Acknowledgements

"Experience is what you get when you didn't get what you wanted."
~ Randy Pausch (The Last Lecture)
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Closing Remarks
Carolyn Vallas
Director of the CDE
"Measurement of the Near Infrared Opposition Surge of Triton Near True Opposition"

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We present Near Infrared (J, H, Ks-band) photometry of Triton obtained around the opposition of August 14, 2007 UT. Observations were conducted using a HA-WAII-1 infrared camera operating at the University of Virginia’s Fan Mountain Observatory’s 31-inch reflector. With Neptune near a node crossing, Triton reached solar phase angles as small as 0.011 degrees. Given a heliocentric distance of 30AU, the Sun’s angular radius was only 0.008 degrees. The observing campaign took place in two parts; one around opposition and the other about a month later in order to measure the opposition surge, and characterize the light curve of Triton at these wavelengths while the phase angle was slowly changing. The observations can be used to characterize the angular width, amplitude, and wavelength dependence of the Near Infrared opposition surge of Triton and provide evidence for a significant contribution from the coherent backscatter effect.
Bladder cancer is a relatively common and costly malignancy. The role of a small class of small G-proteins known as the Ras-like or Ral GTPases have been targeted due to recent advances in the understanding of the molecular pathogenesis of metastatic bladder cancer. These signaling proteins, regulated by the Ras pathway, have shown to be necessary for key cellular phenotypes associated with transformation or cancer progression in diverse cancer systems. This experiment investigated the impact of chemical inhibitors of the ral GTPase by using yeast chemicogenomics to determine the mode of action of the ral inhibitor to reveal any effects other than on ral. Cultures of homozygous diploid cells were inoculated using pooled deletion mutants and grown for 20 generations using chemical ral inhibitors developed by Dr. Dan Theodorescu, a Professor of Urology at the University of Virginia. Two cultures were grown in two separate drug environments, and one in a controlled drug free environment. The pooled cultures of tag yeast deletion mutants underwent a two step process following pooled growth: isolation of genomic DNA and PCR amplification of the barcodes. Due to time limitations on the experiment, no significant data about the effects of the ral inhibitors can be obtained until array hybridization and data analysis is completed. Results may indicate that no mutants are affected, hinting that the drug could be a specific ral target. The second possible outcome is that many mutants are affected, proving the sensitivity of the strains to the drug. In this case, the relationship between the off-target effects on the mutants will be analyzed to determine the other specific targets of the drug.
Neuronal plasticity is a phenomenon commonly observed following damage or impairment to the nervous system. However, the mechanism behind plasticity and the eventual recovery of function, is relatively unknown. In the present experiment, we show that when larval (Drosophila) crawling is impaired via the attachment of a piece of plastic, crawling behavior shows marked recovery over time. What is more, is that this recovery can be quantified. Should the mechanism(s) leading to plasticity such as this become unmasked, the implications could prove promising for those suffering from the debilitating effects of neuronal damage.
The main objective of this semester’s research project was to investigate how cortactin influences the rate of GTP hydrolysis by Dynamin2 in vitro. Cortactin is a protein located in the cytoplasm of cells that can promote polymerization and rearrangement of the actin cytoskeleton. Some recent studies have shown that cortactin is able to associate with dynamin during endocytosis. Dynamin is a cellular protein that catalyzes separation of a newly formed vesicle bud from the plasma membrane. Because both of these proteins function in similar locations of the cell, research studies have shown that cortactin actually does associate with dynamin in a way that affects the rate of GTP hydrolysis. I hypothesized that the SH3 domain of cortactin plays a role similar to the GED domain of Dynamin in order to stimulate the rate of GTP hydrolysis. The GTPase Effector Domain (GED domain) and the GTPase domain are able to associate by means of a hydrophobic amino acids attraction. I believe that the SH3 domain of cortactin shares a similar amphipathic amino acid alpha helix and, as a result, may be able to stimulate the rate of GTP hydrolysis of Dynamin2. In order to achieve this experiment, a number of techniques were done. Several of these include: preparing a standard phosphate curve, conducting GTP colorimetric assays, DNA Transformation and Plasmid Purification, GST- fusion protein preparation, protein induction, DNA sequencing, constructing DNA primers, running PCR and ligation reactions, and a number of other measures. The overall procedure to investigating this question would be to use a fragment of cortactin that is mainly composed of the SH3 domain. Then, by using colorimetric assays, I could measure the rate of GTP hydrolysis by measuring the amount of Pi released during each reaction and ultimately determine if cortactin’s SH3 domain mutant alone will stimulate the rate of GTP hydrolysis.

The TransDominion rail service can be worthwhile for the public. There are at least 400 to 16 million commuters from Bristol to Lynchburg, and from Lynchburg up to Alexandria and Washington D.C. We also evaluated what was the current ridership in 2000 along the TDX route (Northeast Regional and Crescent), prior to TDX service beginning. Next we located the actual ridership in 2009 and some of 2010 after TDX service began. These ridership values were compared and we found out that the 2009 ridership was much higher than what was predicted in 2000 and 2007. Finally math equations were used to determine any missing information and get more accurate results.

We have found that the ridership at each station has increased by at least 64%, which is four times as higher than predicted in 2000. Next we found the number of commuters traveling to and from Bristol, Roanoke, and the other proposed stations along the TDX line. In observing these numbers, a pattern in the number of commuters from one place to another did arise. It seems that from Bristol to at least Lynchburg, a train could be filled and emptied by the time the train gets to Lynchburg and fills up with passengers again. The same pattern seems to arise from Alexandria to Charlottesville, making Lynchburg and Charlottesville midway rail-stations. We also combined the jurisdictions into stations and made a table of predicted ridership by station to station on annual.
**Department of Surgery**

"Interleukin 23 is upregulated in abdominal aortic aneurysms, recruits various immune cells, and alters progression of the disease"

