	0 0.0%	0 0.0%	2.88
To get an idea of what being a graduate student might be like.	25 48.1%	12 23.1%	15 28.8%	0 0.0%	2.19
To figure out if I might really be interested in a research career.	30 57.7%	11 21.2%	11 21.2%	0 0.0%	2.37
My participation would improve my chances of getting into graduate school.	27 51.9%	16 30.8%	9 17.3%	0 0.0%	2.35
My participation would improve my chances of getting into professional school	28 53.8%	10 19.2%	14 26.9%	0 0.0%	2.27
My participation would make me a more attractive job candidate.	29 55.8%	17 32.7%	6 11.5%	0 0.0%	2.44
I needed something productive to do over the summer that would allow me to earn money for school next year.	21 40.4%	18 34.6%	13 25.0%	0 0.0%	2.15
An advisor/faculty member told me I should do it.	14 26.9%	20 38.5%	18 34.6%	0 0.0%	1.92
The subject of the research/project was of special interest to me.	27 51.9%	20 38.5%	5 9.6%	0 0.0%	2.42
To introduce me to a new area of study.	20 38.5%	19 36.5%	13 25.0%	0 0.0%	2.13
To introduce me to a new line of research/study in my major.	23 44.2%	16 30.8%	13 25.0%	0 0.0%	2.19
To improve my understanding of my major.	24 46.2%	20 38.5%	7 13.5%	1 1.9%	2.33
To investigate other areas of study or research.	21 40.4%	17 32.7%	14 26.9%	0 0.0%	2.13
To broaden the scope of my research or study interests.	30 57.7%	16 30.8%	6 11.5%	0 0.0%	2.46
To learn from a faculty mentor/expert.	36 69.2%	10 19.2%	6 11.5%	0 0.0%	2.58
Other, please list.	3 5.8%	0 0.0%	6 11.5%	43 82.7%	1.67



**PRE-SURVEY, ALL RESPONDENTS. Response Rate: 85.2% or 52/61.**

**At this time, what best describes your current post-graduation**

I plan to attend graduate school.	25	48.1%
I plan to attend professional school (e.g., medical, dental, law, business, etc.).	16	30.8%
I don't plan to attend graduate or professional school.	2	3.8%
I am not sure of my plans at this time.	9	17.3%
Missing	0	0.0%

**How confident are you in the following skills and abilities?**

	Very confident (5)	(4)	(3)	(2)	Not at all confident (1)	Missing	Mean		
Keeping a good notes on the progression of a project.	23	44.2%	25	48.1%	4	7.7%	0	0.0%	4.37
Reading and understanding a primary source document.	15	28.8%	29	55.8%	8	15.4%	0	0.0%	4.13
Giving a presentation in front of a group.	17	32.7%	23	44.2%	8	15.4%	3	5.8%	4.00
Working as part of a team.	27	51.9%	19	36.5%	5	9.6%	1	1.9%	4.38
Doing research on my own.	18	34.6%	25	48.1%	5	9.6%	4	7.7%	4.10
Preparing a well-documented paper.	14	26.9%	20	38.5%	14	26.9%	2	3.8%	3.81
Thinking critically.	25	48.1%	21	40.4%	6	11.5%	0	0.0%	4.37
Thinking creatively.	21	40.4%	23	44.2%	7	13.5%	1	1.9%	4.23

**How important are the following goals to you?**

	Extremely important (5)	(4)	(3)	(2)	Not at all important (1)	Missing	Mean		
To enhance my learning by providing opportunities to engage challenging, collaborative and directed projects in an apprentice-mentor relationship with my faculty.	31	59.6%	17	32.7%	3	5.8%	0	0.0%	4.55
To foster student-faculty interaction in creative work.	19	36.5%	23	44.2%	7	13.5%	0	0.0%	4.12
To help me understand the interplay between collaboration and independent thought and action in a complex, open-ended project.	20	38.5%	21	40.4%	9	17.3%	1	1.9%	4.18
To enhance my communication skills.	22	42.3%	19	36.5%	7	13.5%	2	3.8%	4.16
To provide experience that would be helpful to me to pursue subsequent research and learning.	33	63.5%	14	26.9%	4	7.7%	0	0.0%	4.57
To allow me to build my self-confidence to pursue careers and further study beyond Berea.	35	67.3%	12	23.1%	2	3.8%	2	3.8%	4.57
To provide experience that will help me make informed career and graduate school decisions.	36	69.2%	12	23.1%	3	5.8%	0	0.0%	4.65

