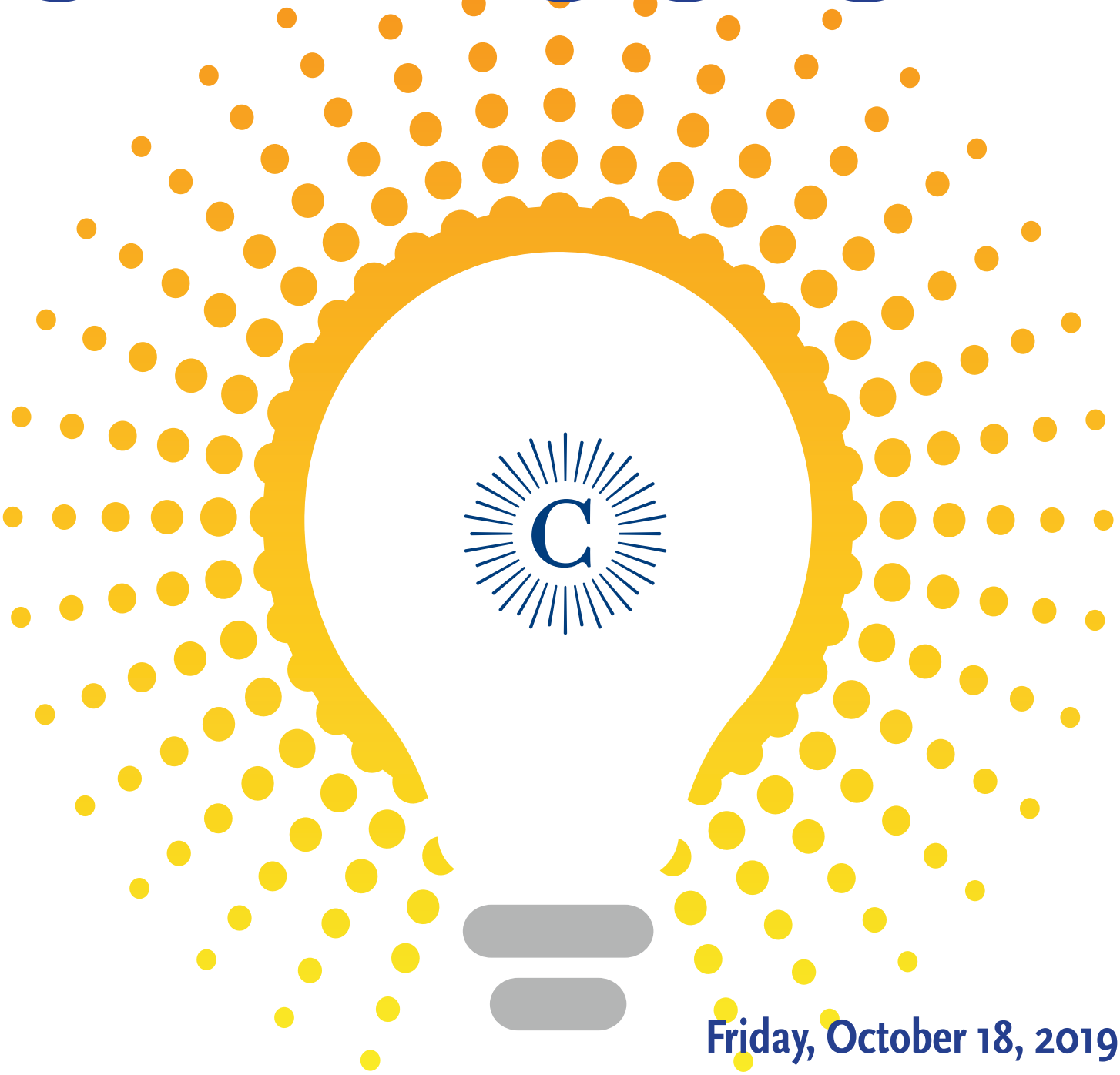
2019 STUDENT RESEARCH SYMPOSIUM



Friday, October 18, 2019
Weitz Commons
3:30-5:30pm

October 18, 2019

Welcome to the 2019 Student Research Symposium and Celebration at Carleton. Today we honor the many students who have engaged in advanced work in their respective fields, building on the knowledge and skills they acquired throughout their course work both at Carleton and on off-campus programs.

Research is at the heart of a Carleton education. Through their posters and oral presentations these students reveal the habits of mind that an outstanding liberal arts education provides – a passion for intellectual exploration, skills of careful observation and analysis, the ability to frame questions in fruitful ways, to interpret both quantitative and qualitative data, and to convey their findings clearly and concisely, both verbally and visually. We are proud of their accomplishments.

We also wish to acknowledge and celebrate the great diversity of research represented here. Faculty from fifteen departments and programs have supervised student research projects, as well as several staff members. Taken together, the work of these students attests to the breadth of research opportunities at Carleton and the many ways in which faculty and staff throughout the College inspire and support student scholarship.

Finally, we call attention to the many significant mentoring relationships that fostered this work and were deepened as a result of it. As generations of Carleton students will attest, the opportunity to work closely with faculty is among the most impactful and memorable of their experiences here. Behind each of these presentations is a faculty or staff member whose guidance, encouragement and coaching enriched the education of students and inspired them to go further than they imagined they could. We are grateful for the dedication and attentiveness of all these mentors.

We invite you to engage with these students, to question them about their work and its significance. In this way, we hope you will join them, at least briefly, on the intellectual journey they have undertaken.

Thank you for joining us for this symposium and celebration.

Bev Nagel
Dean of the College

Carolyn H. Livingston
Vice President for Student Life and
Dean of Students

1. c-Fos Staining in Rat Brain Tissue to Assess Cue-Evoked Activity

Diana Augustin ’21

Other Authors /Contributors:M.J. Carpio, Christelle Cayton, Erica R. Wooner '20, Ankit Sood, and Jocelyn M. Richard

Supervisor: Dr. Jocelyn M. Richard (University of Minnesota)

The process of addiction is complex and involves the synergism of multiple brain structures. To best understand how drugs and drug-related cues inform the addiction process, we must understand the neuronal activation of structures involved in this phenomena. c-Fos is a protein commonly used as a marker for neuronal activity. The localization of c-Fos gives a sense of the neural circuitry that is activated by behavioral events, such as exposure to alcohol cues. In this experiment, we ran a series of immunohistochemical protocols to label the c-Fos expressed in the brains of alcohol dependent or control rats that were perfused after exposure to alcohol cues. Our goal was to identify and quantify areas of high c-Fos concentration in alcohol dependent rats or control rats after cue exposure. In our preliminary experiments, staining for c-Fos was suboptimal. Therefore, we ran an experiment comparing tissue incubated in two different primary anti c-Fos antibodies in combination with three different secondary antibodies to assess which protocol worked best for c-fos staining. We found that 1:2500 rabbit anti c-Fos paired with 1:500 anti-rabbit Alexa 555 produces most optimal c-Fos staining for assessing brain activity in rats after alcohol cue exposure.

This research was funded in part by the North Star Stem Alliance.

2. Taking Action to Reduce Musculoskeletal Pain In Veterans

Nof Babajide ’20

Other Authors /Contributors: Diana Burgess

Supervisor: Diana Burgess (VA Medical Center Minneapolis)

Chronic Musculoskeletal Pain is one of the most common conditions among veterans. The prevalence rate for this condition has been increasing since 2000, which is particularly worrisome, since it is associated with poorer self-reported health status, worse mental health, and lower levels of employment. These measurements are worse when we look across racial and ethnic lines. Racial and ethnic minority groups report greater pain-related disability, physical and emotional impairment, and pain severity compared to whites. This study aimed to address the underlying factors that contribute to low back pain in black veterans. Our approach is to utilize an over-the-phone counseling technique intended to motivate participants to increase walking. We randomly divided participants between Control and Intervention groups. We used self-report surveys to collect data. This study is still ongoing, but the overall aim is to improve quality and equity of pain management in order to better pain outcomes for all veterans.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

3. CD200 As A Stem Cell Marker in Acute Myeloid Leukemia

Polycarpe Bagereka ’22

Other Authors /Contributors: Shelley Herbrich, Marina Konopleva

Supervisor: Shelley Herbrich, Marina Konopleva (Department of Leukemia, MD Anderson Cancer Center, Houston, TX, USA)

Acute Myeloid Leukemia (AML) is an aggressive hematopoietic malignancy initiated and propagated by stem or progenitor cells (LSCs). LSCs are quiescent and resistant to apoptosis making them immune to conventional chemotherapies targeting blast cells. The lab discovered that CD200, a cell surface protein, is overexpressed by LSCs. This summer, we hypothesize that CD200 identifies LSCs in both human and murine AML and that CD200+ cells are more sensitive to stem cell therapies like BCL-2 inhibition. I tested this hypothesis in three different experiments. First, I investigated whether CD200+ cells exhibit stem cell properties such as colony formation. Next, to see if CD200 cells are mechanistically similar to LSCs, a Cell Titer Glow (CTG) assay was performed. Finally, to illustrate that CD200 is also a stem cell marker in murine leukemia, sorted CD200 cells from TET2 FLT3-ITD murine leukemia cells were injected into secondary recipient mice. Results from these experiments indicated that CD200 is a unique marker of AML LSC activities.

4. Examining Style Shriveling sariation in *Heliopsis helianthoides* Pollen Interference on *Echinacea angustifolia*

Julie Bailard ’20

Other Authors /Contributors: Stuart Wagenius

Supervisor: Dr. Stuart Wagenius (Adjunct Assistant Professor, Northwester University)

In interspecific pollen interference, heterospecific pollen prevents a flower from producing viable seeds, posing complication for fragmented tallgrass prairie. Previous research demonstrated that pollen from *Heliopsis helianthoides* interferes with seed set in *Echinacea angustifolia*, causing most affected styles to prematurely shrivel without conspecific pollen. To clarify the role style shriveling plays in this interference, a hand-pollination experiment examined style shriveling in the context of maternal plant and pollen donor genetics. Pollen from *H. heliopsis* individuals was applied to several styles on *E. angustifolia* plants, with each floret receiving pollen from a single *H. heliopsis* plant. Florets were examined after 48 hours to determine the style shriveling rate of each pairing. The non-normal distribution of shriveling rates and the variation among crosses with the same maternal plant or the same pollen donor supports a mechanism in which *E. angustifolia* falsely accepts *H. helianthoides* as a compatible pollen source.

5. At the Crossroads: Doxey Wilkerson and the Jefferson School of Social Science

Guapo Banuelos ’20

Other Authors /Contributors: Charisse Burden-Stelly, and Katerina Katakalides, '20.

Supervisor: Charisse Burden-Stelly (Assistant Professor of Africana Studies and Political Science, Carleton College).

Anti-Communism shaped the growth, expansion, and practice of American federal surveillance in the 20th century. Allegedly responding to fears of foreign espionage stemming from the World Wars, American federal surveillance targeted persons, organizations, and ideas deemed "seditious" or "un-American." While the rhetorical justification of this expansion of federal power into civil liberties rested on a shared anxiety regarding the spread of Communism, more often than not federal surveillance targeted communities engaging in race or labor radicalism thought to be the result of foreign intervention. The pretense of legality allowed Black radicals to be punished for the "crime" of engaging in racial organizing from a Marxist perspective. After outlining decisive moments in the history of federal surveillance, I will demonstrate how federal anti-communism surveillance tactics were effectively weaponized against Doxey Wilkerson and the Jefferson School of Social Science (JSSS) from the early 1940s to the school's end in 1957.

This research was funded in part by the Humanities Center SRP Program and the Mellon Mays Undergraduate Fellowship.

6. Characterization of Novel Anti-Malarial Therapeutics Using Fluorescence Polarization

Henock Befekadu ’21

Other Authors /Contributors: Thomas C. Atack, Donald D. Raymond, and William R. Sellers

Supervisor: Thomas C. Atack (Broad Institute of MIT and Harvard), Donald D. Raymond (Broad Institute of MIT and Harvard), and William R. Sellers (Broad Institute of MIT and Harvard)

Malaria is a mosquito-borne disease caused by Plasmodium parasites endemic to the tropics, especially sub-Saharan Africa. With the emergence of resistance to frontline malarial drugs, there is an unmet need for novel anti-malarial therapeutics with new mechanisms of action. The immunosuppressive drug rapamycin, which binds to FK506 binding proteins (FKBPs), has been shown to have anti-malarial activity. FKBPs are ubiquitous enzymes across all lifeforms, humans have 14 FKBP isoforms while malaria has a single FKBP (FKBP35). FKBP35 is essential for Plasmodium viability and hence is an attractive target for therapeutics. Towards the goal of elaborating therapeutics targeting FKBP35, we have developed a fluorescence polarization assay to identify drug-like molecules that target FKBP35 without the immunosuppressive effects of rapamycin. By counter-screening hits against human FKBPs, compounds with higher selectivity for FBKP35 were selected for further optimization. Ultimately, we have made a library of novel anti-malarial compounds with demonstrated selectivity towards FKBP35.

