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SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM

2015

AT VIRGINIA TECH

July 30th, Goodwin Hall

Virginia Tech Office of Undergraduate Research

WELCOME

The Summer Undergraduate Research Conference is a highpoint of our summer at Virginia Tech. Most students presenting today have spent ten or more weeks immersed in a research project full-time. Summer affords undergraduates the opportunities to dedicate significant time and effort to the planning, execution and analysis of a research project. They have also had the chance to become authentic members of research teams by working side-by-side with faculty, graduate students, postdoctoral fellows and research staff.

Many thanks to all who have mentored undergraduates this summer. Virginia Tech is pleased to offer these summer experience not only to our own students, but also to undergraduates from all over the country. We hope that you have enjoyed your time at Virginia Tech, and we appreciate the diversity of ideas and cultures that you have brought to our campus. Congratulations to all of our presenters!

A very special thank you to Keri Swaby and Anita Dodson for their tremendous work in making this symposium happen!

Jill C. Sible, Ph.D.
Assistant Provost for Undergraduate Education, Professor of Biological Sciences.

THANK YOU TO OUR SPONSORS-

Virginia Tech Office of Undergraduate Research

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HHMI Scieneering Program

Fralin Life Sciences Institute

Virginia Tech Office of Research

And a special thank you to Dr. Ed Nelson and the College of Engineering for allowing us to use the state of the art Goodwin Hall.

A SPECIAL THANK YOU TO

PROGRAM DIRECTORS:

BIOMECHANICS / Dr. Pamela VandeVord (Biomedical Engineering & Sciences)
CENTIRE / Dr. Saied Taheri (Mechanical Engineering), Dr. Ronald Kennedy (Mechanical Engineering)
INTERDISCIPLINARY WATER SCIENCES AND ENGINEERING / Dr. Vinod Lohani (Engineering Education)
MAOP / Dr. Jody Thompson (MAOP)
MICROBIOLOGY IN POST GENOME ERA / Dr. Biswarup Mukhopadyay (Biochemistry)
SPACE@VT / Dr. Robert Clauer (Electrical and Computer Engineering), Dr. Scott Baily (Electrical and Computer Engineering)
SURF / Keri Swaby (Office of Undergraduate Research
TOUR / Dr. Deborah Good (Human Nutrition, Foods and Exercise)
KIDS TECH UNIVERSITY REU / Dr. Kristy Collins (VBI)
BRIDGES TO BACCALAUREATE / Dr. Jill Sible (Biological Sciences), Dr. Stephanie Lewis (Biochemistry)
RET / Dr. Jake Socha (BEAM)

UNDERGRADUATE PEER MENTORS:

KRISTEN FREAD / (Biochemistry, 2015) Fralin SURF (2013)
JOSHUA KIM / (Biochemistry/German, 2016)
KI LEE / (Biochemistry/Psychology, 2016) Fralin SURF (2014)
SHELBIE TURNER / (Human Development, 2015)

UNDERGRADUATE STUDENT ASSISTANTS:

JACK HARTLEY / (JMU Political Science, 2019)
LESLIE MCCREA/ (Journalism, 2016)
WALLIS MILAM/ (Public Relations, 2017)

2015 ACC CREATIVITY AND INNOVATION SCHOLARS

This program funded by the Inter-Institutional Academic Collaborative of the Atlantic Coast Conference (ACCIAC) supports current Virginia Tech undergraduate students who are involved in independent research projects or creative works under the mentorship of faculty. Selected Virginia Tech scholars receive a monetary award that can be used as a stipend and/or direct support of expenses such as supplies, travel, and use of specialized research services. Students from all academic disciplines were eligible to apply to the program. The seven selected students represent five of the seven undergraduate colleges at Virginia Tech.

ZAINAL ARIFFIN ABDUL RAHMAN / ELECTRICAL ENGINEERING

Toward a Smartphone-based Functional Ophthalmoscope for Next-generation Mobile Healthcare. Mentor: Dr. Yizheng Zhu

ALANA DUDEK / BIOLOGICAL SCIENCE

Suiting up: What does feather color convey in red-winged blackbirds?
Mentor: Dr. Ignacio Moore

LOUIS HOLLINGSWORTH / CHEMICAL ENGINEERING

Synthesis of Trityl-poly(ethylene glycol) Oligomers for Drug Delivery Applications.
Mentor: Dr. Richard Gandour

MEGAN LEE MYKLEGARD / MARKETING

Bridging the Gap Between LGBTQ Alumni/ae and Current Students: Experiences and Assessments Through Oral History.
Mentor: Dr. David Cline

MICHELLE NOCETO / ARCHITECTURE

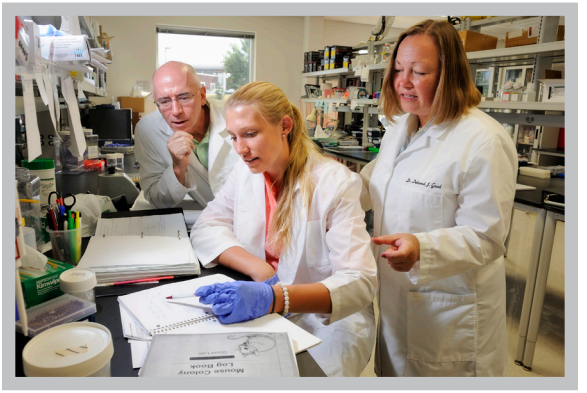
Researching Italian Holistic Approach to Design.
Mentor: Dr. William Galloway

TRAVIS WHALEY / PIANO PERFORMANCE AND MUSIC COMPOSITION

Beethoven's Compositional Process and the Evolution of the Waldstein Sonata, op. 53.
Mentor: Dr. Debra Stoudt

JAMES WOOD / ARCHITECTURE

Images of the Invisible - An Atlas of Shaker Objects, Architecture, and Urban Planning.
Mentor: Dr. James Basset



LEARN ABOUT GRADUATE PROGRAMS AT VIRGINIA TECH

SPEAK WITH REPRESENTATIVES FROM THESE COLLEGES / DEPARTMENTS / PROGRAMS:

- College of Engineering
- College of Science
- Physics
- Psychology
- Translational Biology, Medicine and Health Program
- Veterinary Medicine
- School of Education

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ORAL PRESENTATION SCHEDULE

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Mentor: Dr. Kristy Collins (VBI)

11 / KRISTINE ADRIANO AND MICHAEL NG

Semi-Active Damper Design for Automotive Applications
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11:15 / J. JOSIAH STECKENRIDER

Novel Fourier Transform Deflectometry Method for Characterizing Cell Migratory Patterns and Forces
Multiscale Approach to Biomechanic REU
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11:30 / HANNAH R. MOLITOR

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Interdisciplinary Water Sciences and Engineering
Mentor: Dr. Zhen (Jason) He (CEE)

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Fralin SURF
Mentor: Dr. John Jelesko (PPWS)

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TOUR
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ABSTRACTS
by program

A MULTISCALE APPROACH TO BIOMECHANICS NSF REU

SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

This REU program allows students to experience a multiscale approach to biomechanical research. Students were fully integrated into participating research groups and experienced hands-on lab research, group meetings, and close collaboration with other members of related research groups. By conclusion of the program, students should understand the connection between biomechanical research and fundamental biological processes in health, injury, and disease.

PROGRAM DIRECTOR

Dr. Pamela VandeVord, Biomedical Engineering and Sciences

PROGRAM COORDINATOR

Amanda Covery

Laura Baker
University of Delaware,
Biomedical Engineering
Mentor: Dr. Andrew Kemper

Keleigh Britt
East Carolina University
Mechanical Engineering
Mentor: Dr. Warren Hardy

Kimberly Brown,
Mississippi State University
Biomedical Engineering
Mentor: Dr. Pamela VandeVord

Sarah Denning,
Bucknell University,
Biomedical Engineering
Mentor: Dr. Pamela VandeVord

Kathryn Farkas
Michigan Technical University,
Biomedical Engineering
Mentor: Dr. Steve Rowson

Andres Nuncio Zuniga
University of Arizona
Biomedical Engineering
Mentor: Dr. Clay Gabler

Megan Richards
Kansas State University,
Biological Systems Engineering
Mentor: Dr. Scott Verbridge

Kyle Scheck
Michigan Technical University,
Biomedical Engineering
Mentor: Dr. Costin Untaroiu

Justin Scott
Rutgers University,
Engineering
Mentor: Dr. Bahareh Behkam

Josiah Steckenrider
Taylor University,
Engineering Physics
Mentor: Dr. Amrinder Nain

LAUREN M. BAKER,
BIOMEDICAL ENGINEERING

Evaluating the Effect of Knee Bolster Airbags on Occupant Injury Risk in Frontal Sled Tests with Hybrid III and THOR ATDs

Approximately 30,000 fatalities occur annually in the US due to motor vehicle collisions. During frontal collisions, the lower extremities and chest often experience the most serious injuries. Knee bolster airbags (KBABs) are thought to potentially reduce these injuries. The purpose of this study is to evaluate the effectiveness of KBABs and investigate lower extremity and thoracic injury risk in frontal sled tests using the Hybrid III 50th percentile male anthropomorphic test device and the newly developed 50th percentile male Test device for Human Occupant Restraint (THOR). A series of high severity frontal sled tests (ΔV=56kph) were conducted using polyurethane foams to simulate knee bolsters (KBs) (65psi) and KBABs (19psi). Lower extremity and thoracic compression data were collected using femur and tibia load cells, two 59-channel chestbands, the chest potentiometer in the Hybrid III, and the thoracic IR-TRACC system in the THOR. Preliminary results indicate that KBABs decreased femur, tibia, and chest injury risk for the Hybrid III compared to tests with the KBs. Pending results from the THOR testing, this study will provide a more comprehensive analysis of lower extremity and chest injury risk and help validate the hypothesized benefit of KBABs. Future research includes sled testing with post-mortem human surrogates to evaluate the biofidelity of the Hybrid III and the THOR ATDs. Ultimately, implementing a more biofidelic model in motor vehicle safety testing will improve the understanding of injury during impact and better protect vehicle occupants.

Mentor(s): Dr. Andrew Kemper (Biomedical Engineering and Mechanics)

KELEIGH L. BRITT,
MECHANICAL ENGINEERING

Investigation of Radially Crush of Brass and Aluminum Tubes for Energy Dissipation in the Under-Body Blast Environment

Injury to the pelvis and thoracolumbar spine are of substantial importance to the US Warfighter exposed to under-body blast while seated in military vehicles. The objective of this study is to investigate potential methods to dissipate energy transmitted to the mounted soldier through the seat. Brass and aluminum tubes of varying diameter and thickness are compressed radially using a Material Test System (MTS). Each tube is 50.8-mm long. Holes of varying diameter and number are drilled through the tubes perpendicular to the direction of loading. Reaction load (N) and deflection (mm) are measured. Tests are conducted quasi-statically (1 mm/s). Brass tubes with constant diameter result in increased peak load with increasing thickness. For brass and aluminum tubes of constant thickness, peak load decreases as diameter increases. Increasing the number of holes in the brass tubes incrementally decreases peak load (~ 12% and 6% per hole for mm 9.53 and 6.35 mm diameter holes, respectively). Peak load reduction is linear with respect to increase in hole area. The load-deflection responses compare favorably to the DeRuntz and Hodge (1963) analytical model. The results of these tests will used to design energy dissipating seats without exceeding the fracture threshold of the pelvis.

Mentor(s): Dr. Warren Hardy (Mechanical Engineering)

KIMBERLY A. BROWN,
BIOMEDICAL ENGINEERING

ANovel Ideas for Evaluating Material Properties of Brain during Blasts

Primary blast-induced traumatic brain injury (bTBI) has become a topic of research interest due to recent military conflicts and terrorists attacks. Primary injury from blast is due to the initial overpressure wave and its propagation through tissue. Mechanical forces within tissue and at interfaces could influence biological injury. Currently, there are validated physical models for ballistic and blunt impact scenarios, but there is a lack of models for blast applications. The majority of existing models treat the brain as a homogenous material, ignoring the differences between white and grey matter. To investigate how white and grey matter may receive different biomechanical pulses, several brain/skull surrogates were created using different materials. Surrogates were created with Sylgard 527, a widely accepted brain simulant, or a mixture of Sylgard 527 and 184 to vary the Young's Modulus and density. The Young's Modulus was obtained by performing dynamic mechanical analysis. The surrogates were subjected to a blast wave in an Advanced Blast Simulator. Material effects were determined by pressure readings inside each surrogate. Small variations in material properties could have a notable effect on the pressure wave propagation. This study will provide insight into creating a more biofidelic brain model for future studies of bTBI.

Mentor(s): Dr. Pamela VandeVord (SBES).

SARAH C. DENNING,
BIOMEDICAL ENGINEERING

The Brain, Strain, and Machining Pains: The design and build of a device to measure strain during blast brain injury

While traumatic brain injury has become an increasingly important topic in research, the injuries sustained, particularly from blast induced traumas, are still far from well understood. This project seeks to measure the mechanical response of brain cells to blast injury with the intent to compare results to observed biochemical changes. Thus far the project focus has been in the mechanical design of the device which uses optics to visually compute the strain experienced based on physical cell deformation over the duration of a blast. The device consists of a water filled shock wave generating tube with transition membrane to a test section filled with cell media where cells either on a slide or suspended in a gel will be placed. A microscope objective will then be focused on a cell with the image reflected to a high speed camera to record the blast that can then be analyzed using Ncorr, a digital image program within MATLAB. The current design focuses on maximizing function and ease of use paired with machinability for a simple and efficient build. Once the device is completed, testing to measure cell strain will be conducted.

Mentor(s): Dr. Pamela VandeVord (SBES).

KATHRYN C. FARKAS,
BIOMEDICAL ENGINEERING

Ability of Protective Headgear to Reduce Concussion Risk in Soccer

The significance of concussions in the sport of soccer is becoming more apparent as recent research suggests the potential of long-term neurocognitive consequences. While strict rule implementation, proper heading technique, and specialized strength training are all methods currently used to reduce concussion risk in soccer, protective headgear are becoming popular. The effectiveness of protective headgear is currently unknown. This study was designed to quantify the ability of protective headgear to reduce concussion risk in both head-to-ball impacts and head-to-head impacts. To simulate common game-like head-to-ball impacts, an official NCAA soccer ball was projected at speeds of 15 m/s and 25 m/s at an instrumented NOCSAE headform mounted on a Hybrid III neck. A total of 110 tests were performed; 5 trials on each of 10 different types of headgear as well as the control. In order to simulate head-to-head impacts, one headform was accelerated to impact the other at 1, 2, and 3 m/s using a weighted pulley system. The head impact data demonstrated that protective headgear resulted in no clinically relevant differences in concussion risk for head-to-ball impacts, but had a significant effect in reducing concussion risk for head-to-head impacts.

Mentor(s): Dr. Steve Rowson (SBES).

ANDREAS A NUNCIO ZUNIGA,
BIOMEDICAL ENGINEERING

The "Super Fitbit": Development of Hip- and Wrist-wearable Step-counter

The goal of this project was to design, implement and test a prototype step counter, i.e. a "Super Fitbit." The motivation for this was to develop new techniques and algorithms for wearable biomechanics measurements, with the long term intention of developing a programmable, wearable platform for detection of human gait abnormalities. Motion data was captured from several volunteers using an accelerometer worn either on the hip or on the wrist. The acceleration data were used both to develop an algorithm which counts steps based on appropriate acceleration patterns, and to improve the prototype hardware so as to record less noise. Successive iterations of testing data provided feedback regarding the prototype's accuracy and usability, which in turn led to improvements in noise reduction and hardware design to further improve algorithm accuracy and prototype usability. The end result was a display-equipped "Super Fitbit" able to be worn either on the wrist or hip which updates step-count in near real-time.

Mentor(s): Dr. Clay Gabler (Biomedical Engineering and Mechanics).

MEGAN L RICHARDS,
BIOLOGICAL SYSTEMS ENGINEERING

Targeting Morphological Changes in Glioblastoma with EphrinA1/EphA2 and the effect on Electroporation Therapies

Glioblastoma multiforme (GBM) is a highly malignant adult brain cancer with a survival rate less than one year. Traditional treatment methods aren't effective for this form of cancer due to the high invasiveness and tumor vasculature of GBM. A new method of treatment, irreversible electroporation (IRE) is an appealing technology because it creates lesions in tumors by non-thermal ablation. We hypothesize that changing the physical characteristics and cell morphology of GBM cells will enhance the killing threshold for electroporation therapies. We investigated the interaction of ephA2 receptors, the largest tyrosine kinase receptors, and its ligand, ephrinA1 for their role in changing oncogenic properties and morphology in glioma cell lines. The EphA2 receptor is a good therapeutic target because it is overexpressed in GBM and not found in normal astrocyte cells. In addition, EphrinA1 activation of EphA2 is a time dependent process that decreases malignant properties in GBM, and must be carefully controlled in the application of IRE therapy. Our findings indicate that the EphrinA1/EphA2 interaction directly affects GBM cells by shrinking the cytoplasm and is capable of enhancing IRE therapies by creating larger lesion sizes. Confocal microscopy, immunofluorescence staining, and finite element modeling were used to measure responses to IRE.

Mentor(s): Dr. Scott Verbridge (Biomedical Engineering and Mechanics); Jill Ivey (Biomedical Engineering and Mechanics).

KYLE R. SCHECK,
BIOMEDICAL ENGINEERING

Material identification of human rib cortical bone using finite element optimization

Chest injuries rank second only to head injury in overall number of fatalities and serious injuries. Human finite element (FE) models could be used to improve the design of vehicle restrain systems. The purpose of this study was to identify biofidelic material model for human rib cortical bone based on data recorded in dynamic tension coupon testing. Specific FE models were developed for 34 human rib cortical bone coupons taken from two cadavers. A piecewise linear plasticity material model was assigned to the coupon FE model using Young's modulus, tangent modulus, and yield stress values as design variables with ranges approximated from literature data. The initial values of material parameters were roughly approximated from test data, and FE simulations were performed using the displacement time histories of coupon ends as inputs. The root-mean-square (RMS) was calculated based on the force-displacement data calculated from simulation and corresponding data from testing. The material parameters were identified using an optimization algorithm which minimized the RMS. Statistical analysis was done to calculate averages and standard deviations of the optimized data. The biofidelic rib material will be applied to the rib cage in the GHBMC model to study automotive impact and injury biomechanics.

Mentor(s): Dr. Costin Untaroiu (Engineering Science and Mechanics).

JUSTIN D. SCOTT,
BIOMEDICAL ENGINEERING

Improving Fiber Fabrication for the Study of Cell Migration Along Physical and Chemical Gradients

Understanding what drives cellular motion is critical to advancing knowledge in areas such as wound healing and cancer metastasis since they are dependent on cells' responses to complex cues. Chemical gradients to which cells respond have been studied extensively, yet the structure on which those cells move must be considered simultaneously. Combining physical and chemical gradients gives a more accurate description of how cells move in sophisticated environments like the extracellular matrix, which is comprised of fibers from about sixty nanometer diameter to several microns. We use the previously developed Spinneret based Tunable Engineered Parameters (STEP) technique to manufacture polystyrene fibers that are physiologically sized and investigate fibroblast migration in the presence of a linear gradient of PDGF. Size and shape of the spinneret impacts the diameter of the fiber it creates, so utilizing an automated needle cutting platform ensures greater precision in fabricating iso-diameter fibers. Using a computer-controlled motorized stage to automate needle cutting may lead to more consistent conditions and repeatability when looking at cell migration along the fibers. Migration speed and persistence on the fibers created in this way was studied.

Mentor(s): Dr. Bahareh Behkam (Mechanical Engineering).

J. JOSIAH STECKENRIDER,
ENGINEERING PHYSICS

Novel Fourier Transform Deflectometry Method for Characterizing Cell Migratory Patterns and Forces

A critical component of research in cell mechanobiology including development, repair, and disease biology is understanding how a cell interacts with its environment; specifically, the extracellular matrix (ECM). Most of what we know in cell biology stems from studies traditionally conducted on geometrically featureless 2D flat substrates. Recent advancements have shown the importance of studying cell behavior in 3D environments in which the fibrous ECM is approximated by various techniques including gels and electrospun fibers. In this regard, non-electrospinning Spinneret based Tunable Engineering Parameters (STEP) fibrous platform provides precise control on the diameter, alignment, spacing and deposition of synthetic fibers in single and multiple layers, which have been traditionally challenging to accomplish using electrospinning. Using suspended and fused fibrous nanonets, we have demonstrated that cells exert forces on the fibers, bending them non-trivially, from which forces can be calculated using beam mechanics in the elastic limit. Currently, the technique for analyzing such deflections is limited by tedious manual measurements. Here, we employ a Fourier transform deflectometry (FTD) technique to not only instantaneously capture information about the degree of deflection at every point along individual fibers, but also provide interpolative information about the fiber network as a whole, thus uniquely modeling the region as a continuous "contour map" of deflections. Thus, the goal of this research is to gain an understanding of cell migrational forces at a monolayer level, as well as fundamentally understand how cells are able to distort their environment.