**POST-SURVEY, ALL RESPONDENTS. Response Rate: 45.9% or 28/61.**

What situation best describes with whom you worked during your summer project?	
I worked most closely with my faculty mentor	4 14.3%
I worked with several other students and my faculty mentor	14 50.0%
I worked mostly alone with occasional assistance	4 14.3%
I worked on my own with little assistance	2 7.1%
Other, please explain	3 10.7%
Missing	1 3.6%

What was your overall satisfaction with this arrangement?	
It was perfect for me	20 71.4%
It worked okay	4 14.3%
I would have liked a bit more attention/direction	2 7.1%
I would have liked a bit less attention/direction	0 0.0%
Other, please explain	1 3.6%
Missing	1 3.6%

How much individual contact did you have with your faculty research mentor?	
We worked side-by-side	8 28.6%
We met/consulted daily	12 42.9%
We met/consulted several times a week	4 14.3%
We met/consulted once a week	3 10.7%
me	0 0.0%
Missing	1 3.6%

Which of the following statements best describes your current post-graduation plans?	
I am positive I want to attend graduate school	7 25.0%
I am fairly certain I want to attend graduate school	8 28.6%
I am uncertain I want to attend graduate school	4 14.3%
I am positive I want to attend professional school	7 25.0%
I am fairly certain I want to attend professional school	0 0.0%
I am uncertain about attending professional school	1 3.6%
Missing	1 3.6%

**POST-SURVEY, ALL RESPONDENTS. Response Rate: 45.9% or 28/61.**

**What impact did your summer experience have in helping you define your research interests?**

It introduced me to a new field of research I now might want to pursue.	2	7.1%
It introduced me to a new line of research in my major field that I now might want to pursue.	4	14.3%
It improved my understanding of the field and specialty I have already chosen.	10	35.7%
It encouraged me to investigate other areas of study or research.	5	17.9%
It generally broadened the scope of my research interests.	4	14.3%
Other, please explain.	2	7.1%
Missing	1	3.6%

**Please rate your confidence in your skills and abilities for the following**

	Very confident (5)	(4)	(3)	(2)	Not at all confident (1)	Missing	Mean
Keeping a research notebook or journal.	11	42.9%	3	10.7%	0	0.0%	4.19
Reading a primary research article.	12	42.9%	1	3.6%	2	7.1%	4.26
Giving a presentation in front of a group.	9	32.1%	6	21.4%	1	3.6%	3.93
Preparing a research poster.	10	35.7%	5	17.9%	1	3.6%	4.11
Working as part of a research team.	19	67.9%	7	25.0%	0	0.0%	4.63
Doing research on your own.	10	35.7%	4	14.3%	0	0.0%	4.22

**To what extent did your summer experience contribute to the following**

	To a great extent (5)	(4)	(3)	(2)	Not at all (1)	Missing	Mean
Enhanced my learning by providing opportunities to engage challenging, collaborative and directed projects in an apprentice-mentor relationship with faculty.	16	57.1%	8	28.6%	3	10.7%	4.48
Fostered student-faculty interaction in creative work.	18	64.3%	7	25.0%	2	7.1%	4.59
Helped me understand the interplay between collaboration and independent thought and action in a complex, open-ended project.	16	57.1%	9	32.1%	2	7.1%	4.52
Enhanced my communication skills.	12	42.9%	10	35.7%	3	10.7%	4.19
Provided experience that would be helpful to me to pursue subsequent research and learning	16	57.1%	9	32.1%	1	3.6%	4.48
Allowed me to build self-confidence to pursue careers and further study beyond Berea.	14	50.0%	7	25.0%	5	17.9%	4.35
Provided experience that will help me to make informed career and graduate school decision.	16	57.1%	6	21.4%	4	14.3%	4.33

**PRE-SURVEY, Division One Response Rate: 95% or 19/20. Other than Division One Response Rate: 80% or 33/41.**

How did you first hear about the undergraduate research opportunity/the Undergraduate Research and Creative Projects Program?		
<b>Poster/flyer</b>		
Division One	3	15.8%
Other than Division One	0	0.0%
<b>A faculty member told me about it</b>		
Division One	7	36.8%
Other than Division One	17	51.5%
<b>A former participant told me about it</b>		
Division One	2	10.5%
Other than Division One	10	30.3%
<b>My academic advisor told me about it</b>		
Division One	3	15.8%
Other than Division One	4	12.1%
<b>Other, please list</b>		
Division One	4	21.1%
Other than Division One	2	6.1%
<b>Missing</b>		
Division One	0	0.0%
Other than Division One	0	0.0%

**PRE-SURVEY, Division One Response Rate: 95% or 19/20. Other than Division One Response Rate: 80% or 33/41.**

Please indicate if each of the following was a major reason, a minor reason, or not a reason in your decision to apply.