7. Effect of Polymer Molecular Weight on Block Copolymer Micelle Fragmentation Kinetics

Alison Block ’22

Other Authors /Contributors: Tim Lodge and Julia Early

Supervisor: Tim Lodge (Regents Professor of Chemistry, Chemical Engineering, and Materials Science)

Diblock copolymers are able to self-assemble into spherical micelles in the presence of selective solvents. A greater understanding of the dynamics of these micelles in solution is important for improving usage in applications including drug delivery, nanoreactors, nanolithography, and viscosity modification. As such, the kinetics of non-equilibrium fragmentation with respect to varying molecular weights was studied in one ionic liquid. This was achieved by the direct dissolution of five molecular weights of poly(1,2-butadiene)-block-poly(ethylene oxide) (PB-PEO) in the ionic liquid 1-ethyl-3-methylimidazolium bis-(trifluoromethyl sulfonyl)imide ([EMIM][TFSI]). The kinetics of fragmentation were monitored via temperature-jump dynamic light scattering (T-jump DLS) and liquid-phase transmission electron microscopy (LP-TEM). It was found that copolymers with lower molecular weights led to micelles closer to the equilibrium size, reducing the overall time needed for the system to equilibrate.

8. Tracing the Star Formation History in Local Group Dwarf Galaxies

Sarah Bodansky ’21 and Zitian Yue ’22

Other Authors /Contributors: Cindy Blaha, Vincent He '22, Ann Isaacs '20

Supervisor: Cindy Blaha (George H. and Marjorie F. Dixon Professor of Physics and Astronomy, Carleton College)

Nearby galaxies in a galaxy cluster called the Local Group provide an excellent view of stars and their surrounding emission-line gas. We surveyed five dwarf galaxies in the Local Group for ionized hydrogen (H II) regions in order to explore the composition of star forming areas in these galaxies. To characterize these regions, we analyzed Hα, [O III], and [S II] optical emission-line data from Kitt Peak National Observatory and the Cerro Tololo Inter-American Observatory. A major step in determining the luminosity for the regions was accounting for extinction due to dust within the galaxies, which was done using 24μm infrared images from the Spitzer Space Telescope. After computing the luminosity of the H II regions, we created luminosity functions for the galaxies IC 10 and NGC 6822. Understanding the characteristics of these H II regions provides insight into the history and star formation of the dwarf galaxies studied.

9. Development of a New Method for High-temperature Acid Digestion of Ceramic Pellets

Am Bovornvirakit ’20

Other Authors /Contributors: Ingrid Burgeson, Susan Adami, and Denis Cherkasov

Supervisor: Ingrid Burgeson (PNNL), Susan Adami (PNNL), and Denis Cherkasov (PNNL)

At the Pacific Northwest National Laboratory (PNNL) in Richland, WA, ceramic materials that are used in radioactive experiments are broken down via acid digestion. Acid digestion involves adding acid(s) to the ceramic material in a Teflon vessel, then heating the closed vessel at a high temperature over time. The current method of digestion uses a microwave in order to heat the vessel, but is both time consuming and occasionally fallible. I helped develop and test a new method, one that used an oven instead of a microwave. An oven allowed the lab to use stainless steel digestion vessels on top of the Teflon vessels, which allowed for higher temperatures and pressure. This method was also faster and less fallible. I created test samples using various types of acids (HCl, HF, HNO_3), and ran the samples on an ICP-OES to measure various elements in order to test for contaminants.

10. The Apprentice Learner Architecture for Fraction Malrule Learning

Gabe Brookman ’20

Other Authors /Contributors: Anna Rafferty

Supervisor: Anna Rafferty (Assistant Professor of Computer Science, Carleton College)

Students may make mistakes when solving math problems. Certain machine learning algorithms can assess which mistakes each student is most likely to make and thereby provide customized feedback

or practice problems for that student. However, these algorithms require a general space of possible mistakes to draw from in order to understand the patterns in mistakes made by each student. We attempted to generate this space using the apprentice learning architecture, a framework for simulating the learning process. For fraction arithmetic, we were able to learn single-operator problems with or without negative feedback, but were unable to learn multiple operations regardless of negative feedback. In the future, we could build on this by applying it to the domain of algebraic equation solving instead of fraction arithmetic.

This research was funded in part by the Towsley Endowment.

11. Sonic Signatures

Oliver Calder ’22

Other Authors /Contributors: Eric Alexander

Supervisor: Eric Alexander (Assistant Professor of Computer Science, Carleton College)

In this poster, we explore the relationship between phonological trends of characters in texts and the attributes of those characters. We seek to determine whether it is possible to make predictions about the characteristics of individual characters based solely on the relative occurrences of phonemes in their speech. In particular, we have taken the complete corpus of Shakespeare plays and used machine learning to classify each character in several ways, such as gender and role. We then used several metrics to quantify the success of the predictions, and found that the predictions performed significantly better than random chance. To explore how phoneme trends relate to classes and individual characters, we built an interactive data visualization tool set. Our goal is for these tools to be used to explore a broader corpus of work and perhaps define trends between the writing styles of many authors.

This research was funded in part by the Towsley Endowment.

12. Using Open Source Data to Identify Conservation Priorities at Large Spatial Scales

Mariah Casmey ’20

Supervisor: Murphy Westwood (Morton Arboretum, Botanic Gardens Conservation International) Emily Beckman (Morton Arboretum) and Christina Carerro (Morton Arboretum)

We are in the middle of the sixth mass extinction; therefore, it is vital to quickly identify species at risk of extinction if we are to save them. The effects of human land use extend beyond habitat loss by severing gene flow between subpopulations, which increases their susceptibility to inbreeding depression. These negative genetic effects need to be considered in long-term conservation planning. One way to address this is by assessing the vulnerability of subpopulations that have become genetically distinct due to habitat fragmentation. In this study, we used open source satellite imagery and species occurrence data to create a method for assessing the vulnerability of subpopulations of tree species. To develop this methodology we selected ten target oak (Quercus) species native to Japan. In our results, we identified four likely threatened subpopulations as well as the local gardens and protected areas best situated to conserve them.

13. Temperature Dependence of Mesoscale Magnets on Magnetic Configuration

Anthony Cho ’21

Other Authors /Contributors: Barry Costanzi

Supervisor: Barry Costanzi (Visiting Assistant Professor of Physics, Carleton College), and Dr. Dan Dahlberg (University of Minnesota)

Mesoscale magnets exists on length scales where both classical and quantum effects are relevant, leading to strong size-dependence on magnetic configuration. Understanding the fundamental physics of systems this size is both of interest in its own right, and of relevance for information storage as magnetic bit sizes continue to shrink. We characterize the magnetic state of square permalloy dots with a side length as low as 175 nm by both measuring the dots' anisotropic magnetoresistance (AMR), and by modeling the dots computationally. Qualitatively different AMR responses for the same field sweep parameters in the same dots at room temperature is explained via simulation, showing distinct "U" and "S" shape magnetic

configurations as a result of thermal energy fluctuations. We further confirm the S-shape's temperature dependence by noting its disappearance at low (~4K) temperatures.

This research was funded in part by the Towsley Endowment.

14. Functional Characterization of a BMD-Associated Rare Variant Using CRISPR Gene Editing in Zebrafish

Cecily Choy '20

Other Authors /Contributors: Joyce Tang, Claire Watson, and Ronald Kwon

Supervisor: Ronald Kwon (Associate Professor, University of Washington)

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

15. Proton Beam Therapy Achieves Favorable Organ at Risk Sparing and Minimal Acute Toxicity in Patients with Major Salivary Gland Tumors

Siddharth Chundru '23

Supervisor: Michael Chuong, MD; Siddharth Chundru; William Hartsell, MD; John Chang, MD; George Laramore, MD; Sanford Katz, MD; Henry Tsai, MD; Craig Stevens, MD, PhD; Carlos Vargas, MD

Proton beam therapy (PBT) achieves superior organ-at-risk (OAR) sparing compared to x-ray therapy (XRT). Because many head and neck OARs are adversely affected by even very low dose, PBT may significantly reduce toxicity over XRT. While the potential benefit of PBT for major salivary gland patients may be especially large given the ipsilateral nature of target volumes, there are only limited clinical data to support use of PBT for this indication.The data colleected for this paper indicates thatPBT achieves a substantial reduction in acute toxicity for major salivary gland patients compared to historical XRT outcomes. These data support the use of PBT with curative intent for salivary gland patients in the absence of randomized data.

16. Analyzing Infrasound and Geodetic Data from Kilauea 2018 Eruption

Meritxell Colet '20

Other Authors /Contributors: Rhett Butler

Supervisor: Rhett Butler (Geophysicist - Seismologist at Hawai'i Institute of Geophysics and Planetology, University of Hawai'i at Mānoa)

In 2018, the Kīlauea volcano experienced the largest eruption and caldera collapse of the last century. We examine the infrasound and geodetic data from the Halemaʻumaʻu crater to understand the relative timing of events in May 2018, the beginning of Kīlauea's intense seismic activity period. Analysis of infrasound data for the most explosive events in May yielded mixed results as seismic signals do not always propagate efficiently to the atmosphere. Geodetic data is still being processed but it is expected to provide further insight into the timing of events. Although still in process, this study aims to provide a timing of events for the eruption from last year and provide an outline event timing for future eruptions of Kīlauea volcano.

17. Towards Enantioselective HAT-Initiated Alkene Coupling Catalysts

Anna Conley '20

Other Authors /Contributors: Conner Wilson and Patrick Holland

Supervisor: Conner Wilson (PhD Candidate, Yale University) and Patrick Holland (Professor of Chemistry, Yale University)

The synthesis of biologically-active molecules often requires making complex, substituted carbon chains with chiral centers. Hydrogen atom transfer (HAT) can be used to initiate the formation of substituted carbon-carbon bonds under milder conditions than with other methods. Based upon previous work in the Holland Lab at Yale University, we worked on developing iron-catalyzed HAT-initiated alkene coupling reactions, which form substituted carbon-carbon bonds from simple alkenes. With highly

substituted alkene starting materials, these reactions form a chiral center. We aimed to improve the enantioselectivity of HAT alkene coupling by modifying the ligand environment around the iron center in the catalyst. We synthesized new catalysts and tested their enantioselectivity through chiral High Performance Liquid Chromatography (HPLC). One promising catalyst, which gave higher yields of product than those previously developed, gave 29% enantiomeric excess, higher than any previous results. Further modifications to this complex may lead to even higher enantioselectivity, allowing synthesis of biologically-relevant molecules.

18. Perovskite Nanorods for Luminescent Solar Concentrators

Maya Costales ’20

Other Authors /Contributors: Dr. Matthew Sheldon, Noel Mireles Villegas '23, Nicholas Gripp '19, Rivi Ratnaweera '22, and Smriti Kumar '23

Supervisor: Dr. Matthew Sheldon (Assistant Professor of Chemistry, Texas A&M University)

All inorganic cesium lead halide perovskite nanocrystals with composition CsPbX3 (X= Cl-1, Br-1, or I-1) have gained considerable attention due to their outstanding photophysical properties which make them major candidates for use in Luminescent Solar Concentrators (LSCs) for light harvesting applications. LSCs make use of fluorophores such as organic dyes or quantum dots to waveguide incoming light towards a photovoltaic (PV) cell by means of absorption and reemission. While a conventional LSC achieves light trapping through total internal reflection, our proposed structure utilizes aligned dipole-emitting nanorods to concentrate incoming light towards the PV. CsPbX3 nanorods were synthesized through the water-triggered transformation of nanocrystals and aligned using an A/C electric field. Based on preliminary theoretical studies, we believe that perovskite nanorods would be an ideal material for solar concentration.

19. Boys in the Making: Ritual and Discursive Congruency in Anti-Fundamentalist Approaches to Manhood in Delhi

Jack Coyne ’20

Supervisor: Meera Sehgal (Associate Professor of Women's and Gender Studies and Sociology, Director of Women's and Gender Studies, Carleton College) and **Scott Carpenter (Professor of French, Chair of French and Francophone Studies, Director of Cross-Cultural Studies, Marjorie Crabb Garbisch Professor of the Liberal Arts, Carleton College)**

This project investigated the ways in which anti-fundamentalist and feminist organizations based in Delhi approached the issue of constructed masculinity when engaging with men. In India, a dominant fundamentalist vision of manhood has a pervasive hegemony, and its orientation toward religious nationalism means that this idea of what it means to be a man is inscribed onto bodies using religious talk and religious action. Using Bell's model of ritual theory, I investigated the ways in which we can begin to understand organizations opposed to this hegemonic vision as employing strategies endemic to religious movements for the purpose of reworking and reframing pervasive ideologies.

This research was funded in part by the Center for Global and Regional Studies.

20. Predicting and Discovering Patterns in the Blood Glucose of Type I Diabetics

Cole DiIanni ’21 and Oliver Staten '20

Other Authors /Contributors: Sarah H. Meerts and David Musicant

Supervisor: Sarah H. Meerts (Associate Professor of Psychology and Director of Neuroscience, Carleton College) and David Musicant (Professor of Computer Science, Carleton College)

Type 1 Diabetes is a chronic condition in which a person's body does not produce enough insulin and therefore requires external maintenance of insulin in order to maintain a healthy blood glucose level. Insulin and blood glucose levels for 65 individuals was provided by the organization Tidepool in order to search for trends within the data. The data was reformatted into 5-minute bins to normalizethe time series and allow for Dynamic Time Warping. A SARIMAX linear regression model was created to predict future glucose values using past blood glucose and insluin values. K-means clustering was used to

determine profiles of individuals based on their blood glucose time series. Hierarchical clustering was used to find daily blood glucose patterns within an individual. From the clustering, we determined that the most common cluster represented a “healthy” day time series with few outlier clusters.

