UNIVERSITY of WASHINGTON

Undergraduate Research Symposium May 19, 2017 Mary Gates Hall

Online Proceedings

Poster Session 1

Commons West, Easel 27

11:00 AM to 1:00 PM

Metabolic Burden Impacts of dCas9 Repression Networks

Elizabeth Hazel Glenski, Senior, Biochemistry
UW Honors Program
Mentor: James Carothers, Chemical Engineering
Mentor: William Voje

Recreating digital logic with cellular components has been a newly charted area of engineering research. This has applications in cellular diagnostics and expands our fundamental knowledge of cellular decision making processes. We tested a variety of digital logic systems of dCas9 repression networks in *S. cerevisiae* (yeast). dCas9 has be re-purposed to be a nucleus localized protein which function as a modular transcription factor, which when bound to specific guide RNA (gRNA) is directed to a distinct 20 base pair genomic sequence determined by the gRNA's target sequence. Understanding the activity of the dCas9+gRNA complex, allowed us to use gRNA with a particular sequence to repress the expression of other gRNA. Using this insight, multiple repression cascades have been made with varying complexities to build unique logic pathways, also known as Boolean Expressions. The expression of all gRNA and dCas9 proteins impact cell fitness because they divert carbon and energy for reproduction. The effects of metabolic load these exogenous components add to the cell is a factor that was investigated through cell growth. Cell growth was determined by fitting a logistic population model to a time-series of experimentally measured cell densities. We compared distinct strains of yeast with stable genomic modifications that explored the impact of increasing the network complexity and varying dCas9 expression levels. We anticipate the results to concur with this statement and realize that a gRNA+dCas9 complex may further increase the metabolic burden of the cell from off target repression. Realizing how dCas9 repression networks lead to metabolic load will help guide their applied use in cellular applications ranging from developing programs for crop species to gene therapies.

Session 1C

Sensory Integration, Learning, and Motor Control in Animal and Human Models

Session Moderator: Horacio de la Iglesia, Biology

MGH 231

12:30 PM to 2:15 PM

* Note: Titles in order of presentation.

Exploring the Neural Mechanisms of Perceptual Rod-Cone Flicker Cancellation

Adrianne (Adree) Aguas, Senior, Neurobiology
Howard Hughes Scholar, UW Honors Program
Mentor: Fred Rieke, Physiology and Biophysics
Mentor: William Grimes, Dept. of Physiology and Biophysics

Over the course of a natural day-night cycle, mean luminance levels can span ten log units or more. Mammalian retinas effectively encode visual information over this vast range, in part, by cone photoreceptors in bright conditions. These visual signals, regardless of their origin, must pass through a common set of retinal ganglion cells- thus creating opportunities for signal interactions. The overarching goal of this research is to understand how the retina behaves under intermediate lighting conditions (e.g. dawn and dusk) when both rods and cones are active, and to relate the circuit-level retinal processing of rod and cone signals to human perception. Previous human perceptual experiments have revealed interactions between flickering rod and cone stimuli that are thought to occur in the retina. Here we explore the neural basis of rod-cone flicker interference in On and Off ganglion cells that project to the primate magnocellular visual pathways. Our recordings (from *in vitro* non-human primate retina) reveal a strong, suppressive interaction between rod and cone signals. The dependence of this interaction on the frequency and phase of the temporal modulation is similar to that observed in perceptual measurements from human subjects. This destructive interference between rod and cone signals appears to reflect a linear combination of kinetically-distinct rod and cone signals upstream of the ganglion cell synaptic inputs. Using our empirically-derived data as a foundation, we construct a mathematical model that captures known rod-cone

interactions and accurately predicts retinal output in response to arbitrarily time-varying rod and cone stimuli.

POSTER SESSION 2

Commons East, Easel 81

1:00 PM to 2:30 PM

Curare and the Cortex: How Acetylcholine May Be Involved in Waking the Brain Up

Mckenna (McKenna) Donahue, Senior, Biology (Molecular, Cellular & Developmental)
Mary Gates Scholar
Mentor: William Moody, Biology