	Major reason (3)	Minor reason (2)	Not a reason (1)	Missing	Mean
<b>To gain experience doing research or a creative project.</b>					
Division One	18 94.7%	1 5.3%	0 0.0%	0 0.0%	2.95
Other than Division One	28 84.8%	5 15.2%	0 0.0%	0 0.0%	2.85
<b>To get an idea of what being a graduate student might be like.</b>					
Division One	11 57.9%	3 15.8%	5 26.3%	0 0.0%	2.32
Other than Division One	14 42.4%	9 27.3%	10 30.3%	0 0.0%	2.12
<b>To figure out if I might really be interested in a research career.</b>					
Division One	10 52.6%	6 31.6%	3 15.8%	0 0.0%	2.37
Other than Division One	20 60.6%	5 15.2%	8 24.2%	0 0.0%	2.36
<b>My participation would improve my chances of getting into graduate school.</b>					
Division One	10 52.6%	6 31.6%	3 15.8%	0 0.0%	2.37
Other than Division One	17 51.5%	10 30.3%	6 18.2%	0 0.0%	2.33
<b>My participation would improve my chances of getting into professional school.</b>					
Division One	15 78.9%	1 5.3%	3 15.8%	0 0.0%	2.63
Other than Division One	13 39.4%	9 27.3%	11 33.3%	0 0.0%	2.06
<b>My participation would make me a more attractive job candidate.</b>					
Division One	11 57.9%	5 26.3%	3 15.8%	0 0.0%	2.42
Other than Division One	18 54.5%	12 36.4%	3 9.1%	0 0.0%	2.45
<b>I needed something productive to do over the summer that would allow me to earn money for school next year.</b>					
Division One	7 36.8%	7 36.8%	5 26.3%	0 0.0%	2.11
Other than Division One	14 42.4%	11 33.3%	8 24.2%	0 0.0%	2.18
<b>An advisor/faculty member told me I should do it.</b>					
Division One	4 21.1%	8 42.1%	7 36.8%	0 0.0%	1.84
Other than Division One	10 30.3%	12 36.4%	11 33.3%	0 0.0%	1.97
<b>The subject of the research/project was of special interest to me.</b>					
Division One	11 57.9%	6 31.6%	2 10.5%	0 0.0%	2.47
Other than Division One	16 48.5%	14 42.4%	3 9.1%	0 0.0%	2.39

**PRE-SURVEY, Division One Response Rate: 95% or 19/20. Other than Division One Response Rate: 80% or 33/41.**

Please indicate if each of the following was a major reason, a minor reason, or not a reason in your decision to apply., continued:

	Major reason (3)	Minor reason (2)	Not a reason (1)	Missing	Mean
<b>To introduce me to a new area of study.</b>					
Division One	9 47.4%	8 42.1%	2 10.5%	0 0.0%	2.37
Other than Division One	11 33.3%	11 33.3%	11 33.3%	0 0.0%	2.00
<b>To introduce me to a new line of research/study in my major.</b>					
Division One	11 57.9%	5 26.3%	3 15.8%	0 0.0%	2.42
Other than Division One	12 36.4%	11 33.3%	10 30.3%	0 0.0%	2.06
<b>To improve my understanding of my major.</b>					
Division One	9 47.4%	5 26.3%	4 21.1%	1 5.3%	2.28
Other than Division One	15 45.5%	15 45.5%	3 9.1%	0 0.0%	2.36
<b>To investigate other areas of study or research.</b>					
Division One	9 47.4%	6 31.6%	4 21.1%	0 0.0%	2.26
Other than Division One	12 36.4%	11 33.3%	10 30.3%	0 0.0%	2.06
<b>To broaden the scope of my research or study interests.</b>					
Division One	14 73.7%	3 15.8%	2 10.5%	0 0.0%	2.63
Other than Division One	16 48.5%	13 39.4%	4 12.1%	0 0.0%	2.36
<b>To learn from a faculty mentor/expert.</b>					
Division One	14 73.7%	2 10.5%	3 15.8%	0 0.0%	2.58
Other than Division One	22 66.7%	8 24.2%	3 9.1%	0 0.0%	2.58
<b>Other, please list.</b>					
Division One	1 5.3%	0 0.0%	2 10.5%	16 84.2%	1.67
Other than Division One	2 6.1%	0 0.0%	4 12.1%	27 81.8%	1.67