Mentor(s): Dr. Amrinder Nain (Biomedical Engineering and Sciences).

FRALIN LIFE SCIENCE INSTITUTE SUMMER UNDERGRADUATE RESEACH FELLOWSHIP (SURF)

SUMMER RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

The Fralin SURF program is a 10-week training program designed to give motivated undergraduates the opportunity to engage in full time (approx. 40 hrs/wk) research and related professional development activities that mirror graduate training. The goal is to offer students experiences that will help them determine if they want to pursue a career in research while they develop skills for graduate school. The program includes weekly research and professional development seminars, periodic social events, and a final symposium during which students will present their research.

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CHRISTINE L. ASH,
BIOLOGICAL SYSTEMS ENGINEERING

iGAP: Integrated Genotype and Phenotype Database for Microbial Response to Stress

The accumulation of a stress factor occurs when organisms are subjected to stress, which evokes a response that adjusts the organism to the unfavorable environment. Because of this effect, stress responses are seen as a significant influence to the organism's gene expression and phenotype. Currently, a database is needed to collect and maintain the growing number of genotypic and phenotypic stress-response data to allow for a correlation between them. Some databases solely collect gene expression profiles; however none currently exist to collect both genotypic and phenotypic data. To remedy this, we developed an open source, web-linked database that records and links the phenotypic and genotypic stressful-environment response data for two model microorganisms, Escherichia coli and Saccharomyces cerevisiae. In data collection, we chose research papers containing all necessary information to curate; this included experimental conditions, genotypes and phenotypes. We used the database to correlate the genotype and phenotype of the microorganisms and allow identification of the genes significantly affecting the phenotype. This is the first time genotype and phenotype data have been categorized and correlated in an open source, allowing others to access the database and utilize it to predict the phenotype of microorganisms from their genotypic data.

Mentor(s): Dr. Xueyang Feng (Biological Systems Engineering).

ARDEN P. BLUMENTHAL,
BIOCHEMISTRY

The Reproductive Ecology of Placobdella appalachiensis

A new species of leech, Placobdella appalachiensis, has recently been identified on the highly imperiled Eastern Hellbender salamander (Cryptobranchus alleganiensis alleganiensis) in the Tennessee River Basin in Virginia. Leeches have been indicated as potential vectors for pathogens and can directly influence the health of amphibians, including the Eastern hellbender. This study had multiple purposes: develop a comprehensive timeline of leech reproductive ecology and relate it to the timing of hellbender reproductive activities, provide a detailed description of leech offspring, and describe the reproductive behavior of adult leeches. Leeches were collected intermittently throughout the reproductive period (May-September) to determine the seasonal timing of their reproductive cycle. Leeches were also brought to the laboratory and observed daily. In addition, stored specimens and data archives collected in previous years were examined to further infer how leeches interact with their hellbender hosts. All reproductive stages including spermatophore transfer, ovisac development, eggs deposition, and hatchling attachment were observed and photographed. Specifically, the average time of each stage, measurements of adults, eggs and hatchlings, and parental care behaviors were documented (including guarding and ventilation). A significant difference in body size of reproductive versus non-reproductive leeches was found. This work provides a significant foundation for understanding the seasonal dynamics of reproduction in a new species of ectoparasite in relation to its host's biology, which could contribute to conservation efforts for this declining amphibian.

Mentor(s): Dr. William Hopkins (Fish and Wildlife Conservation); Cathy Bodinof Jachowski (Fish and Wildlife Conservation); Dr. William Moser (Smithsonian Institute Department of Invertebrate Zoology).

MICHAEL A. CORBIN,
BIOCHEMISTRY

The role of the P80 gene in Arabidopsis and Gossypium hirsutum

Gossypium hirsutum (cotton) is an invaluable crop with 170 million acres planted in 2013 in the US alone. Currently chemical defoliants are used to optimize yield by mechanical harvesting. Our goal is to develop a genetic strategy to replace the use of chemical defoliates by causing leaf senescence to occur earlier. We have characterized P80 loss-of-function Arabidopsis plants. They senesce early, suggesting that the P80 gene plays a role in regulating senescence. We examined the role of environment on the P80 mutant phenotype in Arabidopsis and the effect of silencing P80 in cotton. P80 mutant Arabidopsis were grown on different soil types to see if early senescence was affected by particular environmental conditions. Our data indicates that soil environment affects the severity of this phenotype. In cotton, the P80 gene was silenced through viral-induced gene silencing (VIGS) using Agrobacterium to introduce the VIGS constructs into cotton. We confirmed the presence of the virus using Semiquantitative PCR. After this we measured the expression of the native P80 gene and the viral load present in the plant. We showed that this system successfully reduced the level of native P80 RNA. We also found that P80 suppression lead to alterations in leaf shape, size, and color in mature cotton plants. In conclusion we found that the P80 senescence phenotype is dependent on soil environment. Additionally, we have successfully used VIGS to suppress P80 expression in cotton.

Mentor(s): Dr. Glenda Gillaspy (Biochemistry).

CHRISTOPHER C. DICKINSON,
BIOLOGICAL SCIENCES

Optimization of Viral Induced Gene Silencing in Poison Ivy Seedlings

Viral Induced Gene Silencing (VIGS) is a rapid reverse genetic technique to reduce the mRNA accumulation of specific plant genes and thereby identify gene function. To initiate a VIGS response, a viral genome containing a piece of the target plant gene is introduced into living plant tissue. Initial attempts to introduce a Tobacco Rattle Virus (TRV) bipartite genome containing a fragment of a poison ivy Phytoene Desaturase (PDS) gene using Agrobacterium tumefaciens leaf infiltration were ineffective, due to an ostensible plant antibacterial immune response. To avoid such an antibacterial immune response, purified TRV-PDS plasmid DNA was coated over gold particles and accelerated with a gene gun into either poison ivy cotyledons or first true leaves as targets. Likewise, a Firefly luciferase (LUC) construct was similarly introduced to evaluate biolistic transformation and transgene expression efficiency in target tissues. The efficiency of LUC transformation coupled with Luciferase enzyme activity was 64%. Seedlings at the cotyledon stage bombarded with the TRV-PDS construct produced two VIGS-induced phenotypes: i) variable chlorotic mosaic pattern, ii) white vasculature. Both symptoms are consistent with reduced chlorophyll production due to reduced PDS expression. The efficiency of a VIGS-induced reduced PDS expression phenotype was 56% of plants, slightly less than the Luciferase phenotype at 64%. VIGS symptoms were never observed in cotyledon tissues whether or not they were the target of transformation. These results demonstrate that VIGS is a suitable reverse genetic tool for future efforts to validate putative urushiol biosynthesis gene function in poison ivy.

Mentor(s): Dr. John Jelesco (PPWS).

KENDALL W. FOGLER,
FOOD, SCIENCE AND TECHNOLOGY

Antimicrobial Resistance of Manure-Based Dairy Cattle Compost

Administration of antibiotics to animals, either for growth promotion or as a therapeutic agent, selects for antibiotic-resistant bacteria (ARB) both in the gut and manure secreted into the environment. Bacteria break manure down into compost, a nutrient-rich plant growth substrate that is applied to crop land. Examining spread of ARB from compost to soil and vegetables is the long-term goal of the project. This study evaluated levels of antibacterial resistance in composted dairy manure, from cows treated with antibiotics in order to identify a selective media for ARB. ARB were enumerated by plating onto growth media containing varying concentrations of antibiotics belonging to major classes used for humans.Resistance to each of the tested antibiotics was seen at the following maximum concentrations: 10 ug/ml cefotaxime, 10 ug/ml ceftazidime, 2.5 ug/ml tetracycline, 11 ug/ml vancomycin. ARB populations numbered (log CFU/ml): 4.77 cefotaxime, 4.57 ceftazidime, 5.4 tetracycline, 7.3 vancomycin and. Highest resistance levels were to classes of antibiotics that were administered to the cattle. It can be concluded that the composting process does not destroy ARB, and that the antibiotics given to the dairy cattle have selected for ARB, posing a risk for soil and vegetable contamination.

Mentor(s): Dr. Monica Ponder (Food, Science and Technology).

NATHANAEL B. FOX,
BIOCHEMISTRY

A Therapeutic Approach to Endocrine-Resistant Forms of ER+ Breast Cancer: Synthesis of Anti-Proliferative and Anti-Inflammatory Compounds

This project seeks to develop a therapeutic approach for endocrine-resistant forms of estrogen receptor positive (ER+) breast cancers. Inflammation is a key hallmark of many or all cancers. Unfortunately, although all ER-targeted drugs inhibit estradiol-mediated proliferative activity, they also lack its more beneficial anti-inflammatory activity. I have set out to discover selective estrogen receptor modulators that have both anti-proliferative and anti-inflammatory activity. This project involved organic synthesis of a library of small molecule ligands – which are based on a compound (OBHS) known to show both types of activity – as well as making a series of intermediates for an otherwise untested compound (CBHS). These compounds were then purified via chromatographic techniques, and finally characterized by proton NMR and mass spectrometry. These compounds are expected to exhibit both anti-proliferative and anti-inflammatory effects, and their efficacy will be tested in the near future in cell proliferation studies, and anti-inflammatory studies utilizing Interleukin-6 (IL6) modulation as a surrogate marker of inflammation.

Mentor(s): Dr. Jatinder Josan (Chemistry).

EMMA T. HELMS,
ANIMAL AND POULTRY SCIENCES

O-linked β-D-N-actlyglucosamine transferase deficiency improves insulin sensitivity through enhanced lipid catabolism and thermogenesis

The fundamental signaling pathways underlying obesity and its associated metabolic syndrome are largely unknown. We specifically ablated the nutrient sensor O-linked β-D-N-actlyglucosamine (O-GlcNAc) transferase (Ogt), and found Ogt deficiency protected mice from diet-induced obesity. These mice exhibited reduced fat mass, increased energy expenditure, and improved insulin sensitivity. In order to determine the molecular mechanism of the Ogt-mediated metabolic phenotype, we performed quantitative RT-PCR using muscle, fat and liver from wild-type and mKO mice. Expression of genes related to lipogenesis was downregulated in white adipose tissue (WAT) and liver, whereas that related to lipolysis and beta-oxidation was up-regulated in WAT. Additionally, expression of thermogenic genes was up-regulated in muscle, liver, and WAT. To test whether Ogt deficient muscle secretes myokines that impact adipogenesis and WAT browning, we measured the expression of genes of known myokines. Out of seven myokines, Il15 expression was enhanced over 5-fold. Taken together, these findings are consistent with our in vivo data, and support our hypothesis that Ogt functions to maintain skeletal muscle and whole body glucose metabolism and insulin sensitivity. Ogt deficiency-induced expression of Il15 and protection from obesity suggests that manipulation of O-GlcNAc signaling may have potential therapeutic values to ameliorate metabolic disorders.

Mentor(s): Dr. David Gerrard (Animal and Poultry Sciences); Dr. Hao Shi (Animal and Poultry Sciences).

ERIKA L. JOSECK,
ANIMAL AND POULTRY SCIENCES

Effects of the embryonic developmental environment on ornamental traits in zebra finches: implications for understanding sexual selection

The expression of many traits in animals is reliant on early developmental experiences. The developmental stress hypothesis postulates that the quality of these early conditions is reflected in the "honest" signals the animal possesses later in life. In many songbirds, females choose mates based on the quality of their "honest" sexual ornaments, such as plumage quality and symmetry. Previous studies have shown that suboptimal temperature during embryonic development affects a suite of traits in early life. However, the effect of the pre-hatch environment on sexual ornaments of mature passerine species is under-explored. We hypothesized that male passerines require an optimal incubation temperature during embryonic development to properly produce ornamental traits. We used a sexually dimorphic passerine species, the zebra finch (Taeniopygia guttata). Eggs were separated two different incubation temperature treatments: optimal (37.5°C) and suboptimal (35.5-36.5°C). We assessed males at sexual maturity for beak brightness, cheek patch plumage brightness, cheek patch symmetry, and cheek patch area. Optimal incubation temperature produced cheek patch plumage with a mean brightness 56% higher and reflectance intensity 52% higher than those hatched in a suboptimal incubation temperature. These results suggest that embryonic thermal conditions might contribute to the modulation of the expression of a carotenoid-based sexual ornament: cheek patch plumage. Therefore, males exposed to an optimal incubation temperature may have significant fitness benefits because female zebra finches may choose to mate with males with the brightest cheek patches; however this needs to be tested.

Mentor(s): Dr. William A. Hopkins (Fish and Wildlife Conservation).

KATHERINE A. LIPFORD,
WILDLIFE CONSERVATION

Summer Occupancy Rates of Sciurid Populations on Salt Pond Mountain

Sciurid species provide important ecosystem services; therefore, it is important to understand the distribution and ecology of these small mammals. This summer I studied occupancy rates of Sciurid populations on Salt Pond Mountain using camera traps. I established two camera grids (300 m x 450 m) with 12 cameras per grid. Grids were separated by over 600 meters. The cameras were baited and deployed simultaneously in each grid for 14 days. The bait was replenished and the cameras were checked after seven days. Several different Sciurid species such as the southern flying squirrel (Glaucomys volans), the eastern chipmunk (Tamias striatus) and the eastern gray squirrel (Sciurus carolinensis) were found to be present in the study area and the data was used to complete occupancy models with Program PRESENCE. I expect that southern flying squirrels (Glaucomys volans) will be the Sciurid species with the highest occupancy rate in the study area on Mountain Lake due to the abundance of habitat dominated by oak trees, an important food source for this species.

Mentor(s): Dr. Mark Ford (Fish and Wildlife Conservation); Corrine Diggins (Fish and Wildlife Conservation).

NILANKA D. LORD,
CROP & SOIL SCIENCE (CROP GENETICS & BREEDING OPTION)

Let There Be Light: A study of the activity of perceptive genes in Populus trichocarpa during the short to long day transition in photoperiod

The flowering time pathway allows a plant to discern when the best time to flower is in order to give it the best chance to reproduce. This is primarily influenced through perception of photoperiod in leaves followed by long-distance signaling to other plant organs. Similarly, trees use changes in photoperiod to time the transition to winter dormancy in order to maximize growth while avoiding frost injury. In this study, the activity of two of the genes known to be involved in the photoperiodic pathway (FT2 and FD3) were observed and compared as Populus trichocarpa was exposed to a transition from a period of short day-length (SD) to long day-length (LD). Because photoperiod effects overall growth of the trees, we also studied TCP9, which responds to other conditions (specifically water and nutrient availability) that alter plant growth. In order to monitor activity, RNA was extracted from leaf and root samples taken from five different time points along the SD to LD transition. Gene expression of samples at each of the five time points were relatively quantified using a Real Time (RT) PCR which detects double-stranded cDNA using SYBR green as it is amplified during a PCR. We observed higher gene expression of FT2 and FD3 in the LD trees, analogous to their upregulation during LDs to promote flowering in annual plants. We hypothesize that TCP9 expression will be indirectly affected by SDs and thus, show a slower response related to growth cessation.

Mentor(s): Dr. Amy Brunner (Forest Resources and Environmental Conservation).

KERRY A. MAGUSCHAK,
BIOCHEMISTRY

Epigenetic effects in the African malaria mosquito Anopheles coluzzii

The African mosquito Anopheles coluzzii, the major malaria vector, is responsible for transmission of Plasmodium falciparum that causes malaria in humans. The ultimate goal of this study is to understand how development and reproduction in An. Coluzzii are regulated. This knowledge will be useful for designing methods of vector control. We studied the effects of the epigenetic drug 3-Deazaneplanocin A (DZNep) on larva development and mortality, and on fecundity in adult females. Microscopy was used to compare morphology of adult female ovaries as well as eggs obtained from control and experimental groups. Larvae were exposed to different concentrations of DZNep, and we found that at the concentration of 1.0 μM, larvae were less likely to emerge as adults. We also found that high concentrations of DZNep (10 μM) resulted in lower fecundity of adult females. They produced fewer eggs and their eggs were unable to hatch. At 2.5 μM of DZNep, while no obvious morphological differences in eggs or ovaries were observed, a delay in egg hatching suggests that a low concentration the drug still has some effect. Finally, we found that the epigenetic effects of DZNep are likely reversible; once the drug was no longer introduced to the adult females, they appeared to have fully recovered from the negative effects on fecundity and offspring survivability. Our results suggest that epigenetic mechanisms are a promising area of research for design of potential vector control methods.

Mentor(s): Dr. Igor Sharakhov (Fralin Life Science Institute, Entomology).

JOEL MUSHAGASHA,
BIOCHEMISTRY

Assessing Structural Differences and the Potential Link to Allergenicity of Antigenic Peanut Protein Orthologs from the Genus Arachis

Peanut allergy is recognized as one of the most severe food allergies and can cause anaphylaxis to approximately 1% of the U.S. population. Ara h 2 and Ara h 6 are a part of the 2S- Albumin family and are identified as the two most potent protein associated with peanut allergenicity. In this study, the structure-function relationship of Ara h 2 and Ara h 6 within subspecies of the genus Arachis were analyzed to better elucidate the link between protein variance and potential residue interaction with Immunogloblin (IgE) to cause varying allergic response. There are no known Ara h 2 and Ara h 6 structures for the species that are currently being studied and homology modeling was used to generate structures for five Ara h 2 and six Ara h 6 models from various species. Molecular dynamic (MD) simulations were performed in order understand the structure-function relationship in each allergen. For each protein studied, the most notable difference between model and MD structure was in solvent-accessible surface area (SASA), with the intramolecular hydrogen bonding and secondary structure percentages being relatively unchanged. The MD structure SASA decreased, which illustrates a more compact and stable protein structure. In order to better understand allergenicity, future analysis on the specific binding epitopes of each protein will be examined to see if the solvent accessible area changed in those regions. In conclusion, further examining key epitopes within each structure that are linked to IgE binding will be useful in understanding binding interaction and allergenicity.

Mentor(s): Dr. David R. Bevan (Biochemistry).

KEELY R. O'KEEFE,
DIETETICS

Food security in Madagascar: Exploring the diets of women and children living around Betampona Nature Reserve

Objectives: Exploring diet diversity, nutritional status, and food beliefs of mothers living around Betampona, Madagascar. / / Purpose: Many households in Madagascar are food insecure (53%) and stunting in children under 5 years is high (6th highest in the world). Baseline nutrition knowledge is needed to identify possible nutritional interventions. / / Methods: Mothers living in ten villages surrounding Betampona were provided a questionnaire on diet diversity and food beliefs. Weight and height were measured. Descriptive statistics were used to evaluate differences between villages with or without markets. / / Results: A total of 138 women were surveyed, with 55% of women (n=76) without a market, 45% with a market. For women without markets, 15.8% were underweight; 10.5% overweight (no obese), versus with markets, 12.9% were underweight; 16.1% overweight (4.8% obese). The average diet diversity score was 6.9 for mothers and 6.7 for children in villages with markets; 6.2 for mothers and 6.4 for children in villages without markets (max score of 12). The most frequently reported "nutritious foods" were rice (58%), meat (38%), cassava (18%). The most frequently reported "non-nutritious foods" were breadfruit (23%), cassava (23%), green leaves (22%). / / The results will be used to develop education materials/interventions to promote diet diversity and nutritious foods in Betampona. /

Mentor(s): Dr. Alisha Ferris (Nutrition, Foods and Exercise); Elena Serrano (Human, Nutrition, Foods and Exercise).

