Summer Research Symposium – Fall 2012

Wednesday, September 26, 2012
12:40-2:00pm
Carver Science Center

Seventeen Simpson College students from the Division of Natural Sciences participated in undergraduate research programs this summer. The sixth annual Summer Research Symposium is an opportunity for these students to present their work to the Simpson community.

Presentations in Jordan Lecture Hall (Carver 215)

12:45-12:55 Emily Magers

1:00-1:10 Stephen Henrich

1:15-1:25 Kevin Hughes

Presentations in Carver 231

12:45-12:55 Andy Ardueser, Rachel Rice, Kelly Woodard

1:00-1:10 Adam Smith

1:15-1:25 Whitney Thompson

Presentations in Carver 231

12:45-12:55 Michael Frank, Courtney Sherwood, Lauren Tirado

1:00-1:10 Conor Fair

Poster Session in the Carver Atrium

1:30-2:00 Beverly Burgett

Ted Heying

Jacob Johnson

Luke Kirchner

Dianna Krejsa

Abstracts
(alphabetical by last name)

Andy Ardueser, Rachel Rice, Kelly Woodard
Simpson College, Department of Mathematics
An Analysis of Beggar-My-Neighbor

In this talk we will present the work completed in the summer of 2012 during the Dr. Albert H. and Greta A. Bryan Summer Research Program at Simpson College. We furthered the analysis of the card game Beggar-My-Neighbor specifically with the intent of discovering a deal that leads to an infinite game in a 52-card deck. We used combinatorics and programs written in Mathematica to examine and refine the large number of possible deals based on structures that lead to cyclic behavior.

Beverly Burgett
Arizona State University, Mathematical and Theoretical Biology Institute (MTBI)
Evolution of within-host Antibiotic Resistance in Gonorrhea

Gonorrhea is a sexually transmitted bacterial infection caused by *Neisseria gonorrhoeae* that has become resistant to a wider range of antibiotics in recent decades. We study the competition dynamics of multiple *N. gonorrhoeae* bacterial strains within a host in an effort to better understand the development of antibiotic resistance and examine individual-patient treatment regimens to determine conditions for within-host antibiotic-resistance emergence. To that aim, we propose a phenomenological model that takes into account essential ideas such as the effects of different treatment levels, the mutation rates of bacteria, and the response of the immune system. We find steady state solutions and use analytical and numerical techniques to analyze their biological significance and stability behavior. Numerical simulations also provide a more integral view of how model parameters affect the emergence of within-host resistance.

Conor Fair
Can fungal endophytes be used to control ornamental insect pests?

The floriculture industry generated an estimated $32.1 billion dollars in retail sales in 2011.This number would be higher if not for the damage caused by insect pests and the costs to control them. Chronic pesticide use to control pest insects can be expensive and lead to the evolution of resistance. Biological control approaches have used predators to manage pest populations. Unfortunately, many predators are generalist consumers and do not differentiate between pests and non-pests. Microbial biocontrol agents (entomopathogens) have also been used with varying degrees of success. Our study examined the use of fungal entomopathogens as endophytes. Potentially beneficial endophytic fungi can live asymptomatically inside plants. We inoculated Discovery Yellow Marigolds (*Tagetes erecta*) and Benary's Giant Formula Mix Zinnias (*Zinnia elegans*) with either *Beauveria bassiana* or *Paecilomyces lilacinu*one, endophytic entomopathogenic fungi, to control a species of leafminer (*Liriomyza trifolii)*. Successful endophytic establishment was determined by plating surface-sterilized plant tissue on potato dextrose agar petri dishes. Adult leafminers were introduced and allowed to oviposit on inoculated and control plants 14 days after planting. At four days post-infestation, the plants were analyzed for leafminer damage to leaves, endophyte retention and effects on plant growth. Correlations between treatment and the fungal community were analyzed. This data showed what treatment was the most successful in controlling the insect feeding. This research provides growers an alternative to environmentally hazardous pesticides and other integrated pest management methods.

By using these naturally occurring fungi, growers will be able to increase yield without harming the environment.

Michael Frank, Courtney Sherwood, Lauren Tirado
Simpson College, Department of Mathematics
A Model of Invertebrate Richness on Restored Prairies

We will present a differential equations model of prairie restoration. Here, species richness is considered as an indicator of prairie restoration, with the variables for the equation being invertebrate and plant species richness and time. We will incorporate field work from a prairie in Nebraska as an example of our model. Our main goal is determining if planting fewer seeds will yield similar invertebrate richness as planting more seeds, that is, a more cost effective approach.

