

Undergraduate Research Symposium May 17, 2013 Mary Gates Hall

Online Proceedings

SESSION 1D

MEDICAL THERAPEUTICS AND ENDOCRINOLOGY

Session Moderator: Ian Sweet, Medicine

231 MGH

1:15 PM to 2:45 PM

* Note: Titles in order of presentation.

Expression of Costimulatory Molecules in Juvenile Idiopathic Arthritis versus Severe Gingivitis

Megan Christine Yuasa, Senior, Biology (Physiology)

Mentor: Anne Stevens, Pediatrics

The most common rheumatological disorder found in children is juvenile idiopathic arthritis (JIA), a disabling disease of unknown etiology and with no cure to date. Previous studies have suggested autoantibodies of adult rheumatoid arthritis (RA) cross-react with oral pathogens, suggesting that oral infection could trigger arthritis. Severe gingivitis, an inflammatory disease of the gums, is present in 50-100% of adolescents, and may exhibit this same interaction with JIA. Costimulatory molecules on antigen presenting cells are induced during an inflammatory response to regulate T lymphocytes. Specifically, programmed death ligand-1 (PD-L1) known to be expressed during infection, is also highly upregulated in JIA. To test the hypothesis that PD-L1 expression is induced by oral pathogens associated with gingivitis, peripheral blood cells were isolated from JIA patients and healthy children. Gingivitis was scored by oral examination. PD-L1 expression was assayed on myeloid DCs and monocytes by flow cytometry. Preliminary data on a subset of subjects (n=7) showed a higher percentage of monocytes with PD-L1 in JIA patients compared to controls; however JIA patients had a lower density of PD-L1 per cell. There was no association between extent of gingivitis and PD-L1 expression. The results of this study could contribute to a new field of JIA therapy targeted at costimulatory molecules and oral hygiene.

SESSION 1E

SENSORIMOTOR NEUROSCIENCE

Session Moderator: Eric Chudler, Bioengineering

234 MGH

1:15 PM to 2:45 PM

* Note: Titles in order of presentation.

Neuroprosthetic Rehabilitation on Rodents

Tejas Ranade, Senior, Biology (General), Political Science

Mary Gates Scholar

Mentor: Steve Perlmutter, Physiology and Biophysics

Spinal cord injury is currently only treatable to a limited extent and often involves the partial or full loss of motor function. Spinal cord injury is also believed to be a strong factor in muscle loss and motor disorientation in mammals. Recent research has suggested that electrical stimulation of affected areas of the central nervous system can play a role in restoration of the ability to control paralyzed muscles in certain model organisms. Our Neuroprosthetic Rehabilitation project is focused on improving the ability of adult Long-Evans rats to make forelimb movements, via electric microstimulation, after localized spinal cord injury. The subject rats will first undergo behavioral training to achieve aptitude at a repeated task such as using one forelimb to reach for pellets at a certain distance. Following this, suitable candidates will be subjected to unilateral, cervical spinal cord contusions and will once again attempt to reach proficiency at pellet retrieval while micro-stimulation is routinely administered during training sessions. Functional improvement in rats stimulated during the pellet retrieval task will be compared with improvement of those stimulated independently of their behavior, and those not receiving stimulation. It is hypothesized that the improvement in the former group will be more significant than that of the latter groups, but will not generalize as well to other behaviors. Significant results will be instrumental to further understanding of how a damaged spinal cord can be repaired – or the effects of injury mitigated – in people suffering from related conditions.

SESSION 2A

GRAPHS AND GEOMETRY

Session Moderator: Werner Stuetzle, Statistics

085 MGH

3:45 PM to 5:15 PM

* Note: Titles in order of presentation.