AMI PATEL,
BIOCHEMISTRY

Finding A "Happy" Medium: The Effect of the Bacteria Culture Broth on Screening for New Anti-Microbials

Organometallic complexes of cobalt, rhodium and iridium are showing great promise as new anti-microbials in the search to find new antibiotics effective against drug resistant strains of bacteria such as methicillin resistant Staph. Aureus and tuberculosis. A collaboration between the Merola group in Chemistry and the Falkinham Group in Biological Sciences has screened a wide variety of compounds in this search. Two different types of culture media were used in examining the activity of the organometallic compounds against mycobacteria, an example of which is tuberculosis. Brain heart infusion broth (BHIB) and M0178 Middlebrook 7H9 broth base (M7H9), were used to grow Mycobacterium smegmatis and to identify the minimal inhibitory concentration (MIC) of a series of compounds in each medium. The result was that the same complexes tested in M7H9 had erratic MICs whereas BHIB had one consistent MIC per compound. This led the group to study the compounds spectrophotometrically via UV-Visible spectroscopy to observe possible interactions with compounds in the medium. Iridium and cobalt Cp* complexes were synthesized and purified. Those compounds were then analyzed using UV-Vis and the spectra were obtained. The compounds were mixed with BHIB and M7H9 and allowed to react for 4 days at 37 degrees Celsius. The UV-Vis spectra for the compounds mixed with media were obtained and compared to the spectra of the original compounds. Compound interactions were determined by shifts in absorbance peaks. The results of this research were that the compounds that included acetylacetone structures interacted with M7H9, whereas the compounds that included amino acids did not.

Mentor(s): Dr. Joseph Merola (Chemistry).

ALEXANDER R. PELLETIER
FRESHWATER FISH CONSERVATION

Temporal and Longitudinal Mercury Trends Across Russian Arctic Rivers

Studies primarily in the North American arctic have found that biological Hg has been increasing annually by 0.8% and follow a longitudinal gradient with decreasing concentrations from west to east. However, one study discovered that biological Hg in burbot (Lota lota) in the eastern arctic declined by 2.3% annually between 1980 and 2001. Additional data on the pan-arctic watershed are necessary to better understand holarctic biological Hg patterns. Here, we report temporal and longitudinal Hg trends in burbot from eight Russian arctic rivers. Muscle Hg concentrations and total fish weight were recorded in burbot measuring 80 to 100 cm total length. Spatial and temporal Hg trends were then determined using log-linear regression in the PIA contaminant analysis software. We found that mean biological Hg concentrations decreased between 1980 and 2001 in seven of the eight rivers by an average of 2.5% annually. We also determined that mean biological Hg concentrations declined by 1.8% per 10° longitude from west to east. These results suggest biological Hg concentrations and trends in the 1980's and 1990's were significantly different in the eastern and western arctic regions. We suggest that biological Hg patterns in the arctic are mainly controlled by Hg emissions and may depend more on pre-depositional processes than it has been recently suggested.

Mentor(s): Dr. Leandro Castello (Fish and Wildlife Conservation).

ELLA P. RACK,
ANIMAL AND POULTRY SCIENCE

Characterizing the Underlying Biophysical Properties Mediating Magnetic Orientation in C57BL-6J Mice

Evidence for sensitivity to magnetic cues (i.e. magnetoreception) is widespread across vertebrate and invertebrate taxa, yet the underlying sensory mechanisms are poorly understood. Behavioral and theoretical evidence provide support for a light-dependent mechanism in which the sensitivity of specialized photopigments is influenced by the earth's magnetic field. Male C57BL-6J mice trained to build nests in one of four magnetic directions revealed a robust magnetic response relative to the trained direction. We are currently investigating the effect of wavelength on trained magnetic building behaviors using monochromatic (10nm bandwidth) light during testing trials. Though the wavelength series is still in progress, this information will allow greater understanding of how this mechanism works on a bio-physical scale. In addition, female C57BL-6J mice were trained toward a submerged platform in one of the four cardinal directions in a 'plus' arm water maze, and tested in altered magnetic fields. Though the complexity of the water maze assay resulted in more variable baseline results, consistent magnetic preferences were observed, reinforcing the presence of magnetic orientation in two different spatial tasks. The extreme sensitivity of the mammalian magnetic response presents unique difficulties in the development of effective assays, but further confirmation and characterization of the magnetic response is one step closer to understanding the complex mammalian sensory system.

Mentor(s): Dr. John Phillips (Department of Biological Sciences).

HANS B. SMITH,
BIOCHEMISTRY

Characterizing the Role of a Phospholipase Autotransporter from Fusobacterium Nucleatum in the Modulation of the Colorectal Tumor Environment

Fusobacterium nucleatum is a pathogenic gram-negative bacterium that is part of the normal human oral and gut microbiome. Recent studies have shown that F. nucleatum is highly overrepresented in the tissue of colorectal cancer patients, where it modulates the tumor micro-environment and immune inflammatory response through unknown mechanisms. This bacterium produces a diverse set of virulence proteins belonging to the autotransporter family, of which one such member was found to inhibit the cytotoxic effects of natural killer cells on various tumors. The goal of my research was to further characterize FN1704 (FplA), an F. nucleatum autotransporter of interest that was previously characterized in the Slade Lab as a phospholipase A1 enzyme that cleaves lipids and turns on pro-inflammatory pathways involved in colorectal cancer. Through multiple biochemical methods, my research resulted in the successful expression and purification of several FplA constructs, which were used for enzymatic and protein crystallography studies. These results have furthered our understanding of how of autotransporters, and in particular FplA, play a role in virulence and cell signaling in cancer.

Mentor(s): Dr. Daniel Slade (Biochemistry).

KIMBERLY H. SOTO- ALVARADO,
BIOLOGICAL SCIENCES

Analyzing the changes induced by environmental stress in diploid versus tetraploid cells

The doubling of chromosome number in cells, referred to as tetraploidy, is a prevalent characteristic observed in different stages of cancer progression. Tetraploid cells were shown to display tolerance to mitotic errors and to chemotherapeutic drugs when compared to normal (diploid) cells. Some have hypothesized that tetraploidy plays an important role in cancer development, as the extra chromosome copies may act as a "buffer" against negative mutations. A common mutation found in cancer cells is a change in chromosome number, known as aneuploidy. We hypothesized that tetraploidy may allow the cell flexibility to undergo chromosome number changes that benefit cellular fitness in the tumor microenvironment. These changes will then contribute to the greater levels of genomic dys-regulation seen in advanced cancers. However, it is not well understood how environmental stresses (such as those encountered in a tumor microenvironment) might contribute to the evolution of karyotypes in tetraploid cells. Here, we investigated the effects of nutrient starvation on the karyotypes of diploid and tetraploid cell lines derived from hTERT-immortalized, non-transformed retinal pigmented epithelial cells (hTERT-RPE1). The two cell lines were cultured in serum-free conditions for six passages, for a total of 3-4 weeks. We found that both the diploid and the tetraploid cells displayed high degrees of chromosome number variability. Our data suggest that stressful environmental conditions promote chromosome missegregation and aneuploidy in human cells.

Mentor(s): Dr. Daniela Cimini (Biological Sciences).

CYRUS D. TAFTI,
BIOCHEMISTRY

Analyzing Early Earth Metabolism in Sulfurihydrogenibium azorense, a Deeply-rooted Bacterium

Life on Earth evolved about 3.5 billion years ago while oxygen came into the environment 1 billion years after that. Consequently the early inhabitants of Earth were strict anaerobes. Our laboratory is interested in discovering the molecular tools that allowed these early inhabitants to transition to an aerobic metabolism and the specific focus is on how they dealt with oxidative stress and redox shock. For this research, we are using Sulfurihydrogenibium azorense a thermophilic, chemolithoautotrophic, microaerophillic bacterium belonging to Aquificae, the most ancient bacterium phylum, as a model organism. S. azorense grows anaerobically as well as in the presence of oxygen, albeit in low concentrations, and these conditions represent the pre-oxygen and early aerobic stages of Earth. To begin our research, I have developed robust microaerophilic growth (H2 + 2% O2), in liquid and on solid media and made advancements towards genetic manipulation of the organism. The next tasks are to fully develop the genetic analysis tools and bioreactor-based methods for cultivation under precisely monitored and controlled conditions. Then we will use these systems and RNASeq approach to study the molecular responses of the organism to changes in the hydrogen and oxygen concentrations in its environment.

Mentor(s): Dr. Biswarup Mukhopadhyay (Biochemistry); Dr. Dwi Susanti (Biochemistry); Usha Loganathan (Biochemistry).

VERONICA C. TAYLOR,
BIOCHEMISTRY

The Effect of Circadian Deadenylase Nocturnin on Translational Activity

Poly(A) tail length affects mRNA stability and translation, thus, deadenylases , which shorten poly(A) tail length, play an important role in altering the protein profile. Of the eleven known mammalian deadenylases, Nocturnin (Noc) is unique in regards to its rhythmic expression pattern. I hypothesized that the absence of a deadenylase, such as Noc, would lead to a longer poly(A) tail, hence a greater amount of protein. I tested this idea by utilizing Western blot technology and compared the protein expression levels of CD52, BLOC1S1, NDUFB2, and HSPB1 between wild-type and Noc mutant animals using mouse liver and mouse embryonic fibroblasts (MEFs). These four genes were chosen because previous studies have shown that their poly(A) tail length is longer in Noc mutant mice when compared to wild-type. To accomplish this goal, I also performed the necessary steps such as cell culturing of MEFs and homogenizing of liver samples. Among the four genes, there was no change in protein expression between wild-type and mutant mice both in MEFs and mouse liver at the statistically significant level, however, I am further optimizing the experimental conditions to confirm the results.

Mentor(s): Dr. Shihoko Kojima (Virginia Bioinformatics Institute).

JOSE ZUNIGA ARANA,
BIOLOGICAL SCIENCES

Stability of S. typhimurium VNP 20009 after injection in 4T1 mammarygland carcinoma

Strains of Salmonella typhimurium have been used in a variety of tumor treatment studies, due to their ability to preferentially colonize tumors over healthy tissue. S. typhimurium VNP20009 (VNP20009) was constructed from the virulent parental strain S. typhimurium 14028S (14028S) to be attenuated through a modified LPS and be selective in the invasion of cancer cells. Due to the modification of the LPS in the genome, VNP20009 spontaneously deletes 108kb. It was recently discovered that VNP20009 is deficient in chemotaxis, through a single nucleotide polymorphism in cheY, and so chemotaxis was restored in S. typhimurium VNP20009 cheY+ (VNP2009 CheY+). The first goal of this research was to determine the stability of both VNP20009 strains based on three phenotypes, chemotaxis, motility and biofilm formation, after exposure to the tumor environment of a 4T1 mammary gland carcinoma in mice. Four different test groups were created: one without tumor or bacteria (control), one with tumor and no bacteria, one with tumor and wild type VNP 20009, and one with tumor and VNP cheY+ .Colonies were isolated and inoculated on 0.3% agar (swim) plates to test for chemotaxis. 1000 colonies were screened from each group for a deviation from the rest (smaller swim ring or no swimming) and further screening was done on selected colonies. The second goal was to construct a derived strain from 14028S that is attenuated in the LPS but does not delete the 108kb. VNP 20009 chey+ recovered from tumors was found to not lose the chemotaxis+ phenotype thus remaining stable.

Mentor(s): Dr. Birgit Scharf (Biological Sciences).

INTERDISCIPLINARY WATER SCIENCES AND ENGINEERING NSF REU

SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

This NSF-REU Site on Interdisciplinary Water Sciences and Engineering at Virginia Tech was established in 2007. Two cycles (2007-09) and (2011-13) of this Site have been completed and 56 excellent undergraduate researchers (33 women + 23 men) (REU fellows) representing 45 different institutions in the United States have graduated thus far. Faculty members and their graduate students from a variety of disciplines including Engineering Education, Civil and Environmental Engineering, Geosciences, Biological Sciences, Industrial Design, and Crop and Soil Environmental Sciences mentor REU fellows to conduct research on various interdisciplinary aspects of water sciences and engineering. The REU fellows get opportunities to conduct independent research and improve their communication (written and verbal) skills. Field trips and weekly seminars are organized to develop professional skills. Weekly social interactions are facilitated to enhance personal and professional bonding among REU fellows and with faculty/ graduate students. The site will continue until 2016.

SITE DIRECTOR

Dr. Vinod K Lohani (Engineering Education)

Haley A. Canham
SUNY College of Environmental Science and Forestry
Environmental Resources Engineering
Mentor: Dr. Jennifer Irish

Margaret E. Carolan
Virginia Tech
Water Resources, Policy and Management
Mentor: Dr. Marc Edwards

Isha P. Deo
The University of Texas at Austin
Civil Engineering
Mentor: Dr. Mark Widdowson

Elizabeth Erwin
Virginia Tech
Geology
Mentor: Dr. Vinod Lohani

Zachary M Fry
Colorado State University
Civil Engineering
Mentor: Dr. Vinod K. Lohani

Katelyn R Johnson
Boston College
Biochemistry
Mentor: Dr. Kang Xia

April D. Marsh
Clarkson University
Environmental Engineering
Mentor: Dr. Durelle Scott

Hannah R. Molitor
University of Wisconson- Platteville
Environmental Engineering
Mentor: Dr. Zen (Jason) He

Madeline F. Ryan
Virginia Tech
Environmental Science
Mentor: Dr. Cayelan Carey

Brock E. Shilling
Milwaukee School of Engineering
Biomolecular Engineering
Mentor: Dr. Andrea Dietrich

HALEY A. CANHAM,
ENVIRONMENT RESOURCES ENGINEERING

Comparison of Barrier Island Sediment Transport Between Storm and Tsunami Overwash Events

Barrier island storm and tsunami sediment transport and deposition can be simulated through the use of numerical models, though limited work has been done on a modeled direct comparison. The occurrence of a storm or tsunami event has the potential for catastrophic effects on an island. In the event of overwash, large quantities of sediment may be transported and deposited into the inner bay, and could result in total loss of the island. Modeled results may be compared with sediment core samples from the inner bay to provide insight into differentiation, strength, and frequency of historic events. Three barrier island profiles: Santa Rosa Island, Florida; Mantoloking, New Jersey; and Bay Head, New Jersey with varying dune heights and berm widths were used in simulations conducted with the numerical model XBeach. Idealized storms and tsunamis were created with varied wave height, wave period, and storm surge. The level of energy for both events was scaled to be equal for direct comparison. Through the comparison of post event bathymetry, it is seen that tsunami sediment deposition extends into the bay further than storm sediment deposition. Tsunami deposits are also seen to be thinner than storm sediment depositions.

Mentor(s): Dr. Jennifer Irish (Civil and Environmental Engineering,); Dr. Robert Weiss (Geosciences).

MARGARET E. CAROLAN,
WATER RESOURCES, POLICY AND MANAGEMENT

Effects of Flow Rate on Turbidity and Microbial Growth in Household Plumbing Systems

Opportunistic pathogens (OPs) are the leading cause of water-borne disease in developed countries. Water- and energy-conserving plumbing system designs with reduced flow rates can increase OP growth by fostering sediment accumulation, biofilm development, and disinfectant residual decay. A simulated water faucet experiment was constructed, testing four flow rates (1.6-6.5 L/min) in duplicate. Hot (50° C) and cold (<20° C) water was mixed, targeting 37° C at each faucet. The lowest flow rate displayed 22-28% more turbidity and 22-32% more bacterial cells than the highest flow rate, confirming that lower flow rate faucets have an increased potential to facilitate growth. In a parallel bench-scale plumbing rig operated at four flow rates (0.2-9.8 L/min), and flushed with a 50 NTU solution of natural organic matter, 3.5 times more turbidity accumulated in the lowest flow rate pipe than the highest flow rate pipe. Chlorine residual disappeared in the lowest flow rate pipe 7 times faster than a stable chlorine residual control and 5.5-6.3 times faster than the higher flow rate pipes when 5 mg/L free chlorine was introduced. This parallel work confirms that lower flow rates cause favorable conditions for microorganism regrowth. Future work will investigate the effects of low flow on OPs.

Mentor(s): Dr. Marc Edwards (Civil and Environmental Engineering); Dr. Amy Pruden (Civil and Environmental Engineering) William Rhoads (Civil and Environmental Engineering).

ISHA P. DEO,
CIVIL ENGINEERING

A Drought Evaluation in the Northern Shenandoah River Valley

Water supply planning in the Northern Shenandoah Valley requires a careful evaluation of the region's resources, climate, and projected demand, in order to create a more versatile drought response contingency plan for the upcoming water supply plan update. This project aims to create a comprehensive definition of drought for the Northern Shenandoah Valley region by studying the availability of local drought indicator data, including precipitation, stream discharge, and groundwater levels. The spatial distributions and timeframes of the available data were represented on an interactive map, which provided a simple way to recognize useful relationships between the data stations. Furthermore, the drought indicator levels were analyzed using the Standardized Precipitation Index and the Standardized Streamflow Index, allowing the comparison of station data across watersheds. As the SPI and SSI trends showed a close correlation across watersheds, this analysis may be used to identify and quantify drought in the future. This study of the historical data allows for an improved understanding of the regional climate, helping the regional committee create a complete definition of regional drought, typify the drought intensity, and implement appropriate conservation measures to reduce the risk of severe drought impacts.

Mentor(s): Dr. Mark Widdowson (Civil Engineering); Elana Chalmers (Civil Engineering).

ELIZABETH ERWIN,
GEOLOGY

Continuous High Frequency Water Quality Parameters as Surrogates in an Urban Watershed

This study analyzes patterns in water quality parameters during storm events at two locations on the campus of Virginia Tech (VT), in the Webb Branch, which is an upland urbanized catchment of Stroubles Creek. Data for this study was collected using two Hach Hydrolab MS5 Sondes, and grab samples. The Sondes collect data in continuous high frequency (3 minute) intervals and measure various water quality parameters, including turbidity and specific conductance. The intent of the study is to find an empirical relationship between specific conductance and turbidity as measured by the Sondes, and the nutrients phosphorus and nitrogen, which are not measured by the Sondes. Two field sites for Sonde deployment and grab sample collection were selected for this study; the current outdoor field location of the Learning Enhanced Watershed Assessment System (LEWAS) lab, by West Campus Drive, and a second site upstream near Goodwin Hall. Water quality data from both base flow conditions and storm events were collected and analyzed to determine a relationship. This study was conducted during a ten week program called Research Experience for Undergraduates, funded by the National Science Foundation (REU/NSF) and supported by the LEWAS.

Mentor(s): Dr. Vinod Lohani (Engineering Education); Dr. Randel Dymond (Civil Engineering).

ZACHARY M FRY,
CIVIL ENGINEERING

Implementation of the LEWAS Lab at Virginia Tech User Interfaces in a Professional Environment

The Learning Enhanced Watershed Assessment System (LEWAS) is a unique water quality monitoring system created at Virginia Tech. Although this system was originally intended for educational use, it is also used by professionals as well. Both Virginia Tech facility services and the town of Blacksburg, Virginia are parties know to use the LEWAS as a tool in their profession. This study aims at obtaining qualitative data from both facility services at Virginia Tech and the town of Blacksburg as to what needs exist from these professionals in terms of the LEWAS user interfaces. This data would come in the form of a survey and the information would be used to improve the current user interfaces for these professionals in mind. A procedure was also developed to find how much critical sites contribute to polluting a watershed. Although data form the surveys has not yet been collected, an interface was still created to allow pictures from this procedure to be added to the LEWAS database, as well as manually entered data from the user. This system is designed to be used by students, researches, and professionals and will be expanded upon by the LEWAS team in the future.

Mentor(s): Dr. Vinod Lohani (Engineering Education); Darren K. Maczka (Engineering Education).

KATELYN R. JOHNSON,
BIOCHEMISTRY

Distribution of Neonicotinoids in Sediment of a Surface Stream and its Fate in Sediment and Soil

Neonicotinoids, such as TMX and its metabolite Clothianidin (CLO), are widely used insecticides commonly coated on planting seeds, causing an unknown amount to travel through the environment from fields to waterways. However, their accumulation in anthropods and aquatic organisms is sub-lethal, possibly attributing to the decline of the honey bee. In order to understand the distribution of TMX and CLO in an agricultural-urban-mixed impacted stream, their levels in sediments from seven locations along Stroubles Creek, Blacksburg were investigated. The sediment samples were extracted using the liquid/solid extraction, cleaned up using PSA, and analyzed on a triple quadruple ultra performance liquid chromatography- tandem mass spectrometer (UPLC/MS/MS). The levels of TMX at all locations along the creek ranged from 0.10 to 0.15 ppb, with the highest level detected at the location directly below a cornfield at 0.79 ± 0.12 ppb. The levels of TMX at three locations upstream of the corn field were below the detection limit. This indicated that the cornfield plays an active role in the accumulation of TMX in Stroubles Creek, suggesting that the insecticide coating the corn seeds has the ability to travel from the field to contaminate the creek. The levels of CLO, transformation product of TMX, in the sediment samples collected along Stroubles Creek were below the limit. This study suggested that TMX does not stay contained within its application area and has the ability to travel into the adjacent aquatic system.

