WILLAMETTE UNIVERSITY

SCIENCE COLLABORATIVE RESEARCH PROGRAM

FRIDAY, SEPTEMBER 11, 2015

FORD 122

Science Collaborative Research Program
Willamette University Symposium

September 11, 2015 * Ford 122

2:00 - David Craig - Welcome

2:15 - Taylor Ostrander - Internal Torque Partially Accounts for Proprioceptive Acuity (Luke Ettinger Lab)

2:30 - Makayla McKibben & Sawyer Rogers - Progress Towards Characterization of Pre-Transition Droplets in Liquid-Liquid Binary Systems (J. Charles Williamson Lab)

2:50 - Lara Zetzsche & Caleb VanBuskirk - Purification of Isoprene Synthase from *Campylopus introflexus* (Alison Fisher Lab)

3:10 - Sophia Wax & Carlo Gangan - Synthesis of Heteroaromatic Tetracaine Derivatives to Enhance Binding Affinity in Cyclic Nucleotide-gated Ion Channels (Sarah Kirk Lab)

3:30 - Kristian Barajas - Understanding Combination Modes in Multimode Variable Stars (Rick Watkins Lab)

3:45-4:10 BREAK & GROUP PHOTO

4:10 - Hana Busse Hopkins - Framboidal Pyrite Evidence for Prolonged Anoxic and Sulfidic Ocean Conditions Following the End Permian Mass Extinction, Nanpanjiang Basin, South China (Katja Meyer Lab)

4:25 - Amanda Stratton - Mercury(II) Inhibits and Denatures Chymotrypsin: Are Histidine Side Chains Involved? (Todd Silverstein Lab)

4:40 - Kulananalu Tarnas - The Photolysis of Halogenated Estrogens in Aquatic Environments (David Griffith Lab)

4:55 - Peter Warrick - The Effects of Plasma Shielding on Single Pulse Laser Ablation Experiments (Michaela Kleinert Lab)

5:10 - Eric Samelson -An Algebraic Perspective on Voting for Committees (Erin McNicholas Lab)

5:25 - Taylor Heckman & Kathryn Herr - Sugar Coat It: *Caulobacter crescentus'* Defense Mechanism Against Bacteriophage CR30 (Melissa Marks Lab)

5:45 - Tyler Welch - Improving Shallow Water Model using Adaptive Data Assimilation Scheme (Haiyan Cheng Lab/LARC)

Taylor Ostrander **2:15**
Internal Torque Partially Accounts for Proprioceptive Acuity
Mentor: Luke Ettinger
Department of Exercise Science

Shoulder proprioception describes self-awareness of limb position in space in the absence of visual feedback. Common methods for measuring proprioception of the shoulder include; joint position sense (JPS) tasks and kinesthetic time to detection tests. Previous findings indicate that the shoulder demonstrates maximal sensitivity to position sense at 90° of elevation in the sagittal plane. Previous investigators have speculated that this linear increase in proprioceptive acuity coincides with the increase in internal joint torque through 90° of elevation. Here we measured shoulder JPS in several conditions. In this study, we explored the effects of internal torques on the shoulder, aiming to quantitatively determine the extent to which torque accounts for linear changes in proprioceptive acuity at various angles of elevation. To manipulate the internal torque experienced at the shoulder, we exposed participants to a neutral internal torque environment through aquatic submersion and increased external torque through addition of weights. Results from our study indicate that in the absence of internal torque, on average participants demonstrated 3.5° greater proprioceptive error than in the control and weighted conditions $p<.05$. These findings indicate that internal torque alone does not account for proprioceptive acuity by target elevation angle, rather this torque may be integrated with intrinsic coordinate systems which give information of angular position.

This work was completed as part of the Willamette University Science Collaborative Research Program and supported with generous funding from the Mary Stuart Rogers Foundation.