Generalized Ramsey Numbers for Near-Diagonal Pan Graphs and Relatively Prime Tadpole Graphs

Timothy Perisho, Fifth Year, Mathematics, Philosophy, Seattle Pacific University

Mentor: Steve Johnson, Mathematics, Seattle Pacific University

Ramsey Theory is an intricate field of pure mathematics, but it also has applications in computer science, where graphs are commonly used as data structures. Every pair of "forbidden" graphs has a Ramsey number, which indicates when one of those graphs must occur. A Ramsey number for a pair of forbidden graphs is the smallest number of points R for which every edge-coloring of the complete graph on R points includes one of the forbidden graphs in its respective color. In this paper we use two original methods to find and prove new Ramsey number formulas for certain tadpole graphs based upon known Ramsey number formulas for arbitrary cycle graphs. A tadpole graph $Q_{n,t}$ is formed by connecting one end of a path graph on t points (called the "tail") to a cycle of size n (called the "head"). A pan graph Q_n is defined as a tadpole graph with $t=1$. We first use an intuitive counting method to prove exact Ramsey number formulas for all "near-diagonal" pan graphs, i.e. those pairs of pan graphs where the maximum cycle size of the pair is no more than $5/2$ times the minimum cycle size. Then, we demonstrate a number-theoretic method to find exact Ramsey numbers for arbitrarily far-from-diagonal tadpole pairs with arbitrarily long tails. However, the second method requires that the tadpoles meet number-theoretic constraints (rather than size constraints). For example, in the diagonal cases, $n-1$ must be relatively prime to $n+t$, where either $n-1$ has an odd order (mod $n+t$) or the additive inverse of $n-1$ has an even index relative to $n-1$ (mod $n+t$). These "scattered" on- and off-diagonal results provide upper bounds on the Ramsey numbers for other tadpole pairs that fail to meet the number-theoretic constraints.

SESSION 2M

POLITICS AND POLICY IN AMERICA

Session Moderator: John Wilkerson, Political Science

284 MGH

3:45 PM to 5:15 PM

* Note: Titles in order of presentation.

Behind Bars: The Prevalence and Consequences of Jailing Juveniles in Washington State

Max T (Max) Burnham, Senior, Political Science, Law, Societies, & Justice

Victoria Kathleen (Tori) Bishop, Senior, Law, Societies, & Justice, History

Marc Neman Meyer, Senior, Law, Societies, & Justice

Lauren Martin, Senior, Law, Societies, & Justice

Martha Renata (Martha) Muldowney, Senior, Law, Societies, & Justice, Sociology

Sandy Cathy (Sandy) Nguyen, Senior, Law, Societies, & Justice

EIP Scholar, McNair Scholar

Anu Sidhu, Junior, Law, Societies, & Justice, Economics

Elizabeth Zippora Kent, Senior, Law, Societies, & Justice

Mentor: Steve Herbert, Geography

In Washington State, the majority of juvenile offenders are handled by the juvenile criminal justice system. However, juveniles who commit serious violent crimes undergo a process known as declination, in which they are processed as adult defendants in adult courts. These juveniles are typically housed in jail with adult inmates, an experience which nation-wide studies have shown to be severely damaging to both their mental and physical well-being. Research regarding the prevalence of this practice in Washington State is slim. Our report aims to rectify this dearth of information by examining relevant statutes and case law, by interviewing various actors in the criminal justice system—including incarcerated youth themselves—and by sending information requests to all 39 counties in Washington State. The first section of our report will detail the types of declination in Washington and how to distinguish between the four main holding facilities: the Juvenile Detention Center, Juvenile Rehabilitation Administration, jail, and prison. Part two will present statistics regarding the number of declined juveniles held in each county jail since 2009, as well as county policies surrounding these declined individuals. Our preliminary research shows that hundreds of juveniles have been declined and held in jails since 2009. The third section will analyze the repercussions of incarceration on a juvenile's life, as well as detail our personal interviews with several inmates from the Green Hill Juvenile Rehabilitation Administration. Our final section will analyze the differing opinions on the declination process, as well as present some of our own recommendations for improving the current system. We hope that these ideas will lead to the adoption of policies that will protect both public safety and the well-being of the inmates themselves, and provide these youth with the tools they need to successfully reintegrate into society.

SESSION 20

SENSORY INPUT IN MUSIC, SPEECH, AND THE VESTIBULO-MOTOR SYSTEM

Session Moderator: Ludo Max, Speech & Hearing Sciences
288 MGH

3:45 PM to 5:15 PM

* Note: Titles in order of presentation.

