Abstracts for Oral Presentations
Montana Academy of Sciences Annual Meeting
Sessions 1-4
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Session #1

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Polarization LIDAR Measurements of Apis mellifera In Flight for Mapping Pollination Patterns

Rachel Dickson
Dr. Jerry Bromenshenk
Dr. Colin Henderson

A scanning polarized Lidar system was used to detect flying honeybees and map out their exploration of a novel field. A colony was brought into a new area, released to explore the field, and scanned during their initiatory exploration. This data shows that bees do not explore a novel field randomly, and also has the potential of showing correlation with weather patterns, topography, and bloom density. The efficiency of the laser will also be considered, and the data will be thoroughly analyzed through computer software. The polarized Lidar scanning device is the only instrument on the planet that can efficiently map out the distribution of honeybees in flight. The data obtained from the novel field will later be compared to data taken of an established colony’s exploration of a familiar field. This project will begin to show the agricultural community how the world’s most important pollinator explores fields.

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Identification and Characterization of Inhibitors of Rift Valley Fever Virus Nucleocapsid-RNA Interactions

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Rift Valley fever virus (RVFV) is an emerging infectious pathogen that causes severe disease in humans and livestock and has the potential for global spread. Currently, there is no treatment for RVFV infection and no safe and effective vaccine. Inhibition of RNA binding to the essential viral nucleocapsid (N) protein represents an innovative anti-viral therapeutic strategy because all of the functions performed by N during infection involve RNA binding. To target this interaction, we developed a fluorescence-based high-throughput drug screening assay and tested 26,424 chemical compounds for their ability to disrupt an N-RNA complex, and potentially inhibit viral replication. We found compounds that are capable of disrupting the N-RNA complex in vitro from libraries of FDA approved drugs, drug-like molecules and natural products extracts. Currently, we are testing lead compounds for anti-viral activity in cell culture and using biochemical methods to elucidate molecular mechanism(s) of action.

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Effects of the Small Molecules BH3I-1 and HA14-1 on Conidia Germination and Morphogenesis in the Fungus
Aspergillus fumigatus.

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Recent advances in medical therapies for cancer and solid organ failures have greatly extended the life-span of afflicted patients. However, these therapies often place the patient at risk for potentially lethal fungal infections. Treatment options for invasive mycoses caused by Candida albicans and Aspergillus fumigatus are surprisingly limited and there clearly exists a need to develop new therapies. The goal of my research project is to expand upon our discovery of small molecules that inhibit the yeast (budded) to filamentous growth transition in C. albicans, and determine if they inhibit conidia germination and morphogenesis in A. fumigatus. This project focuses on determining the degree and mechanism of inhibition of Aspergillus conidia germination and hyphal growth by BH3I-1 and HA14-1. Initial experiments will determine the minimum inhibitory concentration (MIC) of BH3I-1 and HA14-1 on A. fumigatus conidial germination and hyphal development. With the MICs, the molecules will be utilized in a chemical genetics approach to identify novel regulator(s) of conidia germination and hyphal development. This approach will employ proteins found to genetically interact with BH3I-1 and HA14-1 in C. albicans. These include GRR1 and CDC4 (discovered to interact with BH3I-1 in C. albicans), which have homologues in Aspergillus.

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Microsatellite Analysis of Gene Flow between Culex tarsalis Populations Connected by Irrigation in Yellowstone County, Montana

Mattie Casey

The purpose of this study is to determine whether population connectivity by irrigation enhances gene flow between Culex tarsalis populations in the state of Montana. Four populations of Cx. tarsalis were collected along the Yellowstone and Bighorn rivers and allele frequencies obtained from PCR amplification of five microsatellite loci, visualized using the QIAxcel Advanced System, were used to assess the genetic structure of the populations. Results of two loci indicate lower pairwise $F_{st}$ values between populations connected through irrigation as well as between populations connected by waterway. If the genetic similarity between these populations reflects rates of gene flow, these results suggest that higher degrees of gene flow may not be due to irrigation but rather to connectivity by any waterway. Further analysis of additional polymorphic microsatellite loci needs to be performed to determine if a higher degree of gene flow does indeed occur between these populations.