Makayla McKibben & Sawyer Rogers **2:30**

PROGRESS TOWARDS CHARACTERIZATION OF PRE-TRANSITION DROPLETS IN LIQUID-LIQUID BINARY SYSTEMS

Mentor: J. Charles Williamson
Department of Chemistry

Liquid-liquid binary systems and their phase equilibria have been extensively studied and are important for many industrial applications. The Williamson lab works to accurately determine liquid-liquid phase transition temperatures to ±0.01 °C using laser light scattering techniques. Recently, anomalous behaviors have been observed near the critical regions of seven different binary systems. On one side of the phase diagram, droplets appear to separate from the mother phase ~0.1 °C before bulk phase separation, which suggests that two different phase transitions are occurring. This would imply the existence of a third phase in systems that were previously considered to form at most two. A new instrument was designed and built with the intent of physically collecting these pre-transition droplets for characterization. This instrument can accommodate 100-mL samples and can stabilize temperature to ±0.01 °C. Small angle and 90° laser light scattering are measured at two heights within the sample so it can be determined whether droplets move up or down in solution. The prototype system chosen for droplet collection is aniline + cyclohexane, chosen because its critical temperature of 30.00 °C is just above room temperature. Twenty-two 3-mL samples were prepared to map the aniline + cyclohexane coexistence curve via the synthetic method using pre-existing instrumentation. Preliminary phase transition temperature data are consistent with literature values. Sixteen 3-mL samples of phenol + water were also prepared to look for pre-transition droplets in a water-based system.

This work was completed as part of the Willamette University Science Collaborative Research Program and supported with generous funding from the Mary Stuart Rogers Foundation.

Lara Zetzsche & Caleb VanBuskirk **2:50**

PURIFICATION OF ISOPRENE SYNTHASE FROM *CAMPYLOPUS INTROFLEXUS*

Mentor: Alison Fisher
Department of Chemistry

Isoprene (2-methyl-1,3-butadiene) is the most abundant volatile organic compound produced by plants. Isoprene participates in the formation of ozone in the troposphere (lower atmosphere) and increases the half-life of the greenhouse gas carbon dioxide. In isoprene-emitting plants, isoprene is produced enzymatically by isoprene synthase (ISPS). The protein sequences of a number of ISPSs from angiosperms (flowering plants) have been deduced; however, an understanding of the evolutionary significance of isoprene production in land plants requires sequence information from evolutionarily distant plant species. Mosses diverged from angiosperms 400 million years ago, and more than 50% of mosses emit isoprene. The Fisher lab previously identified and characterized the first moss ISPS from cell-free extracts of heath star moss (*Campylpus introflexus*). This summer we purified ISPS from *C. introflexus* 48-fold via ion-exchange and gel filtration column chromatography. Purified protein fractions were submitted to the shared proteomics facility at OHSU for partial sequence analysis by liquid chromatography/tandem mass spectrometry (LC-MS/MS). Numerous peptide sequences with amino acid similarities to known isoprene or terpene synthases were identified. These sequences will be used in a homology-based RT-PCR strategy to clone the ISPS from *C. introflexus* and ultimately obtain the protein sequence of this novel enzyme.

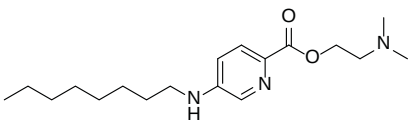
This work has been supported by the Willamette University Science Collaborative Research Program and supported with generous funding by the M.J. Murdock Charitable Trust.

Sophia Wax & Carlo Gangan **3:10**

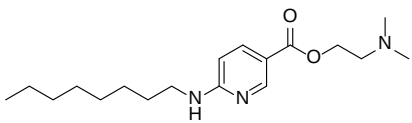
Synthesis of Heteroaromatic Tetracaine Derivatives to Enhance Binding Affinity in Cyclic Nucleotide-gated Ion Channels

Mentor: Sarah Kirk
Department of Chemistry

Retinitis Pigmentosa is a degenerative eye disease that results in the gradual loss of eyesight due to the destruction of rod and cone cells within the retina. One cause of this disease is a mutation in cyclic nucleotide-gated (CNG) ion channels, found in rod cells, which results in unregulated calcium transport eventually leading to cell death. Past research has explored potential CNG ion channel blockers as a treatment, specifically modifying the scaffold of Tetracaine, an FDA approved local anesthetic. Recent studies of tetracaine derivatives have shown that attaching electron withdrawing functional groups to the aromatic ring increase the molecule's binding affinity. In this project, synthetic methods were developed for the novel compounds nicotinic octylcaine and picolinic octylcaine to observe how an electron withdrawing substituent located within the aromatic ring, and the subsequent reduction in size, effects CNG binding affinity. Additionally, altering the location of the nitrogen within the aromatic ring was explored. Various synthetic routes were investigated in an attempt to optimize yield and reproducibility of the desired derivatives.



picolinic octylcaine



nicotinic octylcaine

This work has been supported by the Willamette University Science Collaborative Research Program and supported with generous funding by the Murdock College Research Program for Natural Sciences - Physical Sciences Grant.

