

AUBURN UNIVERSITY AT MONTGOMERY

School of Sciences

UNDERGRADUATE RESEARCH SYMPOSIUM

APRIL 12, 2013

*Presented by:
The Auburn Montgomery School of Sciences*

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The 2013
UNDERGRADUATE RESEARCH SYMPOSIUM

On behalf of the faculty, staff and students of the School of Sciences, I'd like to welcome you to the sixth annual Undergraduate Research Symposium. Undergraduate research allows our students the opportunity to go beyond studying science to actually practicing science: forming hypotheses, designing experiments, and analyzing data, thereby making their own contributions to a better understanding of the world. Research is a difficult but rewarding enterprise, and the projects presented here represent a significant commitment of time and energy on the part of both the students and their faculty mentors. I applaud their dedication, and invite all of you to enjoy these results of their efforts.

Dean of the School of Sciences

Dr. Karen E. Stine

Undergraduate Research Committee

Dr. Bridgette Harper – Psychology

Dr. Kalu Kalu – Political Science and Public Administration

Dr. Steve Arnold – Physical Sciences

Dr. Enoch Lee – Mathematics

Dr. Barr Younker – Justice and Public Safety

Dr. Chelsea Ward – Biology

SCHEDULE OF EVENTS

8 - 8:30 a.m.	Registration Goodwyn Hall Lobby - coffee and snacks provided
8:30 – 8:45 a.m.	Opening Remarks Goodwyn Hall 109
8:45 – 9:45 a.m.	Poster Session I Goodwyn Hall Lobby
9:45 – 11:15 a.m.	Talks Goodwyn Hall 109
11:15 a.m. – 12:15 p.m.	Poster Session II Goodwyn Hall Lobby
12:15 – 12:45 p.m.	Lunch (provided) Goodwyn Hall Lobby
12:45 p.m.	Awards Ceremony and Closing Remarks Goodwyn Hall 109

POSTER SESSION I

1. Larvicidal Activity of American Beautyberry (*Callicarpa americana*) Leaf Extracts Against Mosquito Larvae

Christopher Davis, Roa Zaied*

Mentor: N. Robert Estes II
Department: Biology

2. Effects of Pomegranate on Neutrophil Activity in *Rhinella marina*

Nathan Frazier, Austin Brown

Mentors: Chelsea Ward and
N. Robert Estes II
Department: Biology

3. Relating Parent-Child Security with Children's Friends and Best Friends

Carlos D. Hernandez Jr.

Mentor: Glen E. Ray
Department: Psychology
STEM Scholar

4. Antimicrobial Activity of 4-Benzyl Substituted Furanones

Anna N. Parker, Roa M. Zaied

Mentors: N. Robert Estes II and
John M. Hutchison
Department: Biology and
Physical Sciences