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Many proinflammatory mediators known to be induced by interleukin (IL)-17 and/or Th17 cells, including MMP-9, have been shown to be essential for progression of abdominal aortic aneurysms (AAAs). One key cytokine in promoting the evolution of IL-17 producing Th17 cells from naïve CD4+ T cells is IL-23. However, whether IL-17 is present in AAAs and whether its expression is dependent on IL-23 have not been studied. We show here that IL-23 is upregulated in human AAAs using quantitative polymerase chain reaction (qPCR). Using an elastase perfusion model of AAAs in C57BL/6 (WT) and IL-23 knockout (KO) mice, we found an increased influx of basophilic cells showing characteristic morphology of immune cells including macrophages and neutrophils, in WT mice compared to IL23 KO mice by means of hematoxylin and eosin staining. Precise identity of these cells is currently being identified with antibodies specific to Mac2 (macrophage marker), CD3 (T cells marker), and neutrophils. It was also evident that the widespread erosion of the medial elastic layers seen in WT mice was abrogated in IL23 KO mice by means of hematoxylin and eosin staining. Precise identity of these cells is currently being identified with antibodies specific to Mac2 (macrophage marker), CD3 (T cells marker), and neutrophils. It was also evident that the widespread erosion of the medial elastic layers seen in WT mice was abrogated in IL23 KO mice. Interestingly, qPCR showed that smooth muscle alpha actin, marker of differentiated, contractile smooth muscle cells, was not significantly different in IL-23 KO versus WT mice preliminarily indicating these changes may not be mediated by alterations in the amount of differentiated SMCs although more detailed analysis is necessary. These are the first studies to show that IL-23 is upregulated in human and mouse AAAs and the first to show a functional role for IL-23 in AAA progression. Future study may further identify IL23 antagonism via blocking antibodies and/or small molecules as a potential therapy for AAA.

**Department of Biomedical Engineering**

"Studying the Effect of Basement Membrane-Polycaprolactone Nanofiber Scaffolds on Promoting Peripheral Nerve Repair"

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The basement membrane (BM) is a natural structure consisting of type IV collagen, laminin, nidogen, integrin, and perlecan. The BM creates an essential microenvironment for cell adhesion, growth, and other behaviors throughout the body. In particular, the BM lines the peripheral and central nervous system. To create a basement membrane biomimetic substrate for tissue engineering with specific applications in peripheral nerve, BM was isolated from the murine Engelbreth-Holm-Swarm (EHS) tumor and was electrospun as reconstituted basement membrane (RBM) and RBM with polycaprolactone (PCL). Nanofibers that mimic the ECM have diameters between 50-300nm and minimal amount of beading. At different concentrations of RBM, nanofibers were made with minimal beading at 3% total polymer for 1% RBM and 5% total polymer for 10% RBM with diameters of 139.41 ± 39 nm and 152.25 ± 31nm, respectively. In order to assess the bioactivity of blended RBM-PCL meshes, PC12 cell attachment was characterized. In looking at varying concentrations of RBM in the nanofiber blends with PC12 cells, 10% RBM provides a significantly (p < 0.01) greater amount of attachment than 1% RBM. To interrogate the possible mechanism for increased cellular adhesion to RBM nanofibers, we investigated a component of the mesh: IKVAV, a pentapeptide sequence shown to promote cell attachment and process extension, located near the globular domain on the long arm of the laminin molecule. To investigate neurite extension, IKVAV was conjugated to PCL nanofibers using Sulfo-N-Hydroxysuccinimide (Sulfo-NHS) - 1-Ethyl-3-(3-dimethylaminopropyl) carbodiimide (EDC) conjugation chemistry in order to observe how PC12 cells extend processes. In the case where the laminin peptide was present, more processes were extended as well as more processes per cell. This shows that RBM-PCL nanofibers present a substrate that mimics the behavior of the ECM by increasing cellular attachment as well as promoting neurite extension, which highlights the important role the BM will play in peripheral nerve repair in the future.
**Department of Biomedical Engineering**

“Endothelial inflammatory response under cyclic stretch profiles on micro-patterned lines”  
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Vascular endothelial inflammation is a key component of myocardial injury and cardiovascular disease progression. Studies have shown that endothelial cells aligned in an elongated conformation, similar to those that have been exposed to shear stress, exhibit a mitigated inflammation response. Cells in vivo also are subject to other mechanical forces such as cyclic strain due to the stretching of the vessel wall during pulsatile blood flow. To study the dual effects of predetermined cell shape and various cyclic stretch profiles on inflammation response, bovine endothelial cells plated on micro-patterned fibronectin lines were exposed to the cytokine TNFα, and stretched under uniaxial parallel, uniaxial perpendicular, and equibiaxial conditions. Inflammation response was quantified by the nuclear localization of the transcription factor, NF-κB, downstream of the TNFα receptor. Compared to monolayers of cells under similar conditions, cells on lines exposed to uniaxial parallel and uniaxial perpendicular stretch had attenuated inflammation as measured by reduced NF-κB nuclear translocation. There was a 57.7% reduction in activation between cells on lines that were stretched uniaxial perpendicular compared to unstretched cells on lines and a 50.1% reduction compared to unpatterned uniaxially stretched cells. To verify that this was due to inhibition of the TNFα pathway, we immunofluorescently labeled IKK-β and phospho-IKK-β, the NF-κB regulatory complex in the classical pathway. Relative amount of phospho-IKK-β to IKK-β as determined by light intensity values from fluorescent microscopy images represents NF-κB pathway activity. Preliminary results indicated failure of the antibody to recognize its antigen in bovine endothelial cells. Therefore, further experimentation must be performed with human cell lines to optimize staining. We conclude that the combination of predetermined cell conformation and uniaxial stretch confer inflammation protection and should be strongly considered in future study of vascular endothelial cell inflammation.

**Department of Physics**

“Inquiry based Learning with a Light Meter”  
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With a trip to RadioShack and Lowes (plus one online order) and using tools that any school teacher should have access to, a light meter can be built for around $20 that can be used in middle school and high school classrooms for demonstrations, lessons and a Science Olympiad event.
Department of Pediatrics

“Renin and Smooth Muscle Gene Expression in Embryonic Stem Cells and the Pre-implantation Embryo”
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Renin cells are crucial in the regulation of blood pressure, fluid and electrolyte homeostasis, and kidney vascular development. Renin cells are unique in that they can adopt either a contractile phenotype or an endocrine phenotype. The present study was designed to define whether smooth muscle genes and the renin gene are expressed during early embryonic development. Previous work from our lab indicated that renin mRNA is present early in development, in the blastocyst stage. To evaluate the regulation of smooth muscle and renin in early development, we conducted experiments in blastocysts and in embryonic stem (ES) cells, derived from the inner cell mass.

