Science Collaborative Research Program
Willamette University Symposium
September 22, 2017
Ford Hall 122

… to provide selected undergraduate
Students the opportunity to work directly
with faculty in the natural sciences…

Cover Image: nasa.gov/apod/image/1406/hud2014_1280.jpg

Symposium on Science Collaborative Research Program
September 22, 2017
2:00-6:30 PM
Ford Hall, Room 122

Students from the 2017 Science Collaborative Research Program (SCRP) will present their work at our 22nd annual in-house symposium on undergraduate research. Students giving individual presentations have a total of 15 minutes with the expectation of around 12 minutes to deliver their prepared remarks followed by 2-3 minutes of questions. Student groups of two have 20 minutes total time and groups of three are allowed 25 minutes. You are welcome to join us for all presentations or any portion that fits your schedule and interests.

This symposium is a particularly great time for students interested in science to learn about the exciting and high caliber original research conducted by their peers in collaboration with faculty mentors. Likewise faculty, staff, and administrators can quickly learn about the most recent discoveries and scholarly progress of the research programs led by their co-workers in Olin, Collins, and Ford. The central importance of faculty-student scholarship is a well-established tradition at Willamette and is prized as one of our highest impact practices in training students for careers and lives of meaning.

This symposium contributes to Willamette's mission as we affirm that, "Teaching and learning, strengthened by scholarship and service, flourish in a vibrant campus community." We are also enacting Willamette's strategic plan, which pledges to improve overall student experience by, "Supporting an intellectual culture that includes more opportunities for student-faculty and student-student scholarly engagement across all academic disciplines in studios, laboratories, and the field, as well as in more informal settings."

In reviewing our symposium please note the diversity of research topics and the range of faculty and student participants across the Departments of Biology, Chemistry, Computer Science, Environmental and Earth Sciences, Exercise Science, Physics, and Psychology. Please also note much of the funding for the work you will see today stems from external grants awarded to faculty who have competed nationally to secure resources to support these students. Finally the program owes much to the historical support of programmatic grants from the MJ Murdock Charitable Trust and an endowment gift from John Rogers and the Mary Stuart Rogers Foundation.

If you would like to learn more about the Science Collaborative Research Program at Willamette University please contact SCRP co-directors David P. Craig (dpcraig@willamette.edu) or Chuck Williamson (jcwillia@willamette.edu) and or visit our website (http://willamette.edu/cla/additional-academic-oppo4rtunities/scrp/index.html).

Schedule of Speakers

2:00 PM..... David Craig – Introductions

2:05 PM.....Anya Romig

2:20 PM.....Jessenia Chavez

2:35 PM..... Brandon D. Kennedy

2:50 PM.....Alice Fontaine & Grace Graham

3:10 PM..... Derek Lund & Paige Yeakle

3:30 PM..... Claire DeAngeli

3:45 PM..... Till Kallem & Makayla McKibben

4:05 PM.....Break and Photo with Frank Miller

4:25 PM.....Reid Milstead

4:40 PM..... Elisabeth Simonovich

4:55 PM.....Brighton Sier

5:10 PM..... Terae Jones Jr.

5:25 PM.....Miles Smith

5:40 PM..... Sarah Peery

5:55 PM..... Theo Humphreys, Juan Marquez, & Dane Tippett

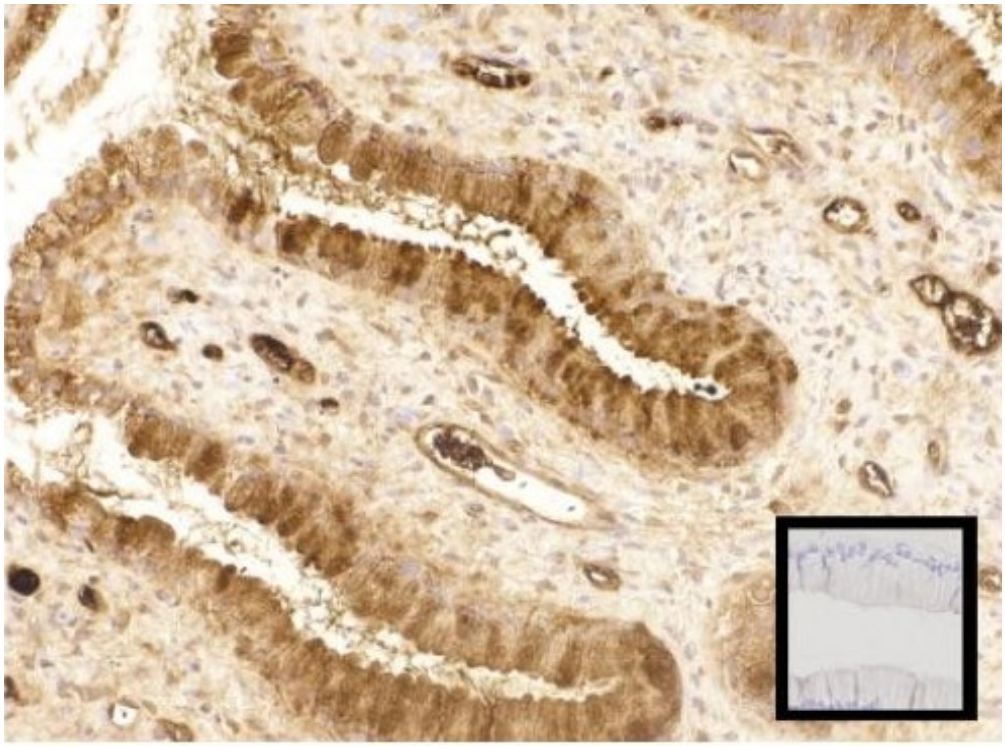
6:20 PM.....Conclusion

Jessenia Chavez

Characterization of CLCA1 in the Primate Cervix

Advisor: Ov Slayden, PhD, Oregon Health & Science University
Funding: M. J. Murdock Scholar Program

