Oct 19, 2018
3:30-5:30pm
Weitz Center Commons

UNDERGRADUATE SYMPOSIUM

RESEARCH

Science

Social Science

Humanities

Arts
Welcome to the 2018 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 and staff from seventeen 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. Layilin in Regulatory T Cells: Role in Cutaneous Wound Healing
   Kano Amagai '21
   **Authors/ Contributors:** Pooja Mehta (Post-doctoral fellow, University of California San Francisco), Michael Rosenblum (Associate Professor of Dermatology, University of California San Francisco)
   Summer 2018
   **Supervisor:** Pooja Mehta (Post-doctoral fellow, University of California San Francisco), Michael Rosenblum (Associate Professor of Dermatology, University of California San Francisco)
   Regulatory T cells (Tregs) are essential to the immune system, especially with regards to autoimmune diseases as they suppress harmful activities of other immune cells. Our lab is interested in studying the skin-specific functions of regulatory T cells. The lab discovered that Layilin influenced the functions of Tregs and aimed to understand the role of Layilin in skin-resident Tregs. Mice with Layilin deficient Tregs were created and were used to study how Layilin plays a role in the cutaneous wound healing process.

2. Assessing the Effects of Colonial Era Ethnic Partitioning on National and Ethnic Sentiment in Africa
   Gregory Amusu '19
   **Authors/ Contributors:** Christian Houle (Assistant Professor of Political Science, Michigan State University)
   Summer 2018
   **Supervisor:** Christian Houle (Assistant Professor of Political Science, Michigan State University)
   Conventional wisdom in African politics has held that the partitioning of various ethnic groups as a result of the imposition of artificial international borders by European colonial powers during the “Scramble for Africa” has had a negative effect on the national sentiment held by members of partitioned ethnic groups. However, analysis of recently obtained individual-level data from Afrobarometer indicates that the converse is true. At its core, my work has two aims. First, to demonstrate empirically that ethnically partitioned groups are, on average, more likely than non-partitioned groups to indicate the primacy of their national identification over their ethnic identification. The second aim is to clearly define a causal mechanism that explains the empirical findings. As such, I argue that it was the act of imposing partitional state borders that reduced ingroup loyalty among divided ethnicities.

3. Analysis Algorithm to Detect Neutrons in the Large Area Neutron Array
   Marshall Basson '20
   **Authors/ Contributors:** Marshall Basson '20
   Daniele Dell'Aquila (Research Associate, National Superconducting Cyclotron Laboratory)
   Betty Tsang (Professor of Nuclear Chemistry, National Superconducting Cyclotron Laboratory/Michigan State University)
   Summer 2018
   **Supervisor:** Betty Tsang (Professor of Nuclear Chemistry, National Superconducting Cyclotron Laboratory/Michigan State University)
   A systematic procedure to distinguish neutrons from photons based on the pulse shape discrimination method in liquid light-sensitive material has been developed for the Large Area Neutron Array (an wall-sized array of this material) at the National Superconducting Cyclotron Laboratory. Performances in the identification of neutrons are evaluated using in-beam experiment data and compare to other methods without the use of pulse shape discrimination.

4. Synthesis of Fusidic Acid Derivatives Yields Potent Antibiotics
   Alex Battiste '19
   **Authors/ Contributors:** Martin Garcia Chavez (Graduate Student, University of Illinois Urbana Champaign), Alfredo Garcia (Graduate Student, University of Illinois Urbana Champaign), Paul Hergenrother (Kenneth L. Rinehart Jr. Endowed Chair in Natural Products Chemistry and Professor of Chemistry, University of Illinois Urbana Champaign)
   Summer 2018
   **Supervisor:** Paul Hergenrother (Kenneth L. Rinehart Jr. Endowed Chair in Natural Products Chemistry and Professor of Chemistry, University of Illinois Urbana Champaign)
   Fusidic acid is a steroidal antibiotic that is currently in stage 3 clinical trials in the US for skin and refractory bone and joint infections. Its potent activity against Staphylococcus aureus and its lack of cross resistance with other clinically used antibiotics make it an especially powerful drug against methicillin-resistant Staphylococcus aureus (MRSA). Due to its low toxicity it can also be dosed at a high level, leading to low levels of resistance. While
structure-activity relationship (SAR) campaigns have been conducted going back to its discovery in 1960, every
derivative that has been synthesized has been less potent than Fusidic acid. Additionally, many of the studies
did not determine minimum inhibitory concentrations (MICs) for their derivatives, which is the current standard for
determining antibiotic potency. This project aims to expand the SAR of Fusidic acid, especially at the side chain,
with the hopes of finding a more active derivative.