Mentor(s): Dr. Kang Xia (Crop, Soil, and Environmental Sciences); Hanh Le (Crop, Soil, and Environmental Sciences).

APRIL MARSH, ENVIRONMENTAL ENGINEERING

The Impact of Stream Fencing on Greenhouse Gas Emissions

Recent climate changes are suggestive of the negative impact of increased anthropogenic greenhouse gas emissions. The agricultural sector is responsible for about 7.7 percent of these total emissions in the United States, with a large portion attributed to livestock. The purpose of this research was to determine correlations between greenhouse gas (CO2, CH4, and N2O) emissions and cattle exclusion from streams. Appropriate research sites were determined based on the presence of cattle, with Doc's Branch fenced off in 1997 and Holtan's Branch remaining unfenced, allowing cattle to access the water. At both tributaries, greenhouse gas concentrations were measured at four transects with five points each, using a Picarro G2508 Gas Analyzer and the unsteady state static chamber method. Differences in the average greenhouse gas fluxes between the two tributaries were calculated to be as large as 450 kg ha-1 d-1 for CO2, 5.34 kg ha-1 d-1 for CH4, and 0.019 kg ha-1 d-1 for N2O, at comparable distances from the water. The overall correlation demonstrated by the results is that the tributary with cows produced higher emissions for all of the greenhouse gases in question, upland of the stream. This trend suggests that cattle should be excluded from streams and rivers to reduce greenhouse gas emissions.

Mentor(s): Dr. Durelle Scott (Biological Systems Engineering); Breanne Ensor (Biological Systems Engineering).

HANNAH R. MOLITOR,
ENVIRONMENTAL ENGINEERING

Resource Recovery from Landfill Leachate through Microbial Electrolysis Cells Coupled to Forward Osmosis

Global concerns over diminishing resources, specifically water scarcity, have prompted investigation of technologies that salvage valuable resources from waste. This study examined simultaneous resource recovery and treatment of landfill leachate, a high strength wastewater, by coupling a microbial electrolysis cell (MEC) to forward osmosis (FO). The synergistic relationship of this coupled system makes it an attractive option for energy-efficient recovery of ammonia, electricity, and water from leachate. The coupled system utilizes anaerobic microbes in the MEC anode to oxidize organic contaminants in leachate for electricity generation, which drives ammonium from the wastewater to be collected in the MEC cathode. The recovered ammonium is then used as a draw solute in the FO for water recovery from the MEC effluent (treated leachate). The performance of the coupled system was evaluated in batch mode through analysis of the chemical oxygen demand (COD) removal, ammonia removal, and water recovery from the leachate. The MEC removed up to 27% of COD, and 40% to 68% of ammonium. Obtained batch-profile current generation was affected by substrate supply and consumption. The FO achieved 51% water recovery from the treated leachate with a 2 M ammonium bicarbonate draw solution. The results indicate that coupled MEC-FO systems may be applied to recover valuable resources from landfill leachate, which would significantly offset the economic and energy requirements of leachate treatment. The coupled system may offer an appealing and sustainable approach to leachate management.

Mentor(s): Dr. Zhen (Jason) He (Civil and Environmental Engineering); Mohan Qin (Civil and Environmental Engineering).

MADELINE F. RYAN,
ENVIRONMENTAL SCIENCE

The vertical distribution of phytoplankton in Beaverdam Reservoir, and the percentage of living versus non-living phytoplankton in managed versus unmanaged reservoirs

Phytoplankton have high biodiversity, and have long been used to study populations and community structures. They are an important indicator of water quality, and can potentially have negative effects on human health and carbon sequestration. One phytoplankton group, the cyanobacteria, are of particular concern to water quality managers due to their ability to form toxic and nuisance blooms. The objective of this research was to investigate the drivers of vertical cyanobacteria distribution in Beaverdam Reservoir (BVR), an unmanaged drinking water source in Vinton, Virginia, USA, and to determine the percentage of living versus nonliving phytoplankton in BVR and its heavily managed counterpart, Falling Creek Reservoir (FCR). We used in-situ fluorometry to measure the abundance of four main phytoplankton groups: diatoms, green algae, cyanobacteria and cryptophytes. We took weekly light, dissolved oxygen, temperature, and pH profiles, and analyzed water samples for metals and nutrients, in order to determine the variables most closely correlated with high cyanobacterial abundance. We combined these techniques with manually filtered chlorophyll measurements to determine the concentrations of living versus nonliving phytoplankton in FCR and BVR. On average, the proportions of living versus nonliving phytoplankton were very similar in both reservoirs. Phosphorous, iron and manganese had an effect on the distribution of the cyanobacteria. These results support previous findings that suggest some cyanobacterial communities are subject to iron-phosphorous co-limitation (North et al. 2007), and may help drinking water managers prioritize water management actions in the future.

Mentor(s): Dr. Cayelan Carey (Biological Sciences); Kathleen Hamre (Biological Sciences).

BROCK E. SHILLING,
BIOMOLECULAR ENGINEERING

Nanoparticle Reactivity from Water Consumption throughout the Human Digestive System

Although the amount of consumer products containing nanoparticles is increasing, research data on the toxicity and reactivity of these nanoparticles is not readily available. The objectives of this research were to: (1) determine the dissolution concentration of nanoparticles in different digestive fluids: saliva, gastric, and intestinal; (2) determine reactivity of common nanoparticles: nano- iron, silver, copper, and silicon dioxide, in the human digestive system by quantifying lipid oxidation using a TBARs assay; and (3) evaluate toxicity of nanoparticles exposed to E. coli cultures by comparing colony-forming unit counts. Results show that copper nanoparticles most readily dissolves in gastric fluid as compared to other digestive fluids. Since ferrous and cuprous solutions are known to induce lipid oxidation, they were the controls in the TBARs experiments. It was found that all nanoparticles induced lipid oxidation in at least one digestive fluid. Nanoiron caused the most lipid oxidation in in all digestive fluids. However, lipid oxidation results varied for copper, silver, and silicon dioxide nanoparticles. These results suggest that nanoparticles exhibit a capability to react in human digestive fluids, which may lead to health concerns and exposure limits. No data with respect to toxicity effects of nanoparticles exposed to E. coli cultures are currently available.

Mentor(s): Dr. Andrea Dietrich (Civil and Environmental Engineering).

KIDS TECH UNIVERISITY: BRIDGING THE GAP BETWEEN PHYSICS, COMPUTER SCIENCE AND K-12 EDUCATION (VBI)

SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

Funded by an NSF grant, this 10-week summer undergraduate training opportunity was centered around bridging the gap between physics, computer science, and K-12 education. During the summer program, 2 undergraduate students (one majoring in Computational Modeling and Data Analytics and another in Psychology and Biology) worked together to produce various online content that will be used in primary schools and on the Kids' Tech University website. A teacher manual and hand-outs were also produced.

PROGRAM DIRECTOR

Dr. Kristy Collins (VBI)

Alex T. Gagliano,
Virginia Tech,
Computational Modeling and Data Analytics
Mentors: Dr. Kristy Collins, Dr. Will Mather

Lily T. Hummer,
Virginia Tech,
Psychology and Biology
Mentors: Dr. Kristy Collins, Dr.Will Mather

ALEX T. GAGLIANO AND LILY T. HUMMER, COMPUTATIONAL MODELING AND DATA ANALYTICS AND PSYCHOLOGY AND BIOLOGY

Kids' Tech University: STEM Education Beyond the Classroom

The goal of The Virtual Kids' Tech University is to improve literacy in primary math and science education to ensure a strong STEM workforce of tomorrow. The Virtual Kids' Tech University targets elementary and middle school students at a critical point in their education and introduces Virginia Math and Science Standards of Learning through online games, lessons, and quizzes. Current expansion of previous KTU modules has led to the development of a multi-faceted cell game, Cell Life. By harnessing the developmental process of exploration, Cell Life presents concepts of cellular physiology in an approachable and entertaining manner. The culmination of resources provided within each module facilitates both a formal educational lesson as well as a home-based learning experience, exposing students to previous, current, and upcoming standards of learning. Future work on the KTU program will focus on the integration of additional modules in the hopes of creating a nationwide resource that utilizes natural curiosity to encourage independent learning. /
This work was supported in part by the following grant: NSF #MCB - 1330180

Mentor(s): Dr. Kristy Collins (Virginia Bioinformatics Institute); Dr. Will Mather (Physics)

MICROBIOLOGY IN A POST GENOME ERA

SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

A 10-week summer research training program for undergraduates that focuses on a wide range of microbiological phenomena. The program integrates the application of state-of-the-art genome-based technologies for fundamental and applied research projects in microbiology.

PROGRAM DIRECTOR

Dr. Biswarup Mukhopadyay (Biochemistry)

Guidalia F. Dormeus,
Oakwood University
Biology
Mentor: Dr. Endang Purwantini

Keane J. Dye,
Virginia Wesleyan College
Biology
Mentor: Dr. Dave Popham

Taylor P. Enrico,
Colby College
Biochemistry
Mentor: Dr. Pablo Sobrado

Emma Willis,
Berea College
Molecular and Cellular Biology
Mentor: Dr. Elankumaran Subbiah

GUIDALIA F. DORMEUS,
BIOLOGY

Characterizing the Glycopeptidolipids of the Mycobacterium smegmatis SSI/73, a mutant strain

The Mycobacterium genus comprises more than 120 different species. Among these different species are pathogenic and non-pathogenic bacteria. The mycobacterial cell wall is very complex due to their various lipid structures. In this research, we are focusing on Mycobacterium smegmatis which is non-pathogenic. Mycobacterium smegmatis resembles Mycobacterium avium, pathogenic mycobacteria causing diseases in HIV/AIDS patients and elderly; immunosuppressive people. Mycobacterium smegmatis is enriched in lipids called Glycopeptidolipids (GPL). GPL decreases the permeability on the cell wall, making the cell wall very leaky. A library of mutants was obtained and screened with plumbagin; mutant SSI/73 was hypersensitive to plumbagin. The cell wall composition was analyzed and it was discovered that there was a decrease in the number of GPL on the outer surface of the cell in the mutant. Instead of 4 GPL on the outer surface of the cell, only one was detected. We grew Mycobacterium smegmatis SSI/73 mutant in Middlebrook 7H9 Broth and extracted the GPL using Thin-Layer Chromatography (TLC). The structure of the single lipid found in the bacteria was revealed using NMR and Mass Spectrometry. By knowing the structure, we were able to determine where in the biosynthesis process was there a blockage. This study is expected to shed light on the mycobacterial complex lipid metabolism, providing a tractable system for antimycobacterial drug development. This drug will work hand in hand with an existing drug, to help that drug work more efficient.

Mentor(s): Dr. Endang Purwantini(Biochemistry), Dr Biswarup Mukhopadyay (Biochemistry)

KEANE J. DYE,
BIOLOGY

Investigation of the Protein YpeB's Interactions within Bacillus anthracis

Bacillus anthracis is capable of forming enviromnetally resistant endospores. A necessary step in the conversion of B. anthracis spores into vegetative cells is the degradation of the cortex. In previous studies the enzymes SleB and Cwlj have been shown to be the primary enzymes responsible for this in Bacillus spores. The stability and function of the SleB enzyme has been shown to be reliant upon the presence of the protein YpeB. YpeB and SleB are expressed from the same operon, in addition to being co-localized within the dormant spore. The two proteins share a co-dependence where the absence of one causes the degradation of the other. The purpose of this research is to further characterize the relationship between the YpeB protein and the SleB enzyme by determining the existence of a physical interaction between the proteins, as well as to isolate any additional proteins which may play a role in that interaction. This will be done through site directed mutagenesis of the three PepSY domains within the C-terminus region of the YpeB gene. Whereby, specific amino acid codons within the gene were mutated into cysteine codons. These plasmids were introduced into B. anthracis through a tri-parental crossover. The alleles were incorporated into the bacterial genome through a temperature sensitive origin of replication and by single crossover. Western blots analysis will be used to determine the presence of each protein. Germination assays will also be used to determine the effect that the YpeB mutations had on the rate of germination of the B. anthracis spores.

Mentor(s): Dr. Dave Popham (Biological Sciences).

TAYLOR P. ENRICO,
BIOCHEMISTRY

Role of H68 and E181 in the Reaction of UDP-Galactopyranose Mutase from Aspergillus fumigatus

UDP-galactopyranose mutase (UGM), a flavoenzyme, catalyzes the step in galcalactofuranose biosynthesis where it converts UDP-galactopyranose to UDP-galactofuranose. Galactofuranose, found in cell wall and extracellular matrix, is an essential virulence factor in many human pathogens. Because deletion of the UGM gene attenuates virulence and because UGMs are not found in humans, UGMs are considered potential targets for drug design against the pathogens that produce them, such as the fungus Aspergillus fumigatus. Previous research has shown that UGMs from A. fumigatus (AfUGM) undergo significant substrate-induced conformational changes, including the movement of loops that shift to close the active site. Two residues, H68 and E181, interact to stabilize the closed conformation of the active site loops. In previous experiments, it was determined that the mutants H68A and E181A exhibited reduced catalytic activity of AfUGM when compared to the wild type. To further explore the role of H68 and E181, the double mutant, H68A E181A, was produced, and its catalytic activity was compared to that of the wild type and single mutants. Because the double mutant exhibited similar activity to the single mutants, data suggest that H68 and E181 interact with each other to stabilize the conformational change, and secondary interactions, if present, do not affect stabilization. Results from this project contribute to our understanding of AfUGM function and will aid in the design of new inhibitors.

Mentor(s): Dr. Pablo Sobrado (Biochemistry).

EMMA WILLIS,
CELLULAR AND MOLECULAR BIOLOGY

Cytotoxicity of Type I Interferon-Sensitive Recombinant Newcastle Disease Virus for Prostate Cancer Cells

Prostate cancer (CaP) is the second most common cancer in American men, with every 1 in 7 men being diagnosed with CaP at some point in their life. Chemoresistance and metastasis are major prognostic markers during tumor advancement. Oncolytic virotherapy has been used as an alternative therapy to treat refractive tumors. Newcastle disease virus (NDV) is an avian paramoxovirus that has previously demonstrated oncolytic properties and preferentially infects tumor cells. NDV is capable of lysing tumor cells through both extrinsic and intrinsic apoptosis mechanisms. The BC/Edit strain of NDV lacks V-protein expression and is interferon sensitive therefore resulting in reduced cytotoxicity and limited viral growth in healthy cells as compared to tumor cells. In-vitro characterization of BC/Edit NDV in terms of cytotoxicity and apoptosis will be carried out in various CaP cell-line models. This in-vitro characterization of NDV will provide essential background information to further explore virotheraputic options.

Mentor(s): Dr. Elankumaran Subbiah (Biomedical Sciences and Pathobiology)

NIH BRIDGES TO THE BACCALAUREATE PROGRAM / MULTICULTURAL ACADEMIC OPPORTUNITIES PROGRAM (MAOP)

SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

The Bridges to the Baccalaureate Program partners with existing programs on the Virginia Tech campus to provide experiential learning opportunities to Virginia Community College System students. This program is funded by the National Institutes of Health (NIH) (grant number 5r25gm17749) as a means to promote diversity and inclusion in the biomedical and behavioral sciences. There are several components to this program which includes outreach programs to our partner community colleges where faculty talk with students about career options and provide resources to lecture and lab instructors, invitations to students to "test drive" Virginia Tech as an option for transferring to a 4-year institution through campus visits and summer research programs, and a year of mentoring as a Bridges Scholar for those that do transfer to help with the transition to the Virginia Tech academic environment.

This summer, Bridges to Baccalaureate program participants were hosted by MAOP. MAOP is an academic success community founded upon the principles of self-help, mentoring and peer support. Central to the goal of MAOP is the promotion of diversification in the student body at Virginia Tech and on the post graduate level- particularly in the science, math, and technology areas. The summer research internship is a 10-week research experience where students work with a faculty member in a mentor/protégé relationship to design, conduct and present a scholarly research paper. Students learn to plan and conduct research in their field of interest, attend seminars, participate in field trips, use state-of-the-art equipment, prepare for the GRE, and attend a two and a half day exploratory retreat.

PROGRAM DIRECTOR

Dr. Jill Sible (Biological Sciences)
Dr. Karen Ely Sanders

PROGRAM DIRECTOR (MAOP)

Dr. Jody Thompson-Marshall

PROGRAM COORDINATOR

Dr. Stephanie Lewis (Biochemistry)

Hajar Chokhmane
Northern Virginia Community College
Mechanical Engineering
Mentor: Dr. Bahareh Behkam

Chentelle M. Guest
Virginia Tech
Psychology
Mentor: Dr. Susan White

Michael Hodge
New River Community College
Biological Sciences
Mentor: Dr. Daniel Capelluto

Jeremy J. Hopson
New River Community College
Computer Engineering
Mentor: Dr. Layne Watson

Alyssa P Johnson
Northern Virginia Community College
Psychology
Mentor: Dr. Jungmeen Kim-Spoon

Ibah Sagusay Odjinar
Northern Virginia Community College
Nursing
Mentor: Dr. Dennis Dean

Deepak Poudel
Virginia Tech
Food, Science and Technology
Mentor: Dr. Mark Williams

Tyler Rudd
New River Community College
Fish and Wildlife Conservation
Mentor: Dr. Donald Orth

HAJAR CHOKHMANE,
MECHANICAL ENGINEERING

Interactions between Microorganisms and the Surface Topography of Electrodes in Microbial Fuel Cells

Microbial Fuel Cells (MFCs) are bio-electrochemical systems that use anode respiring microorganisms to convert organic matter into energy. MFCs have the potential to concurrently treat wastewater and produce electricity and are therefore, considered an alternative energy source to fossil fuels. While much research regarding MFCs has been conducted in the last few decades, understanding of the microorganism-electrode interactions is still limited and technical problems remain unsolved. This research focuses on studying the effects of changing the surface topography of anode electrodes on the performance of MFCs. Anodes with identical chemical characteristics but different surface roughness were designed to ascertain the connection between surface topography of anodes and the development of biofilms, and examine potential correlations with the current density of MFCs. Findings from this work can be used to develop anode surfaces that allow for higher power output of MFCs.

Mentor(s): Dr. Bahareh Behkam (Mechanical Engineering)

CHENTELLE M. GUEST,
PSYCHOLOGY

The relationship between intelligence and aggression in children

The purpose of this research is to explore the relationship between cognitive ability (i.e., IQ) and aggression in children. By definition, aggression involves behaviors that are intended to hurt or harm others, and has long been the focus of clinical research owning to it's strong associations with a host of academic, and social problems, and the fact that aggression during childhood is predictive of criminal behavior, unemployment, and marital problems in adulthood (e.g., Berkowitz 1993). For this study we analyzed data from a sample of 134 youths (ages 7-14, 61.9% male, 83.6% White). In order to measure cognitive ability, we utilized the Peabody Picture Vocabulary test, Forth Edition (PPVT) and the Expressive Vocabulary Test, Second Edition, (EVT), both of which are reliable and valid measures of receptive and expressive language abilities and considered proxies of cognitive ability in the extant research. Aggression was measured using the Behavior Assessment System for Children –Second Addition (BASC) with our primary focus on the aggression scale of the parent rating scales. Given that children of higher cognitive as well as, verbal ability may be expected to possess a broader repertoire of skills for managing anger and other intense emotions, we hypothesized that intelligence would negatively correlate to aggression. We found that our hypothesis was supported ($r = -.235$, $p = .009$). This relationship between receptive processing of vocabulary (a proxy of IQ) and parent reported aggression suggests that cognitive and verbal ability should be considered in prevention and intervention programs targeting childhood aggression.