Kristian Barajas **3:30**

Understanding Combination Modes in Multimode Variable Stars

Mentor: Rick Watkins

Department of Physics

Pulsating variable stars change their brightness over time due to intrinsic fluctuations in their size and temperature. While most of these stars pulsate at a single frequency, some stars pulsate at two or even three frequencies simultaneously. Understanding the amplitudes and phases of modes that arise from the interaction between the independent frequencies, known as combination modes, can provide us with a window into the interior processes of the star. We attempted to model the interaction between the independent modes as nonlinear terms in the equations of motion. We tested our mathematical model by analyzing data from a variety of multi-mode pulsating stars and showed that the amplitudes of the combination modes behave as the model predicts. Our model also predicts the phases associated with the combination modes. When we analyzed the difference between the measured and predicted phases and plotted it against the frequency of the combination mode we found a linear relationship. This unexpected finding may provide an important clue for developing a deeper understanding of these fascinating stars.

This work has been supported by the Willamette University Science Collaborative Research Program and supported with generous funding by the the Mary Stuart Rogers Foundation.

Hana Busse Hopkins **4:10**

FRAMBOIDAL PYRITE EVIDENCE FOR PROLONGED ANOXIC AND SULFIDIC OCEAN CONDITIONS FOLLOWING THE END PERMIAN MASS EXTINCTION, NANPANJIANG BASIN, SOUTH CHINA

Mentor: Katja Meyer
Department of Environmental & Earth Science

Abundant evidence for anoxic and sulfidic ocean conditions and the loss of over 90% of marine species are likely linked through rapid climate warming at the end of the Permian Period, the time of the largest mass extinction of Earth history (~252 Ma). Similar marine geochemical changes are predicted today as a result of climate warming due to increasing atmospheric CO_2. In this study, we examine the extent of anoxic and euxinic (anoxic and sulfidic) conditions in the Nanpanjiang Basin of S. China during the end Permian and Early Triassic recovery interval using framboidal pyrite size distribution and $\delta^{34}S$ isotope analysis. Size distribution analysis of over 1900 pyrites suggests there is evidence for local euxinia at the basin margin from the Late Permian into the Middle Triassic. These results expand the evidence for euxinia into the Middle Triassic locally and are consistent with available global geochemical proxy data. We also demonstrated that SIMS $\delta^{34}S$ isotope analysis of individual framboids is possible for grains as small as 3 μm. This high-resolution approach may further constrain the Early Triassic sulfur record in future studies.

This work was completed as part of the Willamette University Science Collaborative Research Program and supported with generous funding by the National Science Foundation's Research Experience for Undergraduates .

Kulananalu Tarnas **4:40**

The Photolysis of Halogenated Estrogens in Aquatic Environments

Mentor: David Griffith
Department of Chemistry

Halogenated estrogens are potent endocrine disrupting hormones that have been identified at concentrations >10 ng/L in wastewater treatment plant (WWTP) effluent. In order to better understand the fate of this understudied class of estrogens in aquatic environments, this experiment will examine their photolysis as a major potential pathway of removal. Since Griffith (2013) found monobromo-17ß-estradiol (monoBrE2) and dibromo-17ß-estradiol (diBrE2) to be two of the major halogenated species in WWTP effluent, this research focuses primarily on determining the photolytic rate of 17ß-estradiol (E2), and it's brominated forms, monoBrE2, and diBrE2. To do this, Effective, efficient analytical methods needed to be developed and necessary, preliminary photolytic information obtained. First, an HPLC-DAD gradient method was developed which successfully separated estrogen peaks from one another, producing chromatograms in <4 minutes. Second, a solid phase extraction method was developed with >90% yields for E2 and monoBrE2 and >80% yields for diBrE2, all with relative standard deviations of <10%. Finally, a semi-quantitative photodegradation experiment was performed, revealing no noticeable inter-degradation, minimal degradation of dark samples, and giving approximate time scales for the degradation for each compound. These preliminary steps have paved the way for a methodologically sound, quantitative photolysis experiment to be conducted for these estrogens.

This work was completed as part of the Willamette University Science Collaborative Research Program and supported with generous funding by the Mary Stuart Rogers Foundation.