Spontaneous electrical activity in the mouse neocortex has been extensively studied. Two main types of activity are observed: synchronous waves and asynchronous single cell activity. This synchronous activity has been believed to be unique to the developing brain. This research project investigated whether the phenomenon is as much a property of sleep as it is development. Synchronous waves exhibit remarkably similar dynamics to the up-down oscillations of slow wave sleep. Conversely, asynchronous single cell activity is very similar in form to the "persistent up" or wakeful brain state. Thus, the two types of spontaneous activity generally observed in the mouse neocortex may actually be a sign of overall brain state, with asynchronous single cell activity dominating during states of wakefulness and synchronous waves taking over during sleep states. Calcium imaging of slices of neonatal mouse cortex has revealed that application of curare, an acetylcholine antagonist, decreases asynchronous single cell activity and induces synchronous waves. As blocking acetylcholine puts the brain in a state associated with sleep, we hypothesize that the neurotransmitter may be involved in keeping the brain awake. Further experiments were conducted on the effect of curare on synchronous waves. According to our hypothesis, it should increase their frequency and/or propagation. The same experiments were performed with other acetylcholine antagonists, such as mecamylamine, to ensure the observed effect is not unique to curare as a drug. We also conducted experiments with acetylcholine agonists as well to see if they have the opposite effect. These synchronous waves are known to be involved in several developmental neural processes, and this research project may reveal they are a property of sleep, and could serve as precursors to adult slow-wave sleep.

POSTER SESSION 2

Commons East, Easel 80

1:00 PM to 2:30 PM

***In Vivo* Spontaneous, Somatosensory and Sleep Waves in Developing Mouse Cortex**

Jenna Madison Metcalf, Senior, Neurobiology
Mary Gates Scholar, UW Honors Program
Mentor: William Moody, Biology

Spontaneous waves of electrical activity occur in many brain regions during early development and are critically important for many aspects of brain development. These waves are initiated primarily in the hippocampus and the piriform cortex and propagate throughout the neocortex during the first postnatal week. Most studies of spontaneous activity have utilized brain slice preparations and thus the properties of these waves *in vivo* are almost completely unknown. We are using calcium imaging in GCaMP transgenic mice to measure wave activity through the intact skull, which is transparent in neonatal animals. We have been able to measure cortical responses to somatosensory stimuli, and have detected widely propagating spontaneous waves similar to those seen in brain slices. We are now determining the developmental time course of spontaneous waves of activity and asking how they interact with responses to sensory stimuli. Preliminary results have shown a greater distance of wave propagation during sleep, implicating wave activity in the emergence of adult sleep-wake cycles. These experiments will determine, for the first time, the properties of spontaneous waves of activity *in vivo*, providing information about how sensory-driven and spontaneous activity cooperate to shape brain development

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SESSION 2R

ECOLOGY FROM MICROBES TO BIRDS

Session Moderator: Frieda B. Taub, Aquatic & Fishery Science

JHN 111

3:30 PM to 5:15 PM

* Note: Titles in order of presentation.

Mesograzer Density Reveals that Eelgrass (*Zostera marina L*) Grows More When Covered in Epiphytes

Hyejoo Ro, Sophomore, Aquatic & Fishery Sciences
Mary Gates Scholar, UW Honors Program
Abigail (Abby) Von Hagel, Junior, Pre-Sciences
UW Honors Program
Mentor: Sylvia Yang, SEA Discovery Center, Western Washington University
Mentor: William King, Biology

Eelgrass beds in the Salish Sea provide habitat for various organisms, including algal epiphytes and invertebrate grazers. The relationships amongst eelgrass, epiphytes, and graz-

ers are highly complex. Epiphytes have been shown to have a negative effect on eelgrass growth, and epiphyte removal by grazers has been shown to have a positive effect on eelgrass fitness. In some experiments, epiphyte and grazer presence has been shown to have a neutral effect on eelgrass. Therefore, in this study we examined the interactions between *Zostera marina L*, epiphytes, and a native marine invertebrate gastropod *Haminoea vesicula* to measure how these relationships impacted eelgrass growth as a proxy for performance. We collected specimens from two different locations with contrasting gastropod and epiphyte presence- Padilla Bay and Ship Harbor, Washington. We then conducted a series of density gradient experiments measuring dry epiphytic biomass loss under varying mesograzer densities to test whether mesograzers consumed epiphytes, and a follow-up mesocosm experiment to observe eelgrass performance among differing snail density treatments. Our results came to the surprising conclusion that mesograzer biomass and fecal deposits had no effect on eelgrass performance. Additionally, rather than negatively impacting eelgrass performance, the amount of epiphytic cover present on the eelgrass collected in the winter from Ship Harbor, Washington was associated with increased eelgrass growth. This suggests that in some situations epiphytes may not have a negative impact on eelgrass performance. This may have significant implications for eelgrass restoration and monitoring efforts in the Salish Sea.

