WILLAMETTE UNIVERSITY

Science Collaborative Research Program

Symposium

September 19, 2014

Ford 122

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3:00 - Serena Meng & Austin Guimond - Slingshot is Required During Multiple Stages in the Development and Growth of Ovarian Follicles in *Drosophila*

3:20 - Jonathan Saunders - Characterization of Corticosterone Induced Electrophysiological Modulation of Hindbrain Neurons in Male Rough Skinned Newts, *Taricha granulosa*

3:35 - Michaelin Richards - Further Biochemical Charaterization of a Novel Isoprene Synthase from *Campylopus introflexus*

3:50 - Alycia Stuart - Optimizing Ablation Paramters for an Ultrafast Pulsed Laser

4:05 - Aran Johnson & Jonathan Hallsted - Stabilizing Extended Cavity Lasers to Create a Magneto-optical Trap for Rubidium and Calcium Atoms

4:25-4:45 BREAK & GROUP PHOTO

4:45 - Jackson Waite-Himmelwright - Yucca Moths Show a Breakdown of Host Specificity within Joshua Tree Hybrid Zone

5:00 - Malia Santos & Furey Stirrat - Joshua Trees' Population Expansion: A Study Through Demographic and Genetic Lenses

5:20 - Ruvim Kondratyev & David Livingston - Numerical Experiments on Improving Particle Filter Performance

5:40 - Jessica Kawana - Veto Interval Graphs

5:55 - Emily Weatherford - Determination of the Methanol + Carbon Disulfide Liquid-Liquid Phase Diagram

Serena Meng & Austin Guimond

Slingshot is Required During Multiple Stages in the Development and Growth of Ovarian Follicles in *Drosophila*

Mentor: Jason Duncan
Department of Biology

Regulation of the actin cytoskeleton is critical for many developmental and cellular processes in eukaryotes. We identified a novel mutation in the *Drosophila slingshot* (*ssh*) gene that indicates its activity is required for the development and formation of follicles during oogenesis. The ssh gene encodes a protein phosphatase that dephosphorylates the Actin Depolymerizing Factor (ADF)/Cofilin, a potent regulator of microfilament dynamics in the cell, resulting in their breakdown. We examined the ovaries of female *Drosophila* harboring a unique mutant allele of the ssh gene, ssh^{WU6}, as well as other independently derived *ssh* alleles including ssh^{01207}, ssh^{39}, ssh^{1-11}. Stage 5 follicles lacking ssh activity appeared indistinguishable from wildtype egg chambers, exhibiting a normal morphology that included a correct number of nuclei, nurse cells, and ring canals. Stage 10 follicles lacking ssh activity, however, exhibited phenotypes consistent with defective microfilament regulation. Although *ssh* mutant stage 10 follicles exhibited the correct number of nuclei, follicles were observed to have 'floating' and/or degenerate ring canals and evidence of nurse cell fusion. The severity of these phenotypes directly correlated with the reduced level of ssh activity, achieved by selective genetic combination of mutant ssh alleles of different strength. Collectively, these results indicate a requirement for ssh activity in the development and growth of late stage follicles during oogenesis in *Drosophila*.

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, and the M.J. Murdock Charitable Trust.

Jonathan Saunders

Characterization of Corticosterone Induced Electrophysiological Modulation of Hindbrain Neurons in Male Rough Skinned Newts, *Taricha granulosa*

Mentor: Emma Coddington
Department of Biology

Corticosterone, a stress hormone, has been shown to rapidly suppress male courtship behavior in male *Taricha granulosa* through a specific membrane bound receptor, mCR. Binding of corticosterone to mCR causes a suppression of activity in medullary and reticulospinal neurons linked to courtship. Although a causal argument tying the depression of activity in these neurons to suppression of clasping courtship has been made, the intracellular and membrane changes mediated by mCR resulting in depressed electrical activity are poorly understood. This project will directly test the depressive effects of corticosterone through a combination of whole-cell electrophysiological and pharamacological manipulation. Ion channels will be selectively disabled or stimulated through artificial changes in cellular voltage and current, and the introduction of chemicals known to manipulate those channels. Elucidating the mechanism of action of corticosterone could potentially explain its short term modulation of contextual behavior due to an acutely stressful event, as well as its complex interactions with other hormones and peptides like Vasotocin. I will be presenting methodology and recent findings.