5. Comparison of Single-Step and Repeated-Saccharification of Switchgrass in Cellulosic Biofuel Production

Christopher Starr

Mentors: Ananda Nanjundaswamy and
Benedict Okeke
Department: Biology

1. The Stick Problem

Augustine Bertagnolli

Department: Mathematics

2. Diffusive Logistic Equation with Nonlinear Boundary Conditions and Sigma-shaped Bifurcation Curves

Kev Johnson*, Katelyn Sanders*,
Daniel McElveen

Mentor: Jerome Goddard II
Department: Mathematics

3. A Method for Estimating Thermal Conductivity of Nanofluids

Derek Lathan

Mentor: Luis A. Cueva-Parra
Department: Mathematics

4. Effect of a *Punica granatum* Enriched Diet on Immunocompetence in *Rhinella marina*

Anna Parker

Mentor: Chelsea Ward and
N. Robert Estes II

POSTER SESSION II

1. Synthesis of 4-Benzyl-3-Phenyl Butenolide Natural Products

Anna N. Parker, Matthew J. Lock

Mentor: John M. Hutchison
Department: Physical Science

2. Comparison of Antibacterial Activity of Environmental Bacterial Isolates to *Bacillus subtilis*

Claudica Kinnion, Anika Robinson

Mentors: Benedict Okeke and
Sue Thomson
Department: Biology

3. The Stability of a Domain of the Prokaryotic Phage Tailspike Protein

Shelby Nunnelee

Mentor: Robert Villafane
Department: STEM Scholar

4. Lignocellulosic Oligosaccharides Characterization Using Liquid Chromatography-Mass Spectrometry (LC-MS)

Andrew Paulk

Mentors: Ananda Nanjundaswamy and
Benedict Okeke
Department: Biology

5. Tangential Flow Filtration Effectively Concentrates Crude Fungal Enzyme Used In Biomass Feedstock Saccharification

Christopher Starr

Mentors: Ananda Nanjundaswamy and
Benedict Okeke
Department: Biology

6. Complement Activity in Giant Marine Toads (*Rhinella marina*) Fed a Pomegranate-Enriched Diet

Tabitha Michaud, Kathryn Neil

Mentors: Chelsea Ward and
N. Robert Estes II
Department: Biology

7. Antimicrobial Activity of Crude Leaf Extracts from Native Southeastern Shrubs: *Callicarpa americana* and *Morella cerifera*

Nidhi Chigurapati, Mariam McKee, Roa Zaied

Mentor: N. Robert Estes II
Department: Biology



ABSTRACTS

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The Stick Problem

Augustine Bertagnolli
Mathematics

Given sticks of possible sizes one through six, what is the smallest number of sticks we can have to ensure that we are able to form a perfect square? The Pigeonhole Principle tells us that if we have nineteen sticks, we would have at least four of one of the sizes, but can we do better if we take partitions into account? This is one case of the stick problem, which, though simple in statement, proves to be not so simple in solution. In this talk, we define the stick problem and the general stick problem clearly, discuss our methods for approaching and simplifying the problem, provide an algorithm for generating solutions, and present some computer generated solutions for specific cases.

Antimicrobial Activity of Crude Leaf Extracts from Native Southeastern Shrubs: *Callicarpa Americana* and *Morella cerifera*

Nidhi Chirgurapati, Mariam McKee, Roa Zaied

Mentor: N. Robert Estes II

Biology

As the incidence of bacterial resistance to current antibiotics continues to increase, the need for the development of novel antibacterial agents will continue to grow. Several studies have focused on plant-derived compounds, and many of these compounds have exhibited properties that inhibit the proliferation of potentially hazardous microbes. *Callicarpa americana* (beautyberry) and *Morella cerifera* (wax myrtle) are shrubs native to the southeastern United States. In this study, we sought to determine the antibacterial properties of crude leaf extracts from these plants. Fresh or dried leaves were extracted with methanol, ethanol, isopropanol, acetone or water. The crude extracts were then dried under vacuum prior to reconstitution in acetone. The extracts were tested against two gram positive and two gram negative bacteria using the disc diffusion method. Minimal inhibitory concentrations for selected extracts were also determined using broth microdilution assays. Extracts from the leaves of both plants showed inhibitory effects on the growth of the gram positive *Staphylococcus aureus* and *Bacillus subtilis*, whereas only extracts from *M. cerifera* leaves inhibited the growth of the gram negative *Proteus vulgaris*. Leaf extracts from neither plant had any effect against the gram negative *Escherichia coli*. Our results suggest that compounds isolated from *C. americana* and *M. cerifera* have potential for the development of novel antibacterial agents.

Larvicidal Activity of American Beautyberry (*Callicarpa americana*) Leaf Extracts Against Mosquito Larvae

Christopher Davis and Roa Zaied

Mentor: N. Robert Estes II

Biology

Mosquitoes are known vectors for a variety of diseases that affect humans including malaria and West Nile virus. Current control methods include the use of synthetic insecticidal compounds, bacteria-derived toxins, predatory organisms, and habitat reduction. Due to concerns over potential health risks and environmental impacts of airborne insecticides used for mosquito control, there has been considerable effort to find more environmentally friendly control alternatives. Many studies have looked at plant leaf extracts as a possible source for anti-mosquito compounds. *Callicarpa americana* (beautyberry) is a shrub native to Alabama that has been shown to have repellent properties against adult mosquitoes, but there is little data concerning larvicidal activities of beautyberry extracts. Our current study evaluated the larvicidal potential of leaf extracts of American beautyberry against both early stage and late stage mosquito larvae. Mosquito larvae were placed in wells of a 24-well dish in the presence of leaf extracts, and larvae activity was observed at 24, 48, and 72 hours after introduction of the extracts. Leaf extracts using methanol, ethanol, and isopropyl alcohol as solvents showed significant larvicidal activity within 24 hours of the addition of the extracts versus late stage larvae, but showed little effect against early stage larvae out to 72 hours. These results suggest that compounds found in the leaves of American beautyberry have potential for development as natural mosquito control agents.