Use of hormone-based contraceptives can result in serious risks such as stroke, heart attack and contraceptive failure. Safer and more reliable contraceptives are needed. Ion channels in the cervix mediate mucus fluidity. The Chloride Channel Accessory 1 protein (CLCA1) is present in the cervix and is a potential candidate target for non-steroidal contraception. However, development of CLCA1 is inhibited due to the lack of information regarding its expression. In this study, we characterized the regulation of CLCA1 in the macaque throughout the menstrual cycle. Macaques are menstruating nonhuman primates with menstrual cycles identical to women and serve as excellent animal models or contraceptive development. Cervical tissue from rhesus macaques was isolated by microdissection and analyzed via RT-qPCR. Localization of CLCA1 was performed on paraffin sections by immunohistochemistry. We report that CLCA1 within the cervix is regulated by the presence of estrogen and progesterone. CLCA1 was most abundance at the time of ovulation, a period in which women are most fertile. Furthermore, CLCA1 levels increased during the follicular phase of the cycle, as estrogen levels increase, and decrease during the luteal phase of the cycle as progesterone levels increase. CLCA1 was localized to the cervix epithelium and lamina propria within cervical tissue. We conclude that blockade of CLCA1 could reduce mucus fluidity and prevent sperm passage and therefore become a contraceptive. Further development of CLCA1 could produce non-steroid based contraceptives that are more effective and less harmful than current methods.



Claire DeAngeli

Synthesis and Testing of Novel Tetracaine Derivatives as Potential Local Anesthetics

Advisors: Sarah R. Kirk and Jeffery R. Kirsch, MD, Oregon Health & Science University

Funding: Murdock College Research Program for Natural Sciences -Physical Sciences Grant, Department of Anesthesiology & Perioperative Medicine, Oregon Health & Science University

48% of postoperative patients experience pain during the first seven days of their recovery.[1] Local anesthetics (LAs) are utilized to combat this pain and provide patients with higher levels of post-surgery comfort and to decrease the use of narcotic pain medications. LAs act as voltage- gated sodium ion channel blockers in the neuronal tissues in which they are injected. When the transportation of Na^+ ions across the neuron membrane is inhibited, the electrical potential traveling up a peripheral nerve to deliver a pain signal to the brain is prevented.[2] The focus of this project is to synthesize a LA that will prolong duration, and minimize cytotoxicity. Our lab has synthesized several compounds that have potential as LAs including Amide Tetracaine. We modified Tetracaine, an FDA approved LA, to contain an amide linkage in place of the ester linkage via a two-step synthesis (86% yield).[3] Previous studies confirm the amide linkage is hydrolyzed at a slower rate than the ester linkage, which is suspected to lead to prolonged analgesic effects.[3] This Amide Tetracaine compound is tested in rats via a single, percutaneous injection into the perineurium space of a sciatic nerve, and is compared to a known LA. The rats undergo mechanical withdrawal testing with von Frey filaments, and the sciatic nerve is extracted post-mortem for pathological analysis to assess cytotoxicity and neural damage.

Preliminary testing indicates the Amide Tetracaine is effective as a LA nerve block.

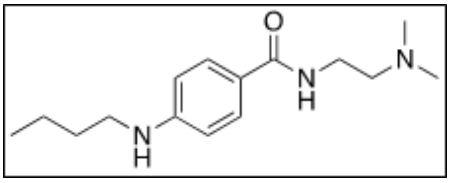


Figure 1. Amide Tetracaine derivative**.**

[1]Rosén, H. I., Bergh, I. H., Odén, A., & Mårtensson, L. B. (2011). Patients´ Experiences of Pain Following Day Surgery - At 48 Hours, Seven Days and Three Months. *The Open Nursing Journal* 2011, 5, 52–59. http://doi.org/10.2174/1874434601105010052

[2]Gadsden J. Local Anesthetics: Clinical Pharmacology and Rational Selection. NYSORA. http://www.nysora.com/local-anesthetics-clinical-pharmacology-and-rational-selection (accessed Sep 10, 2017).