5. Preliminary Studies on the Biosynthesis of the Chemotherapeutic Bleomycin by Streptomyces verticillus
Henock Befekadu '21
Authors/Contributors: Christopher Calderone (Assistant Professor of Chemistry, Carleton College)
Aditya Vaze ’17
Summer 2018
Supervisor: Christopher Calderone (Assistant Professor of Chemistry, Carleton College)
Non-ribosomal peptide synthetases (NRPS) are naturally occurring enzymes that can produce remarkably complex
substances such as the antibiotic vancomycin and chemotherapeutic bleomycin. The goal of this project was to
determine if asparagine and aspartate is hydroxylated by ORF 1 or ORF 15 after being loading onto the BlmX
protein which is part of the Bleomycin NRPS. Hydroxyasparagine is thought to be a component of bleomycin which
could originate from the hydroxylation of an asparagine or aspartate precursor. The first step in the proposed
biosynthesis of the hydroxyasparagine is to load aspartate or asparagine onto BlmX. There are positive results
indicating loading of the amino acids asparagine and aspartate. Future experiments will delve deeper into our
understanding of the hydroxylation of the loaded amino acids.

Elizabeth Budd ’19
Authors/Contributors: Susannah Ottaway (Professor of History, Carleton College)
Summer 2018
Supervisor: Susannah Ottaway (Professor of History, Carleton College)
This summer, I conducted archival research at the London School of Economics Library using manuscript research
notebooks from Charles Booth’s survey of London at the end of the nineteenth century. Much of material enshrines
the voices of middle and upper class individuals, so I sought to uncover and recover working class voices within the
notebooks. Although a challenging task, I found sections that hinted at working class attitudes towards their work,
employers, and each other, and a glimpse into a world of the past from the eyes of historically marginalized voices.

7. Do acidic phenols change the mechanism of an organocatalytic desymmetrization reaction?
David Byun ’20
Authors/Contributors: David Alberg (Professor of Chemistry, Carleton College)
Gretchen Hofmeister (Associate Dean of the College, Professor of Chemistry, Carleton College)
Summer 2018
Supervisor: David Alberg (Professor of Chemistry, Carleton College) and Gretchen Hofmeister (Associate Dean of
the College, Professor of Chemistry, Carleton College)
The asymmetric desymmetrization (ASD) of an achiral molecule results in a racemic mix of two chiral enantiomers
which are often difficult to separate by traditional methods. Organocatalysts, however, provide an efficient means
of selecting for one enantiomer over the other and offer much utility in synthesis especially in the context of
pharmaceutical drugs. In mechanistic studies of this reaction, we discovered that less acidic phenols gave better
selectivity and very acidic phenols yielded racemic mixtures of enantiomers. In order to make sense of this trend,
we need to rule out the possibility that very acidic phenols protonate the catalyst, and thereby change its means of
catalysis. Our results indicate that the mechanism of catalysis does not change with acidity of phenol.

8. Characterizing the Role of uc.206 Long Non-Coding RNA in Zebrafish
Nathan Carroll ’19
Authors/Contributors: Shuo-Ting Yen, Post-Doctoral Fellow, The University of Texas MD Anderson Cancer
Center
Linda Fabris, Post-Doctoral Fellow, The University of Texas MD Anderson Cancer Center
George Calin, Professor, The University of Texas MD Anderson Cancer Center
George Eisenhoffer, Assistant Professor, The University of Texas MD Anderson Cancer Center
Supervisor: Shuo-Ting Yen, Ph.D. (MD Anderson Cancer Center)
George Eisenhoffer, Ph.D. (MD Anderson Cancer Center)

The function of transcribed ultraconserved regions (T-UCRs) in the physiology and pathogenesis in living tissues are not well understood, but their high trans-species conservation implies that they are fundamentally important. T-UCRs are altered at both DNA and RNA levels in adult chronic lymphocytic leukemia (CLL). Here, we used zebrafish (*Danio rerio*) to assess the function of uc.206, a long non-coding RNA whose overexpression is correlated with aggressive types of CLL. We found that overexpression of uc.206 causes alterations in blood flow and cell number. Further, our results suggest that overexpression of uc.206 contributes to resistance of the first-line therapy, ibrutinib. Resistance to ibrutinib occurs particularly in a subset of high-risk CLL patients. It is therefore of prime importance to understand the molecular mechanism of resistance and develop alternative treatment strategies. Together, our results provide proof-of-concept that zebrafish can be used to study T-UCRs for profiling pharmacological agents for ibrutinib-resistant CLL.