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“A Novel Ligand-Receptor Interaction in the Activin Signaling Network in Drosophila”

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Cells must communicate to ensure proper growth and development. This communication, or signaling, often occurs when extracellular ligands bind to transmembrane receptors. In the Activin pathway of Drosophila, two types of receptors, Type I and Type II, are needed to bind a ligand. Previous work has demonstrated that the ligand dActivin signals via isoform B of the Type I receptor Baboon. To demonstrate which Type II receptor dActivin uses to signal, phenotypes induced by over-expression of dActivin were suppressed in developmental timing and wing growth assays. Results of these assays, which included decreasing levels of receptors and/or over-expressing dominant-negative receptors, showed that the Type II receptor Punt is often used in dActivin signaling.

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David Kemp, Nate Bickford, and Cera Lau.

Abstract
The white-tailed jackrabbit Lepus townsendii is a hare of importance to the trophic ecology of grassland and prairie ecosystems. Little is known, however, in regards to their abundance and population cycles in Montana, due in large part to their perceived insignificance by state and federal agencies, as monetary value is marginal, and assumptions regarding their ability to procreate at a sustainably high level keep them from being observed with any measure of diligence. Lack of insight, coupled with increasing pressures from range diminishment attributed to
human encroachment and agricultural practices, alternative energy and fossil fuel development, and unregulated hunting and sport shooting could compound to create a scenario that might potentially alter its range and genetic diversity or cause the hare to diminish in abundance. This study utilizes spotlight, transect line sampling to estimate the population density of the hare in two agricultural and CRP areas near Great Falls, Montana.

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Stochastic Functional Differential Equations Driven By Fractional Brownian Motion And Their Generalizations

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Differential equations are widely used for modeling in almost all fields, including natural sciences, engineering fields and even in social sciences. Some variables behave purely random because of the nature of the variables. Some variables depend on enough other variables that it is good enough to consider the behavior as random. In order to deal with randomness of a variable in a differential equation, we have to use the stochastic differential equations (SDE). When dealing with stochastic differential equations with memory driven by fractional Brownian motion, a comprehensive theory cannot be found. This study develops some tools to address the above issue. We consider a stochastic functional differential equation with infinite memory driven by a fractional Brownian motion with Hurst parameter $H \geq 1/2$. We prove an existence and uniqueness result of the solution to the stochastic differential equation. We investigate the dependence of the solution on the initial condition and the existence of finite moments of the solution. Furthermore we generalize these results to wider classes of stochastic differential equations. The stochastic integral with respect to fractional Brownian motion is defined as a pathwise Riemann-Stieltjes integral.
Session #3

The Relationship between Music and Student’s Cognitive Abilities

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My undergraduate research project consisted of the seventh and eighth grade class of North Middle School in Great Falls, Montana during the school year of 2012-2013. In my seventh grade sample I had 292 students and in my eighth grade sample I had 262 students. I gave the students a test that consisted of fifteen question and then a questionnaire that asked them which kind of instruction they had and how many hours in each instruction there was. The choices they had for kinds of instruction were band, orchestra, choir, and private lessons. In the seventh grade sample the data did not do as I had wanted. The correlations were very strong between the number of hours that a student had instruction and their test score. I could not fit a regression line to fit the data though to help describe the relationship. In the eighth grade sample the correlations were not as high as the seventh grade sample but I could find a regression line but not with high quality. Thus, there is not enough information to determine if there is a strong correlation between the two variables.

"Mommy, Are You Sad?": A Qualitative Analysis of How Mothers Manage Stress

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Understanding the complex and dynamic relationship between motherhood, stress, and depression has been the target of a great deal of recent research. Although empirical evidence has difficulty pinpointing the exact causes for why women and parents experience higher stress levels than other groups, one thing seems clear: Mothers are one of the most stressed and depressed groups within society. The aim of this research project is to gain a better understanding of stress management as well as mood and anxiety symptoms among mothers through the eyes of the mothers themselves. Information for this project was gathered through several focus groups during which mothers discussed four topics: stress in general, sources of stress, stress management, and anxiety /depression. The mothers revealed that their stress level affected their ability to parent their children well. Further, married mothers often felt their husband lacked understanding of their struggles and did not share an equal amount of household responsibilities.