[3]Kirk S.; Andrade A.; et al. “Cyclic Nucleotide-Gated Channel Block by Hydrolysis-Resistant Tetracaine Derivatives” (2011). J. Med. Chem. 2011, 54, 4904–4912

Alice Fontaine & Grace Graham

Role of climate warming and the biological pump in end-Permian ocean anoxia

Advisor: Katja Meyer
Funding: SCRP Rogers

The end-Permian mass extinction coincided with a period of rapid climate warming, high atmospheric CO_2 concentrations, and widespread ocean anoxia and euxinia. Ocean deoxygenation has previously been linked to greenhouse gas-driven changes in the carbon and nutrient cycles, but the extent to which temperature alone impacted ocean anoxia remains uncertain. Past studies have found that a rise in sea surface temperature will accelerate the metabolic activity of heterotrophic bacteria, which will increase the demand for oxygen and alter the depth at which it is consumed. Here, we used the cGENIE Earth system model of intermediate complexity with an end-Permian configuration to quantify the impact of warming on oceanic oxygen budget and distribution. We performed a series of simulations that incorporated a range of proposed atmospheric CO_2 concentrations and varying configurations of the biological pump. In an abiotic ocean, increasing atmospheric CO_2 reduces oxygen but does not lead to anoxia. Implementing a biological pump with a fixed remineralization profile causes a shallowing and expansion of the oxygen minimum zone (OMZ) with increased climate warming. In simulations that implement temperature-dependent remineralization in the biological pump, we observe similar OMZ changes but greater deep ocean anoxia. Overall, we find that the biological pump's sensitivity to climate warming shoals the remineralization depth and enhances the expression of both shallow- and deep-water anoxia.

Keywords: end-Permian, mass extinction, Earth system modeling, anoxia

Theo Humphreys, Juan Marquez, & Dane Tippett

Optics and Photonics Training for Inquisitive eXperimentalists (OPTIX): Improving optics education at Willamette and in the general Salem community

Advisor: Michaela Kleinert
Funding: NSF OPTIX

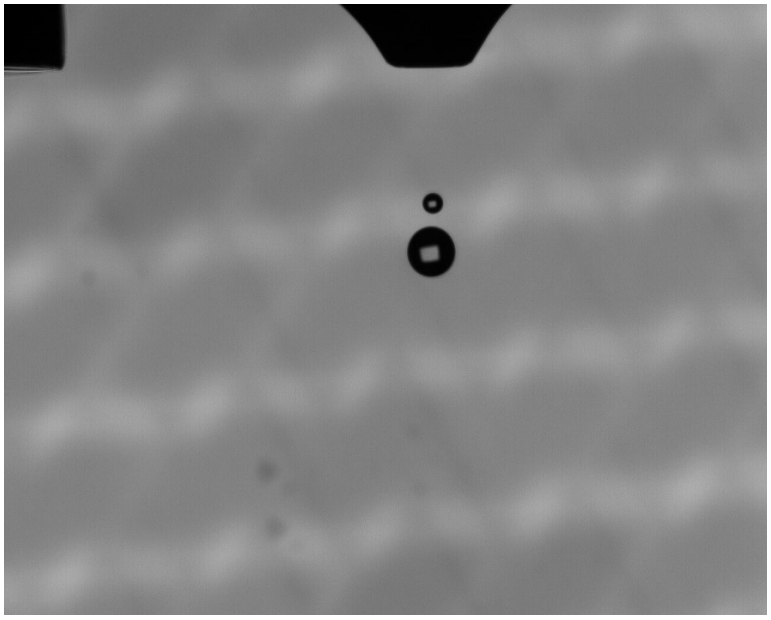
Through their NSF OPTIX grant, the physics department aims to develop innovative, hands-on laboratory experiences for Willamette University undergraduates, both in physics and biology, Chemeketa Community College students, and children who visit the A.C. Gilbert House Children's Museum. At Willamette, this grant has funded research-grade optical equipment to prepare physics students for their senior capstone research project and careers in STEM or related fields after their graduation.

This summer, we developed two biological optics lab modules for Willamette physics and bio-physics students; collaborated for two weeks with Chemeketa faculty and mentored Chemeketa Community College students in the field of optics using research-grade equipment that they otherwise would not have access to; and created simple optics lessons to educate children in and excited of the field of optics.

Terae Jones, Jr.
The Pilot-Wave Dynamics of Walking Droplets

Advisor: Daniel Borrero
Funding: SCRP Rogers

This summer I was responsible for building a Droplet on Demand (DOD) generator as part of the Pilot-wave Dynamics experiment. The importance of making this device is that within the experiment, consistent droplets need to be produced to give accurate results. I used the image from the Daniel M. Harris paper as a base for my generator. I gained skills in CAD programming as we used a 3-D printer to print off a good amount of the parts for the project. Once the DOD generator was made successfully, I was able to go on to more projects such as syncing a high- speed camera with the DOD and gathering images of the droplets. The end goal for this project is to make a system where I can bounce these droplets on a bath shaker consistently.



Till Kallem & Makayla McKibben

Impurity Effects on Liquid-Liquid Binary Systems

Advisor: Chuck Williamson
Funding: SCRP Rogers, American Chemical Society Petroleum Research Fund, 55088-UR10

Mixtures of two or more liquids, known as liquid-liquid systems, serve a prominent role in industrial applications such as petroleum extraction. While liquid-liquid binary systems have been well studied, the effects of impurities within these systems are less understood. This presentation addressed the partially-miscible aniline + cyclohexane (ACH) system and the effect of the addition of 2-picoline as an impurity. Stock aniline was doped with 12 mole percent and 16 mole percent 2-picoline before being combined with neat cyclohexane. Samples for each set were prepared at different ACH mole fractions via the synthetic method. Light scattering data were collected from samples in a 250 mL Dewar with a water bath for temperature control to 0.01 °C. The data were analyzed to determine the one phase / two phase transition temperatures of each sample (Figure 1). The coexistence curves were fit using a modified version of Simple Scaling Theory to find the critical temperature (T_C). Laser light intensities at 90° were analyzed to find the critical composition (X_C). As 2-picoline concentration increased, the value of X_C shifted to lower aniline concentration at a rate of 0.0027 per mole percent 2-picoline. The increase in 2-picoline concentration caused the value of TC to decrease at a rate of 1.00C per mole percent 2-picoline. The normalized change in XC with respect to TC for the three ACH systems was 1.8, in agreement with Jacobs's prediction. The phenomenon known as pre- transition droplet formation (PTDF) was characterized and showed identical behavior to PTDF in the pure ACH binary system.