9. **An Analysis of the Effectiveness of Various Finite-Element Meshes for Modeling a Ridge-Transform Intersection**
   Matthew Carter ’19
   Authors/Contributors: Sarah Titus (Professor of Geology)
   Josh Davis (Lecturer in Mathematics, Statistics, and Computer Science)
   Summer 2018
   Supervisor: Sarah Titus (Professor of Geology)

Advances in computer software have allowed geoscientists to model Earth systems at a higher precision than ever before. I investigated several finite-element meshes for a ridge-transform intersection, which is a type of plate boundary structure that is common in the ocean. My goal was to discover how the mesh geometry and boundary conditions are best able to model the velocity and stress tensor fields for this system. In the future this model will be used to run a maximum likelihood estimate on various parameters and initial conditions of a ridge transform intersection, such as spreading rate and material properties. I plan to use this model using geologic data from the Troodos ophiolite in Cyprus.

10. **Mental Models of Home Networks**
    Jackie Chan ’20, Kirby Mitchell ’20
    Authors/Contributors: Amy Csizmar Dalal (Professor of Computer Science)
    Summer, 2018
    Supervisor: Amy Csizmar Dalal (Professor of Computer Science)

Research around computer networks has been rapidly expanding as the Internet becomes more prevalent in day-to-day life. Despite this rapid expansion in academic interest, computer networks, especially home networks, still remain a challenge for inexperienced individuals to configure and maintain. To remedy this, new data needs to be collected to understand this new audience as computer network usage moves from an academic to residential setting. In our project, we attempt to gain a preliminary understanding by observing the language users, specifically homeowners, tend to use and prefer when talking about their home networks through closed and open card sorting. This research around language can prove to be fruitful because it can provide recommendations to software developers and researchers as we continue to tailor these systems to these new needs and expectations.

11. **"Works for Me!": Motivation by Opportunity Versus Necessity**
    Jennifer Chan ’19 Marshall Ma ’19, Elsa Sandeno ’19, Lena White ’19
    Authors/Contributors: Neil Lutsky (William R. Kenan, Jr. Professor of Psychology, Carleton College)
    Summer 2018
    Supervisor: Neil Lutsky (William R. Kenan, Jr. Professor of Psychology, Carleton College)

Motivation is an integral component of students’ willingness to engage class material. Understanding the mindsets that motivate students can aid development of learning strategies that are optimally effective and intrinsically enjoyable. The present study investigated how motivational mindsets affect students’ perceptions of everyday tasks. Fifty-nine Carleton students were assigned to one of two conditions in which they framed tasks as either required activities or useful opportunities. For six days, they described an upcoming task, wrote about it as something they either had to do or got to do, and rated how enjoyable and beneficial the task would be. Participants who wrote
about the task as a “have to” reported procrastinating more and finding tasks more burdensome than participants who discussed it as a “get to.” These findings indicate that approaching tasks with a “get to” mindset may reduce procrastination and make tasks feel less burdensome.

12. **Is Jet-Scale Overturning Circulation Present in the North Atlantic Ocean?**
   **Jacob Cohen ’19**
   
   **Authors/Contributors:** Sukyoung Lee (Professor of Meteorology, The Pennsylvania State University), Qian Li (Ph.D. Graduate Student, The Pennsylvania State University), Raymond Najjar (Professor of Oceanography, The Pennsylvania State University)
   
   **Summer 2018**
   
   **Supervisor:** Sukyoung Lee (Professor of Meteorology, The Pennsylvania State University), Qian Li (Ph.D. Graduate Student, The Pennsylvania State University), Raymond Najjar (Professor of Oceanography, The Pennsylvania State University)

   Jet-scale overturning circulation (JSOC) is an ocean circulation previously found across eastward jets in the Southern Ocean that has been shown to affect deep mixing of water. This research aims to investigate if JSOCs are present across similar eastward jets in the North Atlantic Ocean. Using positional data from floats drifting at a depth of ~1 km, we defined the location of two jets, the Gulf Stream Extension and the Azores Current, and computed the drift velocity across each jet. If the JSOC is present, we expect to see poleward drift across the jet core in the float data. Instead, our analysis of the data shows convergence at the Azores Current and divergence at the Gulf Stream Extension. This result could be related to the large-scale wind-driven transport of water in the North Atlantic.