**At this time, what best describes your current post-graduation plans**

	Division One	Other than Division One
I plan to attend graduate school	6 31.6%	19 57.6%
I plan to attend professional school (e.g., medical, dental, law, business, etc.)	10 52.6%	6 18.2%
I don't plan to attend graduate or professional school	0 0.0%	2 6.1%
I am not sure of my plans at this time	3 15.8%	6 18.2%
Missing	0 0.0%	0 0.0%

**PRE-SURVEY, Division One Response Rate: 95% or 19/20. Other than Division One Response Rate: 80% or 33/41.**

How confident are you in following skills and abilities

	Very Confident (5)	(4)	(3)	(2)	Not at all Confident (1)	Missing	Mean
<b>Keeping notes on the progression of a project.</b>							
Division One	8 42.1%	11 57.9%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	4.42
Other than Division One	15 45.5%	14 42.4%	4 12.1%	0 0.0%	0 0.0%	0 0.0%	4.33
<b>Reading and understanding a primary document.</b>							
Division One	5 26.3%	11 57.9%	3 15.8%	0 0.0%	0 0.0%	0 0.0%	4.11
Other than Division One	10 30.3%	18 54.5%	5 15.2%	0 0.0%	0 0.0%	0 0.0%	4.15
<b>Giving a presentation in front of a group.</b>							
Division One	7 36.8%	9 47.4%	3 15.8%	0 0.0%	0 0.0%	0 0.0%	4.21
Other than Division One	10 30.3%	14 42.4%	5 15.2%	3 9.1%	1 3.0%	0 0.0%	3.88
<b>Working as part of a team.</b>							
Division One	10 52.6%	7 36.8%	2 10.5%	0 0.0%	0 0.0%	0 0.0%	4.42
Other than Division One	17 51.5%	12 36.4%	3 9.1%	1 3.0%	0 0.0%	0 0.0%	4.36
<b>Doing research on my own.</b>							
Division One	2 10.5%	14 73.7%	2 10.5%	1 5.3%	0 0.0%	0 0.0%	3.89
Other than Division One	16 48.5%	11 33.3%	3 9.1%	3 9.1%	0 0.0%	0 0.0%	4.21
<b>Preparing a well-documented paper</b>							
Division One	6 31.6%	9 47.4%	3 15.8%	1 5.3%	0 0.0%	0 0.0%	4.05
Other than Division One	8 24.2%	11 33.3%	11 33.3%	1 3.0%	2 6.1%	0 0.0%	3.67
<b>Thinking critically.</b>							
Division One	8 42.1%	11 57.9%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	4.42
Other than Division One	17 51.5%	10 30.3%	6 18.2%	0 0.0%	0 0.0%	0 0.0%	4.33
<b>Thinking creatively.</b>							
Division One	8 42.1%	10 52.6%	1 5.3%	0 0.0%	0 0.0%	0 0.0%	4.37
Other than Division One	13 39.4%	13 39.4%	6 18.2%	1 3.0%	0 0.0%	0 0.0%	4.15

**PRE-SURVEY, Division One Response Rate: 95% or 19/20. Other than Division One Response Rate: 80% or 33/41.**

The following are the goals of the Undergraduate Research and Creative Project Program (URCPP).

How important are the following goals to you?	Extremely Important (5)	(4)	(3)	(2)	Not at all important (1)	Missing	Mean
<b>To enhance my learning by providing opportunities to engage challenging, collaborative and directed projects in an apprentice-mentor relationship with my faculty.</b>							
Division One	12	6	1	0	0	0	4.58
Other than Division One	19	11	2	0	0	1	4.53
<b>To foster student-faculty interaction in creative work.</b>							
Division One	8	8	3	0	0	0	4.26
Other than Division One	11	15	4	0	2	1	4.03
<b>To help me understand the interplay between collaboration and independent thought and action in a complex, open-ended project.</b>							
Division One	9	7	3	0	0	0	4.32
Other than Division One	11	14	6	1	0	1	4.09
<b>To enhance my communication skills.</b>							
Division One	9	8	2	0	0	0	4.37
Other than Division One	13	11	5	2	1	1	4.03
<b>To provide experience that would be helpful to me to pursue subsequent research and learning opportunities.</b>							
Division One	13	4	2	0	0	0	4.58
Other than Division One	20	10	2	0	0	1	4.56
<b>To allow me to build my self-confidence to pursue careers and further study beyond Berea.</b>							
Division One	15	3	0	1	0	0	4.68
Other than Division One	20	9	2	1	0	1	4.50
<b>To provide experience that will help me make informed career and graduate school decisions.</b>							
Division One	14	5	0	0	0	0	4.74
Other than Division One	22	7	3	0	0	1	4.59



POST-SURVEY, Division One Response Rate: 40% or 8/20. Other than Division One Response Rate: 49% or 20/41.