RNA was extracted from 129S/V ES cells and probed for the expression of several differentiation markers. Using reverse transcriptase (RT-) PCR, we confirmed ES cell pluripotency by their expression of OCT4, a well-established marker of the undifferentiated state. Renin mRNA was not detectable in these cells. Instead, they express markers of smooth muscle such as α-SMA and smoothelin mRNA, which are known to regulate the development of the vasculature. Since blastocysts express renin whereas ES cells do not, it may suggest that during the earliest stages of development expression of renin is likely suppressed by yet to be identified factors. We recently found that miRNAs could play a role both in renin expression as well as in smooth muscle expression.

miR 330 has a site on the 3’ UTR of renin mRNA and effectively downregulates renin mRNA expression. Contrary to this, miR 125b-5p stimulates smooth muscle gene expression. Also, miR 145 is highly expressed by renin cells and is known to positively regulate the expression of smooth muscle genes. Altogether, the data suggests that miRNAs are playing a role in the high expression of smooth muscle proteins in undifferentiated ES cells and their subsequent expression of renin mRNA during later development as in the blastocyst stage.

We are currently exploring which miRNAs are expressed during ES cell and blastocyst development. If the aforementioned miRNAs are present as we suspect, we plan to inhibit their expression and evaluate their role in the expression of renin and smooth muscle and the differentiation of ES cells and pre-implantation embryo.

Department of Biomedical Engineering

“Platelet-rich Plasma Isolation for Targeted Bone Tissue Engineering”
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Platelet-rich plasma (PRP) is an autologous source of platelet-derived growth factors and sphingosine 1-phosphate (S1P) that is obtained by isolating and concentrating platelets from whole blood through the process of centrifugation. Recent studies have shown that PRP’s growth factors aid in the regeneration of bone and soft tissue, making it an appealing field of study for tissue engineering. S1P is a sphingolipid that is released from activated platelets during blood clotting. S1P acts through binding to five G protein-coupled receptors (S1P1–5), which can be manipulated through the use of various synthetic receptor agonists and antagonists. We hypothesized that activating platelets in PRP may lead to increased S1P concentrations which subsequently speeds osteogenesis at the site of a bone injury.

To test this hypothesis, PRP was isolated from blood of male C57Bl/6 mice, age 2-3 months. PRP was activated using a solution of 1 U/mL thrombin and 1 g/mL CaCl2, with 2 U/mL heparin used to prevent clotting. S1P levels in PRP were quantified by HPLC/MS. MC3T3-E1 (mouse pre-osteoblast) cells were co-cultured with PRP alone and in conjunction with S1P (agonist for all S1P receptors), JTE-013 (an S1P2 antagonist) and FTY720-P (agonist for receptors S1P1, S1P3, S1P4). After 24 hours, cell proliferation was quantified by calcein-AM staining. Migration assays were conducted using a modified Boyden chamber assay that used PRP both with and without the above S1P agonists and to understand the role of these factors in mobilization and recruitment of bone precursor cells. Cells were seeded at a density of 5 x 10^4 cells per well and allowed to migrate over the course of four hours, and maximal migration was found.
Cardiac hypertrophy is a condition in which the heart wall becomes thick. Cardiac hypertrophy can lead to heart failure and sudden death. The mortality rate causes by heart failure every year is very high, around 10%. Therefore, the search for more drugs to better treat cardiac hypertrophy is essential. Previously, our lab has developed a hypertrophy signaling network of 95 species and 151 interactions between them. We use the hypertrophy network and DrugBank, a drug database, to build an extended network by adding 24 FDA approved drugs. The goal is identifying drugs that can have a positive effect or negative effect on cardiac hypertrophy. We run the simulations of drugs’ interaction with the species of the hypertrophy network using MATLAB. The simulations are run with a single drug activated on a hypertrophy heart inducing by endothelin. The results have shown that of 24 FDA approved drugs, only Bosentan can effectively inhibit cardiac hypertrophy, while five other drugs can have significant side effects to induce cardiac hypertrophy. This research shows a new approach by using computational modeling to find drug target.

Regulatory T-cells (T-reg) have been shown to be essential for the maintenance of self-tolerance and aids in protecting your body from its own immune cells. Our laboratory has shown that the T-reg has an important role in determining whether tolerance or autoimmunity will develop in response to various tissue injuries. We study this mechanism through the procedure of vasectomy, which is a common permanent form of birth control. The procedure does not disrupt sperm production in the testis, and sperm continues to accumulate in the epididymis. This accumulation results in the rupture of the epididymal duct and the extravasation of sperm into the interstitial space. It has been shown that this sperm causes inflammation, which leads to a leukocytic encasement of the extravasated sperm as an attempt to isolate them from the rest of the body. The result is an organized tissue inflammation known as a granuloma.

Our previous experiments have shown that in the presence of T-reg, a form of tolerance develops to the sperm antigen that is seen in vasectomized mice. However, in the cases where T-reg was depleted from the body, autoimmune disease develops. In order to determine what influences T-reg has on the outcome of these granulomas, we attempt to discover noninvasive methods for their imaging. The current practice for imaging granulomas requires the euthanization of the mice in order to retrieve the epididymis, however, this method is not equipped with the capability to monitor inflammatory progression. The purpose of my research is to explore two techniques that will possibly permit the detection of the inflammation in the epididymal tissue. The first technique is that of ultrasound contrast agents, also known as microbubbles, and the second is through bioluminescence with the enzyme luciferase.