13. **Analyzing the complex dynamics of semiconductor lasers with state-dependent delay**
   **Meritxell Colet ’20**
   
   **Authors/Contributors:** Dr. Ingo Fischer (IFISC, Institute for Cross-Disciplinary Physics and Complex Systems) and Miguel C. Soriano (IFISC, Institute for Cross-Disciplinary Physics and Complex Systems)
   
   **Summer 2018**
   
   **Supervisor:** Dr. Ingo Fischer (IFISC, Institute for Cross-Disciplinary Physics and Complex Systems) and Miguel C. Soriano (IFISC, Institute for Cross-Disciplinary Physics and Complex Systems)

   Semiconductor lasers have become ubiquitous in science and technology. Most prominently, they represent the light sources that drive our global communication network. Recently, semiconductor lasers were used to implement a system showing self-organized state-dependent switching between different delay times. We analyze the state-dependent switching between different delay times to understand their origin and to explore whether the switching is predominantly of deterministic or stochastic nature. We use time series analysis tools, including permutation entropy, return maps and mutual information to analyze the dynamics. Our approach opens new perspectives and applications in which the self-organized switching can be exploited.

14. **Synthetic and Computational Investigation of Cobalt Silylene Reactivity**
   **Anna Conley ’20**
   
   **Authors/Contributors:** Matt Whited (Associate Professor of Chemistry, Carleton College), Daniela Kohen (Professor of Chemistry, Carleton College), and Jim Zhang ’18 (Educational Associate in Chemistry, Carleton College)
   
   **Summer 2018**
   
   **Supervisor:** Matt Whited (Associate Professor of Chemistry, Carleton College) and Daniela Kohen (Professor of Chemistry, Carleton College)

   Transition metal silylenes (M=SiR₂) exhibit unusual and promising reactive pathways for potential catalytic applications. While silylenes have been extensively investigated using second- and third-row metals (e.g., ruthenium and iridium), examples featuring abundant first-row metals such as iron and cobalt are extremely rare. We have synthesized the first examples of cobalt silylenes and found a surprising substituent effect that allows reductive cleavage of carbon dioxide, and we are using computational models to elucidate the underlying reasons for this reactivity. We have modeled the ground-state silylenes and their cycloadducts with carbon dioxide and the isoelectronic phenyl isocyanate, as well as a transition state for the formation of a cycloadduct with CO₂.

15. **Maternal age effects on offspring life and healthspan**
   **Jackie Culotta ’19**
   
   **Authors/Contributors:** Emily Stone (Marine Biological Laboratory)
F0 generations have lasting effects on future generations' health. Here, we use the rotifer Brachionus manjavacas as a model system to study maternal age effects on male offspring. We found offspring lifespan to be positively correlated with maternal age. Due to the role of mitochondria in aging, we examined mtDNA copy-number and mitochondrial function in offspring from young, middle-aged, and old mothers. We found increased mtDNA copy-number in offspring from older mothers, suggesting a declining ability to remove mitochondria once damage accumulates. We found mitochondrial oxidative potential, which is directly related to the ability of mitochondria to power the cell, declines with maternal age. Offspring health declines with maternal aging, as assayed through reduced heat stress survival and behavioral phototaxis. Our results support the hypothesis that maternal age affects healthspan in future generations. By exploring transgenerational aging, we hope to elucidate aging mechanisms as they apply to all living things.
18. **Computational Investigation of Ruthenium Silylene Reaction Mechanisms**  
*Will DeSnoo ’19*  
**Authors/Contributors:** Daniela Kohen (Professor of Chemistry, Carleton College)  
Matt Whited (Associate Professor of Chemistry, Carleton College)  
Summer 2018  
**Supervisor:** Daniela Kohen (Professor of Chemistry, Carleton College)  
Matt Whited (Associate Professor of Chemistry, Carleton College)  
As part of a research program aimed at unveiling new metal-based chemical reactions involving metal/element multiple bonds, the Whited group has recently synthesized a metal complex that contains a ruthenium silicon double bond and exhibits previously unobserved reactivity with carbon dioxide. In this poster, I present research under the guidance of Prof. Daniela Kohen using computational modeling to gain a better understanding of why and how this complex reacts with carbon dioxide and other similar compounds like carbon disulfide and phenyl isocyanate.