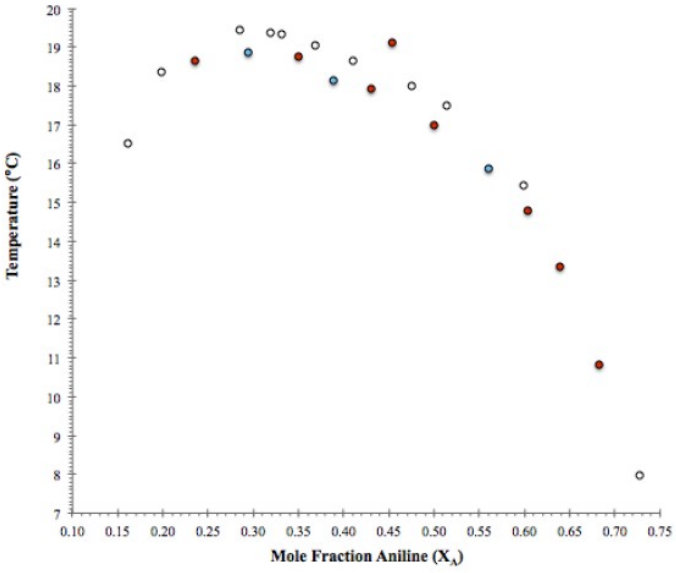


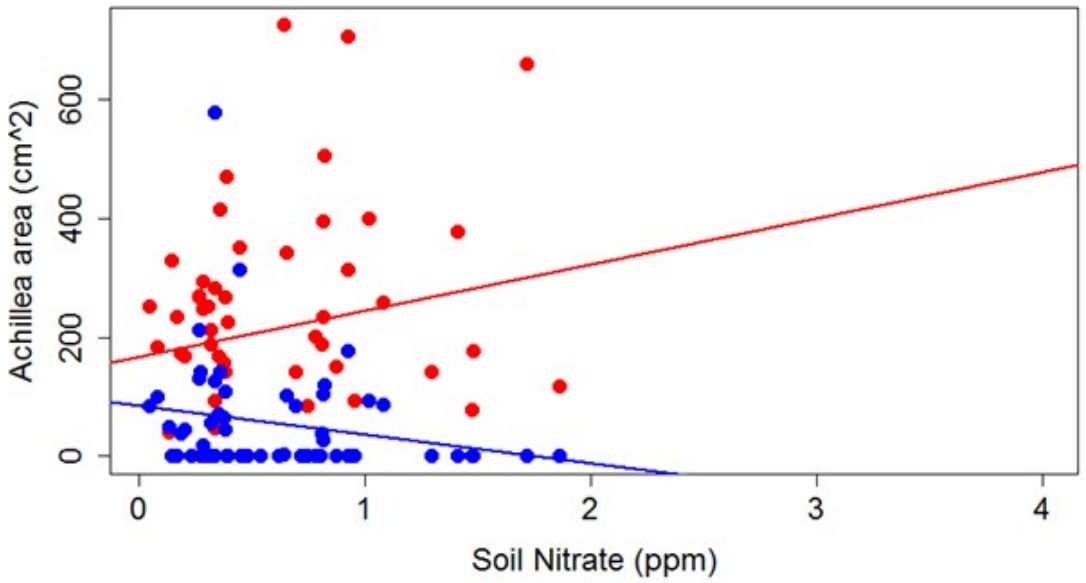
Figure 1. ACH coexistence curve with stock aniline containing 11.57 mole percent 2-picoline.
White points represent the first syringe fill of aniline + 2-picoline during sample preparation, red points represent the second fill, and blue points represent the third fill. Critical composition was determined to be 0.41803 and critical temperature to be 18 $_0$ C.

Brandon D. Kennedy
Ion Chromatography and Soil Nitrate Analysis

Advisor: Briana Lindh
Biology Endowment Fund

This project began with questions about how soil nutrients influence the growth of native prairie plants at Zena. Specifically, we focused on how nitrate and phosphate levels in the soil affect native plants and their interactions with invasive plants. Most of the summer project was spent developing a protocol to measure nitrogen and phosphorus in aqueous soil extracts using an ion chromatograph (IC). The final protocol was to put 10g of soil into 45mL of water, sonicate, centrifuge and filter before putting into the IC for analysis. The main analytes of interest were nitrate and phosphate.

Using the data on native *Achillea* transplants, we found that nitrate has a positive effect on plant growth without competition (p=0.1685) and a negative effect with competition (p=0.1144). These p-values are suggestive of significance, meaning that the invasive plants may use nitrate more efficiently than *Achillea,* outcompeting it in high nutrient plots. Soil depth was also investigated as a proxy for nutrient quality with data collected prior to this summer, but was found to not have a large effect on competition, likely because it is not the most accurate proxy for nutrient quality. The next step in this research is to experimentally alter levels of nitrate and phosphate with fertilizer and sugar addition and measure the effects on plants.