Peter Warrick **4:55**

The Effects of Plasma Shielding on Single Pulse Laser Ablation Experiments

Mentors: Michaela Kleinert of the Department of Physics, and Jan Kleinert with Electro Scientific Industries

Laser ablation is the removal of material using a tightly focused, often pulsed, laser beam. The resulting melt, phase transitions, vapor dynamics, and the thermal conductivity of the material can be modeled using hydro- and thermodynamic equations. I will present experimental data as well as simulation results for copper using a 10-ns pulsed Nd:YAG laser at both 532 nm and 355 nm. From the experimental data, we can conclude that the thermodynamic models fail for the 532 nm light when the fluence exceeds 10 J/cm$^{2.}$ However, the models agree very well with the 355 nm light, even for high fluences. To understand this surprising result, we propose that inverse Bremsstrahlung heating in the plasma above the ablation site, which allows us to model the effective fluence reaching the surface after plasma shielding, is the cause of this discrepancy. This effect is much more severe for longer wavelengths, thus affecting 532 nm more and quicker than 355 nm.

This work was completed as part of the Willamette University Science Collaborative Research Program and supported with generous funding from the National Science Foundation.

Eric Samelson **5:10**
Co-Authors: Ian Calaway (Macalester College) and Joshua Csapo (University of Michigan-Flint)
AN ALGEBRAIC PERSPECTIVE ON VOTING FOR COMMITTEES
Mentor: Erin McNicholas
Department of Math

Voting theory is the study of the mathematical properties of various types of elections. In recent years, Donald Saari has successfully applied a geometric approach to voting theory by viewing votes in an election as vectors, which can then be manipulated in different ways. Algebraic voting theory uses results from group and representation theory to gain new insights into these structures. This talk will focus on a specific committee voting situation in which one of m representatives from each of n departments will be chosen. A significant obstacle in committee voting is the issue of separability. That is, a voter's preference for certain candidates may depend on the presence of other candidates in the committee. By decomposing our vector space into submodules and analyzing the effective spaces of linear transformations, we found that we can determine exactly which types of voter separability are preserved in a given voting procedure and used in the outcome of the election. Currently, this has only been analyzed for specific cases, but we believe it can extend to general m and n.

This work was completed as part of the Willamette Valley Research Experience for Undergraduates and Teachers and supported with generous funding by the National Science Foundation.

Taylor Heckman & Kathryn Herr **5:25**

Sugar Coat It: *Caulobacter crescentus*' Defense Mechanism Against Bacteriophage CR30

Mentor: Melissa Marks
Department of Biology

Viruses that infect bacteria, or bacteriophages, put adaptive pressure on bacterial communities, selecting for the more resistant phenotypes. A sugary extracellular polysaccharide (EPS) layer on the cell surface of *Caulobacter crescentus* wildtype strain NA1000 is responsible for increased resistance to bacteriophage CR30 as compared to the derived, non-EPS producing NA1000ΔMGE strain. This EPS production gives the cells an observable 'mucous-like' layer which may obstruct or conceal phage binding sites on the cell surface and result in a decreased adsorbance of phage. Four single-gene mutant *C. crescentus* strains of differing EPS production ("mucoidy") were tested against the original NA1000 and NA1000ΔMGE strains. Of these four strains, NA1000Δ3998, NA1000Δ469 and NA1000Δ471 are non-mucoid and demonstrate no observable EPS production, while strain NA1000Δ472 demonstrates an intermediate amount of EPS production. We quantified whether the presence of an EPS layer provides increased resistance to bacteriophage infection by obstructing adsorbance. Each strain was challenged with a fixed amount ϕCR30 and then assayed for phage adsorption. We found that non-mucoid strains had significantly higher phage adsorption than mucoid and intermediately mucoid strains. This indicates that even an intermediate amount of EPS secretion provides resistance to bacteriophage attack by blocking the binding of the phage to the bacterial cell surface.

This work was completed as part of the Willamette University Science Collaborative Research Program and supported with generous funding from the Mary Stuart Rogers Foundation.

Tyler Welch **5:45**

Improving Shallow Water Model using Adaptive Data Assimilation Scheme

Mentor: Haiyan Cheng

Department of Computer Science

Data assimilation in initial value problems models results in improved estimates of the state of actual physical systems by modifying the imperfect model states with observations of the actual state. We propose a model which adds steps to the Ensemble Kalman filter model of data assimilation. After assimilation, the distribution of ensemble members from before assimilation is compared with the distribution of members after assimilation using Kullback-Leibler distance (KLD). This value is used to change the frequency of assimilation. The proposed scheme is implemented on 2D Shallow water equation in MATLAB. Numerical results show that our model can achieve similar numerical accuracy with a lower runtime and fewer assimilations.

This work was completed as part of the Willamette University Liberal Arts Research Collaborative (LARC) Summer Research Program with generous funding from the Mellon Foundation.