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

Michaelin Richards
Co-Author: Taylor Gee

Further Biochemical Charaterization of a Novel 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 and, as such, largely impacts the chemistry of our atmosphere. In many plants, an isoprene synthase (ISPS) enzyme catalyzes the production of isoprene from dimethylallyl diphosphate (DMADP). Substantial research has been done on ISPSs from angiosperms (flowering plants). Researchers in the Fisher Lab at Willamette University have identified and partially characterized the first bryophyte ISPS from the moss *Campylopus introflexus* (heath star moss). Over the summer, we continued the biochemical characterization of the *C. introflexus* ISPS. Maximal enzymatic activity was observed at a pH of 8.6 ± 0.5, which is similar to other known ISPSs. The C. introflexus ISPS expressed a higher affinity for DMADP than most angiosperm ISPSs, as indicated by the relatively low K_M for DMADP of 0.49 ± 0.28 mM. Similar to previously studied ISPSs, *C. introflexus* ISPS demonstrated a requirement for a divalent metal ion in order to function properly. Unlike other ISPSs, the C. introflexus ISPS exhibited a preference for Mn2+ rather than Mg2+, indicated by a KM of 9 ± 3 mM for Mg^{2+} and a K_M of 5 ± 3 mM for Mn^{2+}.

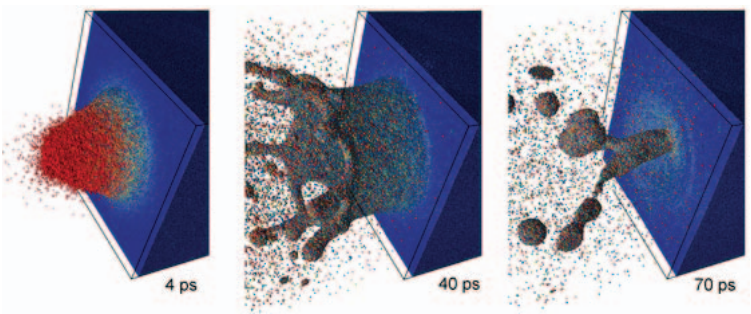
This work has been supported by the Willamette University Science Collaborative Research Program and supported with generous funding by the M.J. Murdock Charitable Trust.

Alycia Stuart

Optimizing Ablation Paramters for an Ultrafast Pulsed Laser

Mentor: Michaela Kleinert
Department of Physics

Although utilizing high-powered lasers for precise material processing has been a standard industrial practice for many years, only recent advancements have made it possible to push pulse duration from the nanosecond regime to the picosecond and femtosecond regimes. Within the field of laser ablation, these advancements allow for higher pulse intensities and less heat transfer to the area surrounding the ablation site thus improving the efficiency and precision of laser drilling. However, laser technology has advanced so rapidly that data for the picosecond regime have not been sufficiently studied. The laser in my lab is capable of 11 picosecond pulses with an average peak intensity of ~8 Watts and a repetition rate between 200 kHz and 4 MHz. Since this project was still in its initial stages when I began my research, I will enumerate on the measures I took to get the project ready for data collection and discuss preliminary laser and ablation data as well as their implications. I will elaborate on the effects of modifying pulse repetition rate, pulse power, pulse duration for materials of varying thermal conductivity. Finally, I will conclude with the future of this project and its potential use for laser drilling and microstructuring.



This work has been supported by the Willamette University Science Collaborative Research Program and supported with generous funding by the Willamette University Hewlett Grant.