Mentor(s): Dr. Susan White (Psychology)

MICHAEL HODGE,
BIOLOGICAL SCIENCES

INPP4B: Function and Analysis

The enzyme inositol polyphosphate 4-phosphatase type II (INPP4B) has been shown to acts as a tumor suppressor in breast, prostate, ovarian, and probably lung cancer. INPP4B negatively regulates Phosphoinositide 3-kinase (PI3K) / Protein kinase-B (AKT) by dephosphorylating phosphatidylinositol (3, 4) biphosphate, thus, regulating cell proliferation. The enzyme contains a C2 domain, which was reported to bind phosphatidic acid, but no further structural and/or functional studies has been reported to confirm its binding activity. Consequently, the recombinant enzyme and its C2 domain were expressed and purified from E.coli to characterize their structure and function. Both INPP4B in its C2 domain were purified to homogeneity by a combination of affinity chromatography and gel filtration. The proteins were tested for binding to phosphatidic acid to confirm previous findings and to further characterize their interactions using biophysical approaches. Current progress of such investigations suggests that the C2 may not bind phosphatidic acid. As C2 domain typically binds phospholipids, they will also be tested for INPP4B C2 domain binding.

Mentor(s): Dr. Daniel Caputo (Biological Sciences)

JEREMY J. HOPSON,
COMPUTER ENGINEERING

Cell Cycle Model Parameter Estimation via a New Optimization Algorithm

Research involved creating an accurate stochastic model to help understand the life cycle of a budding yeast cell. The research used data from wild type yeast cells. The model parameters from an existing stochastic model, due to Laomettachit, were optimized by a new algorithm for stochastic optimization called QNSTOP. QNSTOP uses a Quasi–Newton method to approximate the unknown parameters by minimizing an error measure between an empirical probability distribution and the probability distribution predicted by the stochastic model. The error measure used here is the information theoretic Kulback-Leibler distance. The goal is to find the best possible parameters to use to be able to predict changes in mother and daughter cells when exposed to external perturbations or other experimental conditions. Future applications for such modeling may affect medical treatments for gene related human diseases.

Mentor(s): Dr. Layne Watson (Computer Science)

ALYSSA P. JOHNSON
PSYCHOLOGY

Positive Association Between Identification and Parental Monitoring

Prior research has yielded conflicting results involving the relationship between religiousness and behavior. Religious motivation has been proposed as one factor that has led to these inconsistencies. The present study sought to contribute to the growing literature on the relationship between religious motivation and behavior by focusing on its impact on immediate family environment, more specifically, parental monitoring habits. Based on the literature suggesting the beneficial outcomes of identification as religious motivation, the present study hypothesized that there would be a positive association between identification as religious motivation and parental monitoring. Participants included 157 parents of adolescents (87.3% female, 91.1% white). Self-reports on religious behavior and parental monitoring scales were analyzed via regression. Results showed a significant positive association between identification and parental monitoring. This reinforces the idea that identification is linked with positive outcomes, and it also strengthens the assertion that religious motivation should be considered when analyzing religion's effects on family life.

Mentor(s): Dr. Jungmeen Kim-Spoon (Psychology)

IBAH SAGUSAY ODJINAR,
NURSING

Site-directed Mutagenesis of Methanosarcina barkeri iscS 338Cysteine to Alanine to Determine its Role in Iron-Sulfur Cluster Formation

Iron-sulfur [Fe-S] clusters are inorganic cofactors that are present in organisms and are required to sustain a variety of biological processes (1). For example, [Fe-S] clusters are involved in many biological functions such as electron transfer, substrate binding/activation, iron/sulfur storage, regulation of gene expression, and enzyme activity (1). Medical studies indicate inappropriate [Fe-S] cluster biosynthesis underlies numerous human diseases (2). Research on the assembly of [Fe-S] cluster has been conducted on several species of prokaryotes and eukaryotes. However, the biosynthetic [Fe-S] cluster assembly mechanism in the Archeon Methanosarcina barkeri has not yet been analyzed. We have established that, like other organisms, M. barkerii uses a molecular scaffold, called IscU, and a cysteine desulfurase, called IscS, to form [Fe-S] clusters. In this work I have analyzed the function of the proposed active site cysteine within IscS by using site-directed mutagenesis to substitute this residue with alanine. Surprisingly, I found that expression of the substituted form of IscS, together with normal IscU, was still capable of forming [Fe-S] clusters when recombinantly expressed in Escherichia coli. The nature of the [Fe-S] clusters formed in the substituted complex is now being analyzed by purification of the proteins.

Mentor(s): Dr. Dennis Dean (Biochemistry)

DEEPAK POUDEL,
FOOD, SCIENCE AND TECHNOLOGY

Associative Nitrogen Fixation Potential in Root Zones of Switchgrass Cultivars

Plants obtain a significant proportion of their nitrogen from bacteria that live in soil. In the case of switchgrass, a highly promising bio-fuel feed stock; there is the potential to increase the bacterial contribution that will lead to higher switchgrass productivity. Research in our laboratories has shown that up to 40% of switch grass nitrogen is derived from root-zone nitrogen fixing (diazotrophs). The implications of this high nitrogen fixing activity are supportive of the goals of sustainable agriculture systems, which are to reduce fertilizer nitrogen usage that will reduce nitrogen pollution in the environment and also meet the nitrogen needs of crops such as switchgrass. The focus of my research is thus to characterize diazotroph communities associated with switchgrass and to understand how they contribute to switchgrass productivity. Bacterial diazotrophs convert nitrogen gas into ammonium (NH4+), in a process called Biological nitrogen fixation (BNF), which is a form that plants can use. BNF can help reduce the use of artificial nitrogen fertilizers. BNF is catalyzed by the enzyme nitrogenase. The nifH gene encodes a major component of the nitrogenase enzyme. Hence, nifH gene abundance is widely used to study nitrogen fixation potential. Switchgrass is a warm-season, perennial, tall-grass, whose biomass is used for biofuel. In this study, we aimed to quantify the nitrogen fixation potential in the root-zones of switchgrass cultivars. Towards this end, we used Polymerase Chain Reaction (PCR) to amplify nifH gene present in the DNA of nitrogen fixing bacterial cultures and in the roo.

Mentor(s): Dr. Mark Williams (Horticulture).

TYLER RUDD,
FISH AND WILDLIFE CONSERVATION

Diet overlap between native and introduced catfish species in Virginia's tidal rivers – are white catfish being outcompeted?

From 1973 to 1985, blue catfish Ictalurus furcatuswere in Virginia's tidal rivers to create new commercial and recreational fisheries in the Chesapeake Bay (Jenkins and Burkhead 1994). Accustomed to foraging in the murky waters of rivers like the Mississippi and Ohio, blue catfish are now thriving in the Bay, which has been transformed into a turbid, nutrient-rich system by agricultural runoff and other anthropogenic disturbances (Boesch et al. 2001). Blue catfish began to dominate Virginia's tidal rivers 1990s, while native white catfish Ameiurus catus populations began to crash (Figure 1; Tukey and Fabrizio 2011). The objective of this study was to quantify diet overlap between these two species to determine if competition for food is driving these population declines. It appears that competition with non-native blue catfish have resulted in massive population declines for native white catfish.

Mentor(s): Dr. Donald Orth (Fish and Wildlife Conservation); Joey Schmidt (Fish and Wildlife Conservation).

RET: BIOMECHANICS FROM MOLECULAR TO ORGANISMAL SCALES

SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

This RET program involves in-service high school STEM teachers from the Appalachian region of southwestern Virginia and southern West Virginia, with an emphasis on serving underresourced schools and low income student populations. Each teacher is paired on a one-to-one basis with a biomechanics research laboratory, conducting research and developing new educational material over seven weeks in the summer. Teachers work alongside faculty and graduate students, developing new skills toward addressing specific biomechanics research questions using a hypothesis-driven approach. The partnership and interaction with the laboratory will continue throughout the following school year. Room, board, and stipend will be provided, with teachers housed on-site on the campus of Virginia Tech. During the summer research experience, teachers develop a novel standards-conforming educational module to bring back to their home school, enriching their curricular activities. Teachers will qualify for professional development points that can be used toward fulfilling the requirements for license renewal with the approval of their school systems.

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Mentor: Dr. Sunghwan Jung

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Carroll Co. High School
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Mentor: Dr. Justin Barone

Pamela A. Tegelman Malabad
Mentor: Dr. Jake Socha

MARK A. ENGLAND,
BIOLOGY

A Design for a Biometric Dynamic Sonar Head

The greater horseshoe bat (Rhinolophus ferrumequinum) has very poor vision and thus depends largely on sonar (echolocation) to build a sound picture of the environment. These bats emit ultrasonic pulses from the nostrils and the echo is received by the ears. From the information derived by the echo, the bat is able to interact with its environment by determining factors such as range, velocity, size, and location of objects. It is believed that the nature of the ultrasonic pulses can be altered by the noseleaf that surrounds the nostrils of the bat. The noseleaf covers a large portion of the face and is a highly evolved structure composed of tissue and cartilage. The noseleaf can be complex in shape with many ridges, furrows, and spikes that functions to shape and project the sound. It is believed that these movements are not a byproduct of physiological activities (such as breathing), but rather they are under active muscular control. Based on the geometry and acoustic functions of the ear and noseleaf components, a simplified ear and noseleaf were developed. Ultrasound pulses were generated from a piezo transducer and propagated through a cone waveguide to the two nostrils. The sound emissions can be modulated by the baffles surrounding the nostrils. Microphones were placed behind the two dynamic ears to capture the reflected sound. External DC motors were used to actuate the noseleaf and ear to mimic the real bat's movements of ultrasonic system. The purpose of this project is to improve upon the initial design and create a biomimetic echolocation system similar to those used by bats to explore their environment.

Mentor(s): Dr. Rolf Mueller (Mechanical Engineering)

ANGELA S. GOAD,
CHEMISTRY AND PHYSICS

Constructing a Dual-Pump Microfluidic System

Microfluidic devices are used to manipulate small amounts of fluids in various applications, including engineering and the biomedical fields. While these devices have shown great potential, since their inception in the 1980s there has not been the growth in commercial development and acceptance that was first predicted. One approach to closing this gap is for the research to be more cooperative and cross-discipline. The emerging field of biomimicry is science that seeks to solve human problems using the designs and strategies found in the natural world. One of these natural designs being investigated is the feeding system of the female mosquito. By combining the concepts of microfluidic devices and biomimicry, this study aimed to design, create, and test a mechanical system with the ultimate goal of mimicking the two pump feeding system found in the female mosquito. This system consists of two separate pumps working in line, a cibarial pump located at the proboscis, and a pharyngeal pump, located in the head. These pumps must work in tandem,without clogging, to allow the feeding process to be successful for the mosquito. Multiple materials and designs were explored as possible configurations of the two-pump mimicking system in order to determine the optimal combination. In the present study, the efficiency of the pump fluid transport and the efficacy of clearing blockage was investigated by varying the phase and amplitude of the pumps. Further application of the mechanical two pump system developed in this study could include a simple, portable pump for microfluidic devices.

Mentor(s): Dr. Sunghwan Jung (Biomedical and Engineering mechanics)

DAWN HAKKENBERG,
SCIENCE AND MATH

Does foot curvature assist the Indian skipper frog (Euphlcytis cyanophlyctis) in jumping on water?

Foot shape is important for understanding the physical mechanisms that allow animals such as the basilisk lizard or western grebe to run on water. Previous researchers have modeled the feet of these animals as simple disks and found an impact drag coefficient of 0.7 regardless of size or impact velocity [Glasheen and McMahan, 1996a]. This study builds on their work to determine whether the curvature of the foot at impact affects the Indian skipper frog's ability to 'skitter', or jump on water. This is done by measuring the force produced by five different models of the frog's foot during water impact at 1 – 3 m/s. Models were designed with curvature ranging from that of a flat disk to a hemisphere, while maintaining constant surface area (310 mm2, typical of a frog's foot). We hypothesize that at Reynolds numbers greater than 10^5, the drag coefficient increases with increasing curvature, so that with the constraint of constant surface area there is an intermediate curvature that maximizes drag force. In addition, this study examines the air cavities produced as the models descend into the water. Previous research on the basilisk lizard has demonstrated the importance of the lizard removing their foot for the next step when running on water before the air cavity seals [Glasheen and McMahan, 1996b]. Examining the time it takes for the air cavity to seal and the depth at which the cavity seals will give insight as to whether a foot's curvature could allow slower or faster steps.

Mentor(s): Dr. Jake Socha (Biomedical Engineering and Mechanics)

TIFFANY S. HUNTER,
BIOLOGY

Determination of key parameters of HFIRE for liver cancer treatment

Irreversible electroporation (IRE) is a non-thermal ablation technique that used to treat cancer lesions. The treatment is comprised of electrical pulses projected through electrodes to cause irreversible pore formation within the cancer cell membranes. The voltage causes irreversible changes to the membrane, which results in apoptosis or necrosis. The non-thermal nature shows great potential for tumor therapy because it does not affect the extracellular matrix and allows for treatment on tumors that were previously inoperable due to the location near other vital structures. IRE has been thoroughly studied and will be used as the control for this experiment. Current studies are being conducted to assess the feasibility of HFIRE, the next generation of high frequency IRE, which provides more predictable treatment options and does not require the use of a neuroblocker. The goal is to determine the proper voltage needed for each burst and the effects of varying the voltage, interpulse delay, and pulse number on the treatment of tumors. The success is reliant upon the ability to predict and interpret the electric field distribution and the effects the electric field has within different parameters. Collagen hydrogels, constructed from rat-tails, are used as 3D hydrogels for studying the effects of HFIRE on rat liver cells, H4IIE. 3D gels, in an in vitro environment, are capable of developing the phenotypes and reacting to stimuli as if in an in vivo environment and serve as an important pre-clinical model for studying HFIRE.

Mentor(s):Dr. Rafael Davalos (Biomedical Engineering); Matt DeWhitt

KIMBERLY KERN,
MATHEMATICS

Collagen Fiber Orientation and Straightness in the Uterosacral and Cardinal Ligaments of Swine

Pelvic organ prolapse is a pelvic floor disorder that affects millions of women, in which the pelvic organs fall out of place. The pelvic organs include the bladder, vagina, uterus, and rectum. These organs are supported by muscles and ligaments in the pelvic floor, two of which are the uterosacral (USL) and cardinal (CL) ligaments. The purpose of this study was to examine the orientation and straightness parameters of collagen fibers in the USL and CL of swine using scanning electron microscopy (SEM) images. ImageJ and NeuronJ software was used to analyze multiple properties of the collagen fibers. Results from this and previous studies in the mechanics of soft tissue lab indicate that the arrangement of collagen fiber bundles is in layers oriented mostly along the main in-vivo loading direction and were shown to be slightly wavy. The data from these images will aide in understanding the structure of the tissues. This will supplement ongoing research about the mechanical properties of the tissue. In the future, the study will lead to improved surgical techniques and mesh materials to treat pelvic organ prolapse.

Mentor(s): Dr. Jake Socha (Biomedical Engineering and Mechanics), Raffaella DeVita (Biomedical Engineering and Mechanics)

ALICIA L. LOWE,
BIOLOGY AND ECOLOGY

The effect of incubation temperature on Aix sponsa calling

Incubation of eggs is an important process in early avian development. Studies have shown that variation in incubation temperature of wood duck (Aix sponsa) eggs can have many impacts on the overall health of ducklings. In this study, we aimed to determine if incubation temperature affects development of behavior and physiology in wood ducks. Eggs were incubated at three different temperatures and duckling behavior was recorded in five different trials over 15 days post-hatch. One important behavior recorded in two trials was calling. Time spent calling (TSC) was recorded to determine if calling behavior is affected by incubation temperature, differs between trials, or changes throughout early development. Coupling behavioral measures with physiological responses will help us understand how non-genomic factors during early development, such as incubation temperature, may ultimately affect individual fitness in various environments. The findings may also be applied to conservation efforts, not only for wood ducks, but for similar avian species who are threatened by climate change and habitat loss.

Mentor(s): Dr. Bill Hopkins (Fish and Wildlife Conservation); Sydney Hope (Fish and Wildlife Conservation)

RACHELLE N ROSCO,
BIOLOGY AND STEM LAB MANAGER

Optimization of Bubbles as an Alternative Sanitation Method for Produce

U.S. consumers are increasingly made aware of outbreaks of food borne illnesses due to contaminated food by pathogenic bacteria such as E. coli. These outbreaks are known to occur in high risk foods such as chicken but increasingly, it is becoming a concern in other healthy staples such as fruits and vegetables. Effective methods used today to clean produce are to scrub using brushes or to rinse in water with toxic chemicals. While effective in removing contaminants, they have their limitations such as damaging the produce or posing health and environmental issues. This project addresses these limitations by studying and optimizing an alternative method for cleaning produce. We investigated the use of bubbles coupled with a minimal amount of chemicals with their ability to sanitize produce. We hypothesized that the transient and destructive motion of bubbles would be able to get into the crevices of soft sided fruits and vegetables without damaging their surface and minimizing the amount of chemicals needed. We tested this by creating a small portable sanitation device and then modeled the sanitation process using an artificial strawberry and Glo Germ as the surface contaminant. The color intensity of the light emitted by the Glo Germ was measured to indicate the amount of surface contaminants removed. If this preliminary experiment shows that bubbles are effective at removing this surface contaminant, this hypothesis will be further employed to design sanitization devices for agricultural produce.

Mentor(s): Dr. Sunghwan Jung (Biomedical Engineering and Mechanics)

CARA R. SPIVEY,
CHEMISTRY

Protein secondary structure varies based on location on albatross feather

Samples of albatross feathers, ranging from small (P1) to large (P10), were obtained from the Smithsonian Institute in Washington, DC. Protein structures within the feathers were analyzed using Fourier transform infrared spectroscopy (FTIR). FTIR is an ideal method for examining proteins because it is highly sensitive to chemical composition and protein secondary structure and does not destroy the feathers. Specific locations on the small, medium, or large feathers were analyzed in order to determine if protein secondary structure changed according to location on the fibers or calamus. It was found that on the same feather, β-sheet content in the feather keratin protein varied based on location on the feather.

Mentor(s): Dr. Justin Baron (Biological Systems Engineering)

PAMELA A. TEGELMAN MALABAD,

Morphology of the dorsal vessel in the darkling beetle Zophobas morio

The mechanics of the insect circulatory system, particularly in how it produces flows within the body, are not well understood. The dorsal vessel is the primary pumping organ, a small, simple tube that runs along the dorsal midline. This structure is composed posteriorly of a muscularized heart with valve-like openings, termed ostia, and anteriorly of a simple aorta that empties into the head. In this study, measurements of the dorsal vessel and other associated morphological features will be presented for the darkling beetle Zophobas morio. Using a dissecting microscope, quantitative and qualitative data of the dorsal vessel will be collected, including the number of heart chambers and the length of the heart and aorta regions. Scanning electron microscopy (SEM) will be used to identify smaller structures, such as the location and number of ostia found between heart chambers and diameter of the vessel. The morphological data from this study will be used to generate a 3-dimensional model of the dorsal vessel. This model will be used in future studies to simulate how hemolymph circulates within this beetle, a first step towards developing a full biomechanical model connecting the dorsal vessel, gut, and respiratory system to air and hemolymph movement in Zophobas morio.

Mentor(s): Dr. Jake Socha (Biomedical Engineering and Mechanics); Melissa Kenny (Biomedical Engineering and Mechanics)

SPACE@VT NSF REU

SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

The Center for Space Science and Engineering Research (Space@VT) resides in the Virginia Tech College of Engineering (CoE) with members from the Bradley Department of Electrical and Computer Engineering and the Aerospace and Ocean Engineering Department. Space@VT faculty lead research in both ground based, and satellite based measurements of the upper atmosphere and space weather phenomena, as well as theoretical and modeling research into space plasmas. The REU site exposes students to these various research programs and enables students to select a specific project for detailed focus. We provide undergraduate students an engaging high-quality learning experience over a period of 10 weeks. The program will elevates the students' exposure to space weather and plasma research, while preparing them for positions in academia, industry and government. We recruit talented, motivated and diverse students, and provide them education and orientation with a series of readings, seminars, laboratory work, community-based outreach, and social and professional development activities.