What situation best describes with whom you worked during your summer project?	Division One	Other than Division One
I worked most closely with my faculty mentor	3 37.5%	1 5.0%
I worked with several other students and my faculty mentor	0 0.0%	14 70.0%
I worked mostly alone with occasional assistance	3 37.5%	1 5.0%
I worked on my own with little assistance	1 12.5%	1 5.0%
Other, please explain	1 12.5%	2 10.0%
Missing	0 0.0%	1 5.0%

What was your overall satisfaction with this arrangement?	Division One	Other than Division One
It was perfect for me.	3 37.5%	17 85.0%
I worked okay.	2 25.0%	2 10.0%
I would have liked a bit more attention/direction.	2 25.0%	0 0.0%
I would like a bit less attention/direction.	0 0.0%	0 0.0%
I felt I was largely ignored or felt like a burden.	0 0.0%	0 0.0%
Other, please explain.	1 12.5%	0 0.0%
Missing	0 0.0%	1 5.0%

How much individual contact did you have with your faculty research mentor?	Division One	Other than Division One
We worked side-by-side.	3 37.5%	5 25.0%
We met/consulted daily.	1 12.5%	11 55.0%
We met/consulted several times a week.	2 25.0%	2 10.0%
We met/consulted once per week.	2 25.0%	1 5.0%
He/she was seldom available to meet or consult with me.	0 0.0%	0 0.0%
Missing	0 0.0%	1 5.0%

**POST-SURVEY, Division One Response Rate: 40% or 8/20. Other than Division One Response Rate: 49% or 20/41.**

Which of the following statements best describes your current post-graduation plans?	Division One	Other than Division One
I am positive I want to attend graduate school	1 12.5%	6 30.0%
I am fairly certain I want to attend graduate school	2 25.0%	6 30.0%
I am uncertain I want to attend graduate school	1 12.5%	3 15.0%
I am positive I want to attend professional school	4 50.0%	3 15.0%
I am fairly certain I want to attend professional school	0 0.0%	0 0.0%
I am uncertain about attending professional school	0 0.0%	1 5.0%
Missing	0 0.0%	1 5.0%

What impact did your summer experience have in helping you define your research interests?	Division One	Other than Division One
It introduced me to a new field of research I now might want to pursue.	0 0.0%	2 10.0%
It introduced me to a new line of research in my major field that I now might want to pursue.	0 0.0%	4 20.0%
It improved my understanding of the field and specialty I have already chosen.	2 25.0%	8 40.0%
It encouraged me to investigate other areas of study or research.	2 25.0%	3 15.0%
It generally broadened the scope of my research interests.	2 25.0%	2 10.0%
Other, please explain.	2 25.0%	0 0.0%
Missing	0 0.0%	1 5.0%

**POST-SURVEY, Division One Response Rate: 40% or 8/20. Other than Division One Response Rate: 49% or 20/41.**

Please rate your confidence in your skills and abilities for the following:

	Very Confident (5)	(4)	(3)	(2)	Not at all confident (1)	Missing	Mean
<b>Keeping a research notebook or journal.</b>							
Division One	4	2	2	0	0	0	4.25
Other than Division One	7	10	1	0	1	1	4.16
<b>Reading a primary research article.</b>							
Division One	2	4	0	2	0	0	3.75
Other than Division One	10	8	1	0	0	1	4.47
<b>Giving a presentation in front of a group.</b>							
Division One	2	3	3	0	0	0	3.88
Other than Division One	7	7	3	1	1	1	3.95
<b>Preparing a research poster</b>							
Division One	3	2	3	0	0	0	4.00
Other than Division One	7	9	2	1	0	1	4.16
<b>Working as a part of a research team.</b>							
Division One	6	1	0	1	0	0	4.50
Other than Division One	13	6	0	0	0	1	4.68
<b>Doing research on your own.</b>							
Division One	3	3	2	0	0	0	4.13
Other than Division One	7	10	2	0	0	1	4.26