19. **Analysis of Borehole Infill on Hydrogeological Dynamics and Geothermal Performance**  
*Natasha Dietz ’19*  
**Authors/Contributors:** Mary Savina (Charles L. Denison Professor of Geology, Carleton College)  
Alan Wang ’19  
Summer 2018  
**Supervisor:** Mary Savina (Charles L. Denison Professor of Geology, Carleton College)  
Most geothermal boreholes are filled with cementitious grout, a material used to prevent groundwater flow between layers of bedrock. An alternative to this practice is to use pea gravel, a more porous infill that will likely enhance hydraulic conductivity and heat transfer through geothermal fields. This project aims to gain a deeper understanding of the effects of pea gravel on hydrothermal properties of the field by comparing the thermophysical dynamics of boreholes that utilize different infill materials. Using fiber optic distributed temperature sensing, thermal response tests, and previous literature, I will characterize the interaction between groundwater flow and geothermal performance of geothermal fields at Carleton College. Preliminary results suggest limited difference in performance between differently constructed boreholes, although continuous data collected from fiber optic cabling will provide ongoing temperature profiles and establish an accurate baseline for future studies.

20. **Telluric-Calibrated M Dwarf Radial Velocity Measurement with Low-Resolution Near-Infrared Spectra**  
*Yingqi Ding ’21*  
**Authors/Contributors:** Ryan Terrien ’09 (Assistant Professor of Physics and Astronomy, Carleton College)  
Elisabeth Newton (NSF and Kavli Postdoctoral Fellow, MIT)  
Summer 2018  
**Supervisor:** Ryan Terrien ’09 (Assistant Professor of Physics and Astronomy, Carleton College)  
Elisabeth Newton (NSF and Kavli Postdoctoral Fellow, MIT)  
Radial velocity (RV) reconnaissance of M dwarfs is essential to determine their multiplicity, kinematics and to better understand the properties of their planets. We present here absolute RV measurements for 900 M dwarfs based on a large low-resolution spectral catalog. We improved and implemented a telluric line fitting algorithm presented in Newton (2014), where the absolute wavelength calibration is improved using known wavelengths of observed telluric lines. A Monte Carlo analysis suggests that these updated wavelength solutions enable a typical RV precision of 3.9 km/s. We also considered effects of different choices of RV template spectra, and chose final templates based on SNR and resulting consistency with external catalogs. To verify our measurements, we compared our absolute RV measurements to those measured in Gaia (2018) and Chubak (2012). For 150 stars in common, we found a median offset of +1.6 km/s. These RV measurements will provide useful constraints on RV variabilities, kinematics and ages of M dwarfs.

21. **The Role of Human MIT Proteins in ESCRT Biology**  
*Eavan Donovan ’19*  
**Authors/Contributors:** Wesley I. Sundquist (Distinguished Professor of Biochemistry, University of Utah), Jack Skalicky (Research Associate Professor, University of Utah), John McCullough (Research Assistant Professor, University of Utah), Elliott Paine (Graduate Assistant, University of Utah)  
Summer 2018  
**Supervisor:** Dr. Wesley Sundquist (University of Utah), Dr. Jack Skalicky (University of Utah)
Cell checkpoints halt the cell cycle until errors have been searched for and require Endosomal Sorting Complexes Required for Transport (ESCRT) proteins. ESCRT proteins facilitate more than fifteen known cellular membrane remodeling processes. Specifically, ESCRT-III factors form filaments that act to mediate membrane fission. Our understanding of these processes is incomplete, therefore our primary goal is to characterize new ESCRT-III interactions between MIT Interacting Motifs (MIMs), which bind to proteins that contain Microtubule Interacting and Trafficking (MIT) domains. Through E. coli expression, the fragments of interest are purified using size exclusion chromatography. Fluorescence polarization experiments measure the binding of each MIT domain to the C-terminal MIM elements from all twelve different fluor-labeled ESCRT-III C-terminal tails. Preliminary results indicate novel binding interactions between AMSH (MIT domain containing) and CHMP2B (MIM domain containing).