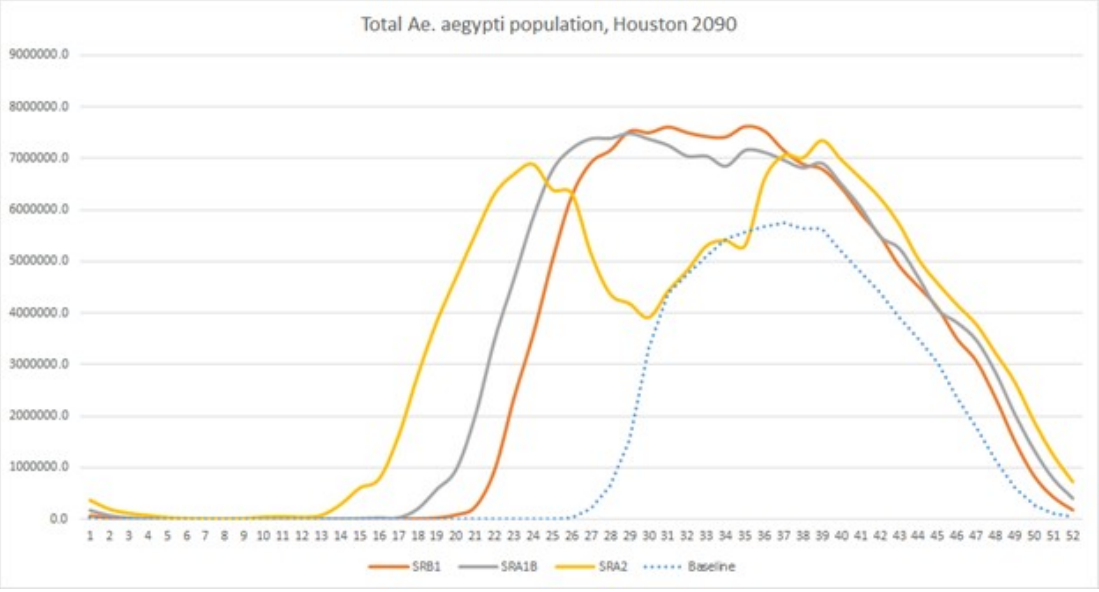


Derek Lund & Paige Yeakle

Climate change and dengue fever: A spatial and temporal analysis of dengue fever in six sites across the southern U.S.

Advisor: Melinda Butterworth
Funding: SCRP Rogers

Dengue fever is the most prevalent mosquito-borne disease, affecting an estimated 390 million people globally each year. Further, the virus has re-emerged in the southern United States after a 70 year absence. The dengue virus is transmitted by *Aedes* genus mosquitoes, a prevalent species in the southern United States. Transmission of the disease is known to be impacted by meteorological variables such as temperature and precipitation. As a result, climate change may impact the risk of dengue fever in the southern U.S. We examine this connection by using
LARS-WG5 (Rothamsted Research), a climate downscaling model to project future daily weather conditions under three different future emissions scenarios for six southern port cities. We then used this data to run the dynamic mosquito model DyMSiM, simulating potential mosquito populations and dengue case data for the 2020s, 2050s, and 2090s. Quantifying the potential increase or change in risk of dengue fever transmission can play an important role in informing public health policy.

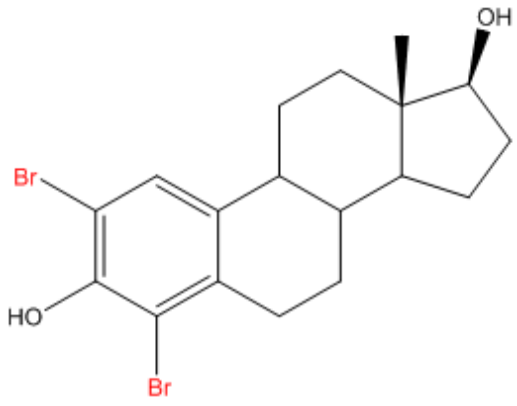


Reid Milstead

Photochemical Degradation of Brominated Estrogens

Advisor: David Griffith
Funding: National Science Foundation, SCRP Rogers

Halogenated estrogens are endocrine disrupting compounds that have been found at relatively high concentrations in treated wastewater. To improve our understanding of halogenated estrogen degradation in aquatic environments, we studied the direct and indirect photolysis of dibromo-17β-estradiol (diBrE2) under natural solar irradiance using a *p*-nitroanisole-pyridine actinometer. Photolysis experiments were conducted at pH 4 and pH 7 to explore differences in photolytic rates of the phenol and phenolate forms of diBrE2. Quenching experiments were conducted at pH 7 in order to quantify the contribution of several key photochemically produced reactive intermediates (PPRIs) to the indirect photolysis process. Our results suggest that at pH 7 diBrE2 degrades on time scales of hours due to higher molar absorptivity values of the more abundant phenolate form. At pH 4, diBrE2 degraded on time scales of days to weeks. Additionally, it was found that the PPRI with the most significant impact on the photolytic process was ^{3}DOM. Overall, our data suggest that halogenated estrogens are particularly susceptible to photochemical degradation at environmentally relevant pH values due to the red- shifted absorbance characteristics and highlight the importance of ^{3}DOM as a PPRI during indirect photolysis.