Effects of Pomegranate on Neutrophil Activity in *Rhinella marina*

Nathan Frazier and Austin Brown

Mentors: Chelsea Ward and N. Robert Estes II

Biology

Pomegranates have been known to provide antioxidant, antitumor, cardioprotective and some immunomodulatory effects to consumers, including humans. By providing crickets with a diet of pomegranate infused agar and subsequently feeding the crickets to toads, we hoped to induce an increase in the ability of toad neutrophils to phagocytize foreign antigens. We were able to measure the changes via a phagocytic assay, which is designed to measure reactive oxygen species (ROS) production in response to antigen processing. Using luminol, which chemiluminesces in the presence of ROS, and a luminometer, we were able to measure neutrophil activity. Data was analyzed using a repeated measures ANOVA and we determined that there was no effect of pomegranate on neutrophil activity ($p=0.8$).

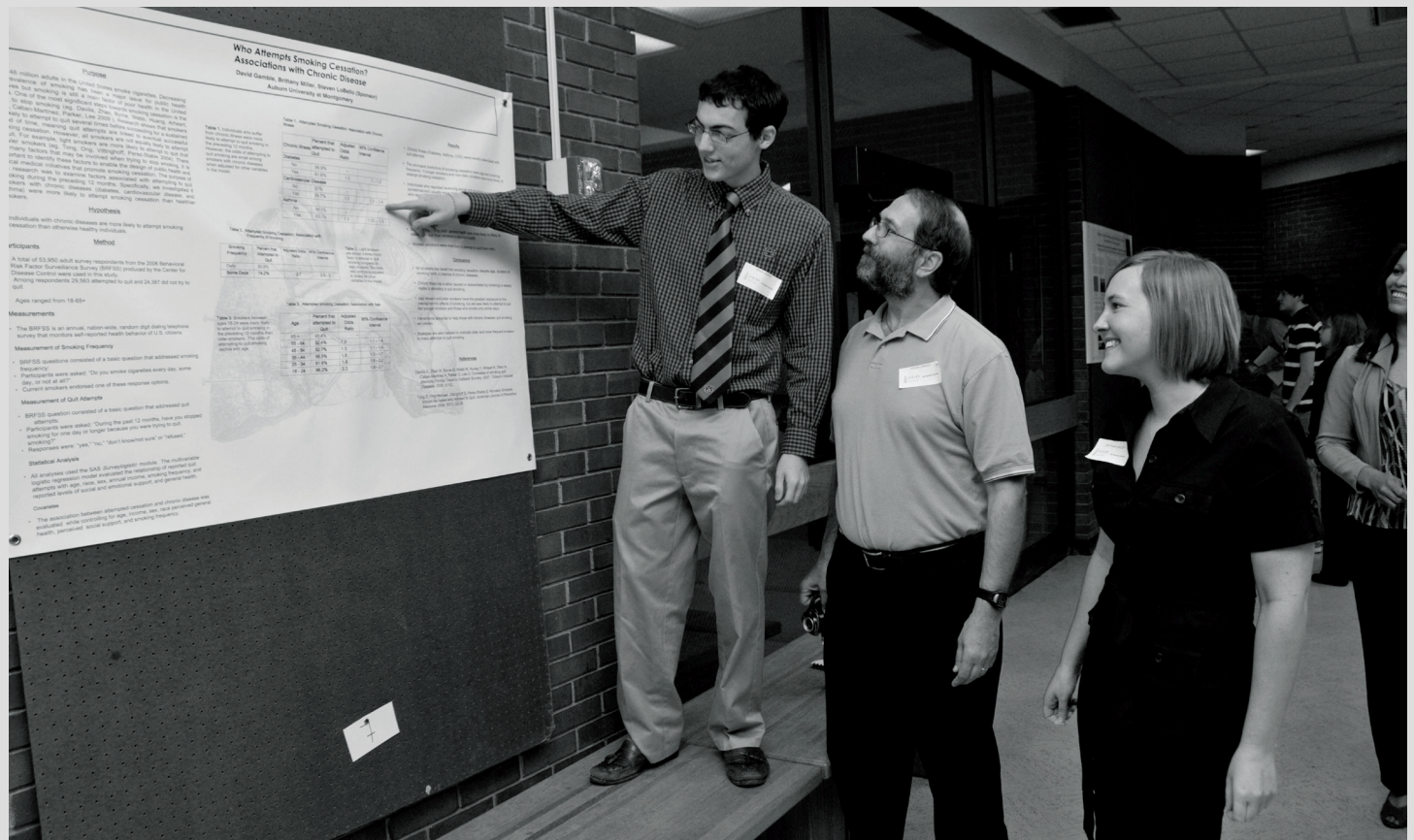
Relating Parent-Child Security with Children's Friends and Best Friends