21. Analysis of Thermite Reaction Behavior for 18O-Labeled Metal Oxides

Karen Ehrhardt ’20

Other Authors /Contributors: Christof Zweifel '21, and Kim Huynh

Supervisor: Kim Huynh (Visiting Professor of Chemistry, Carleton College)

Metallized energetic composites in the form of nanoscale thermite materials have been the topic of much research within the past decade as an alternative material to high explosives, such as trinitrotoluene (TNT), for their potential for transient, high yield energy release and applicational reach. Previous studies conducted on various thermite systems have shown there to be three metal oxides of interest due to their potential exothermicity and differences in the mechanisms by which they react. These metal oxides include Bi_2O_3, a known condensed phase oxidizer with high ion mobility, CuO,a well-studied gas phase oxidizer with favorable heat of formation, and Fe_2O_3, the most common oxidizer for tradition thermite systems. Our study contributes to this work and focuses on the ability to precisely probe the oxygenation path ways originating from ^{18}O-labeled metal oxides synthesized at the University of Maryland College Park. The analysis of the thermite reaction behavior with T-Jump/Time of Flight Mass Spectrometry (T-Jump/TOFMS) was performed at the University of California Riverside.

22. How Can We Use Synthetic Biology to Solve the Space Radiation Challenge Facing Human Space Exploration?

Jithran Ekanayake ’20

Other Authors /Contributors: Jennifer Wolff, Amor Menezes, Robert Martinez, Chase Kelley, Cameron Kelley, Justin McCauley, and Jacob York

Supervisor: Dr. Amor Menezes [University of Florida; NASA Center for the Utilization of Biological Engineering in Space (CUBES)]

Advances in human and robotic space exploration have been powerful propellants of multidisciplinary technological innovation on Earth, and offer promising new ways of fostering international partnerships that promote the peaceful unification of people and nations across the globe. Human extra-vehicular activity during deep space exploration will involve substantial exposure to space radiation, leading to severe health consequences for future astronauts. Synthetic genetic circuits could be used to construct the scaffolding for synthetic biological radiation shields capable of detecting, intercepting, and attenuating or scattering space radiation while being of sufficiently low mass and high maneuverability to allow the wearer to interact efficiently with their environment for extended periods of time, but robust enough to withstand the weathering of abiotic stressors in a hostile extraterrestrial environment. We worked to model, construct and characterize one such synthetic genetic circuit that could eventually be used in the design of such a scaffolding.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

23. Examining the Impact of Deer on a Tallgrass Prairie Plant Community

Maria Fairchild ’20

Other Authors /Contributors: Kait Libbey '19, Mark J. McKone, and Daniel L. Hernández

Supervisor: Mark J. McKone (Towsley Professor of Biology, Carleton College), and Daniel L. Hernández (Associate Professor of Biology, Carleton College)

White-tailed deer (*Odocoileus virginianus*) are selective browsers and can alter plant community composition in areas with high deer population density. There is extensive work on deer impacts in forest plant communities, but less is known regarding the impacts of deer in tallgrass prairie. We hypothesized that deer would have unique effects on specific plant functional groups and reduce plant diversity in areas where deer browsing occurs. To test this, we compared plant community composition inside and outside of long-term deer exclosures in four sections of the Carleton Arboretum prairie

chronosequence that were each planted in different years. By comparing plant species richness and abundance of legumes, grasses, and goldenrods in areas with and without deer access, we provide further insight into the role of deer in grassland plant community dynamics.

24. A Search for Impact Glass in the Sirius Group, Transantarctic Mountains, Antarctica

Julia Felderman ’20

Other Authors /Contributors: Cameron Davidson

Supervisor: Dr. Ralph Harvey (Professor of Planetary Materials, Case Western Reserve University)

The Middle Miocene Sirius Group is found at the peaks of the Transantarctic Mountains, hundreds of kilometers from the ocean and over 2000 m above sea level. The Sirius Group contains Pliocene marine diatoms, spurring two competing hypotheses. One hypothesis says that the East Antarctic ice sheet has been stable for the last 11-14 Ma, and that the diatoms are an eolian contaminant. However, some planetary geologists believe that an impact event hit the Southern Ocean 2.15 Ma causing large tsunamis and lofted the diatoms into the atmosphere, depositing them in the Sirius Group. My research involves searching for tektites and/or impact glass to support or refute the impact hypothesis.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

25. Small Cycladic Islands Project

Aaron Forman ’21 and Sam Wege '22

Other Authors /Contributors: Alex Knodell, MJ Fielder-Jellsey '22, and Aubrey Rawles '21

Supervisor: Alex Knodell (Assistant Professor of Classics, Carleton College)

We worked on the inaugural summer field season of the Small Cycladic Islands Project (SCIP), a survey archaeology project in the Aegean Sea. Focusing on 10 small islands around Paros, we pursued questions of occupation, resource use, and network and connectivity patterns. Using both intensive and extensive survey methods, we participated in artifact collection and analysis, mapping, and feature documentation. Over the course of the season, we collected and studied artifacts ranging from prehistory to the modern period and encountered what we believe to be an archaeological site on the island of Filizi.

This research was funded in part by the Humanities Center SRP Program.

26. Species Swap of Protein VII Reveals Importance of HMGB1 interaction in Adenovirus Infection

David Galambos ’20

Other Authors /Contributors: Kelsey Lynch, Nick Donadio, and Daphne Avgousti

Supervisor: Dr. Daphne Avgousti (Fred Hutchinson Cancer Research Center)

Adenoviruses infect all vertebrate species and can cause clinically significant disease in immunocompromised patients. Adenoviruses encode protein VII, which is a small, histone-like protein that packages with the adenovirus genome. In human adenovirus infections, protein VII also binds to the host protein HMGB1, relocalizing it to the nucleus and thereby preventing its role in activating the immune response. In contrast, protein VII from mouse adenovirus does not interact with HMGB1 from human or mouse tissues. Here, we examine whether the interaction between protein VII and HMGB1 facilitates viral infection. We show that in a chimeric human virus expressing mouse adenovirus protein VII, mouse protein VII does not relocalize HMGB1 and is associated with decreased rates of viral replication and viral protein accumulation compared to wild-type human adenovirus. These results suggest that the interaction of protein VII with HMGB1, and potentially other unknown factors, significantly contributes to viral infection.

27. Meaning in Time: Revisiting the Perceived Long-Term Insignificance of Our Lives

Michael Gasior ’20

Other Authors /Contributors: Neil Lutsky, Jennifer Chan '19, Marshall Ma '19, Nam Ahn Nguyen '19, Maddie Sherwood '19, Elsa Sandeno '19, and Lena White '19.

Supervisor: Neil Lutsky (William R. Kenan, Jr. Professor of Psychology, Carleton College)

Heintzelman and King (2014) argued that people find life meaningful. A prior study completed by student researchers under the guidance of Neil Lutsky showed that when the meaning of life was viewed from a longer-term perspective, people did not find their life as meaningful than in the short-term. To address a possible limitation, we conducted a second study with a set of questions asking people about the meaning of time in their own lives before later asking them questions like those we asked in the first study. Two hundred fifty-five participants completed variations of a survey in which they answered questions pertaining to their purpose, comprehension of their lives, and whether their lives matter, as well as the long-term meaningfulness of other events. Our findings support the first study conducted by suggesting that time dilutes the link between assessments of present meaning and predictions of lasting meaning.

28. Genome Enabled Natural Products Discovery Through a G4 Quadruplex Remediating Enzyme

Jesse Gates ’20 and Jack Delluge ’20

Other Authors /Contributors: Dakota Snustad, Aleksandra Bajer, Stephen Heinsch, Dimitri Perusse, and Michael Smanski

Supervisor: Michael Smanski (Assistant Professor of Biochemistry, University of Minnesota)

Bacteria in the genus Streptomyces are prolific producers of bioactive natural products and have genomes comprised mostly of GC nucleotide pairs, which can form G-quadruplexes (G4). Previous work has shown that the antibiotic undecylprodigiosin is down-regulated by a G4 structure in the promoter region of its biosynthetic gene cluster. G4 structure stability can be controlled by over- and under-expression of the RecQ helicase enzyme in vivo. Streptomyces with remediated G4 regions may produce useful novel metabolites. Here we show the results of untargeted metabolomics of bacteria with remediated G4 structures in their genome.

29. How Dominant Grasses Colonize Unoccupied Sites in Tallgrass Prairie

Ryan Gilbert ’21

Other Authors /Contributors: Dan Hernández, Mark Mckone, and Kait Libbey '19

Supervisor: Mark J. McKone (Towsley Professor of Biology, Carleton College), and Daniel Hernández (Associate Professor of Biology, Carleton College)

Dominant plant species play a pivotal role in shaping ecosystem and community processes. But how do dominant species colonize locations where they are not yet present? In a 2011 experimental community assembly in the Carleton College Arboretum, a set of 28 plots were planted using a diverse mix of prairie plants, but only half of these plots included the two dominant tallgrass prairie grasses: *Andropogon gerardii* and *Sorghastrum nutans*. The percent cover of each of the dominant grasses was estimated for five summers between 2013 and 2019 across all plots. *Sorghastrum nutans* colonized unplanted plots to a small extent (1% cover) until 2019, when abundance in these plots increased significantly (~3% cover). *Andropogon gerardii* rarely colonized unplanted plots (1% cover) and showed no recent increases. In planted plots, *Sorghastrum nutans* was common (mean cover: 19%) while *Andropogon gerardii* was relatively rare (mean cover: 2.5%).The rapid recent increase in *Sorghastrum nutans* suggests that it may become dominant across the study site in the near future. These results also suggest that relative dominance may be contingent upon the order in which an ecological community is assembled.

30. Investigations of Virus-Host Interactions in Fungi

Seth Greengo ’20

Other Authors /Contributors: Lisa Bruno, John Daudu, Charalampos Philippou, Dr. Robert Coutts, Dr. Ioly Kotta-Loizou

Supervisor: Dr. Robert Coutts (University of Hertfordshire) and Dr. Ioly Kotta-Loizou (Imperial College London)

Mycoviruses, viruses that infect fungi, were discovered in the 1940s and have been discovered in all four phyla of fungi. However, the effects of these viruses have only recently started to be investigated. In the Coutts Lab at the University of Hertfordshire, many types of virus-host interactions have been investigated. The main project over the summer was to determine the effects of the virus Beauveria bassiana polymycovirus 3 (BbPmV-3) on Beaveria bassiana, a fungus and popular biocontrol agent. The long term goal of this project is to use mycoviruses to control host life cycles and improve the efficiency of biopesticides, the use of which has impacts on human health and the environment. Additional projects provided insight into the sequence of an unknown RNA found in a virus infecting the human pathogenic fungus Aspergillus fumigatus and the replication cycle of an unknown virus discovered in a specimen of Lecanicillium muscarium.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

31. 3D printing of Nano-scale Energetic Material

Spencer Hamilton ’20 and Xander Idrogo '21

Other Authors /Contributors: Miles Rehwoldt, Dylan Kline, and Zaira Alibay

Supervisor: Dr. Michael Zachariah (Distinguished Professor of Chemical Engineering and Material Science, University of California, Riverside), Miles Rehwoldt (Ph.D. Candidate in Chemical Physics, University of Maryland, College Park) and Dylan Kline (Ph.D. Candidate in Chemical Engineering, University of Maryland, College Park)

Nano-scale energetic materials, such as nanothermites, are a topic of particular interest in applications such as propellants and explosives, due to their high energy density as compared to a traditional micro-scale alternative. However, the increased viscosity of these materials poses an issue for the processing and construction of structured materials.The rise of additive manufacturing has provided a new and effective technique for theconstructionof nano-scale energetic materials, leading to the development of new architectures and allowing researchers to 3D-print a variety of energetic composites with different formulations.This flexibility in architecture and formulation allows for the assembly of novel microstructures which can fulfill a variety of roles and have highly tunable combustion performance. The viability and tunabilty of these 3D-printed energetic materials was exploredthrough the use of a series of physical and chemical instruments, including electron microcopy, highspeed pyrometry and mass-spectrometry.

32. H II Regions in M33

Vincent He ’22

Other Authors /Contributors: Cindy Blaha

Supervisor: Cindy Blaha (George H. and Marjorie F. Dixon Professor of Physics and Astronomy, Carleton College)

The Local Group is the group of galaxies within three million light-years of our galaxy. Their proximity enables us to study their structure and composition in detail. We used hydrogen emission-lines (H II) to study M33, a spiral galaxy in the Local Group. To do so, we needed to account for extinction due to dust within M33. We used a linear combination of the H II image from the Kitt Peak National Observatory (KPNO) and the 24μm infrared image from the Spitzer Space Telescope to obtain an extinction-corrected H II image. By comparing this image with the [S II] and [O III] images from KPNO and by analyzing the H II luminosity distribution, we studied star formation in M33. This study provides us with useful data for further research about the history of M33 as a galaxy's structure and composition are heavily influenced by its star-forming activities.

This research was funded in part by the Towsley Endowment.

33. 3D Printing of Nano-Scale Energetic Material

Xander Idrogo ’21 and Spencer Hamilton '20

Other Authors /Contributors: Michael Zachariah

Supervisor: Dr. Michael Zachariah (University of California-Riverside)

Nano-scale energetic materials, such as nanothermites, are a topic of particular interest in applications such as propellants and explosives, due to their high energy density as compared to a traditional micro-scale alternative. However, the increased viscosity of these materials poses an issue for the processing and construction of structured materials. The rise of additive manufacturing has provided a new and effective technique for the construction of nano-scale energetic materials and has led to the development of new architectures and allowed researchers to 3D-print a variety of energetic composites with different formulations. This flexibility in architecture and formulation allows for the assembly of novel microstructures which can fulfill a variety of roles and have highly tunable combustion performance. The viability and tunabilty of these 3D-printed energetic materials was explored through the use of a series of physical and chemical instruments, including electron microcopy, highspeed pyrometry and mass-spectrometry.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

34. Creating a Luminosity Function of H-alpha Regions in M31

Ann Isaacs ’20

Other Authors /Contributors: Sarah Bodansky, '21, Vincent He, '22, James Yue, '22, and Cindy Blaha

Supervisor: Cindy Blaha (George H. and Marjorie F. Dixon Professor of Physics and Astronomy)

The Andromeda Galaxy, or M31, is our closest spiral galactic neighbor. I studied the ionized hydrogen regions in this galaxy to learn about the history of star formation in M31. Using Kitt Peak National Observatory images, I located regions of high hydrogen emission and measured their size and energy flux. I then corrected for extinction, the loss of light to dust between the region and the telescope, using the Spitzer Space Telescope images taken at infrared wavelengths. Finally, I created a luminosity function, which compares the numbers of regions at each luminosity. This plot provides valuable information about the star formation history of a galaxy. What we learn about M31 from this plot can teach us about other spiral galaxies we cannot observe as closely, including our own.