The Effect of Presentation Mode on Memory for Western and Chinese Music Performances

Jacob Cameron (Jacob) Bloom, Senior, Neurobiology

Mentor: Steven Morrison, Music

Mentor: Steven Demorest, School of Music

Previous research has shown that adults demonstrate better memory for novel music from their own music culture as opposed to music from a foreign culture. This passive learning imprinted upon kids as they grow up in a certain musical culture its known as “enculturation”. Visual information has also been shown to impact musical memory in adults. Pertinent visual images may augment the encoding process of music and lead to greater recall abilities. In this study, we will include a visual component to the audio information presented. This addition will test the facilitation of visual information to the musical memory of culturally unfamiliar music in adults. Using four video/audio excerpts of musicians performing music in a classical Chinese style and four video/audio excerpts of musicians performing western (classical) style music, we tested the audio and visual memory of adult human subjects in culturally unfamiliar and familiar music. To test them we used twenty-four test items (twelve true tests and twelve false tests) in audio or video format. These different test items can be prepared in three different combinations: audio/audio, AV/audio, AV/AV. Preliminary data demonstrated significantly better overall memory for culturally familiar music. However, music memory scores were higher in the audio condition than in the AV condition in culturally unfamiliar music tests. These results indicate that adding visual information does not aid in musical memory of culturally unfamiliar music. Dichotomous from our initial hypothesis, it is possible that this occurred due to the dominance of visual memory in encoding, or that auditory and visual stimuli provided too much novel information for effective recall.

POSTER SESSION 3

Commons West, Easel 14

2:30 PM to 4:00 PM

Rod Hue Biases for Foveal Stimuli on CRT Displays

Katharina Gwinear (Katharina) Foote, Senior, Psychology

Mary Gates Scholar

Mentor: Steven L. Buck, Psychology

Signals from rod photoreceptors shift the hues determined by cone photoreceptors for extrafoveal mesopic stimuli, creating green, blue, and red rod hue biases at long, middle, and short wavelengths, respectively. The fovea contains far fewer rods and S-cones but may not be immune to rod hue biases. Here, we determine which biases are found for foveal stimuli presented on a CRT display. A 1-s duration test disk of 0.5, 1.0, or 2.0 diameter alternated with a 3-s duration array of 0.25 fixation dots placed 4 from fixation, all on a black background. Seven observers adjusted the hue of the test disk around the RGB phosphor triangle, to yield each of the 4 unique hues, Ured, Ugreen, Ublue, and Uyellow. Light levels ranged from 0.05 - 0.17 (CIE2) or 0.08 - 0.03 (CIE10) cd/m². 1-2-diameter foveal test disks (a) produced rod green bias at Uyellow for most observers, (b) favored rod green bias at Ublue over the rod red biases shown in prior extrafoveal studies, and (c) produced less consistent rod hue biases at Ured and Ugreen. 0.5-diameter foveal test disks produced no consistent rod hue biases across observers. 1-2-diameter foveal disks on a CRT display produced relatively strong rod green bias, mediated by rod interaction with L&M cones, presumably in midlevel/parvo pathways. In contrast, these foveal stimuli disadvantaged rod influence mediated by S-cones, presumably in small-bistratified/konio pathways, producing only weak/inconsistent rod red bias at Ublue and rod blue bias at Ured and Ugreen. 0.5 diameter disks disadvantaged all rod hue biases, but with individually idiosyncratic exceptions for some observers. Color is increasingly used to convey information in visual displays and this research helps understand how those colors are altered in low-light-level situations. This research may also contribute to models of neural physiology and ultimately to diagnosis/cures for visual disorders.

POSTER SESSION 3

Commons West, Easel 2

2:30 PM to 4:00 PM

Old Enough to Commit the Crime, Old Enough to do the Time: Prosecuting a Juvenile as an Adult