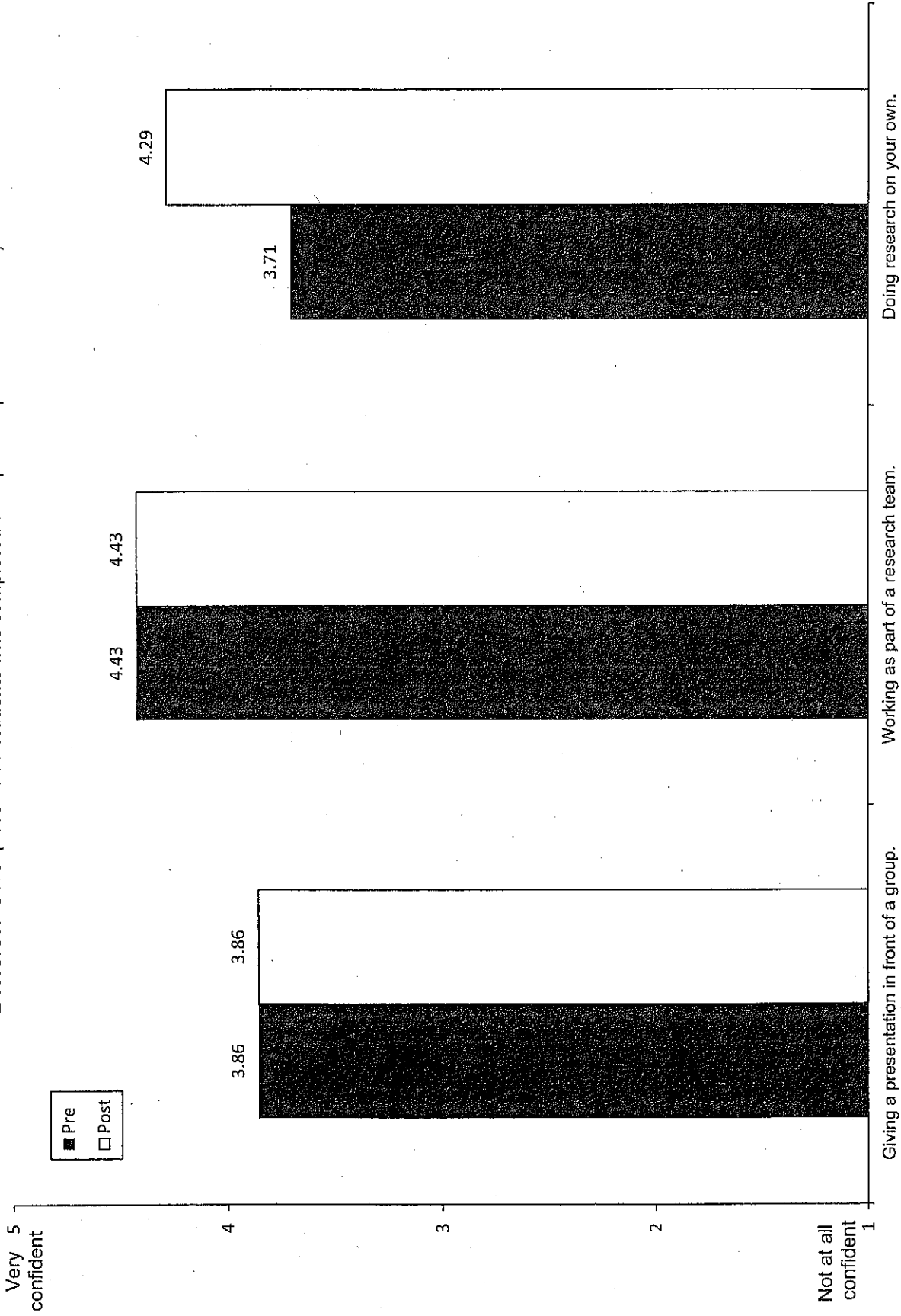
**POST-SURVEY, Division One Response Rate: 40% or 8/20. Other than Division One Response Rate: 49% or 20/41.**

To what extent did your summer experience contribute to the following		(5)	(4)	(3)	(2)	(1)	Missing	Mean
		To a great extent				Not at all		
<b>Enhanced my learning by providing opportunities to engage challenging, collaborative and directed projects in an apprentice-mentor relationship with faculty.</b>	Division One	3	37.5%	2	25.0%	0	0.0%	4.13
	Other than Division One	13	65.0%	5	25.0%	0	0.0%	4.63
<b>Fostered student-faculty interaction in creative work.</b>	Division One	4	50.0%	2	25.0%	0	0.0%	4.25
	Other than Division One	14	70.0%	5	25.0%	0	0.0%	4.74
<b>Helped me understand the interplay between collaboration and independent thought and action in a complex, open-ended project.</b>	Division One	4	50.0%	2	25.0%	0	0.0%	4.25
	Other than Division One	12	60.0%	7	35.0%	0	0.0%	4.63
<b>Enhanced my communication skills.</b>	Division One	4	50.0%	2	25.0%	0	0.0%	4.00
	Other than Division One	8	40.0%	8	40.0%	3	15.0%	4.26
<b>Provided experience that would be helpful to me to pursue subsequent research and learning opportunities.</b>	Division One	3	37.5%	3	37.5%	1	12.5%	4.00
	Other than Division One	13	65.0%	6	30.0%	0	0.0%	4.68
<b>Allowed me to build self-confidence to pursue careers and further study beyond Berea.</b>	Division One	3	37.5%	4	50.0%	1	12.5%	4.25
	Other than Division One	11	55.0%	3	15.0%	4	20.0%	4.39
<b>Provided experience that will help me make informed career and graduate school decision.</b>	Division One	3	37.5%	4	50.0%	1	12.5%	4.25
	Other than Division One	13	65.0%	2	10.0%	3	15.0%	4.37