Sarah Peery

Galaxy Flows from the Cosmic Flows 3 catalog

Advisor: Rick Watkins
Funding: Murdock College Research Program for Natural Sciences -Physical Sciences Grant

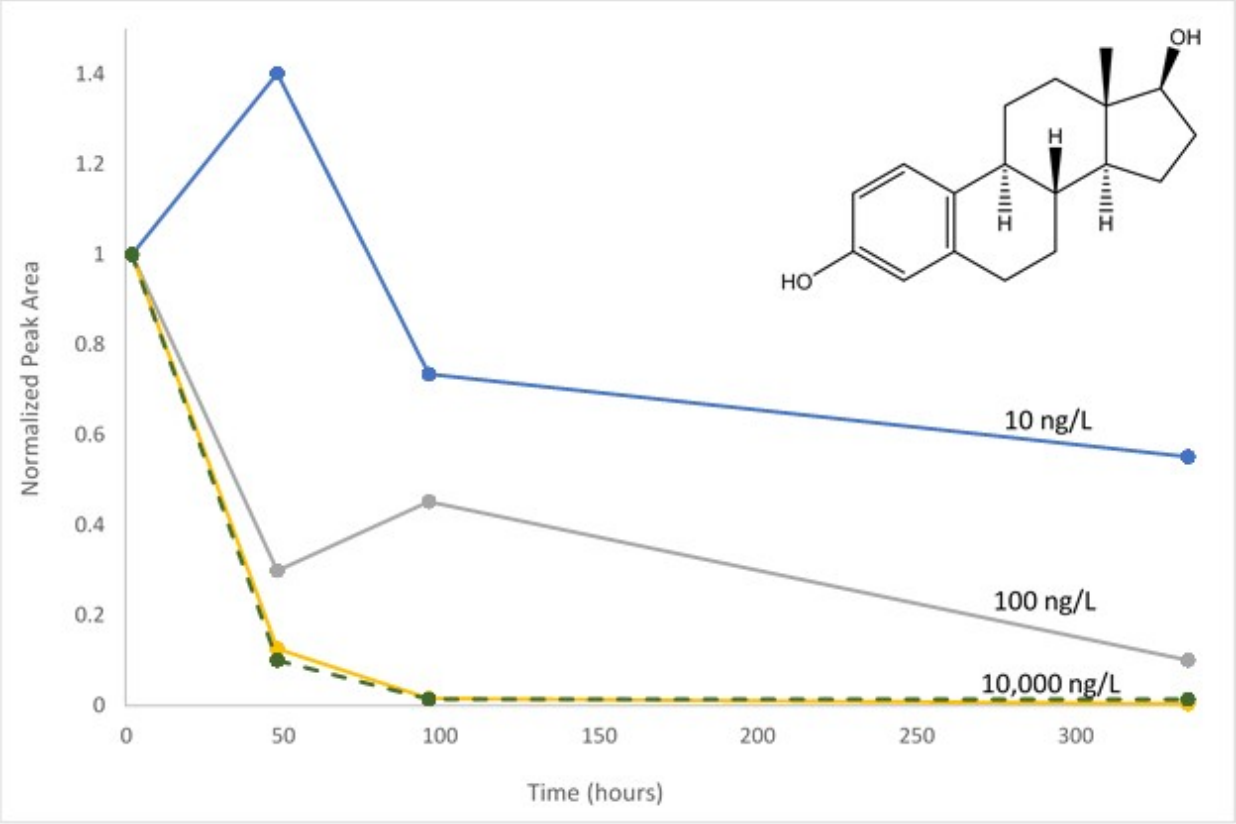
In this study we calculated the Bulk Flow as a weighted sum over the velocities of galaxies, using data from the cosmic flows 3 group catalogue. Bulk flows are useful in testing the standard cosmological model because they can be used to find the distribution of mass in the universe on large scales. The standard model says that the universe is uniform on the largest scales, so the average velocity should go to zero. We used bulk flows to find the scale on which this occurred and found that at 150 Mpc, the largest radius we used, the magnitude of the average velocity of galaxies remained close to 300 km/s with a $\chi 2$ value of 10.85. For three degrees of freedom the probability of finding a $\chi 2$ value and bulk flow that large or larger is only 1%, indicating tension with the standard model that requires further investigation.

Anya Romig

Examining the biodegradation of 17β-estradiol (E2)