Carlos D. Hernandez Jr.

Mentor: Glen E. Ray

Psychology, STEM scholar

The study investigated the associations between concurrent self-perceptions of parent-child security (Mother, Father), classroom friendship network size, and close peer relationship quality (classroom friend and classroom very best friend) among 53 second-third graders (mean age = 8.1y) and 53 fifth-sixth graders (mean age = 11.4y). Results demonstrated a positive relationship between perceptions of parental security (maternal and paternal) and children's close peer relationship (friends and best friends). Interestingly, perceptions of parental dependability were more extensively related to children's close peer relationships than were perceptions of parental availability. Furthermore, for younger children, friendship network size was positively related to perceptions of maternal availability and paternal dependability. Findings are discussed in terms of the role(s) that maternal and paternal security plays with regard to different types of children's close peer relationships.



Diffusive Logistic Equation with Nonlinear Boundary Conditions and Sigma-Shaped Bifurcation

Kev Johnson,* Katelyn Sanders,* Daniel McElveen

Mentors: Jerome Goddard II

Mathematics

Even though population models with diffusion have been the subject of research since the 1960s, still little is known about their varied dynamics. In this talk, we will study the structure of positive steady state solutions to a logistic population model with diffusion and grazing, i.e. a form of natural predation. Of interest, we consider a relatively new direction: a population that satisfies a certain nonlinear boundary condition. We obtain one-dimensional results via the Quadrature Method and numerical computations using the software package Mathematica.® These results yield interesting biological implications.

Comparison of Antibacterial Activity of Environmental Bacterial Isolates to *Bacillus subtilis*

Claudiea Kinnion, Anika Robinson

Mentors: Benedict Okeke and Sue Thomson

Biology

Several environmental bacterial isolates were evaluated for in vitro antibacterial activity using *Staphylococcus epidermidis*, *S. aureus* and *Escherichia coli* as test organisms. Isolates that displayed in vitro antibacterial activity were compared to *Bacillus subtilis* using agar diffusion method. *B. subtilis* produces subtilisin, which is an antibacterial protease. Commercial uses of subtilisin include food processing and manufacture of detergents as well as cosmetics. Results indicate that some isolates produced substantial antibacterial activity compared to *B. subtilis*. Further studies will focus on production of the antibiotic substances in submerged culture and the nature of the antibacterial substances.

A Method for Estimating Thermal Conductivity of Nanofluids

Derek Lathan

Mentor: Luis A. Cueva-Parra

Mathematics

A nanofluid is a new type of fluid that is composed of a pure base fluid with nanosized particles in suspension. Since it is difficult to measure the thermal conductivity of nanofluids, here we explore a Monte Carlo method that uses the Metropolis algorithm to predict this property. The simulation uses a three-dimensional domain where one end of the z axis is hot and remains at a constant temperature. The other end is cold and is represented by an open boundary condition. There are periodic boundary conditions on the x and y axes. The random motion of heat tracers traveling through the domain will characterize the temperature and heat flux. The heat flux, temperature, and heat conductivity of a base fluid, base fluid with fixed nanoparticles, and base fluid with randomly moving nanoparticles will be estimated.