Mandy Duong ’19
Summer 2018
Supervisor: Angela Ebreo (Associate Director of the Diversity Research & Policy Program, University of Michigan), Phillip J. Bowman (Professor of Higher Education, University of Michigan)
This study examines the influence of informal program support on career self-efficacy and PhD plans for first-generation and second-generation college students. Informal program support may provide social and cultural capital for first-generation college students in the form of opportunities to learn about graduate school, which may lead to increased self-efficacy and certainty in PhD plans. A secondary analysis of data from a longitudinal panel survey of applicants to summer research programs, this study analyzed the differences in the perceptions of support (e.g., mentor, staff, and peer) among first-generation and second-generation college students, the relationship between informal program support and the outcomes, and the effect of parental education status on the PhD plans. Analyses of variance indicated that with parental education status taken into account, perceptions of peer and staff support had an effect on PhD plans. Results suggest that educational research should focus more on staff and peer support.

23. The Optokinetic Response In Zebrafish
Madeline Egan ’19
Authors/Contributors: Fernán Jaramillo (Professor of Biology, Carleton College) Brielle Bjorke (Postdoctoral Fellow in Neuroscience, Carleton College)
Summer 2018
Supervisor: Fernán Jaramillo, Brielle Bjorke
Vertebrates have a variety of mechanisms that allow them to stabilize an image on the retina. Known as the optokinetic response (OKR), these mechanisms are important for behavior and are highly conserved. Zebrafish are an ideal model because their OKR is established within 72 hours of fertilization, the larvae are nearly transparent and have dark eyes, they are small, there are many transgenic lines available, etc. We developed an OKR apparatus that can measure OKRs in zebrafish and can serve as a functional assay to evaluate the development of the OKR sensory motor system in the presence of substances known to disrupt development i.e. carcinogens, alcohol, BPA, teratogens, etc. This will also allow us to explore how the vestibular system interacts with the visual system in stabilizing an image on the retina.

24. Biosynthetic Mechanism of the Nonribosomal Peptide AMB in Pseudomonas aeruginosa
David Galambos ’20
Authors/Contributors: Christopher T. Calderone (Assistant Professor of Chemistry, Carleton College)
Summer 2018
Supervisor: Christopher T. Calderone (Assistant Professor of Chemistry, Carleton College)
The Calderone Lab studies a class of proteins called non-ribosomal peptide synthetases (NRPSs). NRPSs are enzymes found in bacteria that synthesize a class of molecules called natural products. Some of these natural products are extremely useful, ranging from antibiotics to potential anti-cancer drugs. Due to their special modular structure, we can use the sequence of an NRPS gene cluster to approximately predict its product. However, the synthetic mechanism for many natural products is still unknown, including AMB. In AMB biosynthesis, there are two enzymes called AmbC and AmbD that are predicted to act on a glutamate (Glu) substrate attached to AmbE. We ran different reaction combinations of these three enzymes and compared the products to AMB using HPLC and
LC-MS. We found that AmbC and AmbD convert Glu to a new product in a way that suggests hydroxylation activity and leads to new mechanistic insights about AMB biosynthesis.

Dynamical complexity and resource complexity as a function of system size in a quantum chaotic system.
Sharan Ganjam Seshachallam '20
Authors/Contributors: Arjendu Pattanayak (Professor of Physics, Carleton College)
Andrew Maris '19
Moses Misplon '17
Summer 2018
Supervisor: Arjendu Pattanayak (Professor of Physics, Carleton College)
We exhaustively studied simulations of the Duffing Oscillator, a chaotic physical system, seeking to isolate size scales where classical and semiclassical approximations of the full quantum Duffing simulation fail to reproduce results within acceptable accuracy. The Lyapunov exponent, an expression of chaos in the system, was used as a measure of said accuracy. Transitions from the quantum expression of the Duffing Oscillator to semiclassical variations proved especially difficult, with computational resources taxed for the simulations increasing exponentially. We then proceeded to analyze aspects of the simulations used to decipher why, at relatively larger sizes, it is impossible to produce results of quantum simulations. Analysis of the initial states of the wave functions provided useful probes into the problem, with further research necessary to completely decipher the behavior of the simulations.