Advisor: David Griffith
Funding: National Science Foundation, SCRP Rogers

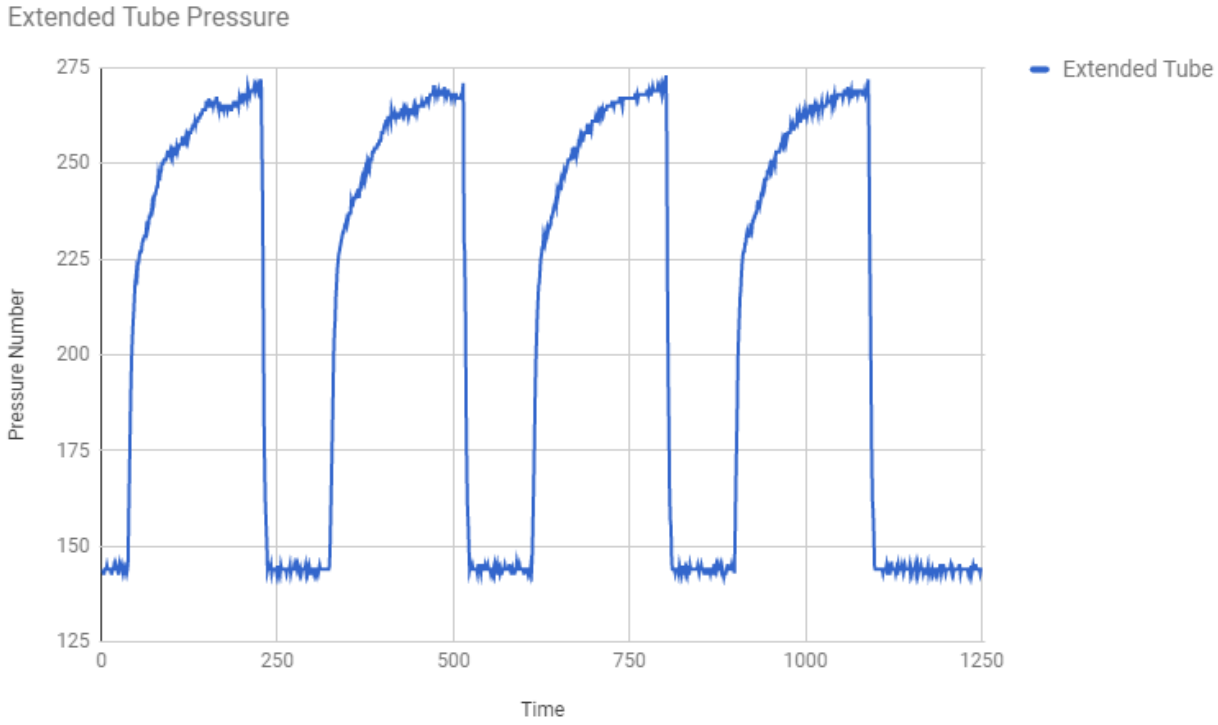
Estrogens are endocrine disruptors that can harm fish populations at concentrations as low as parts per trillion (ng/L). Many studies have sought to determine estrogen concentrations in wastewater effluent and receiving water bodies. Other studies have focused on characterizing removal processes such as sorption, photolysis and biodegradation. These latter experiments are typically conducted at unrealistically high (µg/L-mg/L) concentrations, which we hypothesized would underestimate biodegradation rate constants in most natural waters. In this batch biodegradation study, we determined the removal rates of 17β-estradiol (E2) over a wide range of concentrations (10, 100, and 10000 ng/L) in Willamette River water using solid phase extraction followed by liquid chromatography coupled to triple quadrupole mass spectrometry. Our preliminary results point to desorption of E2 from river sediments and suggest a relationship between higher E2 concentrations and increased rates of degradation.



Brighton Sier
Subcritical Transition to Turbulence in Taylor-Couette Flow

Advisor: Daniel Borrero
Funding: SCRP Rogers

My work this summer consisted of preparing the experimental apparatus that I will be using to conduct my thesis research. For my thesis, I am studying the subcritical transition to turbulence in Taylor-Couette flows. Taylor-Couette flows are flows created by the rotation of two concentric cylinders with a fluid-containing gap between them. By learning about the transition to turbulence in a controlled environment, information found to be true can be applied to other systems.. The actual work involved programming, fabrication, and optimization of apparatus. I first created a program which allows me to control a syringe pump through Python via an RS- 232 connection. This allows me to make consistent and repeatable flows that will be used for introducing perturbations into the Taylor-Couette system. I also wrote code that allows Python to communicate with an Arduino microcontroller. I am using the Arduino to control a valve that opens and closes to introduce perturbations to the Taylor-Couette flow and to monitor the pressure of the perturbations with a pressure transducer allowing me to achieve consistent perturbations. Lastly, I learned to use CAD software to design pieces that I printed with a 3-D printer. With the CAD software, I made pieces to modify the syringe pump to mount syringes in such a way that they are able to both inject and withdraw fluid. Future work will include refinement of the aforementioned apparatus and the collection of data to measure the effects of system size on the finite-amplitude thresholds for transition to turbulence.



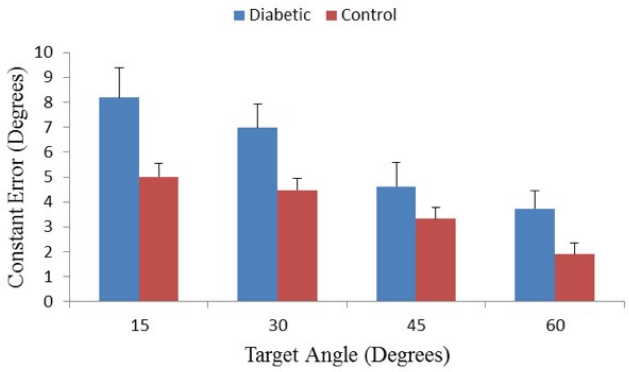
This figure shows replicable pressure data measured by pressure transducer.