Stephen Henrich
The Jackson Laboratory (JAX), Bar Harbor, Maine
Vascular Origins of the Schlemm's Canal

Resting intraocular pressure (IOP) in healthy individuals is produced by the regular flow of aqueous humor (AH) through the anterior chamber of the eye, and is necessary for the nourishment of the chamber's extravascular tissues. Compromised AH drainage leads to increased pressure in the anterior chamber. Chronic elevated IOP induces global alterations in the eye which can cause optic nerve degeneration and blindness; hence, elevated IOP is a major risk factor in glaucoma. The Schlemm's Canal is a drainage vessel in the limbus of the eye which has been shown to resist AH flow in some glaucomatous eyes. Thus, an understanding of the molecular nature of Schlemm's Canal endothelia may provide insight into the etiology of pressure elevation. Here, we have conducted a comprehensive evaluation of Schlemm's Canal endothelial identity by detailing the vessel's developmental origins in mice. We find that the differential expression of venous associated markers throughout development demonstrates the vessel's venous origins. Further, our results indicate that the formation of a mature Schlemm's Canal is dependent upon several key players in angiogenesis.

Kevin Hughes
Screening for Listeria mutants which lyse within the host cytoplasm

Many hosts have developed strategies for detecting and eliminating invading pathogens. These strategies include both methods involved in innate and adaptive immunity such as programmed cell death and production of antibodies, respectively. To disarm and evade these strategies, intracellular pathogens have developed their own strategies for successful invasion and infection of a host. This includes activating and deactivating genes to allow for growth of a pathogen in nutrient-limited cytosol of host cells. We performed a genetic screen to find *L. monocytogenes* mutants that are unable to grow successfully in the cytosol of macrophages. We wanted to determine the adaptations that allow for *L. monocytogenes* to survive and grow in a host cell. We wanted to determine what defense host cells use for recognition and destruction of intracellular pathogens. We screened 1000 mutants and found 57, which have defects that inhibit growth in the macrophage cytosol.

Ted Heying
University of Connecticut, Department of Physiology and Neurobiology
Optimization of in vitro and in vivo Strategies or the Discovery of Kinase Specificity

Posttranslational modifications (PTMs) play a vital role in signal transduction, protein regulation and other cellular processes. Of the many PTMs that proteins undergo, phosphorylation has been particularly well studied. Protein phosphorylation (the addition of a phosphate group to a serine, threonine or tyrosine residue) is carried out by a class of enzymes called kinases. Kinases recognize patterns of amino acids surrounding the residue to be phosphorylated, defining a subset of protein substrates that an individual kinase can modify. By analyzing the substrates of a given kinase, a binding "motif" can be extracted which represents the kinase's substrate specificity. Proteomic Peptide Library (ProPeL) is a low cost, high throughput methodology designed to discover kinase specificity by exposing *E. coli* to an isolated kinase and computationally analyzing the resulting phosphopeptides. In order for the extracted motifs to be meaningful, a large number of unique phosphorylation events must be analyzed. Optimizing the phosphorylation reaction is therefore an essential task. Three particular areas of ProPeL optimization include reaction buffer composition for the *in vitro* experiments and induction point and duration of induction for the *in vivo* approach. The amount of phosphorylation was increased versus previous conditions after the completion of optimization experiments. Increased phosphorylation will allow for a larger data set to be entered into **motif-x**, a mathematical program designed to extract over represented sequences, and potentially improve generated kinase motifs-which represent kinase specificity. Improved knowledge of kinase specificity could greatly speed the diagnosis of diseases and disorders where phosphorylation is altered.

Jacob Johnson
An Investigation into the Properties of Magnetic Thin Films

We investigate the effect of strain, or microscopic stretching, on the magnetic properties of ferromagnetic materials. The idea is to use a piezoelectric substrate on which we deposit a thin ferromagnet. Applying a voltage to the underlying piezoelectric substrate results in strains in the piezoelectric, which in turn will strain any ferromagnet on the piezoelectric substrate.

Luke Kirchner
The Current State of Battery Management Systems

Currently, the best mass produced battery in terms of energy density are Li-ion batteries. However, the problem with Li-ion batteries is that they have a very low tolerance to the amount of current each cell receives making them vulnerable to overcharging and over discharging. If either of these things happens, the cells will be damaged leading to decreased lifetime and efficiency of the battery pack. Due to battery manufacturing and environmental variables the current charging design does a poor job of evenly charging all cells in the battery pack. The goal is to design a passive battery management system which bypasses the current from cells that are charging faster than others in order to get an evenly charging system. This is made possible by hooking each cell to a microcontroller that will detect the state of charge for each cell and determine when to bypass the current. In order to do this, it was necessary to become familiar with programming the microcontroller in the system and the various functions required including interrupts, initializations, and analog to digital conversion.

The result of this is a battery management system that regulates voltage, protects from overcharging, and fully and evenly charges each cell in the battery pack. The positive benefits of a consistent charge cycle leads to faster recharge time, longer lifetime, and increased efficiency of the battery pack.