35. Ancient Jewish Healing Incantations: a Review

Jacob Isaacs ’20

Other Authors /Contributors: Daniel Picus

Supervisor: Daniel Picus (Oden Post-Doctoral Fellow for Innovation in the Humanities Department of Religion, Carleton College)

Language was powerful in Ancient Judaism. This is apparent in the wide array of healing incantations that survive alongside more familiar institutionalized practices. These "magical" texts offer ways to effect material change through language. Magic, rather than existing outside tradition, reflects broader cultural trends alongside the endemic practices of "mainstream" Judaism. Through a review of the corpus of late ancient Jewish magic, informed by contemporary theories of language, we document the specific ways in which these texts act on the world. Selection of words, context, audience, execution, and purpose all play substantial roles in determining material effects.

This research was funded in part by the Humanities Center SRP Program.

36. Black, White, or Red: How Communism Turned Civil Rights into a Crime

Katerina Katakalides ’20

Other Authors /Contributors: Charisse Burden-Stelly and Guapo Banuelos '20

Supervisor: Charisse Burden-Stelly (Assistant Professor of Africana Studies and Political Science, Carleton College)

During the Second Red Scare, Senator Joseph McCarthy fueled anti-communist fears by publicly

declaring that disloyal employees worked for the federal government. In conjuncture with J. Edgar Hoover's already anti-radical FBI, McCarthy promoted the nationwide threat of a violent government revolution. This political climate enabled Hoover and McCarthy to establish or oversee federal committees with goals of monitoring, censoring, and stigmatizing "radical" groups, organizations, and individuals. In criminalizing radical activities and ideologies, McCarthy and Hoover established reasons for discrediting the Civil Rights movement and prosecuting Civil Rights leaders. The arrest and deportation of Communist leader and Civil Rights activist Claudia Jones exemplifies how the federal government, namely McCarthy and Hoover's FBI, successfully abused political power to hinder Civil Rights efforts.

This research was funded in part by the Humanities Center SRP Program.

37. Quantum Tunnelling in Chaotic Systems

Alex Kiral ’20

Other Authors /Contributors: Arjendu Pattanayak

Supervisor: Arjendu Pattanayak (Professor of Physics, Carleton College)

Quantum tunnelling presents a difference with classical thermodynamic ideas, as it is caused by recoherence after a state has decohered. We explore how tunnelling is related to both quantum phenomenon and structures in classical phase space. This is done in the kicked top system, a nonlinear Hamiltonian system which has a mixed phased space in the classical system. We develop a metric that allows us to quantify the quality and rate of tunnelling in a quantum system. We also develop techniques for using eigenvalues and eigenstates of the time evolution operator to predict rates of tunnelling and compare this to phase space structures. This work allows us to understand the way that quantum behavior transitions to classically chaotic behavior as the size of the system grows.

38. Characterizing PIP Binding Interactions Using Solid-State Nuclear Magnetic Resonance (ss-NMR)

An Kitamura ’21

Other Authors /Contributors: Andrew J. Nieuwkoop, Jacqueline Perodeau, Ashley D. Bernstein, Robert D. Palmere, and Stephany M. Lazieh

Supervisor: Dr. Andrew J. Nieuwkoop (Assistant Professor of Chemistry and Chemical Biology, Rutgers University)

Phosphatidylinositol phosphates (PIPs) are lipid membranes that are involved in regulating cellular processes in Eukaryotic organisms. Misregulation of PIPs has been linked to diseases like diabetes, cancer, and immune disorders. Our understanding of PIP binding interactions is incomplete and no direct method of observing this mechanism has been developed. This project aims to characterize PIP binding mechanisms by mapping PIP binding sites using Solid-State Nuclear Magnetic Resonance Spectroscopy (ss-NMR). Specifically, PIP binding to the Pleckstrin Homology (PH) domain of proteins is being investigated.

This research was funded in part by the Sam '75 and Meg Woodside Fund for Career Exploration.

39. The Effects of Bariatric Surgery on Crown Like Structures in Human Adipose Tissue

Alec Kotler ’22

Other Authors /Contributors: Dr. Isabel Casimiro, Dr. Matthew Brady, and Dr. Erin Hanlon

Supervisor: Dr. Isabel Casimiro (Assistant Professor of Endocrinology, University of Chicago), Dr. Matthew Brady (Professor of Endocrinology, University of Chicago)and Dr. Erin Hanlon (Assistant Professor of Endocrinology, University of Chicago)

Obesity causes adipose tissue expansion and remodeling thus depleting oxygen, which then causes adipocyte death.Macrophages will then come into the tissue to surround the dead adipocytes and form a crown like structure. Weight loss has also been shown to promote macrophage recruitment into adipose tissue due to enhanced release of fatty acids.Our studies focus was to compare the number of crown like structures among patients before and after surgery and we tested the hypothesis that the amount

of crown like structures in the adipose tissue after surgerywould go downafter weight loss. The adipose tissue for our study was acquired through needle-biopsies and we then stained the slides of tissue so we could use bioluminescence to count the crown like structures under the microscope. We measured the total area of all samples collected and standardized to the largest area to compare the crown like structures between patients.

40. Coming to My Senses: Experiencing Sound and Space in Björk's Cornucopia and the Audium

Cecilia Kryzda ’20

Other Authors /Contributors: Carol Donelan

Supervisor: Candace Moore (Assistant Professor of Women's and Gender Studies & Cinema and Media Studies, Carleton College)

Björk's videos, and in this case her Cornucopia concert, tend to display sensorial complexity; a constant flow of dense and fantastical imagery which tends to wrap the viewer up in surface rather than narrative exposition. Technically her first "theatrical production," Cornucopia was equipped with 360 degree surround sound. The unfamiliarity of the image forces the viewer to remain in an eternal state of simultaneous disorientation and immersion. Similarly, the 176 speakers arranged throughout a pitch black, circular room in the San Francisco Audium immerse the listener in complex sensorial information which contextualizes future experiments in creating enveloping sonic environments. While she uses sophisticated technology like the Audium, Björk simultaneously channels her performance of self through natural sources, whether geological, floral, or faunal. Björk's work seems to inhabit a space that is both the absolute ancient and the absolute future-present, which results in a strange construction: a natural robot of sorts.

This research was funded in part by the Class of 1963 Fellowship.

41. Sensitizing Tumors to Immunotherapy via Antigen-independent Killing

Sasha Kyrysyuk ’20

Other Authors /Contributors: Deng Pan, Yoshinaga Ito, and Kai Wucherpfenning

Supervisor: Deng Pan (Dana-Farber Cancer Institute), Yoshinaga Ito (Dana-Farber Cancer Institute), Kai Wucherpfenning (Dana-Farber Cancer Institute)

Immunotherapy has made an immense leap forward towards curing cancer. However, tumors frequently outsmart the immune system; the antigen escape constitutes a critical barrier to successful immunotherapies for a wider range of patients. Conventionally, T cells require direct TCR-MHC:peptide recognition to eliminate a cancer cell. However, once the recognition occurs, T cells are able to affect the neighboring cells via cytotoxic cytokines. Yet again, the tumor cells are not susceptible to the cytokine-induced cell death. We showed that the loss of a major factor in the TNFa pathway sensitizes the tumors to antigen-independent killing, leading to a dramatic cancer cell death. Furthermore, we identified novel cytokines that are able to exhibit cytotoxic activities through the TNFa signaling axis after the KO of the studied factor. Finally, we found that a small molecule inhibitor is able to synergize with TNFa and IFNg to induce the cell death of cancer cells.

This research was funded in part by the Career Center Internship Funding.

42. Role of IL-6 in Promoting Palbociclib Resistance in Estrogen Receptor Positive Breast Cancer

Nghi Lam ’22

Other Authors /Contributors: Nicole M. Kettner, and Khandan Keyomarsi

Supervisor: Nicole M. Kettner (Department of Experimental Radiation Oncology, University of Texas MD Anderson Cancer Center, Houston, TX), Khandan Keyomarsi (Department of Experimental Radiation Oncology, University of Texas MD Anderson Cancer Center, Houston, TX)

Clinically, the combination of CDK4/6 inhibitors, i.e. palbociclib, with endocrine therapy has doubled progression free survival for advanced ER+ breast cancer patients. However, most patients eventually

develop resistance and there remains an urgent need to find new therapeutic options for these patients. Data from our pre-clinical palbociclib-resistant models suggested the induction of the IL-6/STAT3 signaling pathway promotes palbociclib resistance. We hypothesize the inhibition of this pathway may restore sensitivity to palbociclib in resistant ER+ breast cancer cells. Data from IL-6-knockdown resistant cells show decreased expression of IL-6 mRNA and proteins involved in this pathway. Cell viability assay in increasing palbociclib concentrations result in a decrease in drug concentration required for 50% inhibition in all three shIL-6 vectors, with a significant decrease in shIL-6 #1 and #2. Collectively, our results suggest the inhibition of the IL-6/STAT3 signaling pathway by IL-6 knockdown resensitizes palbociclib-resistant cancer cells (MCF7 and T47D) to palbociclib.

43. Lake Spray Aerosolization of Harmful Algae Blooms

Isabel Ledsky '20

Other Authors /Contributors: Kim Daley, Madeline Cooke, Ziying Lei, Nicole Olson, and Jia Shi

Supervisor: Dr. Andrew Ault (Assistant Professor of Chemistry, University of Michigan)

Freshwater lakes can contain harmful algal blooms (HABs) of Cyanobacteria that produce toxins and can affect human health. Previous research has shown that biological particles can be identified in lake spray aerosol generation. In this study, markers for the HAB toxin Microcystin-LR were explored through field collection and on a Lake Spray Generator. An aerosol time of flight mass spectrometer was used to analyze Microcystin-LR standards as well as field samples of HAB lake water. Possible mass spectroscopy markers were identified which will be used in further studies and field work to determine if associated HAB toxins are being aerosolized.

44. You Can Make Money Too!: The Unspoken Audience of Personal Finance Books

Danielle Lewis '20

Other Authors /Contributors: Annette Nierobisz, William North, and Lori Pearson

Supervisor: Annette Nierobisz (Professor of Sociology, Carleton College), William North (Director of Medieval and Renaissance Studies, Professor of History, Carleton College), and Lori Pearson (David and Marian Adams Bryn-Jones Distinguished Teaching, Professor of the Humanities Professor of Religion, Carleton College)

Regularly advertised as books for all, personal finance books have provided the American audience with tips and tricks on how to improve their financial wellbeing. However, the knowledge that they provide and the actions that they promote do not always translate to the resources that all people have. This leads to the question: Are these really books for all? In this study, I conduct a content analysis by reading four personal finance books supplied by my local public library. I aim to understand the common information that personal finance books provide, the ideas that they uphold, and the identities of the audiences that typically read them. Using sociological theories that explore how Neoliberalism deals with class, I suggest that these books are not, in the end, for all, but reflect current economic values and inequalities in American society.

This research was funded in part by the Mellon Mays Undergraduate Fellowship.

45. Deep Learning for Embryo Ploidy Assessment Using Time-lapsed Images

Qianzi Li '21

Other Authors /Contributors: Josue Barnes and Pegah Khosravi

Supervisor: Iman Hajirasouliha, Assistant Professor, Weill Cornell Medicine of Cornell University

A previous study has shown that deep learning architectures, such as Convolutional Neural Networks are able to asses embryos quality using a single stagnant image taken from in vitro fertilization. While the current method had great performance in identifying embryo quality as poor or good, the classification result for aneuloidy (abnoramal number of chomosomes) is not high enough to have clinal importance. In this study, we explored the performance of several deep learning architectures commonly used in video classification, such as LSTM+CNN, 3D-CNN, and slow-fast net on IVF images of embryos. But, instead of a single image, we used images taken from consecutive time points, showing the progression process

of each embryo. We achieved a best test accuracy of about 70% on a dataset of 1792 embryos using the LSTM+CNN architecture. Further investigation with a larger dataset is necessary to determine the robustness of our approach.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

46. Spectral Properties of the Exponential Distance Matrix

Aaron Li '20

Other Authors /Contributors: Steve Butler, Kate Lorenzen, Liz Cooper, Zoë Schopick

Supervisor: Steve Butler (Associate Professor of Mathematics, Iowa State University)

Given a graph G, the exponential distance matrix is defined entry-wise by letting the (u, v)-entry be qdist(u,v), where dist(u, v) is the distance between the vertices u and v with the convention that if vertices are in different components, then qdist(u,v) = 0. Weestablish several properties of the characteristic polynomial (spectrum) for this matrix, we give some families of graphs which are uniquely determined by their spectrum, and we produce cospectral constructions.