Grid Selection for Finite Difference Methods Applied to the Heat Equation

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Abstract:
Many important physical processes can be modeled by the heat equation, a partial differential equation that is also known as the diffusion equation. In this study, the system modeled by the heat equation is a one-dimensional rod of metal through which heat can flow, changing the temperature distribution of the rod over time. The temperature at any point in the rod is a function of both time and the location in the rod. In order to solve the heat equation, the boundary conditions (the temperature at each end of the rod) and the initial condition (the temperature distribution of the rod at time zero) need to be known. Finite difference numerical methods, which require the division of the length of the rod and time into a grid of discrete data points, are the focus of this study; in particular, this study strives to improve the efficiency of a particular finite difference scheme by using non-uniform calculation grids, the spacing of the grids calculated using functions such as the exponential,
hyperbolic tangent, etc. The goal is to minimize computation time by using non-uniform calculations grids without drastically reducing accuracy.

Comparative Analysis of Justice/Corrections Project Mandates

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Abstract:
A study of the state of recidivism in the United States, released in 2011 by the PEW Research Foundation, concluded that “total state spending on corrections, is now about $52 billion, the bulk of which is spent on prisons. State spending on corrections quadrupled during the past two decades, making it the second fastest growing area of state budgets, trailing only Medicaid” (Pew Center on the States, April 2011). The realization that people, their children and society are being affected adversely by a massive system of warehousing, punishment and an inability to get treatment for addictions or mental illness, fueled a desire to investigate things like, “Where is the money going?” and “Why and what are some states doing that is working so much better?”

The real question is what can be done to ensure taxpayers are getting the most bang for the buck in corrections spending. This study compared available data from Oregon and Montana; because Oregon had the lowest recidivism rate reported in the PEW study, with Montana reporting a rate approximately double that of Oregon’s.

A Parallelized Genetic Encryption Algorithm for Encrypting Abstract Data

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Abstract:
Encryption has a long history in computer science, stretching back to the founding of the discipline. Parties interested in encryption range from military and government agencies to online product sellers wishing to better secure consumer data during transactions. The immense utility offered by nature’s systems of natural selection has been recognized by computer scientists in the fields of algorithmics and artificial intelligence. In my ongoing research, I have co-opted the process of natural selection to facilitate and derive methods for encryption, a well-known and important optimization problem in computer science. My genetic encryption algorithm operates on abstract data, represented as a matrix. This matrix is partitioned into non-overlapping submatrices, which are independently subjected to several different encryption procedures; each procedure is the result of selection from several randomly generated sequences of operations which tend to maximize the degree to which the encrypted portion resembles Gaussian noise. In this manner, the encryption is completely variable and is actually tailored to the data; the algorithm may produce a practically unlimited number of possible encryption schemes. As the submatrices are completely independent, I utilize parallel processing techniques to improve the execution speed and efficiency of my implementation.

Optimizing touch screen interaction in mobile devices for visually-impaired users

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Abstract:
In this URP, Dr. Keith Vertanen and I are running a pilot study to investigate a faster, more efficient, and easier way of typing text on mobile touch-screen devices without the need for visual feedback. These methods should allow both the blind and people with severe visual impairments to communicate and perform multiple tasks using touch-screen devices without the need to learn sophisticated skills or buy expensive equipment.

In this pilot we plan to evaluate two methods for eyes-free mobile text entry:

1) Gesture keyboard recognition, in which the user traces a keyboard letter sequence on the touch screen as a simple gesture of providing a continuous trace for each desired word.

2) Discrete key tapping: the user provides discrete key tapping events for every letter in the desired word.

Recruited test subjects will be asked to perform the tapping and tracing methods both blindfolded and sighted. Participants will try to provide the requested input quickly and accurately. Once we acquire the data from our participants, we will analyze it and determine the efficiency of both methods sighted and blindfolded.

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An Exploration of the Cases and Difficulties of Fermat’s Last Theorem.