Of the two techniques explored in this study, that of the bioluminescent enzyme luciferase seems more promising for the long-term imaging purposes, while the other, does not seem to even have short-term utilization.
Galactose-alpha-1, 3-galactose, also abbreviated as alpha gal, is an oligosaccharide commonly found on the proteins of nonprimate mammals. Growing numbers of patients, predominantly from the southeastern United States, have experienced anaphylaxis, angioedema, or urticaria 3-6 hours after consumption of this oligosaccharide. According to a previous study by Dr. Platts-Mills, alpha gal is also a major IgE binding epitope on cat IgA, which suggests that alpha gal may be airborne on cat dander. Thus, the purpose of this study is to determine whether or not this allergen can be inhaled. Doing this study may also provide insight into the relationship between the controlling factors of anaphylaxis and the controlling factors of asthma. Allergen collection in this study was performed two ways: ionic air filtration during disturbance in houses with dogs and sieving floor dust from a vacuum filter in houses with dogs. After extracting dust from these samples, we conducted an inhibition assay using I-125 labeled alpha gal to detect any alpha gal in the airborne particles. For the filtered dust, the assay results showed very little evidence that alpha gal is airborne. Additionally, for the collection of sieved floor dust, we used the extracts to attempt to inhibit IgE binding to a dog epithelium Immuno CAP, which correlates well with IgE to alpha gal in affected patients. The results for this showed that alpha gal is not present. This data suggests that alpha gal does not cause asthma because it is not an inhaled allergen. As far as anaphylaxis, however, once alpha gal is consumed by someone with IgE to alpha gal, whether they have a history of asthma or not, this is when alpha gal causes breathing problems along with the other anaphylactic symptoms or angioedema or urticaria.

The focus of this study is to evaluate how the protein TANGO1 contributes to the differentiation of normal trophoblast cells. These cells are the primary and structural elements of the placenta. Trophoblast cells originate from the trophectoderm layer of the blastocyst, and differentiate to form the mature placenta. Failure of trophoblast cells to properly differentiate can lead to placental dysfunction, which directly affects the growth and development of the fetus resulting in fetal death or abnormal growth. Previous inquiry has shown that mice homozygous for the Xst199 mutation develop a placenta that is poorly structured and lacks fetal blood vessels, consequently leading to fetal death. The Xst199 mutation was generated by a beta-galactosidase containing gene trap construct inserted into the Mia3 gene, which encodes TANGO1. Thus, in heterozygous and mutant animals beta-galactosidase is expressed instead of TANGO1 in all cells that normally express this protein. In order to investigate the function of the protein TANGO1 in placental development, mouse embryos isolated at E6.5, E7.5, and E9.5 of gestation, from matings between animals heterozygous for the Xst199 mutation, were stained to localize the expression of beta-galactosidase. Results show that in embryos at E6.5 and E7.5 the Mia3 gene is expressed in the placental precursors, namely the ectoplacental cone and chorion regions of the embryos. Later, at E9.5, beta-galactosidase staining is seen in the forming placenta. Future studies will examine the expression of trophoblast marker genes to understand the function of the Mia3 gene and the TANGO1 protein in trophoblast differentiation. Knowing how the TANGO1 protein is involved in the trophoblast differentiation process will allow for a more thorough understanding about how these factors regulate the behavior of trophoblast cells during placental morphogenesis.
Department of Chemical Engineering

“Effects of Particle Size and TRIS on CHT Chromatography and Methods of TRIS Detection”
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Column Chromatography is a lab technique widely used in protein and other ion separations. Ceramic Hydroxyapatite (HAP) is a calcium phosphate-based compound similar to bone biomater with many useful properties in chromatographic separation of proteins. However, it exhibits limited stability at pH levels below 6.5, and is expensive to replace once corroded. It has been determined that even with careful control of pH levels, unintended drops in pH can occur with variations in salt concentration.

The purpose of this experimentation is to determine uses for cobuffers in maintaining the neutral pH levels at which the resin is stable. TRIS (hydroxymethyl aminomethane) is the proposed buffer, due to its positively charged ionic state and its low cost and effective pH range. Bio-Rad laboratories has proposed an SNS, or surface neutralization step, involving using the co-buffer to prime the resin before elution with high salt solutions. Using this method, with the TRIS buffer tested the effects of the particle size and porosity on maintaining pH stability. It has been determined that a 10 CV SNS step used with less porous (type II) resin minimizes unintended pH drops. Finally, tests are underway to accurately utilize a method to test for the presence and concentration of the TRIS buffer in the effluent from the column, using a chemical marker in the UV or Visible range as detected by HPLC or Spectrometry. This will determine the degree to which TRIS\(^+\) binds to the resin, which may determine its effectiveness and efficiency for commercial protein chromatography.

Department of Mechanical & Aerospace Engineering

“Utilizing Micro-Computed Tomography (CT) Scan Data to Create Finite Element Models of Lower Limb Bones”
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University of Virginia, Charlottesville, VA

Standard methods in the FE modeling of cortical bone include its characterization as a homogeneous, isotropic material, which do not correspond to the actual properties of human bone. Research based on accurately incorporating human characteristics is important in predicting human response during crash incidents through numerical human models, which are an efficient and optimal way of determining safety requirements. By extracting micro-CT scan data from a previous bone coupon test performed on femoral and tibial samples, we will be able to create two different finite element models. Following stages include importing these models and re-creating the tensile test experiment using LS-Dyna to analyze the differences in behavior when each model is subjected to a specific displacement input. The first model created is a simplified, homogeneous version of the bone sample composed of all averages of reported material properties. The second model is a comprehensive version, in which we will assign more detailed material properties to account for the change in geometry. Material properties are assigned according to different relationships between Hounsfield Units, Young’s Elastic Modulus, and bone density of each coupon. Upon the completion of the tensile test simulations in LS-DYNA, we will specifically look at each model’s response in terms of stiffness response and strain distribution.
Vertical-axis wind turbines (VAWT) are less popular in use and research than their horizontal-axis counterparts. Therefore, VAWTs have no optimal performance standards. To help reach the US goal of 20% wind energy by 2030 we are testing kinetic energy produced by an 8’ prototype to find optimal settings of a VAWT for standalone use in low speed (8 mph) wind. By changing airfoil shape/size, spar length, and pitch offset we see changes in rotational speed, inertia, and, therefore, kinetic energy. As kinetic energy changes with inertia, the goal of these experiments is not to find the fastest rotation, but rather the optimal performance through the different presets. Thus far we have found the NACA 8-H-12 airfoil with 8” chord length has had the best results, but difficulty maintaining the blades at their pitch offset after passing 120 rpms has prevented us from determining which angle of offset at which spar length gives the highest energy output. Better friction restraints are needed to complete this work. Further research should be done using a NACA 8-H-12 with shorter chord length to determine whether it was the smaller size or the symmetric shape of the NACA 0012 that caused its poor lift response.