*Pre: How confident are you in the following skills and abilities?*

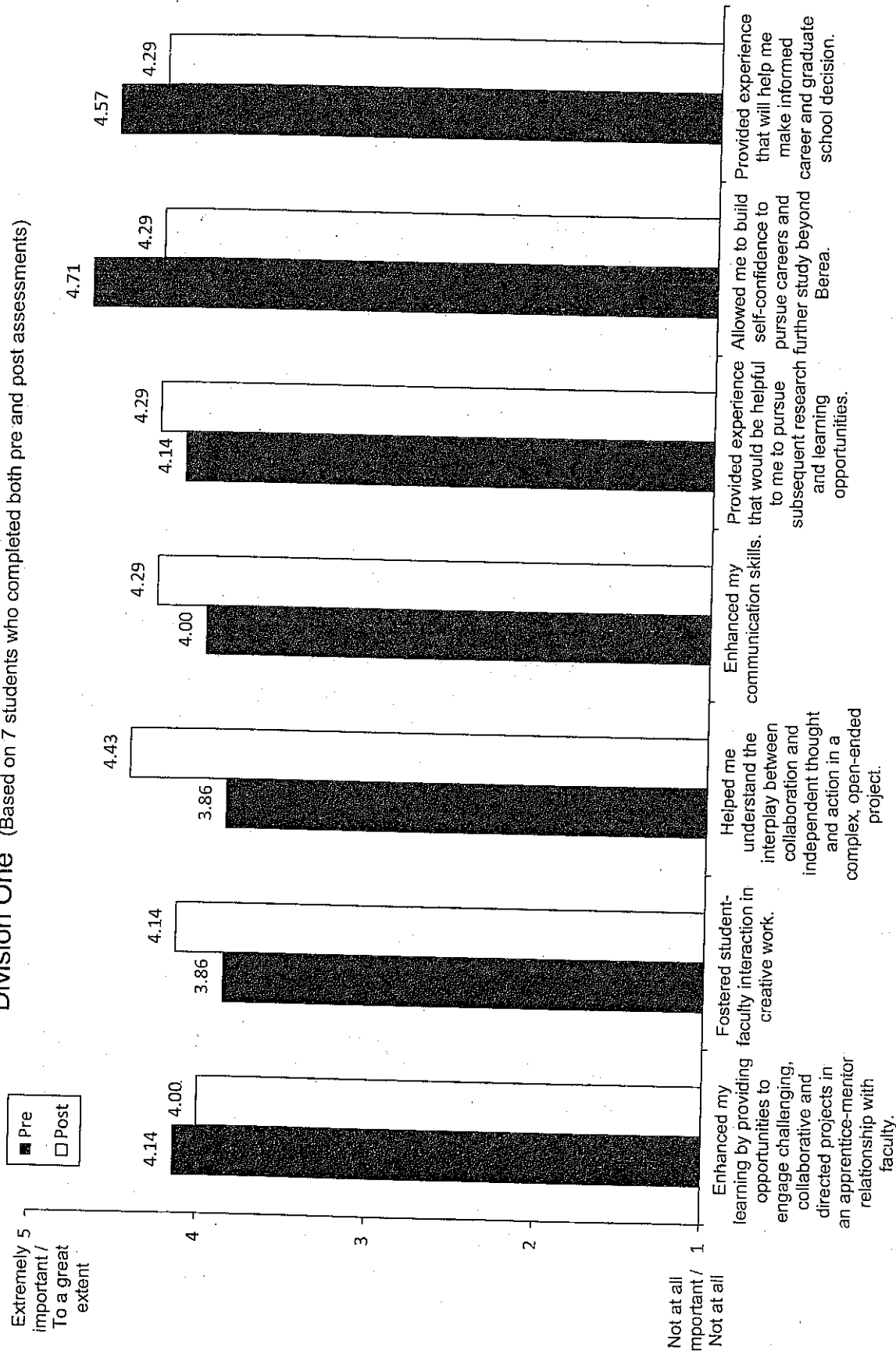
*Post: Please rate your confidence in your skills and abilities for the following:*