47. Non Linear Energy Harvesting

Lawrence Lin '20

Other Authors /Contributors: Arjendu Pattanayak

Supervisor: Arjendu Pattanayak (Professor of Physics, Carleton College)

In a system where the frequency of the driving force is nonlinear, the most efficient way of harvesting this nonlinear driving force for energy is to use a chaotic oscillator. Due to the nature of its broadband energy harvesting capabilities. Usingthe geometry of phase space for the RC coupled Duffing oscillator, we were able to draw conclusions on the ratio of energy taken todrive the system and the energy absorbed by the RC circuit. We found that there are local regions of maximal energy harvesting efficiency, embedded in a global trend of resonance in the RC circuit. By simply changing the resistance value in the RC circuit we can increase the efficiency of energy harvesting by 30-50%. This is a powerful statement because by expending a small amount of energy to "kick" the system in the right way, we can reap much greater energetic rewards.

48. Nanoparticle Formation in Ruthenium-catalyzed Deoxygenation of Glycerol

Joseph Luther '20

Other Authors /Contributors: Margaret Scheuermann

Supervisor: Margaret Scheuermann (Western Washington University)

Biodiesel is a promising carbon-neutral alternative to fossil fuels, however current production methods yield glycerol as a major byproduct. In the interest of converting glycerol to value-added chemicals, a homogeneous ruthenium complex has been previously reported to catalyze the reduction of a model diol substrate to an alkane. Under the reaction conditions required for this catalysis, the complex is reduced to nanoparticles which have been isolated from reaction mixtures via centrifugation. Our studies did not observe significant conversion of the diol substrate to alkane, instead yielding cyclohexene and toluene. Benzene solvent is presumed to be the source of cyclohexene, suggesting the presence of ruthenium nanoparticles. Given that noble metals are known to be effective heterogeneous catalysts, this complex's decomposition poses questions as to the validity of other highly engineered and expensive "homogeneous" noble metal precatalysts.

49. Hot Gene Expression and Function in Caenorhabditis elegans

Kaela Mali '21

Other Authors /Contributors: Rou-Jia Sung and Jennifer Wolff

Supervisor: Rou-Jia Sung (Assistant Professor of Biology, Carleton College)

Despite being structurally similar to alpha-neurotoxins found in snake venom, little is known about the function of the Ly6 proteins. Studies of Ly6 function in mammalian systems are made difficult by the

large size of the family (40 members). In *C. elegans*, however, there are only 10 members of this protein family (the hot genes), making it an apt model organism for establishing an understanding of the function of these proteins. We examined cellular location of these proteins by generating transcriptional GFP reporters followed by fluorescence microscopy for hot 4 and 7. Images show that these proteins are located near the pharynx, alluding to a potentially neuronal role. We also did RNAi knockdown in an attempt to study function; results were inconclusive. Moving forward, we hope to determine the specific cell, or set of cells, where each hot gene is being expressed as well as gather more data regarding function using gene deletion analysis.

50. Neonicotinoids and Nectar Chemicals Influence on *Bombus impatiens* Activity and Survival

Denyse Marquez Sanchez ’21

Other Authors /Contributors: Sarah Richman Ph.D., and Anne Leonard, Ph.D.

Supervisor: Sarah Richman Ph.D. (Biology, University of Nevada, Reno) and Anne Leonard, Ph.D. (Associate Professor of Biology, University of Nevada, Reno)

Past studies have shown neonicotinoid have a negative influence on pollinators such as changing bee's survival and activity. Although, these studies don't take into account nectar chemical in their experiments. Chemicals found in real flower nectar could possibly interact with neonicotinoids and influence bees in a way that past experiments haven't account for. We added field realistic levels of caffeine into a sucrose solution and fed this to bumblebee *Bombus impatiens* in a laboratory setting along with giving different dosage levels of neonicotinoid to investigate potential combined effects of nectar chemistry and pesticides. We did find differences between hazard ratios between the groups of bees that received caffeine and of those that didn't. We don't have telling information on the survival of worker bees but our study suggests that investigating other nectar chemicals might be useful in seeing if they complicate the relationship we currently know between bees and neonicotinoids.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

51. Development of Automated Image Analysis for Underwater Images

Pierce McDonnell ’21

Supervisor: Dr. Dvora Hart (Northeast Fisheries Science Center)

The National Oceanic Atmospheric Administration (NOAA) regional facility Northeast Fisheries Science Center (NEFSC) undertakes research to inform policymakers who set annual quotas for the commercial fishing industry. This research includes collecting data on the population sizes of various fisheries. Through the course of various underwater surveys conducted since 2012, NOAA has collected roughly 40 million images and counting. In order to address the magnitude of this data set, NOAA has developed a computer program, called Video and Image Analytics for a Marine Environment (VIAME), to enable researchers to efficiently sort these pictures. In my project, I trained the VIAME system's Convolutional Neural Networks (CNN) to automatically detect organisms of interest to NOAA, including fish, scallops, and other invertebrates. Specifically, I used a subset of the images, which were manually annotated for content, as a training set by which to teach the VIAME system to distinguish between various sea creatures.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

52. Histone Modifications in Aging and Oxidative Stress

Quinn McVeigh ’20

Other Authors /Contributors: Helena Brendler, Michael Kobor, and Quinn McVeigh '20

Supervisor: Michael Kobor (Senior Scientist, Centre for Molecular Medicine and Therapeutics, BC Children's Research Institute, University of British Columbia)

As age increases, the risk of developing a neurodegenerative disorder, such as Alzheimer's, also increases. One proposed hypothesis for this correlation is accumulated damage to DNA structure from oxidative stress potentially mediated by histone modifications. Our research aims to develop a model

of how oxidative stress affects histone modifications in an age-dependent manner. Using rat C6 glioma cells, we exposed 15 and 45 passage cells to hydrogen peroxide for 24 hours. My work focused on older passages. We used MTT and DCF assays to test for viability and oxidative stress. Using Western blotting and quantitative PCR, we tested for changes in histone modifications and mRNA expression. H3K6me2, H3K4me3, and H4k16ac were found to be higher in passage 44 cells exposed to 0.2 mM H2O2 for twenty-four hours than the control. No change was found in levels of Nrf2, Oxr1, and Sod1 transcripts.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

53. Optimizing Electroporation for Engineering Cardiopoiesis

Keenan Moore ’20

Other Authors /Contributors: Tyler Rolland '18; Mark Li, MASc; Raman Deep Singh, PhD; Christopher Livia; Andre Terzic, MD, PhD; Atta Behfar, MD, PhD

Supervisor: Dr. Atta Behfar (Mayo Clinic)

Cardiovascular disease represents a major medical obstacle in the United States. The use of adipose-derived mesenchymal stem cells (AMSCs) is a novel approach to cardiac regeneration after myocardial infarction due to their ability to redirect towards cardiopoietic stem cells. Clinical trials are underway to test the ability of cardiopoietic stem cells to reduce rates of heart failure after a heart attack. Initially requiring a cocktail of factors, a single transcription factor, Brachyury, has been identified as single-factor pathway capable of inducing cardiopoiesis. Previously, transfection of Brachyury mRNA has primarily been achieved through the use of transfection reagents. The application of this method into clinical practice remains challenged by the toxicity of the reagents. Electroporation provides a promising alternative for transfecting human cells due to its safety and efficiency.

54. Observations of the Relativistic Binary Pulsar B1913+16

Ayaka Moriyama ’22 and Helen Du ’22

Other Authors /Contributors: Joel Weisberg, Joe Swiggum '10, Sanjay Chepuri '17, and Marisa Roch

Supervisor: Joel Weisberg (Herman and Gertrude Mosier Stark Professor of Physics and Astronomy and the Natural Sciences, Emeritus of Physics and Astronomy, Carleton College)

Pulsars are rapidly spinning neutron stars that emit beams of radiation. B1913+16 is part of a binary neutron star system where the components orbit each other in a period of about 7.75 hours. According to general relativity, the neutron stars will lose energy by emitting gravitational waves, which will cause the binary orbit to shrink, resulting in a change in the arrival times of pulse signals. With the new data from B1913+16 taken with the radio telescope at Arecibo Observatory in Puerto Rico and from previous sessions in 2012 and 2016, our analysis yields that the observed rate of change of orbital period is consistent with general relativity. We also discovered an inconsistency between the predicted and observed rotational period in a small part of the 2016 data, which requires further analysis.

55. Marching with the Romans

Patrick Mullins ’20, Isabel McFadden '20, and Gabe Nass '20

Other Authors /Contributors: Jake Morton

Supervisor: Jake Morton (Assistant Professor of Classics, Carleton College)

In the years 171-168 BC, the Roman army waged war in Greece against the Macedonian empire. The first century BC Roman historian Livy recorded the efforts of the Romans to find a way into Macedonia from the south, across the ridges between Mount Olympus and the Vale of Tempe. There is scholarly debate concerning where exactly the Romans went and why. Our research involved a geographical study of the area to see where it was possible for the Romans to go and how these routes align with descriptions in Livy. We also investigated the presence of a developing Macedonian fort system in the area, and how this system affected Roman troop movements. The research produced proposals for the Roman routes of each season's campaign, a new understanding of how the Macedonian forts worked as a system, how this system developed, and new readings of the Latin text of Livy.

This research was funded in part by the Humanities Center SRP Program and the Dean of the College.

56. Invasive Properties of GSCs with known IDH1 Status into Human Cerebral Organoids

Maxime Munyeshyaka ’21

Other Authors /Contributors: Sanjay Singh, Joy Gumin, Jing Yang, Daniel Ledbetter, and Frederick Lang

Supervisor: Dr. Frederick Lang (MD Anderson Cancer Center)

Glioblastomas (GBM) are malignant Grade IV tumors whose prognosis remains dismal, 14.7 months of median survival after standard therapy. GBM biology is traditionally investigated by utilizing patient-derived tumor cells (e.g GBM stem-like cells "GSCs") in mouse models lacking normal human neural tissue. This shortcoming can be addressed by utilizing human cerebral organoids (COs) derived from induced pluripotent stem cells and serve as in vitro model systems to recapitulate human brain microenvironment. Here, we hypothesized that the invasiveness of GSCs within COs is dictated by IDH1 status, where IDH1 wild-type are more aggressive than IDH1 mutant GSCs. We utilized 45 day-old COs and three GSCs lines for in vitro invasion and proliferation assays. Our results show that GSCs with wild-type IDH1 appear to be more aggressive within COs. With further research studies, the use of COs will elucidate the contribution of the normal brain microenvironment to the growth and invasiveness of GBMs.

57. Recreational Marijuana Prohibition and Legalization

Sogra Nassri ’20

Other Authors /Contributors: Christina Farhart

Supervisor: Christina Farhart (Assistant Professor of Political Science, Carleton College)

My research explores what factors drive states to legalize marijuana, with an emphasis on preliminary examination of the adoption of recreational marijuana sales by Colorado local governments. Evidence shows that the decision to legalize marijuana is a result of a combination of policy determinants, policy diffusion, public opinion, and economics; however, public opinion has had the greatest influence on a state or local government's decision to legalize marijuana. Subsequently, since citizen initiative has played a large role in legalizing marijuana, I investigate trends among demographic factors such as gender, religion, race, income, education, and geography, to explore what groups are most supportive or opposed to recreational legalization. Moreover, I look at an anomaly in the mix of 11 states that have legalized recreational legalization -- Illinois. In June 2019, Illinois legalized recreational marijuana; however, Illinois is the first state to do so through the legislative process and the first state to have a thorough social equity program. It would be worthwhile for future research on Illinois to highlight why Illinois is the only state to date to use the legislative process and why other states have not focused on a social equity component.

This research was funded in part by the Mellon Mays Undergraduate Fellowship.

58. When do Prairie Restorations Fail? *Solidago altissima* Dominance in a Restored Tallgrass Prairie

Sarah Newsham ’20

Other Authors /Contributors: Kait Libbey, '19 , Daniel Hernández, and Mark McKone

Supervisor: Mark J. McKone (Towsley Professor of Biology, Carleton College), and Daniel Hernández(Associate Professor of Biology, Carleton College)

Successfully restoring agricultural fields to native tallgrass prairie requires understanding how and why some restorations "fail" due to dominance by a single species. In one restored prairie in the Carleton Arboretum, Canada goldenrod (Solidago altissima) has overtaken one portion of the field. In order to better understand this process, we studied the relationship between goldenrod abundance and plant diversity in that portion of the field since it was planted in 2011. Goldenrod cover has increased significantly since 2011 while diversity of other prairie plants has decreased, consistent with field observations. Grass abundance peaked three years after planting, suggesting that it was outcompeted by goldenrod. These results suggest that goldenrod dominance in restored tallgrass prairie is indeed an alternate stable state, which so far has prevented the establishment of a diverse prairie. Further monitoring will determine if current dominance by a single species will continue.

This research was funded in part by the William Muir Scholars.

59. Deformation Experiments of the Etchegoin Sandstone

Lena Nyblade ’21

Other Authors /Contributors: Kate Nootenboom '20, Peter Lindquist '18, Sarah Titus, and Melodie French

Supervisor: Sarah Titus (Professor of Geology, Carleton College) and Melodie French (Assistant Professor, Earth, Environmental, and Planetary Sciences, Rice University)

Deformation bands are commonly found in the Etchegoin Formation, a Pliocene-age sandstone exposed in folds up to 40 km northeast of the San Andreas fault in central California. To better understand how applied stresses influence deformation of the Etchegoin Formation, we deformed cylindrical samples of the sandstone using a triaxial deformation apparatus. We ran a series of experiments at effective confining pressures from 1.5 to 25 MPa to simulate burial conditions of the Etchegoin Formation (depths of ~1 km), a temperature of 50°C, and an axial strain rate of 10^{-8} s^{-1}. The specimens exhibit a pressure-sensitive elliptical yield envelope characteristic of critical state deformation models. The lack of localization despite high strains indicates that the Etchegoin formation can withstand considerable strain before localization. Our results may help us better interpret naturally-deformed samples of the Etchegoin Formation in the future.