Contact angle and wettability are key components when deciphering the behavior of carbon dioxide during geologic sequestration. Previous experiments, simulated at high pressure and elevated temperatures, explored the interaction on a CO2/brine/rock interface. Based on geologic studies, sandstone, a common rock found below the earth’s surface, is composed of actual rock and a mineral, kaolinite. The ongoing experiment looks at the interface of CO2/brine/mineral in order to compare carbon dioxide behavior on both surfaces and analyze the resulting images using the axisymmetric drop shape analysis (ADSA) sessile drop method. Preliminary data is conducted to create a baseline for carbon dioxide phase diffusion. A brine solution composed of sodium chloride and deionized water fills the windowed high pressure cell, which is set at a specified pressure and temperature via heating tape. Once all air bubbles are evacuated, carbon dioxide is introduced, and the pressure images are taken digitally, with a fireware camera. To measure the contact angle, a sample holder, containing the mineral sample, is placed horizontally in the pressure cell, which is then filled with brine. A carbon dioxide gas bubble is injected using a syringe at the bottom of the sample and the contact angle is obtained. The resulting angle will determine how the carbon dioxide is likely to behave when being stored below the earth’s surface, which is a viable option for solving the greenhouse gas problem that is currently plaguing countries globally.
**Department of Civil & Environmental Engineering**

*“Optimal Design of Ceramic Water Filters Impregnated with Silver Nanoparticles for Point-of-use Water Treatment”*

Borna Kazerooni & James Smith, PhD

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In the developing world, point-of-use (e.g. household-level) water treatment has been endorsed by the World Health Organization as an effective and potentially sustainable approach for treating water for domestic use. Ceramic water filters impregnated with silver nanoparticles (Ag-NPs) were studied because Ag-NPs have remarkable antimicrobial properties, and they function to significantly improve the microbiological quality of treated water when incorporated into ceramic water filters. Because there is little quantitative data on how the quantity and application method of the Ag-NPs affect filter performance, more experiments and data that quantitatively study and describe these design variables are needed. The objective of this research project is to optimize the amount and application method of the Ag-NPs to maximize pathogen disinfection while minimizing release of silver into the treated water. This study investigates the application of the silver prior to firing, which is expected to reduce the release of silver nanoparticles from the ceramic, provide a more uniform distribution of the Ag-NPs throughout the filter, and improve disinfection efficiency relative to the conventional design. To test these hypotheses, two types of ceramic filters were tested: (i) filters without Ag-NPs; and (ii) filters with Ag-NPs incorporated into the ceramic prior to firing. The technological performance of each filter type was quantified by passing an aqueous solution containing E. coli at $10^9$ cfu/100 mL through the filter and sampling the effluent to determine the percent removal (log reduction). Conventional membrane filtration procedure detected approximately 380-400 cfu/100mL of E. coli passing through both the types of filters suggesting that Ag-NPs treated and untreated filters perform similarly. While this is a promising result for filter manufacturers, more extensive testing will be necessary in order to determine whether silver treatment helps prevent bacteria growth in the filter, and thus, enhancing long-term performance. These findings will improve water quality and human health in some of the world’s most impoverished communities.

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**~ Intermission ~**

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**Department of Mechanical & Aerospace Engineering**

*“Thermal Insulation using Vacuums”*

Andrew M. Rowe, Christina Johnson, Donald Jordon & Pamela Norris, PhD

Department of Mechanical & Aerospace Engineering

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Thermosyphons, a type of heat pipe, are closed two-phased heat exchangers used to passively transfer heat from one location to another. For air-cooled thermosyphons at steady state, the rate of heat transfer is determined from measured power input to the thermosyphon heat source. Insulation of the heat source is necessary to reduce the amount of heat lost to the atmosphere and improve the accuracy of the heat transfer measurement. Thermal insulation using a vacuum container is very effective for this application. Evacuating the container substantially reduces the amount of heat lost since the only means of heat transfer is radiation from the heater to the container walls and conduction through a small area where the heat source is in contact with the bottom of the container. With the vacuum container keeping most of the heat directed into the thermosyphon, measurement of rate of heat transfer will tend to be more accurate and will therefore reduce error. In this investigation, a vacuum container was designed and constructed from Delrin, which is strong enough to withstand the pressure load from the vacuum, and has a low thermal conductivity ($k = 0.3$ W/mK). The heater block was placed inside the vacuum container and cartridge heater power consumption (W) required to hold the heater block temperature constant was recorded with the container under both vacuum and normal atmospheric pressure. The results clearly demonstrated that power consumption with the container under vacuum is lower than under atmospheric pressure and much lower than applied to insulate the heater block.
An artificial cardiac cell (gel cell) is being developed from electroactive polymer materials to aid in the study of cardiac fibrillation and the development of new therapies for cardiac dysfunction. As a part of this artificial cell, an ion-sensitive probe is needed to detect the presence and location of potassium ions within the cell. For this research project, a potassium-selective ion sensor was produced following research described by Pandey et al. This consisted of electropolymerizing pyrrole onto a gold mesh in a conventional three-electrode electrochemical cell to create a polypyrrole (PPy) membrane. A sensing solution incorporating dibenzo-18-crown-6 as the ionophore was placed onto the membrane and allowed to evaporate leaving a thin membrane sensing layer. The potassium ion sensor was then tested for functionality in various concentrations of aqueous potassium chloride solutions, ranging from 1 M to 0.00001 M KCl. The voltage drop between the sensor and a reference electrode (Ag/AgCl) was recorded while the sensor was in solution. A calibration curve of the sensor showed a linear relationship between concentration and voltage under certain conditions. However, it was found that ion specificity was poor, and the sensor saturated in the presence of ionic liquid was unable to detect potassium levels. Since ionic liquid is the main component of the artificial cardiac cell in its current configuration, the ion sensor will not function properly in the polymer gel cell. As a result, hydrogels were investigated as a potential solution as the foundation of the gel cell due to their hydrophilic nature. Through extensive literature search, various recipes for hydrogels were found and among these a promising hydrogel was chosen for its ability to incorporate polypyrrole throughout. Future research will therefore examine the potential use for the ion-selective sensor in hydrogels by creating a sensor that incorporates the hydrogel and then testing its ability to measure potassium levels in the hydrogel foundation.