Complement activity in Giant Marine Toads (*Rhinella marina*) Fed a Pomegranate Enriched Diet

Tabitha Michaud and Kathryn Neil

Mentors: Chelsea Ward and N. Robert Estes II

Biology

Pomegranate is known to have antioxidant properties that may promote immunocompetence when ingested regularly. In this study, *Rhinella marina* (Giant marine toads) were fed crickets which had been fed a pomegranate-enriched diet and complement activity (lytic compounds in blood) were measured using a bacterial killing assay (BKA). Whole blood was taken from each toad by cardiac puncture and centrifuged to obtain the plasma. Each plasma sample was mixed with a known dilution of *E. coli* and cell culture media. A sample of the mixture was immediately spread onto culture plates (time 0). The plasma mixture was then allowed to incubate at room temperature for 30 minutes, allowing complement proteins to interact with the bacteria. After 30 minutes another sample was spread onto culture plates (time 30). All plates were then incubated for 24 hours. The difference in the number of colonies on plates from time 0 and time 30 indicates the number of bacteria lysed by the complement proteins in the plasma. Preliminary data shows that ingestion of pomegranate through the diet significantly increases the complement activity of blood. This would indicate that the flora where an animal forages for prey may have an effect on its immunocompetence.

The Stability of a Domain of Prokaryotic Phage Tailspike Protein

Shelby Nunnelee

Mentor: Robert Villafane

STEM scholar

The stability of protein structures is of major importance in the study of protein structure and function, especially since it is known that the majority of proteins exist on the brink of instability. Like many other important studies, its analysis in a prokaryotic system will allow for a facile genetic dissection of most research areas. Our studies are aimed at using the prokaryotic phage P22 tailspike protein (P22 TSP) as a model for protein-protein interaction. When the phage assembles inside the bacterial cell, the last step in its assembly is the attachment of the TSP to a viral structure that is missing only its tail (called a “head” structure). Protein-protein interactions are critical to life of a living cell. But since the P22 TSP is a homotrimer, it is imperative to know how this protein maintains its trimeric structure before we study how it interacts with the rest of the viral structure. The poster represents the first research efforts to use the well-known P22 TSP system to study protein-protein interactions. Some new data are also presented.