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Abstract:
Fermat’s Last Theorem was first proposed nearly 400 years ago by Pierre de Fermat. The theorem reads; For any positive integers a, b, c, and n being a natural number greater than 2, $a^n + b^n$ is never equal to $c^n$. During the years after Fermat’s death several of the world’s greatest mathematicians, such as Euler and Gauss, attempted to prove Fermat’s Last Theorem, but none succeeded until 1994, when Andrew Wiles modified and created new methods to finally prove this aging conjecture. Using elliptic curves and modular forms Wiles finally has slain one of the greatest mathematical “dragons”. This project focused on the development of knowledge of maths required to understand attempted proofs of Fermat’s Last Theorem and the proofs of various cases of the theorem. Wiles’ proof was also considered, but, due to its deeply technical nature, was not examined at length. The case $n=4$ of Fermat’s Last Theorem was examined in depth and effort was put forth to develop an unique proof to this case of the theorem. The case was examined with a number of basic group and ring theory ideas in mind in an attempt to use modern algebraic methods to construct a proof.

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“A Detailed Analysis of Big Big Win Keno to Determine the Optimal Gameplay Strategy.”

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Abstract:
Gambling is a popular form of entertainment, and keno is a common choice amongst gamblers. The keno game Big Big Win, which is the focus of my research, rewards the player with extra plays, which vary based on the numbers matched. The trigger for the bonus round depends on the amount of numbers the player matches, which are specified by the game, (e.g. 6 out of 8, 7 out of 10, etc.) To find the optimal gameplay strategy, I researched the rules and possible outcomes and payouts of Big Big Win keno. The amounts of numbers a player can choose are 4,5,...,10. Using results from probability theory, as well as Matlab and the mathematical computing software Maxima, I determined the expected payouts for each amount of numbers.
Session #4

“Butte Water: Is it Safe?” A video documentary

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Abstract-
This is a documentary film project exploring an important public health question and the peculiar nature of the Butte water system. Our qualitative research question is, “Is Butte’s water safe to drink?” As students who moved to Butte in order to study at Montana Tech, we were shocked to hear people tell us things like, “Drink Butte water and you’ll grow an extra toe.” Safe drinking water is a huge public health priority. We wondered if coming to Butte was a bad idea, and if Butte’s government had somehow failed its public health responsibilities. After living here several years, we learned more about Butte’s water and, in this project, we want to correct misinformation and address a lingering public health question.

The Effects of Handling on the Measured Crush Strength of Proppant

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Abstract
“Fracture stimulation is the creation of a crack – or a fracture – in a rock that allows natural gas and/or crude oil trapped in underground formations to move more freely through isolated production tubing so that it may rise to the surface at faster rates and, in turn, increase hydrocarbon production from reservoirs. Basic elements – sand, water and pressure – are used to create fractures.” (Halliburton, 2012) This URP looks at how the measured crush strength, as defined in ISO13503-2, is affected by handling and to determine if there is a relationship between the handling technique and the measured crush strength. We hypothesized that handling of the sample and cell during the crush test procedure will not produce a significant difference in the measured crush strength of the proppant.

Installation of Distributed Strain and Temperature (DST) Fiber Optic Cables to Measure Ground Deformation in an Open Pit Mine

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Abstract:
Distributed Strain and Temperature (DST) fiber optic cables have previously been used to monitor deformation of bridges and other structures, but little research has been conducted to monitor deformation of rock. Montana Tech’s Omnisens DITEST STA-R Fiber Optic Temperature and Strain Analyzer can continuously monitor the strain induced by mechanical or thermal loading, and is being used in this research to monitor rock deformation. This machine records Brillouin frequency shift which can be converted to strain or temperature by using a known linear relationship between strain/temperature and frequency shift. This laboratory testing has revealed the ability to locate points of elevated strain along the fiber optic cable, providing the capability of locating points of deformation along a cable attached to rock. Montana Tech has been given the opportunity to install DST cables.
in a 300’ deep borehole at Golden Sunlight Mine to monitor ground deformation. The data collected by the Omnisens provides Brillouin frequency versus cable location at 0.1m increments. Using this data, points of elevated frequency shift are interpreted as thermal or mechanical loading, which can then be correlated with the thermal gradient or ground deformation, and compared to traditional inclinometer data.

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The Infection of Staphlococcus aureus by JB Bacteriophage in the Presence of Iron-doped Nanoparticles

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Abstract:
Bacteriophages are viruses that infect bacteria. In addition to many different uses in scientific research, bacteriophages have potential applications as a therapeutic treatment against antibiotic resistant bacterial infections. Phage therapy has received increased attention in recent years due to the increase in the antibiotic resistant strains of pathogenic bacteria. The use of a mixture of bacteriophages to kill antibiotic resistant bacteria is a potential therapeutic option for the fight against antibiotic resistant strains of harmful bacteria. There is also the possibility of applying non-biological materials to the phage mixture to increase the infection rate of the phage which would increase the efficacy of phage therapy.