In an urban landscape, stormwater flows rapidly across land surfaces and arrives at a system of catch basins and pipes or stream channels, often in concentrated bursts of high discharge. This leads to severe downstream flooding, seepage of reemerged stormwater, and erosion of receiving waterways. This study examines the performance of stormwater management controls in decreasing the peak discharge and delaying the time to peak flow of stormwater runoffs from parking lots and roads. The impact of a stormwater control measures (SCM) was analyzed to better understand its functions, limitations, and possible drawbacks of in the role of controlling stormwater movement and restoring catch basins and creeks around these impervious areas. Three storm events were monitored over a one month period at a biofilter installation at Charlottesville High School in Charlottesville, VA. Two monitoring sites were equipped with ISCO Flow Meters and Portable Samplers; one located at the SCM inflow from the parking lot and the other in a pipe at the outflow down to the football field. With data collected from the Flow Meters, hydrographs for both inflow and outflow sites and analyzed for any relationships that upstream and downstream might have in system performance. In first two storms, there was total reduction in total volume and peak flow and complete delay in time to peak discharge flow because no discharge was recorded in the outlet flume. However, in the last storm, the outflow demonstrated a reduction in total volume and peak flow and in a delay in time to peak discharge flow, validating the effectiveness of the bioretenction filter. One factor that might have enhanced the effectiveness of the bioretenction filter might have been due to 14 days of antecedent dry days before the rainfall on July 10th compared to one day in between the data collected on July 10th to the 12th and July 12th to the 14th. Due to lack of storm events and many factors that can alter results, no relationship between the intensity of the storm and the efficiency of the bioretenction filter could be measured.
This experiment was conducted to demonstrate the effectiveness of a Cooperative Adaptive Cruise Control (CACC) algorithm created by Joyoung Lee at the intersection consisting of two-lane, two-way roadways. The system will control the vehicles to either decelerate or accelerate, but never come to a stop near the intersection. The network was tested with Vissim, a simulation program that measures road data utilizing the variable of inputted vehicle amounts to the network. The experiment will show the incremental steps of vehicle inputs of the four approaches to the intersection and correlate the optimum flow to the car counts the signal will be able to handle. The experiment will show the threshold for the total number of vehicles that will be able to travel through the intersection unimpeded.

The goal of this project is to design and fabricate an autonomous robotic manta ray based on biological data. A robot that resembles this creature would enable use in a wide range of marine research without disturbing the natural environment. A skeletal model of the wing was created through the use of rapid prototyping technology. The undulatory flapping motion of a manta ray’s wing was recreated with a combination of mechanical and electronic actuation of the wing skeleton. When placed under water, the actuation should produce a thrust that will propel the robot. The anticipated outcome of these tests will confirm the notion that undulatory motion is an efficient method of swimming. The results may be useful in developing autonomous underwater vehicles and other tools related to the field of marine biology.
Although much work has been done to try and eliminate the formation of soot in gas turbine engines, very fine particles (10-100 nm) are still formed. This research focuses on modeling the precursors to soot formation, such as benzene rings, in the hopes that understanding soot precursors might help eliminate them and in turn reduce soot formation. The importance of this research lies in two distinct and important sectors. First, soot is the result of unburned fuel and hence soot reduction would mean increased engine efficiencies. Secondly, soot reduction would mean the reduction of pollution, a major worldwide problem. The first part of the modeling process consisted of being able to control the combustion of fuel and thus the formation of soot particles under atmospheric pressure. In order to fine tune the process, cartridge and furnace heaters were used in combination. Testing for the desired temperature profile yielded useful information which was used to better the rig. A computational model was also developed to simulate the temperature profile in the incolnel tube. This was done using both transient and steady state assumptions; as well as constant heat and constant flux boundary conditions. Finally, a FORTRAN computer program was used to model steady laminar one-dimensional premixed flames. This program reports the species and temperature profiles in the premixed flow as it is heated. Once this part of the modeling process is achieved, continuing research will work to create and validate high pressure scenarios (25-50 atm). This will be done using a counter flow flame nested in a high pressure chamber. Fuel-rich premixed flows (equivalence ratios of 1-2) will be heated under controlled conditions to optimize the formation of soot particles. Then a laser and a light refraction method will be used to measure the size and number of soot particles present in the flow.

Biofilters are an increasingly common best management practice (BMP) solution used in stormwater management. To ameliorate the runoff from an adjacent parking lot and residential area with a combined 4-acre drainage area at Charlottesville High School, a biofilter was installed in 2010. Prior to the installation of the biofilter, the stormwater from the parking lot ran directly to a nearby creek without passing through any constructed treatment. In addition to the reduction of stormwater flow, the biofilter was designed to improve the water quality before the stormwater reaches nearby waterways. Using an ISCO automatic event sampler at the inflow and outflow pipes of the biofilter, water samples were collected from three storm events. The flow at the outflow pipe during the first two storms was not high enough to trigger the sampler, thus removal of pollutants such as nitrates and phosphates was one hundred percent. In the third storm, both samplers were triggered and after an analysis for nitrates and phosphates, it was found that mass loads of pollutants at the inflow greatly exceeded the mass loads at the outflow, indicating improvement in water quality. There are improvements in the turbidity of the water samples from the outflow as compared to the ones from the outflow, also indicating that the biofilter is effective to some extent in improving water quality. In the storm where outflow data was acquired, the biofilter had a 92.5% removal efficiency for nitrates and a 95.4% removal efficiency for phosphates. This shows a high level of performance for the installation; however, more events need to be monitored under more conditions to determine the true effectiveness of the biofilter.
Department of Computer Science