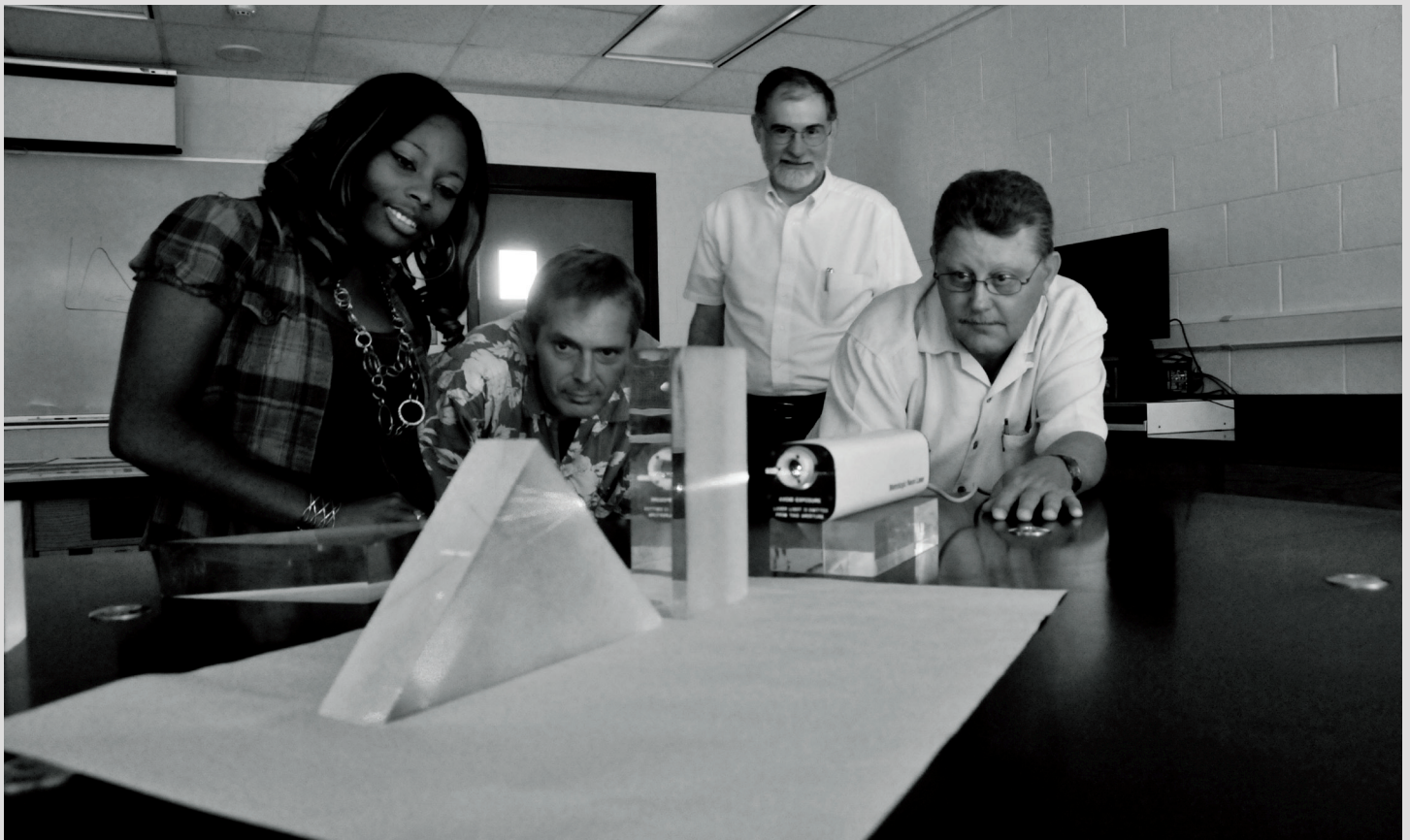
Effect of a *Punica granatum* Enriched Diet on immuno-competence in *Rhinella marina*

Anna N. Parker

Mentor: Chelsea Ward and N. Robert Estes II

Biologyw

Punica granatum, or pomegranate, is a fruit originating from the Middle East and is thought to possess both therapeutic and immunostimulatory properties. Several studies have shown that individuals experiences increased humoral activity following direct ingestion of *Punica granatum*. The goal of this study was to determine if the immune properties of *Punica granatum* could be conveyed from the plant to crickets and then to *Rhinella marina*, giant marine toads, through diet specialization. A dosage of 0.010 g/mL of lyophilized, powdered pomegranate was added to agar and fed to crickets designated for the enriched diet. The control crickets were fed a standard agar diet. From a sample size of thirty *Rhinella marina*, the fifteen experimental toads consumed a diet consisting of crickets fed the pomegranate enriched diet, while the fifteen control toads consumed a diet consisting of crickets fed the standard agar diet. During the experimental period, two measures were performed three days apart. Toads were fed crickets on either a standard agar diet or a pomegranate-enriched agar diet one day prior to assays. Blood samples were taken and leukocyte profiles were determined for all individuals. Preliminary data indicates the toads fed the pomegranate-enriched diet show an increase in eosinophils, which is indicative of an immunomodulatory effect as compared to controls. This indicates that the flora in the environment where insectivores forage may have a significant effect on the physiology of the animal.