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PROGRAM COORDINATORS

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RAMY ARMANOUS
ENGINEERING SCIENCE AND MECHANICS

Determining launch dates and times for the sounding rocket mission to measure Nitric Oxide using stellar occultation

Nitric Oxide (NO) is a minor constituent in the thermosphere but it plays an important role in the chemistry and structure of the upper atmosphere. NO helps in maintaining the energy balance in the lower thermosphere by acting as a cooling agent. Its production and destruction depends on solar irradiance and energetic particle precipitation. Being a radical, NO can destroy ozone when transported to lower altitudes; therefore understanding the levels of NO in our atmosphere is essential. To improve our understanding of NO behavior created by energetic particle precipitation during the polar winter, a sounding rocket experiment is being launched from Poker Flat, Alaska in late January/early February. The objectives of this mission is to measure the levels of NO in the lower thermosphere created by energetic particle precipitation, and understand how much of it descends downwards to destroy ozone in the polar winter. The technique used to measure NO with the rocket is stellar occultation technique where a star is chosen for observation and measuring the brightness from the star provides a measure of NO. In this poster, we present the process of choosing a star for the mission (Algenib) and explain the reasons for selecting it for the mission. The process of selecting a star involves calculating the optimum angles, times and altitudes for observing the levels of NO. We also present the reasons for selecting an apogee of 275km and the process of selecting the launch date for the sounding rocket mission, which we predict to be January 21, 2016, around 4:40AM.

Mentor(s): Dr. Scott Bailey (Electrical and Computer Engineering)

IAN A BEAN
AEROSPACE ENGINEERING

Numerical Comparisons of FDTD-Type Algorithms

Three different forms of finite difference time domain (FDTD) algorithms used to solve electromagnetic field propagation are compared. These are FDTD, alternating direction implicit FDTD (ADI-FDTD) and a recently proposed Leapfrog ADI-FDTD. A team at Virginia Tech led by Dr. Bhuvana Srinivasan is currently using the Washington Approximate Riemann Problem (WarpX) algorithm to simulate detachment from magnetic nozzles. These simulations can be fairly computationally expensive especially when run for extended periods, therefore the goal of this study is to develop an algorithm for EM propagation to replace the explicit Euler solver currently being used in the WarpX algorithm in an effort to improve computational efficiency. Accuracy and efficiency of the new algorithms are compared using a simple 2D Sine source simulated in a vacuum with periodic boundary conditions. The explicit FDTD is found to be less computationally expensive but its maximum time step is constrained by the Courant-Friedrichs-Lewy (CFL) limit. The implicit versions are more expensive at the same time step but they remain stable for arbitrary increases in time step at the cost of accuracy with the Leapfrog version being the less expensive and less accurate of the two. Finally, future viability of the parallelization of each of these algorithms is also discussed.

Mentor(s): Dr. Bhuvana Srinivasan (Aerospace and Ocean Engineering)

DAVID KNAPICK,
PHYSICS & ASTRONOMY

Space Mission Analysis

The space race began on October 4th, 1957 with the launch of Sputnik I. Since then, space vehicles have become more sophisticated, as nations strive to dominate Earth's upper atmosphere. Placing vehicles into orbit can be a difficult task since it depends on specific launch parameters. Once in orbit, vehicles are subject to intense perturbations from drag, solar storms, and J2. Learning how these perturbations affect spacecraft's is important to prevent collisions, and premature reentry into Earth's atmosphere. This project focuses on understanding fundamental concepts of Astrodynamics. Particular topics include: shuttle inspection analysis, rocket launch window analysis, calculating a spacecraft's position, and velocity vectors from its classical orbital elements and vice versa. Given a set of position and velocity vectors, using Matlab, the second order, nonlinear, vector, differential equation of motion for a two-body system can be solved to compute additional position and velocity vectors over a specific duration. In the Systems Tool Kit Software (STK), these vectors can be uploaded to plot the trajectory and model complex simulations. These concepts are important in designing, and analyzing future space vehicles, and their orientation in space, as nations continue to place objects into orbit.

Mentor(s): Dr. Jonathan Black (Aerospace and Ocean Engineering) and Andrew Rogers, (Aerospace and Ocean Engineering)

PAYAM MEHRAEI,
ELECTRICAL ENGINEERING

Software-Defined Radio Receivers and GPS: A Qualitative Analysis of Relative Receiver Performance

Since the inception of Global Navigation Satellite System (GNSS) technology, conventional Global Positioning System (GPS) receivers have been implemented through dedicated hardware devoted solely to the advanced signal processing necessary. Recent innovations through software-defined radio (SDR) receivers hold promise in providing a cheaper alternative to costly GPS hardware. As implied by their classification, SDR receivers contrast traditional hardware receivers in that their function is entirely defined via software and implemented with integrated circuits. In order to gain a qualitative understanding of their potential, this paper examines the performance of a single SDR GPS receiver by using both hardware simulated and live L1 GPS signals. Initial results indicate a significant degree of accuracy when receiving live signals from antennas (both low and high power) within meters for the height accuracy, while simulated signals provide satisfactory accuracy results for both stationary and motion vehicles. The is discrepancy in positioning relative to the reference is due to parameters impacting the signal processing which are explored to optimize the receiver performance.. Based on the preliminary results of varying the signal processing, higher end SDR receivers, still significantly cheaper than conventional alternatives, allow high precision results that compare favorably with hardware implemented GPS receivers.

Mentor(s): Dr. Wayne Scales (Electrical and Computer Engineering)

MACK W OHNSTED,
PHYSICS

Statistical Analysis of GPS Scintillations in the Antarctic High Latitude Region 2014-2015

Ionospheric irregularities are structures in the ionospheric plasma density that can cause diffraction and scattering of trans-ionospheric radio signals, which can be measured as phase and amplitude scintillations. These scintillations can lead to power fading, phase cycle slips, receiver loss of lock and other effects, which can be detrimental to the quality of satellite navigation systems. There have been a fair amount of irregularity studies done in the low latitude (equatorial) regions; however, high latitude regions remain relatively unexplored mainly because of insufficient observations. Lack of infrastructure, dark and harsh winters, limited power supplies and limited memory space make it difficult to deploy instruments such as GPS stations. Autonomous Adaptive Low-Power Instrument Platform (AAL-PIP) deployed in Antarctica host dual frequency GPS scintillation monitors that can measure GPS scintillations in high latitude regions. I looked at three AAL-PIP stations along the 40° magnetic meridian in the eastern Antarctic plateau and one station at the geographic South Pole from January 2014 to June 2015. A statistical study was then performed to estimate seasonal and diurnal trends to help us better understand the behavior of ionospheric irregularities. From the analysis of the available data, we concluded that the phase scintillations occurred more than twice as often as the amplitude scintillations. On quiet days 85% of the scintillations occurred during January and February. Also, on quiet days 65% of the scintillations and on active days 40% of scintillations occurred during the midnight hours UT.

Mentor(s): Dr. Kshitija Deshpande (Electrical and Computer Engineering).

KARIELYS ORTIZ-ROSARIO,
COMPUTER ENGINEERING

Space Weather Measurements using Global Navigation Satellite Systems (GNSS)

Global Navigation Satellite Systems (GNSS) are now commonly used for geographic positioning, timing data, economic applications (such as international banking), space weather studies and atmospheric science analysis. GNSS currently consists of four constellations: the United States' Global Positioning System (GPS), the Russian Federation's Global Orbiting Navigation Satellite System (GLONASS), the European Union's Galileo, and China's BeiDou Navigation Satellite System (BDS). GNSS signaling can be adversely affected by the concentration of plasma (the collection of free moving electrons and ions) in the Earth's ionosphere. Therefore, the measurement of the Total Electron Content (TEC) in the ionosphere is particularly essential in order to reduce the data error and generate more accurate results. The objective of this project is to use pseudorange data, the measured distance between the GNSS satellites and their receiver, from all four GNSS constellations to study space weather and its impact on navigation systems using TEC calculations. Therefore, live data was collected from NovAtel, Ashtech, and ASTRA GNSS receivers, as well as the NASA Crustal Dynamic Data Information System (CDDIS) website. Subsequently, a MATLAB Script was generated to use rinex3 navigation and observation files to acquire pseudorange data and perform TEC calculations. This work presents the data analysis and shows that the TEC peaked at dusk and dawn. Statistics on the data analysis are used to explain the inaccuracy within the GNSS signaling due to the TEC concentration.

Mentor(s): Dr. Wayne Scales (Electrical and Computer Engineering).

ELEXA B PALACIO,
AEROSPACE ENGINEERING

Characterizing Plasma Flow From a Railgun

Plasma railguns have been built since the 1960's, however; their capabilities are still being developed and tested. The goal of our project is to build a small, efficient plasma railgun as a prototype for a propulsion system on smaller spacecraft than have ever been used before. CubeSats are an example of this class of satellites. Electrode erosion is still a problem with plasma railguns and we plan to further study and understand it. Electrode erosion occurs because of different mechanisms like impacts of charged particles and electrode heating. Our goal is to understand how to use thermal conductivity to reduce electrode wear and limit the number of impacts to electrodes. Previously, solid state switching has limited the ability to control thrust on plasma propulsion devices. We plan to use pulse forming networks for quick control of thrust. In order to understand thrust control on this device we must be able to view and study the plasma flow inside a vacuum. A spectrometer will be used to determine the species inside the plasma flow, and estimate the plasma temperature and speed. I designed and built a telescope to gather light from the plasma flow at a certain distance inside the vacuum chamber. The telescope couples light into the spectrometer which allows us to characterize the flow. Other diagnostic tests will be developed to further examine the railgun as the project progresses.

Mentor(s): Dr. Collin Adams (Aerospace and Ocean Engineering)

PRIYA PATEL,
PHYSICS

Hall Thrusters

Hall thrusters are a form of ion thrusters; an ion thruster is used for spacecraft propulsion that creates thrust by accelerating ions. They are simple devices entailing of a cylindrical channel with an interior anode, a magnetic circuit that generates a primarily radial magnetic field across the channel, and a cathode external to the cylindrical channel. Hall thrusters mainly rely on an axial electric field generated by a potential drop across the channel to accelerate the ions and produce thrust. They wrap electrons azimuthally around the chamber via an ExB force (E being the electric field and B the magnetic field) to ionize the incoming propellant. The details of the channel structure and magnetic field shape determine the performance, efficiency, and life. In this project, the following is examined; the necessity of a radial electric field to provide a centripetal force in order to insure that the electrons move circularly in the chamber and the definition of a spatially defined magnetic field. This will be done by simulating the set up in cylindrical coordinates using Matlab. An examination of a spatially defined magnetic field and the impact of a radial electric field are conducted with a combination of a parametric model and a Boris particle mover. After application of the magnetic field, simple test examples are run with varying initial conditions to gain insight into the operating conditions of a Hall thruster.

Mentor(s): Dr. Bhuvana Srinivasan (Aerospace and Ocean Engineering)

UPAL S. PATEL,
ELECTRICAL ENGINEERING

Analysis of GPS Scintillations with Multi Frequency GNSS Receivers

Ionospheric scintillations are primary cause of the signal fades in a GPS receiver. These may cause loss of lock and degrade positioning accuracy or even the ability to navigate. The scintillations are mainly due to irregularities in the Earth's ionosphere especially the region near 300 kms above the earth's region. This region is called the F-region. The main cause is highly dense plasma. Plasma contains electrons and ions; the area with maximum dense plasma causes the scintillations in GPS signal, when the GPS radio frequency signal passes through it. Scintillations can cause loss of tracking in airplanes, which can be very dangerous. Geomagnetic storm also causes scintillations in GPS. Geomagnetic storms occur when the solar winds interacts with the magnetic field of earth, and causes perturbations in plasma density. Hence, GPS signals being electromagnetic waves which depend on electron density are disturbed during a geomagnetic storm. In this report we will study the GPS scintillations on three different frequencies L1, L2, and L5 for GPS, and on 3 different constellations GPS (the American system), GLONASS (the Russian system), and GALILEO (the European system). The scintillation data was collected using the Novatel GPStation-6 receiver. The main parameters while taking the data considered were the carrier to noise ratio, and S4, which is the amplitude scintillation. The variation of scintillation with frequency is a new avenue of investigation and the current study will provide contributions to further knowledge on scintillation behavior on the various constellations.

Mentor(s): Dr. Wayne Scales (Electrcial and Computer Engineering)

RAINE H. SAGRAMSINGH,
MECHANICAL ENGINEERING

Multi-Constellation Global Navigation Satellite System Positioning

Recent development of the four major Global Navigation Satellite System (GNSS) constellations provides an increased opportunity to utilize multi-frequency and multi-constellation receivers to calculate position. With over 50 operational U.S. and Russian GNSS satellites, multi-constellation GPS/GLONASS receivers are offered. By 2020, the European Union plans to have 30 satellites and the Chinese 35, allowing access to more than double the number of GNSS satellites currently available. Variation in satellite orbit leads to increased probability of overhead lock with at least four satellites and offers the capability to calculate position more accurately in even the lowest coverage areas. The acquisition of Galileo and GPS SPIRENT RF Hardware Simulators by the Virginia Tech GPS lab offered a chance to work with Galileo navigation and observation data from satellites not yet launched. This study developed a Systems Tool Kit (STK) model that allows for accurate satellite coverage prediction of a specified point at any time. Additionally, preexisting Matlab scripts, which calculated position using GPS L1 and L2 frequencies, were modified to find position using data from each of the constellations and frequencies. Live data and simulated data were used to test and modify the navigation solution script in order to evaluate the precision of the calculations. Currently, Galileo only has three fully-operational satellites available, creating a greater need to study the accuracy of the Galileo system using multi-constellation navigation.

Mentor(s): Dr. Wayne Scales (Electrical and Computer Engineering)

CARSON O SQUIBB,
AEROSPACE ENGINEERING

Dayside Ionospheric Response to X-Class Solar Flare Events Observed with Reverse Beacon Network High Frequency

Solar flares represent a severe hazard to dayside high frequency (HF) radio communications. During a shortwave fade-out (SWF) event, high levels of X-ray flux associated with a flare results in increased D-layer ionization, which can cause the absorption of radio waves typically refracted back to Earth and radio blackout. SWF is one of the first adverse impacts of space weather, typically following the occurrence of an earthward-directed solar flare by only 8 minutes. In this study, we compare X-class solar flare events identified in GOES 15 satellite data with HF amateur radio communication links observed by the Reverse Beacon Network (RBN) and Canadian riometer absorption data. It was expected that that HF communications would degrade and absorption would increase monotonically as a function of frequency with the onset of the flare. Several flares from 2013 to the present were analyzed, and data from quiet time solar activity was also studied to understand the diurnal patterns in amateur radio. Five frequency bands ranging from 3.5 MHz to 28 MHz were chosen from the amateur radio spectrum to see the effect of communication loss. The results showed strong correlation in higher frequencies with significant drops in RBN links, whereas lower frequencies displayed muted effects. This HF communication loss was observed as X-ray irradiance rose above 10-5 W*m-2, before the flare peak. Maximum loss was seen at or soon after the flare peak, with communication recovery beginning afterwards. Further research should focus on unknown biases, such as varying number of radio operators and the seasonal effects of flare intensity on Earth.

Mentor(s): Dr. Joseph Baker (Electrical and Computer Engineering) and Dr. J. Michael Ruohoniemi (Electrical and Computer Engineering)

KEITH A. TIEMANN,
ELECTRICAL ENGINEERING

Programming and Calibration of a Helmholtz Cage

With the rise in popularity of miniature satellites such as CubeSats, many universities are in the process of developing the technology needed for their effective use in space. A key component is the attitude determination and control system (ADCS), used to keep the CubeSat in a proper orientation throughout an experiment. Using a Helmholtz Cage, a 3-axis uniform magnetic field can be produced to mimic the geomagnetic field in space. This allows for extensive testing of the ADCS in a safe and controlled environment. With Virginia Tech's own CubeSat research underway, a Helmholtz Cage was constructed with the goal of creating a uniform magnetic field of at least 2 gauss to test a CubeSat of at least 3 liters in volume. The cage is connected to three power supplies as well as an Arduino to produce the magnetic field needed. A GUI was created via MATLAB to handle the power supplies and the Arduino as the simulations ran while also allowing magnetic field data to be transferred from a pre-made report file or directly from STK itself. Once completed, calibration of the cage allows for it's immediate use in testing CubeSats. Inadequate results are resolved by re-aligning the cage's individual coils or by removing ferromagnetic material near it.

Mentor(s): Dr. Johnathan Black (Aerospace and Ocean Engineering).

EMMANUEL M. TORRES,
MECHANICAL ENGINEERING

Magnetic Nozzle Modeling and Plasma Detachment

The concept of the magnetic nozzle is a vital piece of science and engineering due to its incorporation in advanced propulsion systems such as magnetoplasmadynamic thrusters (MPD's), helicon and radio frequency thrusters, and the Variable Specific Impulse Magnetoplasma Rocket (VASIMR). In these devices, magnetic nozzles are used to expand and direct plasma propellant thereby generating thrust. In order to obtain a specific thrust needed for a mission, the output on a magnetic nozzle needs to be changed. Some of the ways to change the output on a magnetic nozzle include varying its size, the number of turns in a coil, and the current flow. This requires computational modeling for various designs under different conditions. These models will then be investigated before manufacturing and experimentation. Accelerating an ionized gas (plasma) while following magnetic field lines is the concept used for magnetic nozzles but in order to generate thrust, the plasma also needs to detach from the magnetic field generated by the magnetic nozzle with minimal plume divergence. This duality of requiring confinement and separation presents the primary challenge in the design/performance of the magnetic nozzle. The transition from plasma containment to detachment must be understood to optimize the performance/behavior of magnetic nozzles. In this poster we present various maps of the electromagnetic fields generated by various solenoids and coils and discuss its performance/behavior. We will also discuss the predictions of the strong guiding magnetic lines of the magnetic nozzle.

Mentor(s): Dr. Colin Adams (Aerospace and Ocean Engineering)

MICHAEL A VANDER MEIDEN,
MECHANICAL ENGINEERING

Quadrotor Control and System Identification Development Using BeagleBone and Python for Satellite Simulations

The purpose of this project is to develop a robust control and system identification software for quadrotor aerial vehicles. Currently, the most common quadrotor control system utilizes a Pixhawk flight computer with Mission Planner software. With this system we succeeded in flying both with a controller and autonomously using the Mission Planner software. However, developing our own customizable software would be more beneficial for satellite simulations. Originally Matlab's system identification toolbox was going to be used with data from the Pixhawk for the system identification. However, because of different data collection rates and other problems, mapping into Matlab proved difficult. To overcome this problem and make the system more specific to satellite applications, the Pixhawk and Mission Planner software were replaced with the BeagleBone microcomputer and python code. Ultimately, this system will be used to perform a variety of quadrotor-based satellite control algorithm simulations where quadrotors will be used in lieu of satellites to test autonomous mapping and docking maneuvers. In addition, this quadrotor system identification software could eventually be expanded to become an adaptive system identification that will be able to identify many types of control system hardware including satellites and other micro aerial vehicles.

Mentor(s): Dr. Johnathan Black (Aerospace and Ocean Engineering)

SUMMER VETERINARY STUDENT RESEARCH PROGRAM

SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

The objective of the SVSRP is to expose veterinary students to research and oppurtunities for a biomedical research career. Veterinarians with a biomedical research background are in demand and this career provides many oppurtunities in universities, federal, biotech, and pharmaceutical institutions.

Corren Freeman
Tuskegee University
Biology
Mentor: Dr. Irving C. Allen

Caroline S. Moon
VA-MD Regional College of Veterinary Medicine
Biological Sciences
Mentors: Dr. Ansar Ahmed; Dr. Mike Edwards

CORREN FREEMAN,
BIOLOGY

Interleukin-1β Inhibition Attenuates Colitis in Nlrp3-/- mice

Inflammatory bowel disease (IBD) is a condition characterized by excessive gastrointestinal inflammation. IBD is comprised of two distinct diseases, Crohn's disease and ulcerative colitis. Together, these diseases are a significant global healthcare and economic burden. Nlrp3-/- mice demonstrate significantly increased disease pathogenesis in models of experimental colitis (EC), suggesting that the NLRP3 inflammasome protects the host from IBD. The NLRP3 inflammasome is responsible for the production of IL-1β and IL-18. The goal of this study was to test the hypothesis that the increased inflammation observed in Nlrp3-/- mice during colitis is associated with an increase in IL-1β and/or IL-18, rather than decreased levels of these cytokines. To evaluate this hypothesis, we administered antibodies toward IL-1β (anti-IL-1β) and IL-18 (anti-IL-18) to both wild-type (WT) and Nlrp3-/- mice in a model of EC. Our data demonstrates a significant improvement in animals treated with anti-IL-1β, rather than IL-18. Furthermore, we also observed a significant increase in NF-κB signaling in the Nlrp3-/- mice. NF-κB is a master regulator of gene transcription and is associated with IL-1β production. Thus, the increase in disease pathogenesis in the Nlrp3-/- mice appears to be associated with increased inflammatory gene transcription and IL-1β production.