“Tracking Height and Location throughout a Home with Ultrasonic Distance Sensors”
Raymond Dawson, Timothy Hnat & Kamin Whitehouse, PhD
Department of Computer Science
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The umbrella project of my research is the development of a smarthome that can adapt its operation to suit people currently within the home. An important aspect of this system is the use of ultrasonic distance sensors to uniquely track individuals as they traverse the house. We first defined the hardware usage goal of the sensors to be the reliable and accurate tracking of an individual through a doorway. This can be achieved by capturing a data envelope as a person walks through a doorway that shows a ramp up in height data as the person walks toward the sensor, a peak as they are directly under it, then a ramp down as they walk away. The next step was to identify which aspects of the sensor would positively influence this goal the most. Although testing is still ongoing, preliminary results show three key aspects to accurately identifying the home’s occupants: the amount of sensing area available to detect a person, the rate at which the sensor can be triggered to gain more data points, and the amount of power used in the ultrasonic transmissions to reduce interference between adjacent devices. A product that satisfies these requirements is currently unavailable commercially; thus, development of a custom circuit was required. At the end of its development, the complete smarthome project aims to completely automate mapping and power consumption of an entire home through tracking and usage algorithms, thus reducing its energy footprint.

Department of Mechanical & Aerospace Engineering

“Flame-Acoustic Interactions in the Counter-Flow Field”
Te-Rique Barney, Brendyn Sarnacki & Harsha Chelliah, PhD
Department of Mechanical & Aerospace Engineering
University of Virginia, Charlottesville, VA

Replication of a combustion system in which “singing flames” are heard is done to model the phenomenon known as “flame-acoustic interactions”. The frequency of the traveling waves within a nozzle is a function of the length of the nozzle the flame burns in. Ultimately, ways to quiet the noise can be found by altering the length of the nozzle, which would create standing waves within the nozzle and nullify the noise. The experiment includes a counter-flow setup in which pre-mixed air and nitrogen gas blow against premixed methane gas (fuel) and nitrogen gas, and is then ignited. Results so far show that a decrease in frequency (and thus an increase in audible noise) is due to changes in three experimental controls: increases in nozzle length, decreases in the air-to-fuel ratio, and decreases in the mass-flow rate of the gases. Increasing length creates longer wavelengths, shorter frequencies, and thus louder noises depending on other parameters. Increasing fuel (methane gas) produces hotter flames and stronger heat waves that add to the amplitude of the acoustic waves. Additional nitrogen nullifies combustion capabilities for safety purposes, and higher flow rates alter the position of the sitting flame within the nozzle for counter-flow setups. Higher sample rates, before reaching the Nyquist frequency, produce more accurate data acquisition of pressure-acoustic wave frequencies for which to perform Fast Fourier Transforms (FFTs). Expected results also show that pressure increases would also decrease the frequency within the nozzle. If the expected results are accurate, and further data acquisition and analysis is done, then (with knowledge of the magnitude of the heat levels the flame will dissipate within the nozzle, the change in the equivalence ratio as fuel is consumed, and the other mentioned parameters) computation of formulas for which we can alter either the flow-rate or nozzle length (the variables) automatically within combustion systems can occur to obtain and maintain minimum noise levels. Successful application of this phenomenon would have many uses, including the prevention of instabilities in many combustion systems, premature rocket explosions due to interference with sensitive equipment, and loud engine noises in luxury cars due to large sound waves.
A reliable way to have advanced warning of a pending earthquake could minimize damage and potentially save lives. A variety of theories have been proposed for detecting earthquake indicators, but none have yet given consistent warning. Many theories involve the properties of the earth’s surface when it is stressed and compressed.

This experiment explores the electrical discharge phenomena that can occur when rocks break. At the point of fracture, a charge difference builds up between the sides of the crack, resulting in a spark. These sparks may turn the oxygen in the surrounding air into ozone, which could be detected. This experiment put samples of common granite and basalt under pressure until they fractured. A quadrupole mass spectrometer (QMS) was used to detect gas molecules around the rock samples as they were crushed. In the work done thus far, ozone was not reliably detected. To test the sensitivity of the detector, a Tesla coil was used to create ozone gas. These tests showed that the RGA was not effective at detecting ozone gas, probably due to the long inlet capillary length and the unstable nature of ozone. Future work will employ a dedicated and sensitive ozone detector as well as additional rock types to determine if ozone is created and detectable when the rocks are broken.

Experimentation with nanofibrous scaffolds which mimic the extracellular matrix of various tissues is a thriving area of tissue engineering. It can be duly noted that working on the nanoscale is spreading throughout the research community. The motivation to provide nanoscale cues to cell guidance for tissue regeneration is due to the effect on nanoscale dimensions of cell communication channels. The cell conducts information to the outside world through ion channels which exist on a nanometer scale. To mimic the extracellular matrix, nanofibers are aligned through the stretching and repulsion forces caused by electrospinning. Electrospinning has become the method of choice for making nanofibers because of its simple set-up, versatility and high throughput efficiency. Here we compare and contrast the effects of spinning poly(D,L-lactic-co-glycolic acid) (PLGA) fibers at different mandrel speeds. We use 0 rpm as a control and then vary the degree of alignment of each scaffold to include 2000 rpm, 6000 rpm and 7000 rpm. Fibroblast cells were then seeded onto the four different scaffolds and monitored closely to determine the cell morphology, which includes elongation patterns and angular deviation of the cells. The experiment aims to determine the minimum degree of alignment required to guide cell morphology and its dependence of size of the nanoscale cue. Although there are many other aspects in working with cell seeding on nanofibrous scaffolds, we believe that the knowledge gained through experimentation with scaffolds of varied rpm is one step forward in the integration of such scaffolds into the specific architecture of the extracellular matrix.
We are reaching the physical limit on how much smaller transistors can be fabricated. Many factors contribute to the limits on scaling of MOSFETs. One limit addressed in this research is the dopant variation in current silicon devices. As MOSFETs become smaller, controlling the location and concentration of dopents becomes an issue. As transistors approach the nano scale, the conventional method for changing the conductivity of silicon channels on the transistor becomes less accurate and less consistent. In order to change the conductance of silicon devices by addition of organic molecules, the chemists in the research group synthesized different organic compounds to test on the devices. A MOSFET test structure is then fabricated in the cleanroom to evaluate the behavior of the organic molecules. Once the fabrication is done, the structure of the device is analyzed to confirm the design. The Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM) are used for imaging the test structure prior to electrical measurements. Devices are tested before and after molecular deposition to observe the effect the molecules have on the conductance of the devices.