60. Investigating Potential False Detections with the Habitable Zone Planet Finder

Katy Oda ’22

Other Authors /Contributors: Ryan Terrien, Suvrath Mahadevan, Dr. Guðmundur Stefánsson, and Dr. Joe Ninan

Supervisor: Ryan Terrien (Assistant Professor of Physics and Astronomy, Carleton College) and Suvrath Mahadevan (Professor of Astronomy and Astrophysics, Pennsylvania State University)

he Habitable Zone Planet Finder Spectrograph (HPF) looks for shifts in the spectra of nearby stars resulting from orbiting planets. For accurate measurement, HPF tracks the target star using several guide cameras to monitor the star's position in the frame. There was concern that systematic guiding error and/or poor visibility were leading to false planet detections. To evaluate this possibility, I developed code to search for a correlation between the guide camera data and the measurements from the HPF spectra. Such a correlation would indicate that the spectra were being affected by the performance of the guide camera, which would call past planetary detections into question. Having compared the guide camera data and HPF spectra for two target stars, we found no correlation between the guide camera performance or the visibility and the observed spectral shifts. These techniques can be extended to search for false detections in other stars.

61. Heterodyne Spectroscopy for the Detection of Exoplanets

Freja Olsen ’21

Other Authors /Contributors: Ryan Terrien

Supervisor: Scott Diddams (National Institute for Standards and Technology, University of Colorado at Boulder), Connor Fredrick (National Institute for Standards and Technology, University of Colorado at Boulder)

Combining the light from a distant star with laser light in what is called a heterodyne enables high-resolution spectroscopy of the star and may ultimately make it easier to find exoplanets. We use known lines in the sun's spectrum to asses the capabilities of heterodyne spectroscopy. The heterodyne combines sunlight collected with a small telescope and light from a 1550 nm diode laser that scans around the wavelength of a solar absorption line and is then detected by a photodetector. When the laser scans over the wavelength of the desired absorption line the power level detected by the photodetector drops, letting us see the spectral line. The successful detection of the line in the heterodyne signal provides proof of concept for the prototype set up and it can be refined for future experiments aimed at understanding sources of stellar activity that mask the radial velocity information needed to identify exoplanets.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

62. Developing Feature Width Control in Bilayer Liftoff by Varying Deposition Parameters: a Step Toward 3-Electrode DMTJs

Dasha Palenova '22

Other Authors /Contributors: Barry Costanzi

Supervisor: Barry Costanzi (Visiting Assistant Professor of Physics, Carleton College)

Magnetic tunnel junctions (MTJs) are nano-scale devices whose resistance depends on spin-dependent quantum tunneling of electrons across a classically insulating barrier. Development of a double barrier MTJ (DMTJ) with electrical contact to all three electrodes would offer many opportunities to probe the fundamental physics of tunneling, but a device geometry of this sort that also achieves clean, unoxidized barrier interfaces has thus far been elusive. As a first step toward this goal, we have developed a fabrication technique to allow sputter deposition of features of varying widths using the same resist bilayer pattern with an aggressive undercut. By varying the sample-target distance during sputtering, features with up to 25% difference in lateral size can be deposited without breaking vacuum. This will allow deposition of thin metallic wires followed by wide insulating barriers in situ, protecting tunneling interfaces from oxidation that has previously plagued this type of multi-step MTJ process.

63. An Investigation of Semantically Motivated Second Language (L2) Acquisition of Accusative Case Particle Ellipsis in Korean

Hannah Parrott '21

Supervisor: Cherlon Ussery (Associate Professor of Linguistics, Carleton College)

This summer I conducted a study on the second language acqusition of a phenomenon in Korean known as case particple ellispsis (CPE). CPE is when case particles, which attach to nouns in order to indicate their function in the sentence, are omitted from a phrase. In informal and conversational Korean, it is very common to omit the accusative case particles, or case particles that mark the direct object of the verb, and this omission follows several patterns for native speakers.The goal of my study, which consisted of a survey conducted online, was to see to what extent non-native speakers of Korean perform this case particle ellipsis in native-like ways.

This research was funded in part by the Professor Roy F. Grow Research Fellowship.

64. Mechanistic Study of SEI using 13C labeled components

Duncan Peterson '20

Other Authors /Contributors: Kim Huynh

Supervisor: Kim Huynh (Visiting Assistant Professor, Carleton College)

Lithium ion batteries (LIBs) are ubiquitous in day to day life. Understanding how they work should therefore be an ongoing project in modern research. Recent work has been done on the solid-electrolyte interphase (SEI) of LIBs that shows that the SEI is primarily composed of lithium ethylene mono-carbonate (LEMC) and lithium methyl carbonate (LMC), instead of the previously suspected lithium ethylene dicarbonate (LEDC). Developing a better understanding of the SEI can lead to breakthroughs that allow for longer lasting, more efficient, and more environmentally friendly batteries. However, when extracted and studied in dimethyl sulfoxide (DMSO), the SEI forms products that do not form in a LIB. This work attempts to understand the mechanism of SEI formation by synthesizing and following 13C labeled ethylene carbonate (EC).

65. Tissue-specific Heating Leads to Differential Gene Expression in Marine Mussels

Maya Powell '20, Alex Whitis '20 and Maggy Osha '21

Other Authors /Contributors: Mike Nishizaki and Shawn Galdeen

Supervisor: Mike Nishizaki (Assistant Professor of Biology, Carleton College)

Organisms in marine intertidal zones are subject to large temperature fluctuations associated with daily cycles of immersion-emersion. Whereas, the internal tissues of a mussel are thermally uniform

when submerged, patterns of tissue-level heating are less clear during aerial exposure. In both lab and field experiments, we measured differential heating rates for various mussel tissues that coincided with variable levels of gene expression (e.g., heat shock proteins) during aerial exposure in the marine mussel, *Mytilus trossulus*. These results imply that various physiological processes may respond differently to thermal stress and suggest a re-examination of previous physiological work.

This research was funded in part by the Towsley Endowment.

66. Effects of Flow and Temperature on Feeding and Respiration in Marine Mussels

Alex Whitis ’20 and Maya Powell '20

Other Authors /Contributors: Mike Nishizaki, Shawn Galdeen, and Maggy Osha '21

Supervisor: Mike Nishizaki (Associate Professor of Biology, Carleton College)

The goal of this project was to investigate how the marine mussel Mytilus trossulus responds to environmental changes. We explored the effects of flow and temperature using two metrics: respiration and feeding. Individual mussels were placed in a closed-loop circulation tank. Respiration was recorded via ruthenium-based fluorescence for up to two hours, while feeding trials were analyzed using spectrophotometry. Computational analysis was performed with the RespR package (v. 1.0.5.1). Response patterns of respiration and feeding to temperature and flow differed, suggesting that predictions regarding future climate change may be more complex than current models reflect. Future studies should aim to monitor these metrics under fluctuating conditions, as in situ temperatures and flow rates constantly change.

This research was funded in part by the Towsley Endowment.

67. Purchasing Culture in the Persian Gulf

Willie Powers ’20

Other Authors /Contributors: Adeeb Khalid and Serena Zabin

Supervisor: Adeeb Khalid (Jane and Raphael Bernstein Professor of Asian Studies and History, Director of Middle East Studies, Carleton College) and Serena Zabin (Professor of History, Broom Fellow for Public Scholarship, Director of American Studies, Carleton College)

Over the past two decades, the ruling families of the United Arab Emirates and Qatar have funded the creation of world-class museums on regional, islamic, and international themes. Many of these museums draw their authority from well-established cultural institutions including the Louvre, Guggenheim, and British Museum. These museums have gained the attention of the international world as the Arab Gulf states have gained prominence in the global economy. This prominence is partly enabled by the post-Gulf War proliferation of foreign military bases in the Persian Gulf and the instability of the region in the early 2000s. My research explores the ways in which these new museums, staffed and curated by westerners, communicates the local to visitors. I determine that the new museums are part of a project of cultural accumulation as well as a state-branding effort, designed to sway international opinion which is vital to the state's security.

This research was funded in part by the Class of 1963 Student Research Fellowship.

68. Disruption of CSF Glymphatic Flow After Anti-AQP4 Antiboy and Bumetanide Injection

Daniel Quintero ’20

Other Authors /Contributors: Nagesh Shanbhag, Martina Petrasova, Helén Axelberg, Iben Lundgaard

Supervisor: Lawrence Wichlinski (Associate Professor of Psychology, Carleton College), Nagesh Shanbhag (MD-PhD Neuroscience Post Doc, Lunds Universitet) and Iben Lundgaard (Associate senior lecturer of Glia-Immune Interactions, Lunds Universitet)

Clearance of extracellular products in the periphery happens through lymphatic vessels. This pathway, though, is not preserved within the brain. Recently, the glymphatic system was described, which moves cerebrospinal fluid from periarterial spaces to the interstitium via aquaporin-4 water channels in astrocytic end-feet. Dysfunction of this system has been implicated in many illnesses, yet methods to

specifically target AQP4 water channels are not available. Here, using in-vivo and ex-vivo fluorescent imaging, we first provide further support for the glymphatic system. We then show that anti-aquaporin-4 antibody and bumetanide injected intracisternally affect AQP4 water channels and significantly disrupt CSF dynamics within the brain. These findings may have implications for future development of therapeutic treatments.

This research was funded in part by the Carleton Summer Science Fellows, Dean of the College Travel Grant, and the Louis Stokes Alliances for Minority Participation.

69. Dominant Grasses Lower Diversity in Tallgrass Prairie Across Time

Peter Richieri ’20

Other Authors /Contributors: Kait Libbey '19, Mark McKone, Daniel Hernández

Supervisor: Daniel Hernández (Associate Professor of Biology, Carleton College)

Although there are dozens of plants in a typical tallgrass prairie community, some species are much more abundant and as a result could have a larger role in regulating community characteristics. However, the relative influence of these dominant species is not well known. We established a prairie planting in the Carleton Arboretum that experimentally included or excluded the two dominant species, Andropogon gerardii and Sorghastrum nutans, to test how their presence affects species richness, evenness, and diversity. After 4, 6, and 8 years following planting we measured plant community composition in high diversity prairie plots that were planted with or without the dominant grass species. A. gerardii and S. nutans consistently lowered the diversity, species richness, and evenness of the plots that they were planted in for every year that was tested. This experiment demonstrates that dominant grasses can consistently and measurably affect the overall composition of the tallgrass prairie community.

70. Using scRNA-seq to Explore the Contribution of Tumor Microenvironment in Neuroblastoma Pathogenesis.

Tom Rubino ’21

Supervisor: Dennis Gan (Post Doc Fellow, Mayo Clinic), Cassie Flachs (GREP Student, Mayo Clinic), Zaug Paj Her (GREP Student, Mayo Clinic), Shuai Li (Senior Post Doc, Mayo Clinic), Hu Li (Associate Professor, Mayo Clinic), Jane Zhu (Assistant Professor, Mayo Clinic)

The tumor microenviroment (TME) includes more than just tumor cells. It is made up of many different types of cells, including immune cells, endothelial cells, and blood cells. These cells, along with their interactions in the TME, may offer insight as to why some tumor cells more readily metastasize than others. This is especially valuable in the case of an aggressive cancer like Neuroblastoma. Single cell RNA sequencing (sc-RNAseq) is a novel technique that can be used for determining RNA expression levels of cells found in primary tumor sites. These expression levels allow for the clustering of similar cell types, which can be used to identify unique cell types found in a particular TME. This technique may help with the determination of the heterogeneity of the tumor cells, which may lead to the discoveryof subtypes of cells among the primary tumor that are more prone to metastasis.

71. An Evolutionary and Genetic Analysis of the Molecular Composition of the *Drosophila melanogaster* RNA exosome complex

Lakshya Seth ’21

Other Authors /Contributors: Maria Sterrett '14 and Anita Corbett

Supervisor: Maria Sterrett (Graduate Student, Emory University) and Dr. Anita Corbett (Professor, Emory University)

The RNA exosome is a highly conserved, ribonuclease complex that processes numerous coding and non-coding RNA classes. Structures of the complex have been solved for archaea, Saccharomyces cerevisiae and human RNA exosomes. All solved structures show a 10-subunit barrel-like structure composed of three cap subunits (yeast Rrp4/40/Csl4-human EXOSC2/3/1), a lower ring of six core subunits (yeast Rrp41/42/43/45/46/Mtr3-human EXOSC4/7/8/9/5/6), and a 3'-5' riboexonuclease subunit, Rrp44/DIS3, at the base. Mutations have been identified in the cap and core subunits that

are linked to a variety of tissue-specific diseases, now classified as "Exosomopathies". With the number of identified exosomopathy-linked mutations growing, it is imperative to be able to study the RNA exosome's biology and composition within model systems to better address human health questions. These studies are dependent on the conservation of the RNA exosome between eukaryotic systems. Interestingly, within the genetic model system Drosophila melanogaster, one core RNA exosome component, EXOSC8, has yet to be identified. This could suggest that the Drosophila melanogaster RNA exosome does not have the same 10-subunit structure as seen throughout eukaryotic and prokaryotic life or that one of the other core D. melanogaster RNA exosome subunits is able to compensate for the lack of an EXOSC8-like member.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

72. The Effect of Light on Cleavage of SAM by PFL-AE

Tess Sevetson ’20

Other Authors /Contributors: Joan Broderick, PhD, Sarah Hill, Elizabeth McDaniel, Stella Impano, and Emma Dolen

Supervisor: Dr. Joan Broderick (Montana State University)

The Broderick group researches radical SAM enzymes, a huge superfamily of enzymes that all cleave the small molecule S-adenosyl-L-methionine (SAM) to initiate radical chemistry, which produces another small molecule deoxyadenosyl (dAdoH). The focus of this project was to investigate how the presence or absence of light affects the rate of SAM cleavage in one specific radical SAM enzyme, pyruvate formate-lyase activating enzyme (PFL-AE). In reactions without PFL-AE's substrate, PFL, only non-productive cleavage of SAM occurs, whereas productive cleavage of SAM occurs when PFL is present. Reactions were performed with PFL-AE and SAM in the light and the dark to compare dAdoH production, measured by HPLC. dAdoH prodction due to productive cleavage in the light and dark was also measured from reactions containing PFL-AE, SAM, and PFL. The goal of the project was to inform future researchers working with PFL-AE about its optimal performance conditions.