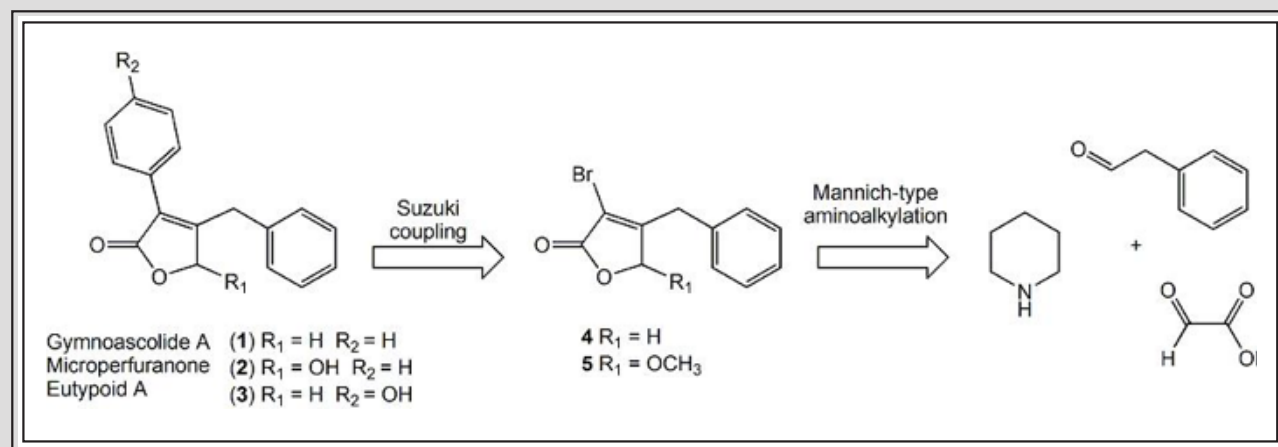
Synthesis of 4-Benzyl-3-Phenyl Butenolide Natural Products

Anna N. Parker and Matthew J. Lock

Mentor: John M. Hutchison

Physical Science

Butenolides [2(5H)-furanones] are common moieties found in a variety of biologically active natural products. Over the past decade, several natural products possessing the unique 4-benzyl-3-phenyl-substituted butenolide motif have been isolated as metabolites of terrestrial and marine fungi. Given that several of these 4-benzyl-3-phenyl-substituted butenolides exhibit kinase inhibitory activity, anti-microbial properties, and/or anti-fungal properties, we sought to develop an efficient and flexible route for the synthesis of three natural products bearing this structural motif. The key steps in the synthesis of gymnoascolide A (1), microperfuraneone (2), and eutypoid A (3) involve the Suzuki coupling of an aryl boronic acid with the appropriate 4-benzyl-3-bromofuranone (4 or 5) and a Mannich-type aminoalkylation of commercially available 3-phenyl propionaldehyde.



Antimicrobial Activity of 4-Benzyl Substituted Furanones

Anna N. Parker and Roa M. Zaied

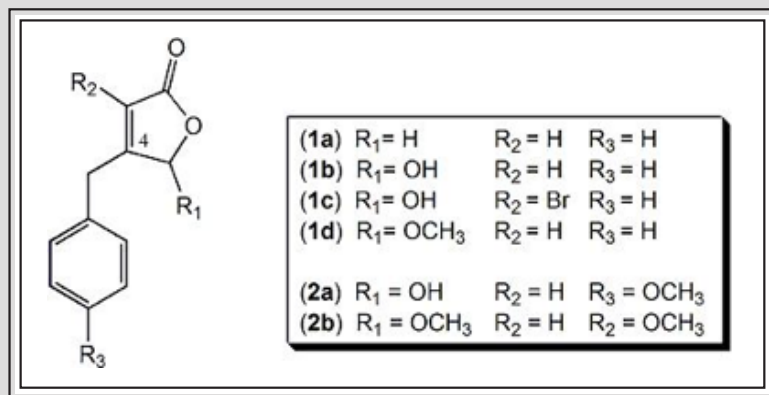
Mentors: N. Robert Estes II and John M. Hutchison

Biology and Physical Science

Since the discovery of the first antibiotic – penicillin – antimicrobials have played an integral role in the reduction of infectious diseases caused by bacteria. Conventional antibiotics work by interfering with fundamental cell processes, such as protein synthesis, DNA replication, and inhibition of metabolic pathways. Although several classes of antibiotics have been discovered over the past century, the overuse of broad-spectrum antibiotics has resulted in the emergence of antibiotic resistant bacteria. To combat this problem, both academia and the pharmaceutical industry are constantly searching for new antimicrobial agents.