The objective of this research was to tabulate Q-factors for wavelength-multiplex fiber optic communication systems for varied parameters such as the modulation frequencies and number of optical filters in the system. Because of the difficulty associated with setting up a physical fiber optic network, previous research has produced MATLAB model for the dispersion of signals in time and frequency in optical fibers. To this model, optical, Butterworth filters are added with their number being a parameter of the system. The system is then put through a photo detector, an electrical filter, and a sampling switch, the effects of which are modeled by the MATLAB program. The quality-factor (Q-factor) is a measure of the effect of two signals on each other. Specifically, it is the ratio of the decrease in signal strength through the system over the original signal strength. With the MATLAB code, the Q-factors are tabulated for a series of parameters. These Q-factors will be used in future fiber optic communication research at the University of Virginia to develop algorithms to cancel the distortion and interference that exists in fiber optic communication systems.
Dielectrophoresis (DEP), allows for highly selective trapping of bio-particles and nanostructures based on the characteristic frequency response of the dielectric permittivity of material versus medium. We aim to overcome current limitations by optimizing electric field geometries of constriction-based DEP in microfluidic systems, to enhance the electric field gradient over the net electric field intensity, and thereby enhance DEP trapping forces over dissipative electrothermal forces. Experiments were performed to determine the ability to selectively manipulate bio-particles (cells, DNA and proteins) and nanostructures (nanotubes and nanowires) in fluids and at localized fluid/surface interfaces, within media of a wide range of conductivity. We used a theoretical approach to simulate the electrical field and gradients for various constriction and electrodeless dielectrophoresis geometries. This method will be of fundamental use too many applications in biomedicine and nanoelectronics to determine the ability to selectively manipulate bio-particles such as DNA, cells and proteins in fluids.

Luncheon
Wilsdorf Cafe
12:00pm—1:15pm

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Research Scientists, Research Associates, Research Assistants, Graduate Students, Undergraduate Students & Professor Rosalyn Berne
Department of Electrical & Computer Engineering

“Software for the Identification of Organization Names and Countries Corresponding to IP Addresses”
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Department of Electrical & Computer Engineering
University of Virginia, Charlottesville, VA

The Department of Energy deploys a hybrid network, ESnet, in order to support two independent services: an IP based service for normal traffic and a dynamic circuit service for extremely large file transfers. However, ESnet is not able to fully utilize both services because it lacks a control structure that determines when and/or how to redirect large file transfers to the circuit service. This research project is in support of an overall DOE-funded project to develop a new prototype system, the Hybrid Network Traffic Engineering Software (HNTES) system, which will enable such redirection. A reverse IP-lookup software module is required, which determines the name of the owning organization and its country for each IP address encountered in flows monitored by the HNTES system. Design and implementation of this software module is the primary objective of this REU research project. This program reads in the output of another component on HTNES, in the form of a file containing the IP addresses carried in flows, and looks up the organization that owns each of these IP addresses as well as the country they are located in. It uses the “whois” command supported by Linux systems. The software then populates a MySQL database with the information obtained for each IP address that is then used by another component of the HNTES system. The program was successfully integrated into the overall HNTES system, and functions as expected. The IP-lookup program is an important part of the software because it provides users of HNTES additional information that is not directly discernible from IP addresses. On a larger scale, this software will greatly improve efficiency of network usage for ESnet and other comparable networks since redirecting larger flows to circuits will allow for the IP service to be operated at higher occupancy levels. This software could also be used by other government or private organizations that regularly transmit extremely large files.

Department of Electrical & Computer Engineering

“Investigation of Active Layer Thickness in Poly(3-hexylthiophene):6,6-Phenyl C61-Butyric Acid Methyl Ester Organic Solar Cells”
Ellen Reifler, Kejia Li & Joe Campbell, PhD
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As we use more energy as a society, there is a greater need to become less reliant on non-renewable energy sources such as oil (especially considering that oil resources are waning). One promising renewable energy source is solar energy, harnessed by solar cells. For the last few decades numerous types of solar cells have been created, researched, and tested, including solar cells made of organic polymers. Organic solar cells are cheaper and easier to fabricate than other solar cells (like silicon), but organics currently have efficiencies of 7.9%, while silicon boasts an efficiency of 25.0%. In the hopes of increasing efficiency and one day being able to cheaply manufacture solar cells for consumer use as a viable source of renewable energy, more in-depth research of organic solar cells must occur. In order to further understand the mechanisms within organic solar cells, poly(3-hexylthiophene):6,6-phenyl C61-butyric acid methyl ester (P3HT:PCBM) bulk heterojunction organic solar cells were examined in this study. P3HT:PCBM solar cell devices were fabricated using a 45:55 P3HT:PCBM ratio with active layer (P3HT:PCBM) thicknesses of 71.5nm, 117.3nm, and 171.2nm, and were then tested for their current-voltage (IV) responses under illumination and under dark conditions. From the IV curves, short-circuit current, open circuit voltage, fill factor, and efficiency were determined. The 71.5nm active layer thickness device produced the highest efficiency, 1.2%.

Part of the reason the active layer thickness effects efficiency is because of exciton (an electron-hole pair created when a photon from sunlight excites an electron in the solar cell) recombination. Future work to be done to further the understanding of recombination in organic solar cells is to measure the mobilities of the holes and electrons within the P3HT:PCBM. This can be done by fabricating an organic field effect transistor (OFET) with a silicon substrate, insulator, and P3HT:PCBM as the semiconductor. From the slope of the IV curve obtained with this device, the hole mobility and electron mobility in this material can be determined.