Sandy Cathy (Sandy) Nguyen, Senior, Law, Societies, & Justice

EIP Scholar, McNair Scholar

Mentor: Steve Herbert, Geography

Currently, under Washington State’s Automatic-Declination Laws, juveniles can be prosecuted as adults in court and held in adult detention facilities. Auto-decline laws are one of three types of discretionary hearings that juveniles can experience while in the criminal justice system. My research

explores the history of the juvenile justice system on the state and local level through Supreme Court rulings and laws and synthesizes the ways in which previous laws have shaped and influenced current procedures. Differences between the juvenile court and adult court are examined to characterize the experiences of a juvenile who is facing auto-decline in comparison with their juvenile court counter-parts. Methods include reviewing the current literature on juvenile justice and interviewing courtroom actors and juvenile facility coordinators. This research has revealed that related laws have changed from a focus on the rehabilitative to the punitive and have become more restrictive. The results also point to a possible weakness in the system resulting from a majority of the power in charging a juvenile resting with prosecutors. My research suggests that one possible way to equalize the balance of power between the prosecutor, the defense attorney, and the judge is to make transfer and discretionary hearings mandatory prior to processing a juvenile as an adult. Future research should focus on assessment of the ability of current juvenile detention centers to handle youths who are prosecuted as adults.

POSTER SESSION 4

Commons East, Easel 62

4:15 PM to 5:45 PM

An Algorithm for Finding Hamiltonian Cycle

Thanh Dang, Sophomore, Mathematics, Seattle Central College

Mentor: Steve Kangas, Mathematics, Seattle Central Community College

A Hamiltonian cycle is a path that goes through all vertices exactly one and comes back at the starting vertex. Finding Hamiltonian cycles is a well-known problem in graph theory. While necessary and sufficient conditions for Hamiltonian cycles remain unknown, we have developed an algorithm for finding Hamiltonian cycles in polynomial time in certain types of graphs presented in the paper. The algorithm involves finding k cyclic subgraphs within the original graph by deleting edges and then reconstructing some specific edges to create one single Hamiltonian cycle. Along with several algorithms developed earlier, this can contribute to a more general solution, or solutions of the classic Travelling Salesman Problem.

POSTER SESSION 4

Balcony, Easel 124

4:15 PM to 5:45 PM

Validation of Prognostic Biomarkers in Total Tumor Areas on Prostate Cancer Tissue Microarrays

Michael Tang, Junior, Biochemistry

Mentor: Anthony Rizzardi

Mentor: Steve Schmechel, Pathology

In the United States prostate cancer (PCa) is one of the most commonly diagnosed cancers and estimated to affect 239,000 men in 2013. Although few prognostic biomarkers are currently used in the clinical setting, biomarkers that predict the risk of disease aggressiveness leading to prostate specific antigen (PSA) failure after prostatectomy may assist clinicians in selecting adjuvant therapies following prostatectomy. In studies utilizing co-registered pre-operative imaging data with post-operative pathology data, validated prognostic biomarkers may also be highly useful as “gold standards” against which to train imaging methods to assess disease aggressiveness pre-operatively. We previously identified 33 potentially prognostic biomarkers from the analysis of multiple gene expression datasets and current literature. Using tissue microarrays containing PCa tissue from 170 prostatectomy specimens from men with detailed PSA and follow up data, we quantified immunohistochemical (IHC) staining for these markers within selective tissue sub-regions (malignant epithelium) and identified 16 of the 33 biomarkers which were associated with shorter time to PSA failure. While our aim is to use validated biomarkers to pre-operatively train *in vivo* imaging methods, current imaging capabilities have lower resolution than digital histology and it is unclear whether biomarker expression in total tumor areas (encompassing malignant epithelium, benign epithelium, stroma, and other tissue structures) which are resolvable by imaging methods will also be prognostic. In this study, we have re-evaluated our list of 16 strong candidate biomarkers to determine if IHC expression within total tumor areas are associated with PCa aggressiveness (PSA failure following prostatectomy) using our TMA cohort.

POSTER SESSION 4

MGH 241, Easel 171

4:15 PM to 5:45 PM

Spinal Cord Injury Treatment: ECoG-Based Spinal Stimulation with Activity-Dependent Physical Therapy

Alison Yik Hei (Alison) Chan, Senior, Sociology, Biology (Physiology)