Mentor(s): Dr. Irving C. Allen (Biomedical Sciences and Pathobiology) and Dylan McDaniel (Biomedical Sciences and Pathobiology)

CAROLINE S. MOON,
BIOLOGICAL SCIENCES

Effects of Common Rodent Diets on Glomerulonephritis and Methylation in Lupus Model MRL/lpr Mice

The study conducted aimed to better understand the role that diet plays in the autoimmune disease systemic lupus erythematosus (SLE), by focusing on the effects that varying levels of phytoestrogens, vitamins, and inulin (plant fiber) in standard commercial rodent diets have on DNA methylation, glomerular C3 and IgG deposition, as well as the concentration of cytokines in serum and tissue supernatants of MRL/lpr mice. SLE is a multi-systemic autoimmune disease that affects both humans and animals with no known cure. The leading causes of mortality in patients diagnosed with SLE are renal failure, secondary to inflammation in the kidneys, and heart disease. Patients are currently being treated with anti-inflammatories and corticosteroids to control symptoms, and research that could provide information on the beneficial effects of diet and nutrition could be vital information for patients diagnosed with SLE. In this study, three different diets were given to groups of mice. After disease onset, the degree of kidney inflammation of the mice was measured by histopathology and examining the concentration of C3 and IgG antibodies present in the glomeruli of the kidneys using a florescent microscope. Cytokine concentrations present in the serum and various tissues, along with splenic cells DNA methylation quantification were analyzed by ELISA tests. The conclusion of this study is that diet does indeed play an important role in SLE disease parameters.

Mentor(s): Dr. Ansar Ahmed (Biomedical Sciences & Pathobiology) and Dr. Mike Edwards (Biomedical Sciences & Pathobiology)

TIRE AND AUTOMOTIVE ENGINEERING (CenTire) NSF REU

SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

Virginia Tech's Center for Tire Research offers summer undergraduate researchers the opportunity to participate in a broad range of research topics including: Design and Fabrication of a Bevameter, Design and Fabrication of a Shear Box, Portable Road Profiling System, ABS Validation, Tire Testing Trailer, Quarter-Car Suspension Test Rig, Piezoelectric Based Energy Harvesting towards a Smart Tire, BASE Suspension Testing, and Real Time Robotic Driver System.

PROGRAM DIRECTORS

Dr. Saied Taheri, Mechanical Engineering and Dr. Ronald Kennedy Mechanical Engineering

PROGRAM COORDINATOR

Kristine Adriano,
Virginia Tech,
Mechanical Engineering
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Andrew Read,
James Madison University,
Mechanical Engineering
Mentor: Dr. Mehdi Ahmadian

Yuhao Zhao,
Virginia Tech,
Mechanical Engineering
Mentor: Dr. Saied Taheri

KRISTINE ADRIANO AND MICHAEL NG,
MECHANICAL ENGINEERING

Semi-Active Damper Design for Automotive Applications

The Center for Tire Research is designing a semi-active damper assembly that can be used in an automobile suspension. This damper uses a Hydraforce, computer controlled proportional valve to adjust the fluid flow through an existing Fox Racing shock. In practice the vehicle's on-board computer will control the damping coefficient of the shock according to road conditions, ensuring vehicle safety and comfort in all scenarios. A 3-D model of the strut assembly, containing the coil spring, sensor mounts, and shock that fits into an existing lower A-arm and quarter car testing rig was created in SolidWorks. Using test parameters based on a three quarter ton commercial truck undergoing a maximum, uni-axial force of 4Gs, stress and deformation tests of this model were performed to ensure design strength and stability under testing conditions. Once created, this semi-active damper assembly will be mounted on to CenTiRe's quarter car rig for testing. The strut assembly will be stimulated with a shaker using various input forces to simulate varying road conditions, and a computer will adjust the damping coefficient of the shock accordingly. Acceleration and displacement data will be recorded with a National Instruments DAQ, allowing experimenters to ensure that the semi-active damper is minimizing strut oscillations and maintaining equilibrium. If the experimental data validates the effectiveness of the semi-active damper, companies can use this technology to maintain the optimal level of comfort and control in their vehicles regardless of road surface.

Mentor(s): Dr. Saied Taheri (Mechanical Engineering).

CASEY JAMES BATE,
MECHANICAL ENGINEERING

MFC Energy Harvesting Towards a SMART Tire System

Tire energy harvesting systems have the potential to power small sensory equipment inside an operational tire. A new approach for tire energy harvesting is studied by using a Macro Fiber Composite (MFC) material that targets vibrational energy in the tire sidewall due to contact patch deformation. This deformation is caused from the load exerted by the car on the tire at the bottom of the rotation cycle. A couture gauge was used to retrieve the curvatures of the top (unloaded) and bottom (loaded) sections of a tire while the tire was attached to a car. The height of these curves was measured to attain the amplitude of deformation. A testing rig utilizing an APS 113 shaker and a tire sample cut from a tire, of identical size to the one measured, was then constructed to mimic this deformation at various driving speeds. Testing results produced an AC Voltage generation ranging from 22 volts peak to peak at 2.33Hz to 50 volts peak to peak at 15.17Hz. Generated DC voltages ranged from 5.6 volts at 2.33Hz to 17.7 volts at 15.17Hz after a smoothing capacitor. Additionally, AC power outputs were measured across 100, 1K, 10K resistors producing a max power output of 30.42μW. Finally, various frequencies were tested independently of shaker amplitude indicating a tire resonance frequency around 9.34 Hz. These results can be used to design rechargeable battery circuits capable of being integrated with various tire sensory equipment.

Mentor(s): Dr. Pablo Tarazaga (Mechanical Engineering).

NEEL B. BHATIA,
MECHANICAL ENGINEERING

Battery Powered Electric Bicycle

A design project was undertook to design and build a functioning, battery powered electric bicycle. The purpose of this project was to serve as an example of alternative transportation and as a prototype for future projects to be conducted in the lab. Based on the budget set for this project of $1000 - $1500, and previous designs of electric bikes, performance goals were set to have a bike that can reach max speed under its own power in less than 10 seconds, travel about 20 miles, and achieve 15-20 mph. In order to accomplish these goals, the components had to achieve a maximum ratio of power to weight. A 24 V electric motor was selected and powered by an extremely light 24 V LiFePO4 battery mounted above the rear tire. The motor was mounted and set up with a chain to be able to spin the front sprockets, where a freewheel was installed to allow the sprockets to spin independently of the pedals. A second freewheel was installed on the motor, so that even if the front sprockets were spun by the pedals, the motor would not spin. Once the motor, battery, and chains were installed, the bike was completed by wiring a throttle, controller, brake lever and key switch to the bike. Once completed, the bike will be tested to assess the established performance goals.

Mentor(s): Dr. Saied Taheri (Mechanical Engineering).

MATTHEW D. BOULDIN AND ANDREW READ, MECHANICAL ENGINEERING

Instrumentation of a Heavy Truck to Evaluate Performance of BASE Air-Suspension System

Tractor-trailer trucks are some of the least dynamically stable vehicles on the road, subject to uneven lateral load transfer across the air springs creating unsafe roll conditions. The focus of this research was to evaluate the performance of the BASE suspension system compared to the stock suspension based on the parameters of suspension displacement, tire deflection, and ride comfort. The BASE system is a patented rerouting of the truck's pneumatic suspension, consisting of equal length hoses to both sides of the truck which pass through ride height control valves and then split into equal length hoses that deliver pressurized air to the individual air springs. The BASE suspension has the advantage of having two ride height control valves, one for each side, instead of the one valve present in the common OE system. To acquire data, a Volvo 6x4 tractor with the capability of switching between its stock suspension and the BASE system was instrumented with accelerometers, string potentiometers, pressure sensors, and laser distance sensors to accurately measure the differences in ride characteristics between the two systems. A professional driver took the tractor across a stretch of typical highway from Blacksburg to Wytheville to collect sensor data which was compiled using a National Instruments CompactRIO device. The expected result of this testing is to see reasonable reductions in the roll characteristics of the tractor when performing lane change maneuvers. Reducing the body roll of the truck decreases the possibility of rollover, provides better ride comfort, and can reduce tire wear.

Mentor(s): Dr. Mehdi Ahmadian (Mechanical Engineering).

JEFFREY HUMPTON,
MECHANICAL ENGINEERING

Tannewitz Tire Cutter Improvements

The goal of the project is to improve the performance of the Tannewitz diamond-studded band saw. The band saw will cut tires with the implementation of a support fixture to keep the tire secure, and a lubricant sprayer to decrease friction between the blade and the tire.The tire's cross sections will be studied for educational purposes. Understanding the position and function of the components in a tire will help in understanding the function and physics of a tire as a whole. To carry out the project, a spread of tire sizes that can be encountered in the CenTiRe lab was formulated, and the minimum and maximum dimensions for the support fixture was determined. 3D modeling software was used to develop potential designs, and a prototype support fixture was created and tested to gather data on how to improve the design. Different lubrication systems were researched and compared, and a cold air gun was ultimately decided upon because it would effectively reduce the heat of friction between the band saw blade and the tire as well as minimize the mess a liquid coolant sprayer would create. Tire cross sections can now be cut more smoothly and with less user hassle.

Mentor(s): Dr. Ron Kennedy (Mechanical Engineering).

SENA HUNDE AND YUHAO ZHAO,
MECHANICAL ENGINEERING

Developing an Intelligent, Controllable Unmanned Ground Vehicle for Testing Tire-Based Control Algorithms for

In order to develop an intelligent unmanned ground vehicle (UGV), it is necessary to detect and analyze terrain characteristics while autonomously adjusting wheel speeds. To study and develop the system, an advanced six-wheel robot was designed and built at the Center for Tire Research (CenTire). The robot designed and built in this process is similar to the original prototype; however, this new robot is equipped with additional sensors and controls which capture more in-depth data. Some important features that the UGV is equipped with include: a set of free rotating wheels equipped with an encoder, more powerful motors, separate motor drivers for each of the driven wheels, accelerometers, external encoders for the driven as well as free rotating wheels, and a master switch for ease of use. Terrain analysis is performed by analyzing the vibrations in the tire and the friction potential of the surface and the tire's contact patch. Upon completion, the new vehicle will be used to test algorithms which automatically adjust motor speeds on different terrain, thus improving mobility. Furthermore, having a model for an intelligent tire system on a UGV can pave the way for the application of such technology in our daily vehicles which will increase mobility, comfort and efficiency.

Mentor(s): Dr. Saied Taheri (Mechanical Engineering), Sayedmeysam Khaleghian (Mechanical Engineering).

JAMES MARTIN,
MECHANICAL ENGINEERING

Road Surface Modeling to Detect Pavement Defects

Current pavement surface measurement techniques lack the precision required to detect individual flaws in a road surface or to produce results that are traceable and repeatable. The goal of this research is to develop methods of data processing and build a pavement surface measurement system (PSMS) capable of collecting data accurate enough to ultimately produce a full profile of the road surface. The system uses an array of lasers to take a full transverse profile of the road, and a GPS / Inertial Navigation System to record the movement of the trailer which contains the PSMS. The current focus is to optimize the PSMS as well as to refine the calibration and testing methods enough to develop a standardized method for this type of testing. Progress has been made with assembly and testing of the PSMS, building calibration equipment, and writing operating procedures for use of the system.

Mentor(s): Dr. John Ferris (Mechanical Engineering).

EMILY E. PIRKL,
MECHANICAL ENGINEERING

Terrain Edge Characterization for Path Alignment

Event detection allows analysis of terrain surfaces and identifies the significant changes such as cracks and potholes. Current techniques compare points to each other and develop gradients based on changes between the points. Finding these events is important for making road repairs and adjusting equipment. Potentially, these results can be used in path alignment of road data as well, since the events are unique markers along terrain that should be identifiable in data clouds. Path alignment is also important in terrain surface alignment because it entails comparing and adjusting multiple data runs of a path. The path could be aligned by using the events as points for adjustment, but currently there is no clear definition of using the gradient results from event detection code in path alignment code. This definition is developed using MATLAB 2015a, specifically using Image Processing tools, polar plotting, and distance weighting. The result is that a gradient image of events can be transformed into points defined by a radius and with evenly spaced angular distance around a central point. Further, using interactive point selection and linear transformations, plots of terrains can be adjusted by events or other path markers. These tools can make events easier to describe and more significant and useful in path alignment, which could be a huge step for terrain analysis.

Mentor(s): Dr. John Ferris (Mechanical Engineering).

TRANSLATIONAL OBESITY UNDERGRADUATE RESEARCH

SUMMER RESEARCH SYMPOSIUM AT VIRGINIA TECH

PROGRAM DESCRIPTION

The Translational Obesity Undergraduate Research Scholars (TOUR-Scholars), under the umbrella of the Fralin Translational Obesity Center (Fralin-TORC) and its Interdisciplinary Graduate Education Program (IGEP), is a research-intensive summer experience, which prepares students for graduate and medical education in translation obesity research. Five undergraduate students from departments across Virginia Tech, along with one student from the State University of New York, College at Fredonia, were chosen to participate in the 2014 summer program.

TOUR-Scholars were matched in a translational project with two faculty mentors, working across disciplines. Funding was obtained through faculty-mentor matching of funds, the Department of Human Nutrition, Foods, and Exercise, the College of Agriculture as well as contributions from the Fralin Translational Obesity Research Center, to provide a research stipend for each of the students, and some discretionary funds.

PROGRAM DIRECTOR

Dr. Deborah Good (Department of Human Nutrition, Foods, and Exercise)

Robert L. Fuchs
Virginia Tech
Biochemistry
Mentor: Dr. Samantha Harden

Jaeo Han
Virginia Tech
Statistics
Mentor: Dr. Paul Estabrooks

Peter Heise
Virginia Tech
Human, Nutrition, Foods and Exercise
Mentor: Dr. Robert Grange

Christine Koehmstedt,
George Mason University
Bachelor's of Individualized Studies
Mentor: Dr. Vivica Kraak

Dimple Mozhi
Virginia Tech
Human, Nutrition, Foods and Exercise
Mentor: Dr. Jamie Zoellner

Taylor N. Vashro
Virginia Tech
Human, Nutrition, Foods and Exercise
Mentor: Dr. Matt Hulver

Kathryn M Wingfield
Virginia Tech
Human, Nutrition, Foods and Exercise
Mentor: Dr. Jay Williams

ROBERT L. FUCHS,
BIOCHEMISTRY

Systemic Evaluation of Physical Activity Level of Youth at Northern Virginia 4H Camp

Health professionals recommend that youth engage in at least 60 minutes of moderate-to-vigorous physical activity each day. A 4-H camp can provide the opportunity for behavior change modification in that camp fosters a supportive environment (led by teen/adult volunteers) to engage in physically-driven games and activities. The purpose of this study was to determine the degree to which youth were meeting these physical activity recommendations while attending camp at Northern Virginia 4H Educational Center (i.e., 4 days for one week of camp). Children were observed using the validated System for Observation of Physical and Leisure Activity in Youth (SOPLAY) protocol. Scans will be conducted during 3 class activities, various walking paths as well as pool and recreation time each day for a total of 12 days. The study is currently in the data collection stage, and data from weeks 1 and 2 have been collected. After collection and analysis of the data, we hope to gain a better understanding of the level of physical activity of the youth/campers/participants as to address any areas of the camp that are in need of modification to better meet the national recommendations for physical activity. An exploratory aim of the study is to provide scientific and anecdotal feedback on the SOPLAY protocol to determine its applicability at camp. Results of this investigation may lead to protocol amendments in order to more robustly measure physical activity of youth attending 4H camp.

Mentor(s): Dr. Samantha Harden (Human, Nutrition, Foods, and Excercise)

JAEO HAN,
STATISTICS

Validation of exercise intensity of a publicly available fitness application

Fitnet is a personalized mobile fitness application that allows users to perform 5-minute workouts of varying levels (e.g., beginner, intermediate, and advanced) targeted at cardiovascular fitness, strength, and flexibility with certified trainers regardless of time and place. Fitnet also uses the camera imbedded in a tablet or smartphone device to provide feedback to participants by counting movements with biometric tracking. This research will compare the intended activity intensity and type promoted by Fitnet to actual activity intensity as measured by heart rate monitors, participant ratings of intensity, and accelerometers (a small device worn on the hip that documents exercise). Twenty healthy adults between the ages of 18 and 55 participated in a 3-day validation study to determine how well an in-app physical activity monitoring tool accurately captured moderate and vigorous physical activity within the publicly available fitness app. Each day consists of a 5-minute warm-up and 12, 5-minute segments of cardiovascular and/or strength exercises targeting different levels of intensity. Correlation analyses and multiple regressions were used to determine the relationship between the average exercise intensity measured by the Fitnet camera counts, accelerometer counts, heart rate, rating of perceived exertion over each 5-minute segment of exercise. Results of the study showed that beginner, intermediate, and advanced levels are associated with increasing exercise intensity and that the camera count data can be used to track physical activity of different levels accurately.

Mentor(s): Dr. Paul Estabrooks (Human Nutrition, Foods, and Excercise)

PETER HEISE,
HUMA,N NUTRITION, FOODS, AND EXERCISE

Investigating endurance training adaptations in resistance wheel run mice.

Few studies have investigated the effects resistance wheel running (RWR) on skeletal muscle exercise adaptation in rodents, but results thus far suggest that RWR may promote skeletal muscle adaptations similar to both endurance and resistance training (e.g., increased oxidative capacity and strength, respectively). Previous studies have indicated that endurance training in rodents induces large increases in total Cytochrome C content in skeletal muscle. Because Cytochrome C is a mitochondrial protein, it is used as an accurate indicator of mitochondrial content in skeletal muscle. The purpose of this study was to investigate endurance training adaptations in RWR mice by assessing total Cytochrome C content in skeletal muscle and to test the hypothesis that resistance wheel running increases mitochondrial content in skeletal muscle. This was achieved by performing Western blots to determine Cytochrome C content in 2 muscles: tricep and gastrocnemius.

Mentor(s): Dr. Robert Grange (Human, Nutrition, Foods and Exercise), Adele Addington (Department of Human, Nutrition, Foods and Exercise)

CHRISTINE KOEHMSTEDT,
BACHELOR'S OF INDIVIDUALIZED STUDIES

A Systematic Evidence Review to Inform an Evaluation of the FNV Campaign to Increase Fruit and Vegetable Sales and Intake Among Teens and Millennial Moms in Two U.S. Cities

The U.S. government recommends that Americans consume 5-9 servings of fruit and vegetable (F&V)/day to prevent chronic diseases. F&V intake is inadequate among children and teens. In 2015, the Partnership for a Healthier America launched the FNV Campaign to increase F&V sales and intake among Gen Z teens (14-19 years) and Millennials (ages 20-35) in Norfolk, VA and Fresno, CA. The FNV Campaign uses integrated marketing communications to increase F&V sales and intakes among these target groups. Two research objectives were identified to inform the FNV Campaign design, impact, expansion and sustainability. We conducted a systematic evidence review of food-related advertising and health campaigns (RO1) and celebrity endorsement (RO5). Eight electronic databases and Internet sources were reviewed (1990-2015) to select evidence to synthesize insights from campaign evaluations and celebrity endorsement. For RO1, we identified n=2329 resources reduced to n=1916 after removing duplicates, imported these into an Endnote database, and we will review and synthesize resources into a publication. For RO2, Internet searches were organized into an Excel database for 165 unique entertainment and athletic celebrities involved in branded food, beverage and restaurant product endorsement. We will use the database to design a mixed-methods study exploring the target populations' views about diet-related celebrity endorsement.

Mentor(s): Dr. Vivica Kraak (Human, Nutrition, Foods and Exercise)

DIMPLE MOZHI,
HUMAN, NUTRITION, FOODS, AND EXERCISE

Exploring relationships between subjective and objective health literacy measures and changes over time: outcomes from the Talking Health study.