Aran Johnson & Jonathan Hallsted

Stabilizing Extended Cavity Lasers to Create a Magneto-optical Trap for Rubidium and Calcium Atoms

Mentor: Michaela Kleinert
Department of Physics

Prof. Kleinert's ongoing research program focuses on the cooling and trapping of rubidium and calcium atoms, and the subsequent formation of cold RbCa molecules via a process known as photoassociation. These dimers find potential applications in ultracold chemistry, precision spectroscopy, quantum computation, and quantum cryptography, and have never been created in the lab before. Since they are not stable at room temperature, cooling the atoms to milliKelvin temperatures before the molecule is formed is essential. In order to optimize this process, rubidium and calcium atoms must be loaded from a magneto-optical trap into a conservative trap, an optical dipole trap. To optimize the transfer into this trap, we spent the summer improving the frequency and pointing stability of the rubidium and calcium laser systems by adding aluminum plates around the extended cavity diode lasers. We further optimized the rubidium laser system by including mechanical and acousto-optical switches to control the laser beams with millisecond precision, and coupling the lasers into fiber optical cables to ensure pointing stability. All the individual components have been tested and characterized, and we are now ready to bring them together to trap, for the first time, rubidium and calcium atoms together and form RbCa molecules.

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

Jackson Waite-Himmelwright

Yucca Moths Show a Breakdown of Host Specificity within Joshua Tree Hybrid Zone

Mentor: Chris Smith
Department of Biology

Plant pollinator relationships played a central role in the evolution of terrestrial life. The immense diversity of angiosperms is widely thought to be a result of their specialized pollination systems. However, the exact mechanisms by which this relationship might generate diversity remain unclear. Obligate pollination mutualisms, where one insect is the sole pollinator of a species of flowering plants can provide insight into the mechanisms by which co-evolution may promote speciation. One such relationship is the interaction between Joshua trees (*Yucca brevifolia*) and their yucca moth pollinators. Across their range, Joshua trees are associated with two species of pollinator, *Tegeticula synthetica* and *T. antithetica*, and trees associated with each moth are genetically and morphologically distinct. At one site, Tikaboo Valley, the two pollinators and their associated trees occur in sympatry, forming a hybrid zone that serves as a natural laboratory for our work. We use sticky traps, floral morphology data, and PCR genotyping to examine the moth's host specificity. Our findings show that within the zone of sympatry both moths show a reduced level of host specificity, but may select hosts based on specific features of floral morphology, particularly style lengths. This finding supports previous work suggesting selection for phenotype matching between style length and ovipositor length.

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 .

Malia Santos & Furey Stirrat

Joshua Trees' Population Expansion: A Study Through Demographic and Genetic Lenses

Mentor: Chris Smith
Department of Biology

Global climate change is predicted to affect the distribution of many organisms through both regional extinctions and range expansions. We examined the population ecology of Joshua trees (*Yucca brevifolia*) in and around the Pahranagat range in Nevada. Using empirical demographic and population genetic studies, and simulations of demographic and range changes under various environmental conditions, we evaluated evidence that Joshua Trees are expanding their range in response to climate change. Although demographic data suggest an excess of seedlings along the northern edge of the range, simulations suggest that this pattern is not necessarily indicative of population expansion. Analysis of population genetic data produces mixed results, providing some evidence of population expansion, but these were not statistically significant in all analyses. Additional data and analytical approaches may be needed to determine the effects of climate change on Joshua Trees.