73. Peripheral Vision Biases in Font Size Data Encoding

Muyang Shi ’21

Other Authors /Contributors: Eric Alexander and Danielle Albers Szafir

Supervisor: Eric Alexander (Assistant Professor of Computer Science, Carleton College)

Word clouds are popularly used to represent statistical summaries of document collections. They make frequently used words stand out by increasing the relative font sizes. While font size can be an intuitive dimension for the viewer, using it as an encoding may bias the perception of the underlying values. For example, words in the center of a cloud tend to attract more attention from people; we investigated and quantified biases that peripheral vision makes on font size perception. We performed a human subject pilot study and found in the piloting data that people's ability to read font size differences is weaker in peripheral vision than in central vision. This directed us to potential future studies that include additional influencing factors like colors, semantics, etc., as well as studies that measure how differences between peripheral and foveal vision affect the viewer's high-level processing ability such as gist-forming.

This research was funded in part by the The Towsley Endowment.

74. Quantum Measurement Backaction Based Control of A Strong Interacting BEC

Yueheng Shi ’21

Other Authors /Contributors: Stuart Szigeti and Arjendu Pattanayak

Supervisor: Stuart Szigeti (Research Fellow of Department of Quantum Science, Australian National University) and Arjendu Pattanayak (Professor of Physics and Astronomy, Carleton College)

Previously, we have demonstrated how measurement phase choice could effect the energy dynamics of a nonlinear quantum system. In this project, we aim to manipulate the measurement backaction on a strong interacting Bose Einstein condensate (BEC) continuously monitored under phase-contrast

imaging setup. We have derived the master equation and wavefunction evolution for the BEC, including the measurement phase dependent backaction, by using the fixed number state approximation. Further approximation and numerical results are still undergoing and future applications may include quantum measurement thermo engine.

75. Machine Learning of Active Space Selection for Diatomic Molecules

Claire Shugart ’20

Other Authors /Contributors: Sam Stoneburner, WooSeok Jeong, and Laura Gagliardi

Supervisor: Laura Gagliardi (Professor, Principal Investigator, University of Minnesota Twin Cities)

Appropriate active space selection for complete active space self-consistent field and complete active space second-order perturbation theory is necessary for accurate results. Machine learning can be used to select an active space provided that the training set includes appropriate active spaces based on size and accuracy. This project explores active space selection for first and second row diatomic molecules using the representative examples H_2 and BeH. These examples demonstrate the selection of appropriate orbitals to include in an effective active space. For five of 23 diatomic molecules, a sufficient active space cannot be found using ten or fewer consecutive orbitals. The remaining five diatomic molecules require active spaces with more orbitals or non-consecutive orbitals. All of these common and exceptional cases of accurate active spaces are important to a successful machine learning training set so as to make methods involving active space choice more accessible.

76. Iterative Respacing of Polygonal Curves

Milena Silva ’20

Other Authors /Contributors: Marcella Manivel and Robert Thompson

Supervisor: Robert Thompson

Start with a list of points in the plane. Create a piecewise linear curve by drawing line segments connecting consecutive points in this list. Next create a new list of points by sampling from the piecewise linear curve at evenly spaced intervals of arclength. Iterate this process, using the new list of points produced as the staring point of a newiteration. In this research, we study the properties of this strange discrete curveiteration from different viewpoints :both as a fast algorithm for smoothing and respacing data sampled from curves and also as aniterationdefining a discrete dynamical system.

This research was funded in part by the Towsley Endowment and the Summer Science Fellowship.

77. Between Black and White: Biracial in the U.S.

Justis Starks ’20

Supervisor: Liz Raleigh (Associate Professor of Sociology, Chair of Sociology and Anthropology, Carleton College)

This project seeks to learn about how Black/white biracial individuals in the U.S. understand their racial identity, how they choose to self-identify, and what it means to be a Black/white biracial person today. In recent decades, self-identified multiracial groups have grown significantly in the United States. From 2000 to 2010, individuals who identify as both Black and white grew 133% (U.S. Bureau of the Census, 2010). This growth, and the expanding leniency of hypodescent (or the"one-drop" rule) have led to the creation of diverse identity choices, including biracial and multiracial identities (Davenport, 2016). My study is based on interviews with ten individuals who have one white and one Black American parent. I seek to understand how they relate to the Black and white experience in America, and to explore what factors shape and impact the identity and self-understandings of Black/white biracial individuals in the Midwest.

This research was funded in part by the Mellon Mays Undergraduate Fellowship.

78. Investigating the Mechanism of Cyclocreatine-Induced Glycogen Accumulation in HER2+ Breast Cancer Through PI3K/14-3-3Œ∂ Signaling

Kaylin Steinberg ’20

Other Authors /Contributors: Taro Hitosugi, Elizabeth K. Wiese, Sadae Hitosugi, and Annapoorna Sreedhar

Supervisor: Taro Hitosugi, Ph.D. (Mayo Clinic)

One in every five women diagnosed with breast cancer has a mutation that results in the upregulation of oncogene human epidermal growth factor receptor 2 (HER2). While HER2 inhibitors such as trastuzumab, T-DM1, and lapatanib are generally effective, resistance and relapse are prevailing problems. Our lab previously identified molecule cyclocreatine (CCr) as an effective treatment for reducing proliferation of trastuzumab-resistant and -sensitive cancer cell lines through blocking HER2-induced creatine metabolism. Other effects of CCr on cellular functions are not well understood. This project investigated the mechanism behind an apparent increase in glycolysis in cyclocreatine treated cells. We hypothesized that CCr interacts with a signaling molecule in the IGF-1/PI3K/Akt/mTOR downstream pathway due to the role of this pathway in glycogen synthesis and tumor metastasis. We found that CCr induces glycogen accumulation in HER2+breast cancer cells, likely by affecting the monomerization of signaling protein 14-3-3Œ∂.

79. Climate Change in the “Wetland of the Future”: Examining the Effects of Elevated Atmospheric CO2 on Soil Redox Potential

Allegra Tashjian ’20

Supervisor: Genevieve Noyce (Postdoctoral Fellow, Smithsonian Environmental Research Center), Roy Rich (Researcher, Smithsonian Environmental Research Center), Pat Megonigal (Principal Investigator, Smithsonian Environmental Research Center Biogeochemistry Lab)

Understanding the role(s) that increased temperatures and atmospheric CO_2 concentrations have on soil geochemistry in tidal wetlands is an imperative part of predicting changes in the global carbon cycle and, thus, in planning for a future marked by climate change. This ongoing research project examines how increased temperature and CO_2 concentrations affect soil redox potential in the Salt Marsh Accretion Response to Temperature eXperiment (SMARTX), a warming and elevated CO_2 experiment operated out of the Smithsonian Environmental Research Center's (SERC) Global Change Research Wetland (GCReW) in Edgewater, MD. Following data collection in the summer of 2019, a statistically significant relationship was found between exposure to elevated atmospheric CO_2 and increased redox potential in marsh plots warmed to +5.1°C and dominated by the C3 clonal sedge *Schoenoplectus americanus*. Moving forward, further quantification of the roles of tidal cycles, precipitation, and water level on soil redox potential are being explored.

80. Regulation of Cebpa in Macrophage-Neutrophil Differentiation

Raba Tefera ’21

Other Authors /Contributors: Madison Naylor and Tapas Bhattacharyya

Supervisor: Dr. Manu (Assistant Professor of Biology, University of North Dakota)

Cebpa encodes for the CCAAT enhancer-binding protein alpha transcription factor which serves a vital role in the macrophage-neutrophil cell-fate decision during hematopoiesis. The expression of Cebpa is finely controlled by a complex network of six cis-regulatory modules (CRMs) that serve as either enhancers or silencers. In this study, two of the six previously identified CRMs are examined individually and jointly in order to understand their effects in amplifying or repressing Cebpa expression. The plasmid vector pGL4.17 was manipulated using Gibson Assembly to insert CRM7, CRM16, and CRM7+16. A luciferase reporter assay found that empty vector with no promoter still expressed luciferin. This was caused by a lack of a synthetic poly(A) signal/pause site. The goal of this project was to include the poly(A) signal/pause site in the insert. These constructs were verified via gel electrophoresis and will further be confirmed by DNA sequencing. In the near future, these DNA constructs will be inserted into the PUER genome via HDR-CRISPR to confirm that the luciferin signal in empty vector has been diminished.

81. Focus of Attention and Self-Objectification: A Non-Representational Approach to Stereotype Threat

Lewis Thelen ’20

Other Authors /Contributors: Carl Bou Mansour '15

Supervisor: Tony Chemero (University of Cincinnati)

Traditionally stereotype threat has been explained in terms of self-objectification through internal representations of self. Research has focused on overall performance tasks stereotypically associated with a particular social or cultural group such as throwing for studying male versus female self-objectification. This study seeks to explain the phenomenon in terms of the participant's focus of attention (FOA) where FOA towards the goal is associated with higher performance and internal FOA tends to lead to disruption of performance. The experimenter will direct the participant's FOA either inwards or outwards and assess participant sway patterns. The task at hand would also not be a traditionally stereotyped activity and instead would consist of pointing a laser at a target. Overall this would be a strong step forward towards a more dynamically open interpretation of the problem of gender differences in throwing and movement in general.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

82. Identifying Behavioral Tests that are Sensitive to The Effects of Chronic Low-Level Lead Exposure in Young Mice

Zichen Tian ’22 and Evan Wright ’20

Other Authors /Contributors: Gisel Flores-Montoya

Supervisor: Gisel Flores-Montoya (Assistant Professor of Psychology, Carleton College)

Chronic low-level lead exposure reduces memory in children however the brain mechanisms mediating these effects are unknown. Previous studies showed that lead exposure reduced olfactory memory and exploratory activity in young mice. The present study was designed to identify additional behavioral tests that are sensitive to the effects of chronic low-level lead exposure in young mice. Thirty-six male mice were exposed to 0 ppm (controls), 30 ppm (low-dose), or 430 ppm (high-dose) of lead acetate via dams' milk from post-natal day (PND) 0 to 28. At PND 28 mice were tested for developmental milestones, muscle strength, motor activity, anxiety, and olfactory memory. It was found that chronic low-level lead exposure increased body weight, yet no other significant effects were detected. These results suggested that chronic low-level lead exposure might alter mechanisms associated body weight and that motor function might not be associated with exploratory deficits previously detected.

83. Charcaterizing Fracture Sets in Cambrian Sandstone, Wyoming: Application of the Normalized Correlation Count technique

Finn Tierney ’20

Supervisor: Stephen Laubach (Jackson School of Geosciences, Bureau of Economic Geology, Univeristy of Texas at Austin) and Stephanie Forstner (University of Texas at Austin)

Fractures are extensional features in rock that occur in low strain environments. Over time, sets of fractures will develop in certain orientations as a result of similar regional stresses. Accurate characterizations of fracture patterns and fracture attributes over multiple orders of magnitude can inform our understanding of fluid movement through rock, evolution of regional stress, and strain conditions during fracturing. Studies have approached the topic of comprehending the evolution of fracture patterns in rock using a variety of methods. This project uses new method to qualify and quantify the fracture patterns (or lack thereof) in Flathead Sandstone outcrops to the north of Hurricane pass in the Teton range in order to identify fractures' tendencies towards arrangement at both the thin section and outcrop scale. This project considers fracture patterns of varying ages and observes scaling tendencies at macro and micro-scales for each set. This project also served as a test of the Normalized Correlation Count (NCC) Method (Marrett et al., 2018) in order to refine and identify the parameters and limitations of the method.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

84. Functional Characterization of Transcription Factor LOB-DOMAIN42 in Relation to Leaf Polarity

Kevin Tran ’20

Other Authors /Contributors: Wesley Neher, Leticia Meza, Barbara Jablonska, Dr. Patricia Springer

Supervisor: Wesley Neher (Graduate Student of Botany & Plant Sciences, University of California-Riverside) and Dr. Patricia Springer (Professor of Genetics, University of California-Riverside)

In many plants, the leaves are divided into 2 distinct regions. The adaxial side faces the meristem, and the abaxial side faces away from the meristem. In previous research, it has been shown that the ASYMMETRIC LEAVES2 (AS2) transcription factor contributes to leaf polarity by conferring adaxial cell fate inArabidopsis thaliana. Overexpression ofAS2 in the abaxial region changes cell fate, producing an entirely adaxialized leaf. However, in anas2 mutant, the leaf maintains polarity, suggesting that there may be another gene that contributes to the adaxial cell fate. LOB domain-containing protein 42 (LBD42) has been identified as a potential gene that may be redundant to AS2. The goal of this project is to characterize the expression pattern of LBD42 in Arabidopsis thaliana throughconstruction ofa lbd42 mutant and GUS staining.