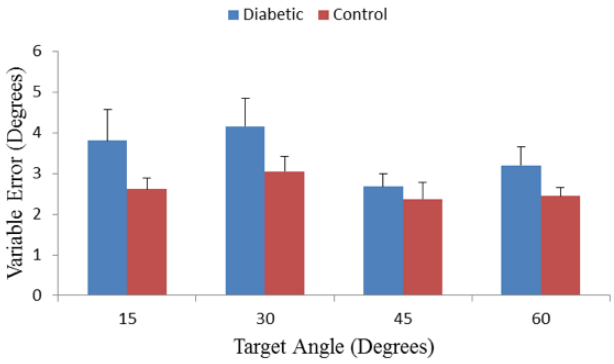
Elisabeth Simonovich

Diabetic Neuropathy Results in Reduced Proprioceptive Acuity in the Knee

Advisor: Luke Ettinger
Funding: SCRP Rogers

With the rising incidence of Type II Diabetes, understanding the signs and symptoms may be paramount in early detection, treatment, and prevention. Type II Diabetes is often associated with peripheral neuropathy, particularly affecting the lower extremity. There is paucity in the literature pertaining to biomechanical analysis of the neuromuscular imbalance in Diabetics. This objective of this study was to measure the extent of proprioceptive differences between individuals with Type II Diabetes and a control population. We measured knee joint position sense (JPS) from 46 participants: 23 diabetics and 23 controls. The diabetic population was matched for age, and gender and leg dominance with a control participant. We recorded knee extension torque and plantar flexor torque using a Biodex. For JPS measurement, an Apple iPod Touch was used to measure the proprioceptive data using a custom JPS application. Results of our two 2-way mixed effects ANOVA indicates significantly greater proprioceptive error in both accuracy and precision in Type II Diabetics versus controls. Further, results of our independent samples t-test indicate significant force differences for both knee extension and plantar flexion. This data indicates that Diabetic neuropathy may be measured non-invasively through JPS application.





Miles Smith

Analysis of Non-Gaussian Galaxy Velocity Distributions

Advisor: Richard Watkins
Funding: Murdock Charitable Trust

The Universe can be thought of as containing a gas of galaxies, Using the Doppler shift, we can measure whether a galaxy is moving toward or away from us, allowing us to gather information on how galaxies are moving. Using this radial component of velocity, we can build galaxy velocity distributions. These distributions are typically thought of as being gaussian; however, the tail regions of the distribution deviate significantly from a gaussian, due to some galaxies moving faster than anticipated. The high speeds are due to galaxies falling into and forming larger clusters of galaxies. Our research centers around categorizing the non-gaussian regions of the distribution and developing a method to accurately describe the velocities of these galaxies. This presentation details the development of our method, and discusses its effectiveness in modeling velocity distributions.

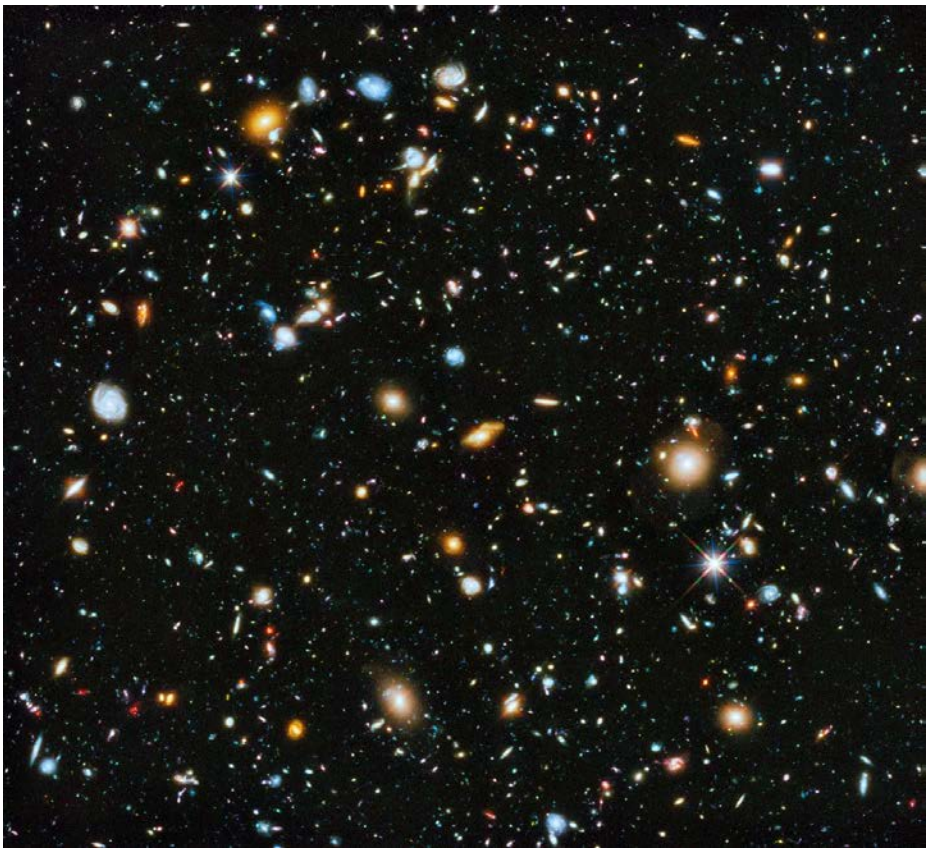


Image: nasa.gov/apod/image/1406/hud2014_1280.jpg