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Development of Sulfide Depends on Type of Organic Material and Sediment Grain Size

Annalee Cappellano, Senior, Environmental Studies
Mary Gates Scholar
Kaylie Elizabeth Bazzano Carr, Senior, Aquatic & Fishery Sciences
Mary Gates Scholar
Rachel M (Rachel) Scott, Junior, Oceanography
Mentor: Sylvia Yang, SEA Discovery Center, Western Washington University
Mentor: William King, Biology

Organic matter, such as detritus, occurs naturally in marine sediments. However, anthropogenic activities, such as historical timber industry practices and nutrient enrichment (eutrophication) leading to algal blooms, have enriched organic matter in marine sediments, compromising the stability of benthic communities. Added organic material can facilitate microorganisms, which alter the chemistry of the water in marine sediment. This study focused on factors associated with the success of benthic anaerobic bacteria that reduce sulfate into sulfide, which can be detrimental to organisms living in and on the sediment. We investigated if wood or algae would be a more productive carbon source for sulfate reducing bacteria and if grain size, fine versus coarse, would affect the amount of sulfide produced by anaerobic bacteria. Sediment microbial communities were cultivated in a four-week long mesocosm experiment in which wood or algae carbon sources were mixed in fine or coarse sediment. We measured sulfide levels throughout the experiment to determine which treatments were most productive. We found that algae led to earlier and higher sulfide levels within four weeks, as compared to wood. Furthermore, fine grained sediment produced higher concentrations of sulfide, particularly in the presence of algae. Our findings suggest organic material in the form of algae, such as from algal blooms, is a more readily available source of carbon for sulfate reducing bacteria. Future research could extend the timeline of an experiment to investigate what sulfide levels may be produced with wood in sediment.

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3:30 PM to 5:15 PM

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Eelgrass Origin Affects Performance in Warm Water

Malise Yun, Senior, Pre-Sciences
Mary Gates Scholar
Josephine Marie Melanie (Gigi) Gaultier, Junior, Aquatic & Fishery Sciences
Mentor: Sylvia Yang, SEA Discovery Center, Western Washington University
Mentor: William King, Biology

Eelgrass (*Zostera marina*) meadows provide important habitat to waterfowl, invertebrates, and fishes and are the focus of restoration efforts in Washington State. Given the variation in water temperatures of different Pacific Northwest eelgrass habitats, we investigated how water temperature of source locations could affect how the eelgrass could perform as potential donor candidates. In our study, the sites designated for eelgrass shoot donation differed in water temperature; Padilla Bay was generally warmer than Ship Harbor. We

hypothesized that plants from the warm site would perform better in warmer temperatures and handle warm temperature extremes. We conducted a mesocosm experiment in which we manipulated temperature and measured eelgrass growth, morphology, and decay. Eelgrass in the warmed treatment decreased in length compared to plants reared at the ambient seawater temperature (control), with Ship Harbor eelgrass decreasing in shoot length more than Padilla Bay eelgrass. The eelgrass from Ship Harbor started to decrease in length at 21 days, compared to 28 days for Padilla Bay. Furthermore, the warmed treatment had more decay after 28 days than the control treatment and eelgrass from Ship Harbor decayed more severely than those from Padilla Bay. Surprisingly, new growth from Ship Harbor was greater than that from Padilla Bay. Our results suggest that Padilla Bay eelgrass could have been better acclimated to warmer temperatures, but the increased temperature still lead to a decrease in performance. The implication for eelgrass restoration is that the temperatures of donor and receiving sites should be similar to improve eelgrass transplant success.

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ECOLOGY FROM MICROBES TO BIRDS

Session Moderator: Frieda B. Taub, Aquatic & Fishery Science

JHN 111

3:30 PM to 5:15 PM

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How Do Variations in Air Exposure Affect the Desiccation of *Z. marina* Gathered from Different Tidal Zones?

Elizabeth Marina (Liz) Allyn, Senior, Aquatic & Fishery Sciences

Mary Gates Scholar, UW Honors Program

Jennifer (Jenn) Gonzaga, Senior, Envir Sci: Conserv Biol & Ecol (Tacoma)

Mary Gates Scholar, Undergraduate Research Conference Travel Awardee

Mentor: Sylvia Yang, SEA Discovery Center, Western Washington University

Mentor: Megan Dethier, Biology

Mentor: William King, Biology

Eelgrass (*Zostera marina*) are important ecosystem engineers that provide food and habitat to diverse organisms. Some eelgrass beds are declining in locations around the Salish Sea, leading to a subsequent decline in biodiversity and productivity. One proposed restoration strategy is to transplant shoots from healthy to declining sites. Transplantation efforts, however, should consider the effects of desiccation on eelgrass during extreme low tides. Desiccation can decrease transplant success by decreasing photosynthetic rates and causing tissue damage in transplanted shoots. To understand how desiccation affects transplanted eelgrass performance, we conducted a mesocosm experiment that manipulated air exposure durations to simulate eelgrass transplantation between tidal elevations. Plants collected from three tidal heights in Ship Harbor, WA were randomly placed in tide tanks that mimicked the emersion periods of three different tidal elevations. We measured changes in eelgrass morphology, growth, and tissue damage throughout the experiment. We predicted that shoots in treatments with similar air exposure durations as their original locations would exhibit the highest growth rates and the least amount of damage. We found that eelgrass originating from a high intertidal zone that were exposed to a low intertidal treatment exhibited the least amount of bleaching damage. Neither origin nor treatment, however, affected eelgrass growth rates. Our findings suggest that transplanting shoots from the high to low intertidal zone is a useful strategy for eelgrass restoration.