Mary Gates Scholar

Mentor: Steve Perlmutter, Physiology and Biophysics

Mentor: Jacob McPherson, Physiology and Biophysics

In Perlmutter lab’s ongoing study, a combination of activity-based motor training and EMG-triggered electrical spinal stimulation is used as therapeutic intervention for rats with spinal cord injuries (SCI). In addition to the reach training being a form of physical therapy, electromyogram (EMG)

electrodes are implemented into rat's impaired arm and on the spinal cord area that receives related motor commands from the brain. By detecting electrical potentials produced by the skeletal muscle, the electrodes then carry out electrical stimulation on the spinal cord. In response to repetitive and consistent transmission from a presynaptic neuron to a postsynaptic neuron, the connection between two neurons is reinforced as a result of Hebbian "plasticity" or the ability to strengthen or create new synaptic connections with the associated neurons. Although preliminary data suggested greater functional recovery in this novel intervention, many rats did not recover fully. This may be due to discrepancies in the timing between the EMG and the descending command arrival in the spinal cord, preventing optimal timing of the electrical spinal stimulation. In my proposed experiment, I hypothesize that triggering the electrical stimulation from the source of the descending motor commands, the brain, rather than from residual muscle activity will enable better synchronization of the stimulation, hence optimizing the intervention. Instead of EMG electrodes, electrocorticographic (ECoG) electrodes that are designed to detect brain electrical activity will be implanted on the surface of the brain. During the 12-week intervention along with the reaching exercise, a device called the Neurochip will record and trigger the stimulation of spinal cord. The ECoG technique may provide a less noisy signal by recording directly from the brain and enable a better estimate of the occurrence of spinal stimulation, thus maximizing the therapeutic potential of the intervention.

POSTER SESSION 4

Balcony, Easel 86

4:15 PM to 5:45 PM

A Web-Based Community Firn Model

Paul Daniel (Paul) Harris, Senior, Applied & Computational Mathematical Sciences (Scientific Computing & Numerical Algorithms)

Mentor: Edwin Waddington, Earth And Space Sciences

Mentor: Jessica Lundin, Earth and Space Sciences

Mentor: Max Stevens, Earth and Space Sciences

The distribution of temperature and precipitation on our planet (i.e. our climate), affects plant growth, animal habitats, and the livability of Earth's varied regions. In order to predict future climate we need to know about our past climate. This is important to better understand how temperature and weather conditions change when the radiative forcing (e.g. CO₂ greenhouse effect) on our atmosphere increases. The best way to predict these changes is researching past radiative forcing increases and how these events impacted Earth's climate. Some details of our past climate are discovered by analyzing polar ice and the gas bubbles trapped within. Firn is fallen snow that compacts and eventually turns into glacial ice. During this process gas can move relatively

freely throughout the firn. When the firn densifies enough to block the air passageways, young gases are trapped in significantly older ice. This work is building a web-based community firn densification model that allows the user to accurately determine the difference between the age of a gas sample and the age of the ice surrounding it. Our transient model determines this delta age more accurately than current steady-state models by accounting for changing conditions as the firn turns into ice, instead of assuming conditions remain static throughout the firn evolution. This model is open-source, and written using the Python programming language, along with the NumPy library, allowing the model to be free and usable by anyone. Because the model is modular, users can easily change it to fit specific conditions or to incorporate different physical processes. Our goal is to provide a model that is simple to use, freely available, and helpful for developing a more accurate understanding of our past climate.

POSTER SESSION 4

Balcony, Easel 97

4:15 PM to 5:45 PM

Firn Model Inter-Comparison

William Procter (Will) Leahy, Senior, Interdisciplinary Visual Arts

NASA Space Grant Scholar

Mentor: Edwin Waddington, Earth And Space Sciences

Mentor: Jessica Lundin, Earth and Space Sciences

Mentor: Max Stevens, Earth and Space Sciences

Our 800,000-year climate record is dependent primarily on data obtained from ice cores. Analyzing and dating the ice, gas, and sediment in these cores allows us to construct a remarkably accurate historical record of Earth's climate and atmosphere. However, the dating and chronology of the ice record is not as exact as we would like it to be, especially deeper in the ice. Our ability to date ice cores with accuracy depends on our understanding the evolution of glacial firn, fallen snow that gradually compacts into ice. Researchers have developed many different models of firn evolution. The aim of this project is to run these models against each other under the same boundary conditions, so that we may compare their responses and determine the strengths of each model. Participants have submitted their model output and our results have been returned to them. A second inter-comparison will be organized to address issues brought up by our initial results. These comparisons will improve future efforts in firn-modeling, ultimately leading to a better understanding of our climate record.