The objective of this study is to describe relationships between subjective and objective health literacy (HL) measures and to assess changes in measures over time. Talking Health was a 6-month HL intervention of two treatment conditions: SIPsmartER and MoveMore. HL was assessed using: 3-item screening (subjective), New Vital Sign (NVS, objective), Rapid Estimate Adult Literacy in Medicine (REALM, objective), and Subjective Numeracy (SN, subjective). Correlations assessed relationships among baseline HL measures. Multilevel mixed-effects linear regression models, controlling for baseline characteristics, determined changes over time. Participants (n=301) were from Southwest Virginia: 93% Caucasian, 81% female, 33% low HL, 32% ≤high school education, and 55% annual income <$20,000. At baseline, scores for each measure were screening 13.45/15; NVS 3.97/6; REALM 61.45/66, and subjective numeracy 4.19/7. Measures were significantly correlated ($p<0.001$): NVS/REALM r=~0.48, Screening/SN r=~0.32, Screening/REALM r=~0.53, Screening/NVS r=~0.39. NVS scores significantly improved for both SIPsmartER [0.32, (CI: 0.17, 0.47)] and MoveMore [0.27 (CI: 0.11, 0.43)] participants, REALM scores significantly improved for only MoveMore participants [0.21 (CI: 0.01, 0.41], while no changes were observed for subjective measures. The objective HL measures are among the mostly highly correlated and most likely to show improvements over time.

Mentor(s): Dr. Jamie Zoellner (Human, Nutrition, Foods and Exercise) and Kathleen Porter (Human, Nutrition, Foods and Exercise)

TAYLOR N. VASHRO,
HUMAN, NUTRITION, FOODS, AND EXERCISE

The effects of high fat feeding on metabolic flexibility and pro-inflammatory stress kinases in skeletal muscle.

Chronic activation of pro-inflammatory signaling pathways is associated with metabolic disorders such as obesity, diabetes, and metabolic syndrome. The purpose of this study was to determine effects of an acute, 5-day, isocaloric high fat diet (HFD) on pro-inflammatory stress kinases in healthy, non-obese, male humans. Thirteen subjects (age 22.09 ± 1.7 years, BMI 22.3 ± 2.76) were fed an isocaloric control diet for 2 weeks followed by 5 days of an isocaloric HFD (30% CHO, 15% protein, 55% fat [25%saturated fat (SF)]). Before and after the HFD, the subjects underwent a high-fat meal challenge consisting of 880 kcal (63% fat [10% SFA]). Following an overnight fast, muscle biopsies were obtained immediately prior to and 4 hours following the meal challenge. Metabolic flexibility was assessed by measuring the oxidation of [1-14C]-pyruvate oxidation +/- palmitic acid and western blotting was used to analyze phosphorylation status of the stress kinases p38 MAPK and JNK in skeletal muscle samples. High fat feeding resulted in a significant reduction in metabolic flexibility but did not elicit changes in p38 MAPK or JNK. Studies are underway to measure phosphorylation status of ERK and protein content of toll-like receptor 4.

Mentor(s): Dr. Matt Hulver (Human, Nutrition, Foods and Exercise)

KATHRYN M. WINGFIELD,
HUMAN, NUTRITION, FOODS AND EXERCISE

Total Energy Cost of Competitive Soccer

Soccer continues to gain popularity in the United State and requires many physical demands. One physical load that was looked at in this study was energy cost. A typical soccer match requires 700-1000 kcal of energy for a 90-minute match with players covering 8-10 kilometers of total distance. This data does not take into account for non-match activities such as the warm-up period. The subjects included 16 female varsity college players during 25 competitive soccer matches. The main objective of the study was to quantify the total energy cost and physical demands of a soccer match including both the warm up and match play. To determine the distances covered, speed and acceleration profiles, a 10Hz GPS and a triaxial accelerometer were worn by each player. These measures were used to calculate energy expenditure. During warm-up and match, players covered 3.1±0.1 and 10.2±0.1 kilometers of total distance, respectively. The main energy expenditures during warm-up and match were 15.4±0.7 and 51.0±0.6 kJ/kg, respectively or 238.3±10.5 and 788.3±9.8 kcal. The results of this study suggest that the warm-up period accounts for 20-30% of the total distance covered and energy expanded during a completive soccer match. This energy should be considered when evaluating the physical demands of the match and designing a nutritional recovery program.

Mentor(s): Dr. Jay Williams (Human, Nutrition, Foods and Exercise).

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SAMUEL A. AKINYEMI,
MATHEMATICS

Miniature In-Air Sonar for a Biomimetic Dynamic Bat Head

Horseshoe bats (familiy Rhinolophidae) have a sophisticated, miniature sonar system that combines high-amplitude emission (through the nostrils) and reception (via the two ears) in a space of just a few centimeters in diameter. Here, an acoustic emission and reception subsystem for a biomimetic sonar head inspired by horseshoe bats is presented. As in the bat, the emitted and received wavefields are subject to a time-variant diffraction by deforming baffle shapes upon emission as well as reception. The baffles were coupled to the transducers via a narrow opening to create a near-field with approximately spherical spreading - at least in one direction. The spherical spreading ensured that the baffle surfaces received large near-field amplitudes and could hence contribute substantial diffracted components to the overall wavefields. On the emission side, an electrostatic transducer with 30mm diameter was used a source for ultrasound. It was connected to the nostrils through a conical waveguide with a circular exit cross-section that was 8mm in diameter. On the receiving side, a microphone is used to pick up all of the bouncing ultrasounds that the transducer emits, to mimic that of a horseshoe bat.

Mentor(s): Dr. Rolf Mueller (Mechanical Engineering).

JOHN B. CAUGHMAN,
MATHEMATICS

Numerical Analysis of Cell Network

T follicular helper (Tfh) cells are a subset of CD4+ T cells influential in promoting an inflammatory response. This inflammation chronic and eventually harmful dictated by the balance of CD4+ T cell phenotypes. The presence of regulatory T follicular helper cells (Tfr) helps to achieve such a balance. A network model is created of Tfh and Tfr cell differentiation. From this model is defined by a set of differential equations. Stability analysis shows that there are 2 stable states, a Tfh dominant and Tfr dominant, separated by an expected bistable region. Bistability is important in a biological system because it underlies cell division, differentiation, and apoptosis. To analyze this bistability of the system, one of the differential equations is substituted, and then the other equations are solved. Initial substitutions were ineffective, being either too simple or too complex, so numerical analysis was then used, specifically continuation analysis in order to find points of bistability. Two numerical analysis tools were looked at: MATCONT and XAUTO. MATCONT was first looked at however, it was not dynamic enough for the particular analysis, and XAUTO is now being used. XAUTO will be used to determine if there is bistability and the range of parameters in which the bistability is achieved.

Mentor(s): Dr. Josep Bassaganya-Riera (Virginia Bioinformatics Institute) and Dr. Vida Abedi (Virginia Bioinformatics Institute)

ALLISON DANIEL, ANTHONY DANZELLA AND JOSH HAMMES, GIS/ REMOTE SENSING, AEROSPACE/ MECHANICAL ENGINEERING AND GIS/ REMOTE SENSING

Peru Disasters II

In recent years, natural disasters have severely devastated the rural regions of Peru. Large flooding events in 2008, 2013, and 2014 disrupted central highlands districts, including the Cascas district of the Gran Chimu province about 110 km inland from the coastal city of Trujillo. The primary study area for this project was the Ochape river sub-basin near the city of Cascas, the capital of the Gran Chimu province. In partnership with Water for People and the Instituto Nacional de Defensa Civil Del Peru (INDECI), this project aimed to create resources and tools necessary for flood risk assessment projects in the Cascas district of Peru. NASA Earth observations were used in this project to provide input datasets for the Coupled Routing and Excess Storage (CREST) Distributed Hydrological Model, which was developed by the University of Oklahoma in collaboration with NASA SERVIR. These inputs included Digital Elevation Models (DEMs) and related data from the HydroSHEDS portfolio of NASA's Shuttle Radar Topography Mission (SRTM), rainfall data collected by Tropical Rainfall Measuring Mission (TRMM), and Landsat 8 imagery. All final maps, models, datasets, and tutorials developed in this project will enable Water for People and the Peruvian government to better prepare for flooding based on historical examples.

Mentor(s): Dr. Kenton Ross

ANASTASIA Y. KARETNYI,
BIOLOGY

Evaluating the contribution of non-inflammasome forming NLRs in host-pathogen interactions following exposure to HEV

HEV is a viral pathogen transmitted by the fecal-oral route that causes acute hepatitis. This virus is an emerging zoonotic pathogen that can be transmitted to humans by pigs. When a virus, such as Hepatitis E (HEV) invades a host, it faces the innate immune response, which is induced by the activation of host pattern recognition receptors (PRRs). The PRRs are the innate immune systems first response to detection of various pathogens that enter the system. PRRs are divided into multiple, distinct families including the NBD-LRR proteins (NLRs). NLRX1 is a protein-coding gene within the NLR family that is a regulator of the mitochondrial antivirus response. Here, we hypothesized that following HEV infection, NLRX1 gene expression will increase due to the activation of various transcription factors such as NF-kB. Subsequently, pathways associated with NLRX1 regulation would also be significantly altered following infection. Our results showed that after infecting a porcine macrophage cell line (3D4) with HEV, NLRX1 expression and associated cytokines were significantly up-regulated at multiple time-points. These preliminary data emphasize the role of NLRX1 as a regulator of antivirus immunity.

Mentor(s): Dr. Irving C. Allen (Biomedical Sciences and Pathbiology)

A. LINETTE,
CELLULAR MOLECULAR BIOLOGY

The Inflammasome Plays a Minor Role in PAMP Recognition and Cytokine Production in Epithelial Organoids

Inflammatory Bowel Disease (IBD) is associated with inflammation of the digestive tract. IBD has been found to be attenuated by the activation of the inflammasome, a protein complex that is responsible for immune system regulation. The inflammasome is composed of NLRs, the ASC adaptor protein, and caspase-1. Activation of the canonical canonical inflammasome triggers the proteolytic activation of caspase-1, which results in the maturation of the proinflammatory cytokine IL-1beta. A second, novel non-canonical inflammasome has recently been described and is associated with activation of caspase-11. While also associated with IL-1beta maturation, the true function of the non-canonical inflammasome is still unclear. Both inflammasomes can be successfully triggered through the detection of pathogen-associated molecular patterns (PAMPs), such as LPS. In order to evaluate the effects of the inflammasome in a tissue specific manner, small intestine organoids were generated from genetically modified mice that lack either ASC (canonical inflammasome) or caspase-11 (noncanonical inflammasome). After stimulating organoids with several PAMPs, inflammatory cytokines were measured via RT-qPCR at the mRNA level, as well as secreted cytokines at the protein level via ELISA. Our results indicate that the inflammasome plays only a minor role in PAMP recognition and inflammasome associated cytokine production in epithelial organoids.

Mentor(s): Dr. Irving C. Allen (Biomedical Sciences & Pathobiology Department), Daniel Rothchild (Biomedical Sciences & Pathobiology Department)

MARLON H. LEVY-FAGAN,
PACKAGING SYSTEMS AND DESIGN

The Effect of Sidewall Support on the Compression Strength of Corrugated Boxes

In this study, the sidewalls of corrugated boxes were braced both internally and externally with foams of different stiffness to determine the effect of additional sidewall support on box compression strength. The strength of a box can be estimated with the "McKee Equation," which utilizes box geometry and the short column compression strength and bending stiffness of the constituent corrugated paper. Material adjacent to the box sidewall, such as product inside the box, will brace the sidewall and effectively increase the bending stiffness and the box strength by reducing the effective column length. The McKee model does not capture the effect of adjacent sidewall support, and as a result, it regularly underestimates the strength of a box in real world scenarios. 90% of all goods are shipped in corrugated boxes, where over-packaging and subsequent compromises to supply chain sustainability regularly occur when the strength is underestimated. By providing a correction factor to the model that accounts for sidewall support, the packaging industry will be able to reduce over-packaging and improve the sustainability of their supply chains.

Mentor(s): Dr. Laszlo Horvath (Sustainable Biomaterials); Matt Baker (Sustainable Biomaterials)

MEGAN LEE J. MYKLEGARD,
MARKETING

Bridging the gap between LGBTQ+ alumni and current students

In the fall of 2014, faculty and students in the Virginia Tech History Department, along with colleagues in the University Libraries' Special Collections and various LGBTQ+ campus partners, began collecting oral histories to document the history of Lesbian, Gay, Bisexual, Transgender, and Queer life in the 20th century American South and specifically at Virginia Tech. By supporting this ongoing project and including voices of alumni/ae who reside in various locations across the United States, the objective of the research is to augment current campus knowledge related to LGBTQ+ experience at Tech. Throughout the summer of 2015 nine interviews have been conducted of LGBTQ+ alumni/ae, current students, and allies residing in Blacksburg, VA, San Francisco, CA, and Austin, TX. The interview questions cover the interviewees' childhood experiences, their first introductions to the LGBTQ+ community, their experiences in relation to the LGBTQ+ community at Virginia Tech, and a discussion of their current occupations and lifestyle. The questions were formulated to uncover comparisons between life in the LGBTQ+ community at Tech presently with that of the past. A review of the transcriptions has led to a notable assessment; each interviewee found a unique comfort in the community at Virginia Tech. Further evaluation and comparisons of the interviews are planned to take place in the fall semester of 2015. Information from the interviews will be placed on the Timeline of LGBTQ+ History at Virginia Tech located on the Special Collections webpage and transcriptions are located in the Special Collections sector of the Newman Library.

Mentor(s): Dr. David Cline (History)

DIAMOND NORTHINGTON,
NEUROSCIENCE

Insights into Amyloidogenicity: Molecular Dynamics Simulations of Aβ(17-42) (p3) in Varying Environments

The aggregation of amyloid β (Aβ) fibrils and their interaction with the neuronal cell membranes is often classified as a primary cause of Alzheimer's disease (AD). Aβ is cleaved from the amyloid precursor protein (APP) in a sequential two-step process, with either Aβ or p3 (Aβ17-42) being produced depending on cleavage site. Currently, there are many conflicting studies on the amyloidogenicity of p3. To gain further insight into the potential amyloidogenicity of p3, molecular dynamics (MD) simulations were used to analyze the interactions of p3 in various environments. Two structures of p3 (PDB ID: 1IYT, 2BEG) were placed in various environments. A system to mimic how p3 interacts with other p3 peptides was generated by placing three p3 peptides in a box, while simulations to mimic peptide-membrane interactions were generated by placing three p3 peptides above a raft membrane. Analysis of p3 peptide-peptide interactions showed that the trimer showed an increase in β-strand structure by 9%, indicating potential aggregation abilities. In addition, key intra- and intermolecular interactions between the peptides were found between the central hydrophobic core (CHC) regions and C-terminus – C-terminus regions. When introduced to the raft membrane, a decrease in β-strand structure was observed. In conclusion, these results indicate that p3 has amyloidogenic qualities, such as aggregation potential, as indicated by the indicated by the increase in β-strand structure in the trimer simulations and does interact with a model raft membrane. These peptide-peptide and peptide-membrane simulations can provide insight into the mechanism of Aβ toxicity.

Mentor(s): Dr. Dave Bevan (Biochemistry) and Anne Brown (Biochemistry)

ANTHONY R. RANASINGHE,
BIOLOGICAL SCIENCES

Actuation System for a Dynamic Biomimetic Sonar Head

Horseshoe bats (family Rhinolophidae) sense their surroundings using a sophisticated biological sonar system. Central to this sonar mechanism is the dynamic motion of baffle shapes that surround the bats' nostrils and ears. Ultrasonic waves that are emitted through the nostrils are diffracted by two rapidly deforming adjacent structures called the anterior leaf and the lancet. Similarly, shape changes caused by rapid rotation and deformation of the outer ears have an impact on acoustic function on the receiving side. Here, actuation mechanisms have been devised to mimic the deformation of these structures for implementation in a biomimetic sonar head. A one-point actuation mechanism was used to push the lancet approximately 10 mm at a speed of 0.3 m/s as observed in horseshoe bats. A cam-like mechanism was designed to displace the anterior leaf 7 mm at a speed of 0.5 m/s, also observed in horseshoe bats. Finally, a one-point actuation mechanism was used to rotate and displace the tip of each ear. Maxon DC motors, which were controlled by an off-head control unit, were used to produce these high-speed movements. Future research should look to further miniaturize these actuation mechanisms to make a more realistic sonar head.

Mentor(s): Dr. Rolf Mueller (Mechanical Engineering), Uanging Fu (Mechanical Engineering), Phillip Caspers (Mechanical Engineering)

AMANDA L. SEBASTIAN,
MICROBIOLOGY

Determining the role of the three CheW proteins in Sinorhizobium meliloti via bacterial two-hybrid system

Symbiotic soil bacteria such as Sinorhizobium meliloti are important to the field of agriculture in their ability to improve crop yields. Through studying bacterial chemotaxis, we can learn more about how these bacteria interact with their environment. To facilitate chemotaxis in S. meliloti, the adapter protein CheW, mediates binding of the chemoreceptors to the histidine protein kinase (HPK) CheA. After autophosporylation, CheA donates a phosphate group to the response regulator CheY which controls bacterial flagellar motor rotation. S. meliloti, however, possesses three genes coding for the protein CheW. It is unclear which of the three CheW proteins is used for chemotaxis. A bacterial two-hybrid system based on adenylate cyclase (AC) reconstitution was used to dissect communication between CheA and the three different CheW proteins. By fusing CheA with the T18 subunit of the AC gene and fusing the three CheW proteins (CheW1, CheW2, and CheW3) with the T25 subunit of the AC gene, protein interaction was observed through the restoration of AC activity on MacConkey media plates. Additionally, single and multiple cheW deletion strains were constructed and their chemotactic behavior was assayed on swim plates. Results from these studies will inform about the contribution of individual CheW proteins to chemotaxis.

Mentor(s): Dr. Birgit Scharf (Biological Sciences)

SHANE C TAYLOR*
CHEMICAL ENGINEERING

Generation and Characterization of Targeted Release Systems, Based on Two-Phase Emulsions

This study investigates the dependency of the stability of fat microcapsules based on the water/stabilizer solution, PVA or PVP, used to prepare the microcapsules. Soy sauce was encapsulated using a double emulsion via melt dispersion technique (MDT). Microcapsules can be used as drug delivery vehicles. It is vital that a drug is not released too quickly or too slowly to a patient. Therefore, the stability of release of a drug plays a major application in pharmaceutical industries. In this study, soy sauce was encapsulated in fat, Witepsol W31, microcapsules. The microcapsules were subject to mixing in water in order to release the soy sauce. Release of the soy sauce at various times was quantified by measuring the conductivity of the aqueous phase that the soy sauce had been released into. The conductivity measurements were related to weight percentages of the soy sauce in the aqueous phase using a calibration curve of conductivity vs weight percent of soy sauce in water. These quantities were then related to the overall weight percentage soy sauce released from the capsules for regulated time increments. The results of the experiment proved to be inconclusive. The various temperatures at which the microcapsules had been prepared caused a broad range in the amount of soy sauce encapsulated for all the batches made. In the future, controlling the temperature of the preparation of the microcapsules could allow for more conclusive results.

Mentor(s): Dr. Rebecca Scholz (Ruhr University Bochum, Department of Process Engineering and Transport Processes)

*RUB Exchange Student

ALEXANDER THAI*
MECHANICAL ENGINEERING

Designing a Brake System for the Terramechanics Rig

The purpose of this project is to design and implement a brake system for the current terramechanics rig in the Center for Vehicle Systems and Safety (CVeSS) Lab. The terramechanics rig allows a tire to roll across an enclosed surface. The surface enclosed in the rig is roughly 25 feet by 7 feet. The system is powered by two separate motors: one for the tire, and one for the carriage. This allows the carriage, which moves laterally across the surface, and the tire to drive at separate speeds. By doing this, the slip of the tire can be adjusted from 0 percent slip to 100 percent slip. Additionally, the rig is capable of varying the toe and camber of the tire. With the current setup of the rig, data can be collected for several different driving conditions. With the addition of a brake to the rig, a new dynamic is achieved, and data can be collected during various braking conditions. The process for completing this project started with extensive literature review. The main paper being reviewed was Jeffrey Biggans' Master's Thesis detailing the design of the terramechanics rig. Next, various brake systems and parts were considered. When a proper brake system was decided upon, multiple design options were created using SolidWorks. These drawings helped to further illustrate and verify the design. By the end of the project the lab will have multiple detailed assembly files showing the design for the brake system. A bill of materials will be supplied listing everything that needs to be purchased. A custom mount for the brake system will be created in SolidWorks and FEA will be performed on the mount to show that it can withstand the torque from the brake force being applied.

Mentor(s): Dr. Corina Sandu (Mechanical Engineering)

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