POSTER SESSION 3

Commons East, Easel 72

2:30 PM to 4:00 PM

Forest Snow Interception

Max Mozer, Senior, Civil Engineering

Mary Gates Scholar

Mentor: Jessica Lundquist, Civil And Environmental Engineering

Mentor: William Currier, Civil and Environmental Engineering

For efficient water management, quantifying the amount of water stored in mountains through accurate hydrologic modeling is critical. Snow is an essential aspect of water resources because it acts as a natural storage, and melted snow accounts for a large amount of our water supply. Snow forest interception is the process of trees blocking snow from reaching the ground. Forests cover almost 40% of snow covered regions, and trees can intercept up to 60% of the total annual snowfall. Thus, forest interception has a large influence over how much water is stored in surrounding watersheds. Current methods for modeling forest-snow interception are based on parameterizations from few observations in non diverse areas. Evaluation of such methods is necessary and improvements in modeling will lead to improved hydrologic forecasting and planning. To evaluate such forest-snow interception parameterizations, I used time-lapse photography and citizen science through a project called Snow Spotter. Snow Spotter is an online tool where users can answer questions about the presence of snow intercepted by trees, from time-lapse photography throughout the western United States. Based on the classifications of our users, I created a time series of data containing

the interception patterns which I used to develop a temporal understanding of forest snow interception which I compared to modeled parameterizations. The differences outlined in my research allows the time-lapse photography to improve these parameterizations. Thus, it improves the modeling process and the quantification of water resources in general, enabling better water resource management in the future.

POSTER SESSION 4

Commons West, Easel 8

4:00 PM to 6:00 PM

Evolution Outliers: Characterizing Emission Line Stars

Aislynn Wallach, Junior, Physics: Comprehensive Physics, Astronomy

NASA Space Grant Scholar

Mentor: Benjamin Williams, Astronomy

Our goal is to quantify the fraction of H-α emitting B stars in M31. A small subset of massive stars emits strongly in H-α, which indicates the presence of hotter gas than is typically associated with such stars. These stars' line emission may be related to stellar rotation, but it is unclear what causes the rotation or if there are other possible causes for the line emission. In order to shed light on this problem, we've begun a project to identify a homogeneous sample of these stars in M31. Our data are comprised of imaging from six fields in M31. Using resolved photometry of over two million stars, we have found 50 candidates. Using a ratio of these candidates to ordinary stars of the same temperature that are not emitting in the H-α, we can put observational constraints on models of the formation of stars in this mass range, as any viable model must be able to reproduce the observational statistics of these rare stars. Therefore, despite their rarity, they provide a key diagnostic of stellar evolution models fundamental to many fields of astrophysics.

POSTER SESSION 4

Commons West, Easel 7

4:00 PM to 6:00 PM

High-Resolution Multi-Wavelength Examination of a Supernova Remnant in the Nearby Spiral Galaxy NGC 300

Jacob Alexander Gross, Senior, Computer Science, Physics: Comprehensive Physics

Mary Gates Scholar

Mentor: Benjamin Williams, Astronomy

Supernovae enrich the interstellar medium, allowing it to create fascinating and exciting objects such as stars, planets, and people. However, supernovae are difficult to study because, most of the time, we do not observe these supernovae directly, since the whole event can occur in a very short time. Fortunately, they leave behind bright remnants that can give us information about the supernova and even the stars that existed before. We have observed one such supernova remnant in the nearby spiral galaxy NGC 300, which is approximately three million light years away from Earth. We have acquired multi-wavelength data of this source from *Chandra X-ray Observatory*, *XMM-Newton X-ray Observatory*, and *Hubble Space Telescope*. Using this variety of telescopes, we can understand how this supernova remnant behaves in both the x-ray and optical energy bands which gives us a more complete picture of our source. From our *Hubble* data, we gain detailed measurements of the size and shape of the source. From our *Chandra* and *XMM-Newton* data, we can shed light on the properties of this supernova remnant by performing a spectral analysis on the x-ray data. This spectral analysis gives us information about the temperature and metallicity of the source, as well as the density of the surrounding gas. With these quantities, we can better understand this supernova remnant and supernova remnants like it which, in turn, let us better understand the life of the star that created this source.