85. Quantifying Immunohistochemical Levels of Biomarkers for Brain Insulin Resistance in Parkinson's Disease

Margriet VanDerwerker ’20 and Hannah Uttley '20

Other Authors /Contributors: Konrad Talbot, Ph.D. and Timothy Distel

Supervisor: Dr. Konrad Talbot, Ph.D. (Loma Linda University) and Timothy Distel (Loma Linda University)

Alzheimer's Disease dementia (ADD) and Parkinson's Disease (PD) are debilitating neurodegenerative diseases that affect 44 million and 10 million people worldwide, respectively. Thus, finding an effective therapeutic intervention is more urgent than ever. Previous studies show that insulin resistance-- caused by serine inhibition of the insulin receptor IRS-1-- increases in the brains of AD and ADD cases compared to normal aging brains. To respond effectively to insulin resistance and alternatively regulate blood glucose, neurons increase expression of the leptin receptor (OB-R). Consequently, increased expression of P-OBR is indicative of brain-insulin resistance. Because P-OR levels increased in AD and ADD, we investigated their expression levels in PD and PDD brains. Our lab has observed increased expression of OB-R in Parkinson's Disease (PD) and PD with dementia (PDD). Currently, our lab is examining insulin resistance relating to leptin signaling through ex vivo stimulation methods that directly measure insulin responsiveness in most-mortem PD tissue.

This research was funded in part by the Kolenkow-Reitz Fund for Undergraduate Research.

86. Individual Differences in Second Language Learners of Spanish

Grisel Vidal Munoz ’20

Other Authors /Contributors: Dr. Janet Van Hell and Dr. Fatemeh Abdollahi

Supervisor: Dr. Janet Van Hell (Pennsylvania State University, Department of Psychology)
Dr. Fatemeh Abdollahi (Pennsylvania State University)

Recent research suggests that children learning a second language (L2) show sensitivity to the translation of words at low levels of proficiency. The Revised Hierarchical Model (RHM) predicts that sensitivity is shown at high proficiency. We tested whether children and adults had sensitivity to meaning of words at 25 hours (low proficiency) of classroom exposure to L2. Participants (N = 54) included elementary, middle school children and young adults. Participants viewed 80 word pairs including correct, incorrect semantically related, and incorrect semantically unrelated words in Spanish and its translations in English and were asked to indicate whether the translation pairs were correct. An electroencephalogram was used to measure event-related potentials (ERPs) mean amplitude as a result of these manipulations. It was found that young adults and middle school students had significantly increased sensitivity to incorrect word pairs and adults had a larger semantic sensitivity effect than

middle school aged children. Individual differences in language proficiency, working memory and motivation when correlated with the ERP data across developmental groups showed no correlation. Sensitivity to translation was shown across all developmental groups at low levels of proficiency.

This research was funded in part by the Mellon Mays Undergraduate Fellowship

87. Accio Knowledge: Children's Expertise in the Domain of Harry Potter

Jed Villanueva '22

Other Authors /Contributors: Kathleen M. Galotti, Katherine Hauge '19, Christopher Leppink-Shands '19, and Valerie Umscheid '19

Supervisor: Kathleen M. Galotti (Director of Cognitive Science, Carleton College)

We conducted a conceptual replication of Chi and Koeske (1983) and Gobbo and Chi's (1986) studies on child expertise. One hundred elementary school students were asked to recall information about Harry Potter and the Sorcerer's Stone. Expertise was derived by a summation of factor loadings that were drawn from the free response and trivia tasks as well as from the number of Harry Potter books and movies a child reported having read or watched. Different measures of expertise were strongly intercorrelated, but were only moderately correlated with grade. Furthermore, regardless of age, children with higher expertise scores sorted characters more cohesively and with more sophistication, and used categories that require a deep understanding of the first Harry Potter book. Additionally, while there was a significant correlation between grade and expertise, nearly every other measure when correlated with expertise maintained statistical significance, even when controlling for grade. These results reinforce the idea that expertise is an aspect of knowledge that can be separated from a child's level of cognitive development and is associated with a deeper and richer knowledge base.

88. Pump-Probe Spectroscopy for Testing Semiconductor Sample

Yunping Wang '22

Other Authors /Contributors: John Prineas

Supervisor: Dr. John Prineas (University of Iowa)

Testing the carrier dynamics of the semiconductors sample is crucial for developing semiconductor samples. One of the major properties that are tested is the carries decay channel.As carriers electron behaviors exist in the range of femtoseconds, a setup that can observe such phenomenon needs to be developed. We built a pump-probe laser setup that will first excite the electrons with one laser beam and then send another laser in to observe the change in the frequency for the exiting photons to determine how fast the carriers decays. If the decay is small enough, we may be able to use the material to develop lower-cost infrared LEDs.

89. Effects of Transcriptional Start Site Variability on Coaxial Stacking in the 5' UTR of the HIV-1 Virus

Seth Warner '21

Other Authors /Contributors: Jonathon Kitzrow and Karin Musier Forsyth

Supervisor: Jonathan Kitzrow (Ohio State University), Karin Musier Forsyth (Ohio State University)

The effects of transcriptional start site variability on the structure and function of the 5' UTR region of the HIV-1 genome are not well understood or characterized. Previous studies have shown differing quantity of guanines at the start of the HIV-1 genome leads to preferential packaging of the virus through either a base stealing model or through a coaxial stacking model hypothesized in the Musier-Forsyth group. Previous in vivo mutational work of the HIV-1 virus had provided evidence for the coaxial stacking mechanism, and this research aims to further that work through characterization of those mutants. Using UV Melting studies and RNA native gels differential folding patterns of the mutants were observed, showcasing that the mutants generated exhibited destabilization of coaxial stacking in the 5' UTR, providing evidence towards this mechanism of preferential packaging. If further validated, this work presents a potential novel drug target for treatment of HIV-1.

90. Synthetic Tailorability and Conductive Properties of pi-conjugated Molecular Wires

Luke Westawker ’20

Other Authors /Contributors: Daniel Frisbie and Quyen Van Nguyen

Supervisor: Dr. Daniel Frisbie (Distinguished McKnight University Professor and Head of Chemical Engineering and Materials Science, University of Minnesota)and Dr. Quyen Van Nguyen (Postdoc in Chemical Engineering and Materials Science, University of Minnesota)

Molecular wires are long molecules that can utilize their conjugated pi-orbitals to efficiently transport charge over a long distance, resulting in many technological applications including OLED displays and organic solar cells. I studied how synthetically modifying these molecules affects their ability to transport charge, specifically comparing flat molecules and angled molecules. I used Palladium-Catalyzed Suzuki-Miyaura cross-coupling to synthesize molecules misaligned by 30, 60, or 90 degrees. Schiff base chemistry allows us to create molecular wires with these angled molecules, which can then be electronically characterized using a customized AFM. This fundamental research has helped improve our understanding of how simple synthetic modifications to molecules can affect the efficiency of sustainable electronic technologies.

91. Identifying Behavioral Tests That are Sensitive to The Effects of Chronic Low-Level Lead Exposure in Young Mice

Evan Wright ’20 and Zichen Tian '22

Other Authors /Contributors: Gisel Flores-Montoya

Supervisor: Gisel Flores-Montoya (Assistant Professor of Psychology, Carleton College)

Chronic low-level lead exposure reduces memory in children however the brain mechanisms mediating these effects are unknown. Previous studies showed that lead exposure reduced olfactory memory and exploratory activity in young mice. The present study was designed to identify additional behavioral tests that are sensitive to the effects of chronic low-level lead exposure in young mice. Thirty-six male mice were exposed to 0 ppm (controls), 30 ppm (low-dose), or 430 ppm (high-dose) of lead acetate via dams' milk from post-natal day (PND) 0 to 28. At PND 28 mice were tested for developmental milestones, muscle strength, motor activity, anxiety, and olfactory memory. It was found that chronic low-level lead exposure increased body weight, yet no other significant effects were detected. These results suggested that chronic low-level lead exposure might alter mechanisms associated with body weight and that motor function might not be associated with exploratory deficits previously detected.

92. Understanding Student Behavior in Open-Ended Learning Environments

Louis Ye ’22 and Shiyue Zhang '22

Other Authors /Contributors: Anna Rafferty

Supervisor: Anna Rafferty (Assistant Professor of Computer Science, Carleton College)

Students often use simulation environments and educational games to learn or supplement their learning. Unfortunately, some students learn a lot from these environments and some don't. To explain this difference in their outcomes, we explored student behavior within these learning environment. We used k-means to cluster students by their actions, differential sequence mining to find differences in actions or action sequences between the clusters, and lasso regression to predict learning outcome based on the actions or type of actions taken by the student. In the future, we hope to build on this work by using students' behaviors and strategies to provide recommendations and interventions that can improve learning.

This research was funded in part by the Towsley Endowment.

93. Crystallization of Three Enzymes Involved in the Modification of tRNA and DNA with 7-deazaguanines

Stuart Yi ’20

Other Authors /Contributors: Manal A. Swairjo, Susan Bayooz, and Josh Savage.

Supervisor: Manal A. Swairjo (Professor of Chemistry, San Diego State University).

tRNA and DNA bases undergo extensive modification to form novel nucleotides that are crucial in numerous physiological functions. The biosynthesis pathways for the three 7-deazaguanine modifications archaeosine (G+), preQ_0 and queuosine (Q) are well documented, however the structures of key biosynthesis enzymes remain unknown. Crystallization of three of these enzymes was attempted over the course of 8 weeks. GAT-QueC catalyzes the final step in the biosynthesis of G+ in the D-loops of archaeal tRNAs and stabilizes their structures. DpdA is a DNA guanine transglycosylase that installs PreQ_0 in bacterial DNA as part of a restriction-modification bacterial defense system. DUF2419 is a putative nucleoside hydrolase involved in human salvage of Q from gut microflora, a process necessary for the biosynthesis of neurotransmitters. Initial crystals of GAT-QueC and DpdA were successfully grown using the vapor diffusion method. Further study will aim to mass-produce and harvest these crystals for structural analysis.

94. Tracing the Star Formation History in Local Group Dwarf Galaxies

Zitian Yue ’22

Other Authors /Contributors: Cindy Blaha, Sarah Bodansky '21, Ann Isaacs '20, and Vicent He '22

Supervisor: Cindy Blaha (George H. and Marjorie F. Dixon Professor of Physics and Astronomy)

Nearby galaxies in a galaxy cluster called the Local Group provide an excellent view of stars and their surrounding emission-line gas. We surveyed five dwarf galaxies in the Local Group for ionized hydrogen (H II) regions in order to explore the composition of star forming areas in these galaxies. To characterize these regions, we analyzed HŒ±, [O III], and [S II] optical emission-line data from Kitt Peak National Observatory and the Cerro Tololo Inter-American Observatory. A major step in determining the luminosity for the regions was accounting for extinction due to dust within the galaxies, which was done using 24¬μm infrared images from the Spitzer Space Telescope. After computing the luminosity of the H II regions, we created luminosity functions for the galaxies IC 10 and NGC 6822. Understanding the characteristics of these H II regions provides insight into the history and star formation of the dwarf galaxies studied.

95. Dakota Project: Linguistic Fieldwork in Lake Traverse Reservation

Alex Zhai ’20 and Sarah Steinke ’20

Other Authors /Contributors: Mike Flynn and Anna Grove ’21

Supervisor: Mike Flynn (William H. Laird Professor of Linguistics and the Liberal Arts, Carleton College)

The trip to Lake Traverse reservation this summer is a continuation of the Dakota Project, a long term partnership between the Carleton Linguistics department and the Sisseton Wahpeton Oyate Dakotah Language Institute (SWODLI). During this trip, professor Mike Flynn, Anna Grove '21, Sarah Steinke '20, and I (Alex Zhai '20) aimed to collect data from native speakers in order to answer several outstanding questions about the language's phonemic inventory. Specifically, we were looking for features such as word-initial aspiration and glottal stops in vowel initial words. We were able to conduct a linguistic interview Mr. Clifford Canku, one of the around 40 remaining native speakers of the language.

This research was funded in part by the Humanities Center SRP Program.

96. The Roles of Glutamatergic Receptors on Zebrafish Swimming

Mary Zhang ’22

Other Authors /Contributors: Mark Masino

Supervisor: Dr. Mark Masino (University of Minnesota)

NMDA (N-methyl-D-aspartate) is a glutamatergic receptor that can influence swimming locomotion (i.e. swimming) in larval zebrafish. The role of AMPA (alpha-amino-3-hydroxy-5-methyl-4-isoxazole propionic acid, also a glutamatergic receptor) however is not well understood. In order to examine the potential effects of these receptors on locomotion, a pilot behavioral study was conducted using a larval zebrafish model. Larval zebrafish (N > 30) were decapitated and put into NMDA/AMPA solutions for observations on their motor patterns. No formal measurements were made, but qualitative observations were recorded for pattern analysis. It was found that AMPA receptors are important for locomotion but play a different role as compared to NMDA receptors. Additionally, it was found that different concentrations of both NMDA and AMPA can induce swimming in different strengths and frequencies. Although the difference between NMDA and AMPA was not well-understood, the fact that higher concentrations of both causes faster and stronger swimming provided some insights into the recruitment pattern of spinal interneurons and motoneuron. It might be that neurons that are only active during high-frequency swimming have higher pharmacological activation thresholds than neurons that fire in low-frequency swimming.

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