Division One (Based on 7 students who completed both pre and post assessments)



Pre: How important are each of the following goals to you?  
 Post: To what extent did your summer experience contribute to the following:

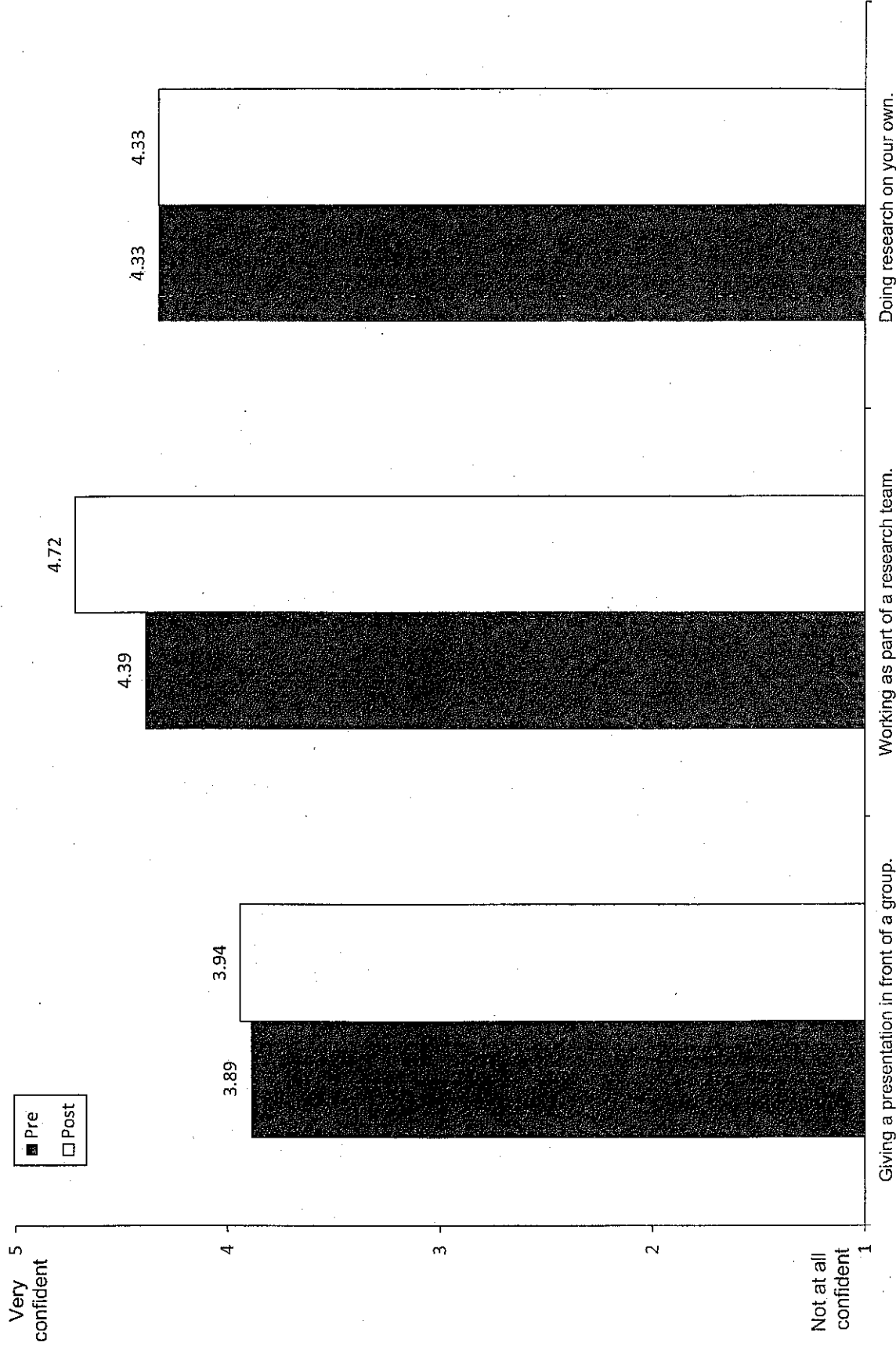
Division One (Based on 7 students who completed both pre and post assessments)



Pre: How confident are you in the following skills and abilities?

Post: Please rate your confidence in your skills and abilities for the following:

### Other than Division One (Based on 18 students who completed both pre and post assessments)



Pre: How important are each of the goals to you?

Post: To what extent did your summer experience contribute to the following:

Other than Division One (Based on 18 students who completed both pre and post assessments)