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

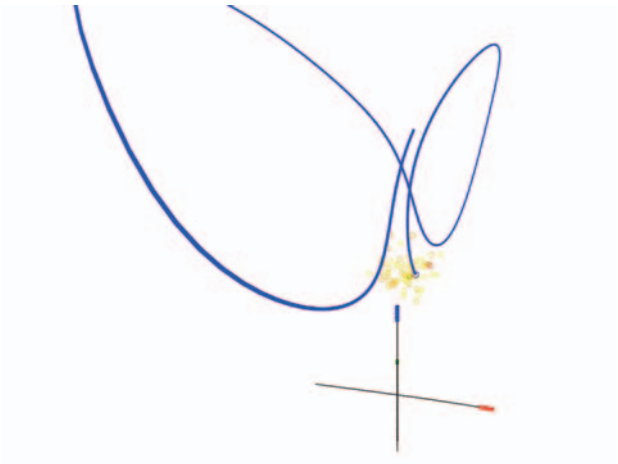
Ruvim Kondratyev & David Livingston

Numerical Experiments on Improving Particle Filter Performance

Mentor: Haiyan Cheng

Department of Computer Science

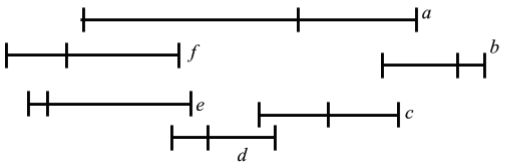
Particle filtering (PF) is a numerical method used to improve the forecasted complex system state by adjusting the states based on the discrepancy of the forecasts and the observations, where both forecasts and observations contain numerical error. Our research aims to improve particle filter efficiency through the following: 1. implement an on-the-fly adaptation of the particle ensemble size through KLD sampling; 2. implement a hybridized particle filter by introducing the Particle Swarm Optimization (PSO) into the particle filter. Numerical tests for PF-PSO on the Lorenz-63 model give promising results. There is a small run-time cost to PSO, but there is also reasonable accuracy improvement. The PSO algorithm is particularly useful for scenarios with sparse observation frequency.

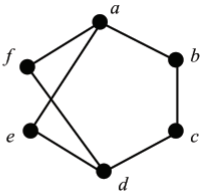


This work was completed as part of the Willamette University Science Collaborative Research Program and supported with generous funding from the National Science Foundation.

Jessica Kawana
Co-Authors: Dana Lapides and Stephanie Partlow
VETO INTERVAL GRAPHS
Mentor: Josh Laison
Department of Math

Given a set S of intervals on the real line, we can construct a graph with a vertex for each interval in S, and an edge between two vertices if and only if their corresponding intervals intersect. Conversely, given a graph G, G is an interval graph if it has such a representation. We define a variation of interval graphs called veto interval graphs, where each interval contains a veto mark, and two intervals do not count as intersecting if either contains the veto mark of the other. We explore properties of veto interval graphs and their relation to other classes of geometric intersection graphs. No previous knowledge of graph theory will be assumed.





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.

Emily Weatherford

Determination of the Methanol + Carbon Disulfide Liquid-Liquid Phase Diagram

Mentor: J. Charles Williamson
Department of Chemistry

Characteristics of liquid-liquid interactions are utilized for the extraction of impurities in a variety of settings, from undergraduate organic chemistry labs to the petroleum industry. Some of these characteristics can be mapped on a binary liquid-liquid phase diagram, which show the miscibility of two compounds. An excellent system to study the fundamental interactions of two liquids on a phase diagram is carbon disulfide and methanol (CSM). A set of twenty-six CSM samples with varying mole fractions were created and their phase behaviors were observed using elastic laser light scattering techniques. The resulting coexistence curve appeared asymmetric on the CS2 heavy side and had a T_{max} of 39.92±0.08 °C with a composition at T_{max} of X_{MeOH}=0.3041±0.0002. Furthermore the data from opalescent scattering indicates a critical composition of X_{MeOH}=0.38923±0.00009. This incongruity between compositions would suggest the presence of a contaminant. When the coexistence curve was fit with an equation accounting for impurity, a critical temperature of 35.3±0.4 °C and a critical composition of X_{MeOH}=0.38±0.007 were identified, both aligning with previous studies of this system and the opalescent data. In conclusion, there was an impurity present on the CS2 heavy side of the coexistence curve, suggesting a contaminant in the CS2.

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.

Cover image: Jonathan Saunders
Photo credit: Gabrielle James