Among common moieties found in a variety of synthetically useful compounds, several natural products, and

drugs with diverse biological activities are 5-hydroxy-2(5H)-furanone and 2(5H)-furanone. Although the antimicrobial activity of several 5-hydroxy-2(5H)-furanone and 2(5H)-furanone derivatives have been reported, the influence of benzyl substitution at the C4 position on the furanone ring has yet to be addressed. In this study, four 4-benzyl furanone (1a – 1d) and two 4-methoxybenzyl furanone (2a – 2b) derivatives were prepared and each tested against *B. subtilis*, *E. coli*, *P. vulgaris*, and *S. aureus*. The initial results of the tests have revealed key structural features in these types of compounds necessary for bacterial growth inhibition.



Lignocellulosic Oligosaccharides Characterization Using Liquid Chromatography-Mass Spectrometry (LC-MS)

Andrew Paulk

Mentors: Ananda Nanjundaswamy and Benedict Okeke

Biology

Oligosaccharides are polymers containing two to ten monosaccharide units. During the production of biofuels by the degradation of lignocellulosic biomass by enzymes like cellulase and beta-glucosidase, a mixture of monosaccharides and oligosaccharides is produced. Oligosaccharides characterization will not only aid in improved understanding of enzyme-assisted de-construction of cellulosic biomass but will also assist in developing strategies for potential elimination of di-saccharides like cellobiose, which are known inhibitors of yeast fermentation. In this study the use of liquid chromatography-mass spectrometry (LC-MS) as an effective tool to characterize oligosaccharide intermediates of cellulose degradation is outlined. The profiles of di-, tri-, tetra- and pentasaccharides characterized during saccharification of switchgrass will be discussed.

Comparison of Single-Step And Repeated-Saccharification of Switchgrass in Cellulosic Biofuel

Christopher Starr

Mentors: Ananda Nanjundaswamy and Benedict Okeke

Biology

The core steps in cellulosic biofuel production are pretreatment of feedstock, saccharification of pretreated feedstock and ethanol fermentation of sugars released from saccharification. Presently, saccharifying enzymes contribute towards the high cost of biofuel production. A promising solution is the production of crude enzymes from hyper-cellulolytic fungi and supplementing them with commercial enzymes. *Trichoderma SG2* is a hyper-cellulolytic fungal strain and produces cellulase, xylanase, β -glucosidase and β -xylosidase. In this study, single-step and repeated saccharification of switchgrass were compared. Single addition of crude enzyme of 2 and 5 percent acid-pretreated switchgrass resulted in 9.4g/L and 11.7g/L glucose and 2.4g/L and 2.7g/L xylose after 72h of saccharification respectively. Whereas in repeated saccharification, enzyme addition every 24h up to 72h after removal of sugar resulted in 7.5g/L and 13.3g/L glucose and 2.3g/L and 4.5g/L and xylose respectively. Using 10ml enzyme in one-time addition of crude enzyme to switchgrass yields far greater sugar when compared with 30ml enzyme addition by way of repeated saccharification. Even if there were marginal increases in sugar yield in 5 percent switchgrass, it is not proportionate to the amount of enzyme used. In conclusion, repeated saccharification of saccharified-biomass does not enhance overall sugar yield as compared with one-time enzyme addition at least in the case of acid-pretreated switchgrass.

Tangential Flow Filtration Defectively Concentrates Crude Fungal Enzyme Used in Biomass Feedstock Saccharification

Christopher Starr

Mentors: Ananda Nanjundaswamy and Benedict Okeke

Biology

One of the limitations for the commercial production of cellulosic ethanol is the high cost associated with enzymes for saccharification. Enzymes for large-scale biomass saccharification cost at least \$2-\$3 per gallon of biofuel. In this study, the use of tangential flow filtration to concentrate fungal enzymes and its effect on feedstock saccharification was examined. *Trichoderma* SG2 enzyme was concentrated two-, five- and ten-fold. Highest protein content was seen in ten-fold concentration followed by five-fold concentration. The highest cellulase activity was seen in ten-fold concentration whereas five-fold concentration resulted in highest activities for beta-glucosidase and xylosidase. Ten-fold concentration of enzyme resulted in highest sugar yield from acid-pretreated switchgrass followed by five-fold enzyme concentration. Overall, tangential flow filtration was able to concentrate fungal crude enzyme and ten-fold concentration was ideal for saccharification.