I have been working with bacteriophage JB that infects Staphlococcus aureus PS88 Rosenbach Strain and community associated methicillin-resistant strains (MRSA). JB phage was isolated by a student at Montana State University. With the application of 30% Iron-doped Hydroxyapatite nanoparticles (30% FeHA NPs) a 128% increase in the viral infection rate as observed by plaque assay. I also completed further experiments to find the maximum effective dosage amount of FeHA NPs that could be applied to the virus/host system and experimented with the application of Iron-doped nanoparticles of various iron species and lattice composition.

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Research and Analysis of the Mycobacteriophage “Gigantor”

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Abstract:
Bacteriophages, or phage for short, are viruses that infect bacteria. They are a widely studied research subject in the fields of ecology, evolution, genomics and medicine. This project has isolated, purified, amplified and characterized a mycobacteriophage named Gigantor. The isolation and characterization of this phage gives comparable data to the mycobacteriophage population as a whole and it also gives insight to determine if this phage would be an interesting candidate for further genetic sequencing and annotating for comparative genomic studies. A mycobacteriophage such as Gigantor could also be used in phage-typing bacterial identification and in the treatment of infections of mycobacteria such as Mycobacterium tuberculosis.

Characterization of Gigantor included a gel electrophoresis of a DNA restriction enzyme digest. This digest gel was then compared to other phages, giving evidence to the possible placement of Gigantor within the mycobacteriophage cluster A. Other characterization procedures were also carried out. Lysogens containing a Gigantor prophage have been isolated and stored. The lysogens were used to test homoimmunity with other mycobacteriophages. Transmission electron microscopy was used to visualize Gigantor to give a tail length and virion structure. The effects of iron-doped hydroxyl apatite nanoparticles on Gigantor’s virulence was also tested.
Natural Day Refuges of Peromyscus Maniculatus in Montana

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Abstract:
Hantaviruses are rodent-borne viruses that produce chronic infections in their reservoir hosts. Sin Nombre Virus (SNV) is the Hantavirus that causes the human illness, Hantavirus Pulmonary Syndrome (HPS). The primary reservoir host of SNV is the deer mouse, Peromyscus maniculatus. Because of this connection between deer mice and human health, there is an interest in understanding the ecology of deer mice. A thorough understanding of both the population biology and social behavior of this species is needed to understand host-virus dynamics. One aspect of deer mouse behavior that has been little studied in regards to SNV transmission is movement. My study was initiated to compare movement patterns between SNV infected deer mice and non-infected mice. I used capture data from a long-term, mark-recapture study to evaluate movements of P. maniculatus on one hectare mark-recapture grids in Southwestern Montana. Locations of captures on the grids were recorded using a hand-held GPS unit. Data were examined using ArcGIS and the geographic information system software was used to determine total linear distance moved for individuals on each grid. Total linear distance was standardized for the number of captures and was then compared between individuals that differed by SNV infection status, age, and sex.

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An Analysis of Variances in Eggshell Thickness of Fossilized Spheroolithidae Specimens

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Abstract:
The very nature of an egg makes the likely hood that it will survive the fossilization process low, while surviving completely intact almost non-existent. In most cases specimens are discovered altered, weathered and fractured. Unless fossilized embryos are within the egg, identifying which species the egg belongs to is nearly impossible. If a standardized method was applied to the known species of egg, and a pattern was identified, it could be replicated with other unknown specimens to identify them. To test this theory, data was collected from what is hypothesized to be 41 fossilized Spheroolithidae egg specimens. 382 individual measurements were analyzed and categorized according to a standardized method that was created and developed specifically to organize the research data. The purpose was to discover if there were variances in the eggshell thickness of the Spheroolithidae specimens, and whether such variances could be used to potentially classify unknown fossilized eggshell specimens. Furthermore, a standardized method along with a summation of any variances in eggshell thickness will assist paleontologist in understanding some of the physiological, phonological and behavioral implications of dinosaur reproduction and nesting habits.