Dianna Krejsa
Texas A&M University, Department of Entomology
Genetic variation in insectary-produced and wild-caught biological control species Diglyphus isaea (Hymenoptera: Eulophidae) and Chrysoperla rufilabris (Neuroptera: Chrysopidae)

Biological control is an environmentally sound way to combat insect and mite pests. Many arthropod parasitoids and predators used in biological control are mass-produced in insectaries, distributed to clients, then released in a target area to control pest species. Abiotic and biotic conditions at release sites can often be different than those encountered in the insectaries in which these natural enemies are reared, thus generating concern about the adaptability of insectary-reared insects to different release conditions. Genetic diversity is frequently related to the ability of a population to adapt to novel environmental conditions. However, mass-produced populations risk a loss of genetic diversity. When individuals are collected to establish an insectary colony, they represent only a sub-set of the source population's diversity. After remaining in isolation for many generations, diversity may be further narrowed by selective breeding, genetic drift, and inbreeding. In this study, we test this hypothesis by comparing the genetic fingerprint of field- and lab-produced populations of two biological control species: the haplodiploid parasitoid wasp, *Diglyphus isaea* (Hymenoptera: Eulophidae), and the diploid predator green lacewing, *Chrysoperla rufilabris* (Neuroptera: Chrysopidae). DNA extraction followed by AFLP analysis assessed the degree of genetic variation among populations. Our data did not find significant loss in variation between insectary-produced individuals and their wild-caught relatives of either species. Similarly, no significant differences in genetic variation were observed among insectary-reared populations in any of the two natural enemies studied.

Emily Magers
Overcoming Tolerance to Transcutaneous Electrical Nerve Stimulation by Modulating Frequency

Transcutaneous Electrical Nerve Stimulation (TENS) is a non-invasive, electrical stimulus that is applied to the skin for pain relief. Clinically, TENS is used to treat acute and chronic pains including low back pain, neck pain, and osteoarthritis. Recent studies in healthy human subjects suggest that the usefulness of TENS is limited because tolerance develops over a period of 4-5 days. Importantly, animal research suggests that it may be possible to overcome this tolerance by administering mixed rather than high frequency of TENS. It remains unknown whether this is true for humans. In this study we compared high frequency TENS to mixed frequency TENS to determine if mixed frequency TENS delays tolerance in human subjects. TENS was administered to 2 groups for 20 minutes every day for 5 consecutive days. One group received mixed frequency TENS and the other received high frequency TENS treatments. Our results showed that both mixed and high frequency TENS produce significant pain relief. The STAI, which is a widely accepted self-report of anxiety, strongly predicted the response of mixed frequency TENS on day 1. Those who scored higher on the STAI reported a lower response to TENS on the first day. In addition, initial statistical analysis suggests that those with a greater response on day 1 may have experienced more tolerance over

time. Our results also suggest that tolerance was delayed with mixed frequency TENS, but did not reproduce the previously reported finding that tolerances develops with repeated administration of high frequency TENS. Together these data suggest that TENS reduced pain and that neither an increase nor decrease in analgesia occurred with repeated administration.

Adam Smith
Parameterized construction of a base-n counter in the abstract Tile Assembly Model

Winfree's abstract Tile Assembly Model (aTAM) describes a simplified model of nanoscale tile-based self-assembly. In the model, tiles are non-rotatable units with sides having a label and integer glue strength; a tile's side matches an adjacent tile's corresponding side if they share the same label and glue strength. These tiles self-assemble on a grid. A tile will be placed on the grid if the sum of the glues of its matching sides is at least some integer constant. Under the model, sets of tiles can be constructed that self-assemble into some structure or perform some computation. One of the simplest computational constructions possible in the aTAM is a binary counter. A set of tiles can be created in which tiles represent bits; constructed properly, these tiles will then assemble into rows of incrementing binary values. Extending this construction, a set of tiles can be created for any given base. However, using this method, each construction requires a unique set of tiles. In this paper, a finite tile set is described that can be used to assemble a counter in any base. Additionally, this construction makes use of tiles with parameterized labels. These labels allow tiles to be described in terms of a function mapping inputs to outputs, simplifying construction of the tile set.

Whitney Thompson
University of Michigan, School of Information
Promises Made, Promises Kept?

Tough economic times caused many Americans to owe more on their homes than they were worth. While it may have been financially strategic to default on their mortgage, many people continued to make payments. We examine whether an affinity for keeping promises explains this type of behavior. We simulate the mortgage environment in a trust game where subjects have the option to make a non-binding promise to take an action. We vary the cost of keeping such a promise throughout the experiment in order to mimic the dilemma faced by homeowners who are underwater to various degrees.