Comparing the Efficacy of Clinical Iron Chelators Desferal, L1, and Exjade in a Human Hepatocyte Cell Line
Elijah Goldberg '22
Authors/Contributors: Dr. David Killilea (Children's Hospital of Oakland Research Institute) and Kathleen Schultz (Children's Hospital of Oakland Research Institute)
Summer 2018
Supervisor: Dr. David Killilea (Children's Hospital of Oakland Research Institute)
Thalassemia (Thal) is a blood disorder that affects over 100,000 live births annually. In Thal, one of the hemoglobin genes is mutated so that overall bodily hemoglobin is lowered. To mediate this, patients with Thal are transfused to supplement their hemoglobin. As a consequence, excess iron is also transferred into the patient which can cause serious morbidity. To correct for iron overload, patients with thalassemia are given iron chelators, which remove excess metals from the body. However, researchers have recently hypothesized that chelators may be removing minerals other than iron. Using transformed human liver cells living in a low-glucose environment, we induce iron overload by introducing ferrous ammonium citrate to mimic the iron overload present in a patient with Thal. Subsequently, chelators are administered to the cellular environment. After 24 hours, the cells are counted, harvested, and mineral content assessed via inductively coupled plasma-optical emissions spectrometry (ICP-OES).

High-Resolution Heterodyne Spectroscopy
Winston Goldthwaite '19
Authors/Contributors: Ryan Terrien (Assistant Professor of Physics and Astronomy, Carleton College)
Summer 2018
Supervisor: Ryan Terrien (Assistant Professor of Physics and Astronomy, Carleton College)
High-resolution spectroscopy has astrophysical applications in analyzing stellar spectra to remove low-level noise and for exoplanet discovery. Heterodyne spectroscopy offers a novel method for high-resolution spectroscopy. We construct a high-resolution heterodyne spectroscopy experiment in the laboratory to explore its functionality and practicality. A narrowband 780 nm laser is frequency-scanned and combined with a source (target spectrum) to create optical heterodyne beats. These beats will be stronger when the narrow-band laser is scanning a high power portion of the target spectrum. Using a photodiode detector to convert optical signals into electrical, we can map the strength of the target spectrum to the frequency given by the scanning laser. We have been successful in using this method to examine a target signal’s spectrum to a resolving power of 256000 and are currently working to improve the repeatability and stability of the process.

Elegit: Helping Students Learn Git
Miriam Gorra '20, Eva Grench ‘19
Authors/Contributors: David Musicant (Professor of Computer Science, Carleton College)
Summer 2018
Supervisor: David Musicant (Professor of Computer Science, Carleton College)

Students and professional programmers alike often rely on version control systems (VCSs) to track history and collaborate on projects on a regular basis. Unfortunately many VCSs, including the popular option Git, are challenging to learn and therefore to be used as the powerful tool they are. Elegit is a Git client that has been in development for the past 3 summers with two major goals: providing an intuitive interface for Git and helping programmers understand how Git functions. To make Elegit more user-friendly we added a conflict resolution tool to help programmers track their changes across different versions of code. We also added a feature to relate uses of Elegit back to their Git equivalents to help build fluency in command line Git. We discuss the features added and their relevance to Elegit’s purpose, as well as the design process and possible extensions.

29. Exploring the Constitutional History of Environmental Regulation in Washington D.C.
James Harren '19
Authors/Contributors: Kimberly Smith (Professor of Environmental Studies and Political Science, Carleton College)
Summer 2018
Supervisor: Kimberly Smith (Professor of Environmental Studies and Political Science, Carleton College)
The Forest Service was founded in order to withdraw public land to create forest reserves. While creating and administrating these forest reserves, the Office of Law within the Forest Service interpreted the laws governing the powers of the Forest Service strictly after the transfer of 1905. Why did they spend so much time seeking and debating legal opinions about their authority? This way of interpreting the Forest Service's power developed legitimacy for the new office. By fostering an image of credibility, the Forest Service was able to cooperate with other government institutions so it could best conserve the nation's forests.

30. Towards a New Continuous Aminoacylation Assay
Jacob Heath '19, Kyle Duplessis '20
Authors/Contributors: Dr. Joe Chihade, Carleton College, Ian McCarthy '20.
Summer 2018
Supervisor: Dr. Joe Chihade, Carleton College

Aminoacyl tRNA synthetases are enzymes crucial in protein biosynthesis. Specifically, aminoacyl-tRNA synthetases catalyze aminoacylation reactions, chemical reactions where tRNAs are charged with the appropriate amino acid, ensuring that proteins have the structures encoded by the genomic DNA. Traditionally, aminoacylation is measured using expensive radioactive assays that are difficult to work with. In our study, we aim to find a non-radioactive method for observing the aminoacylation reaction, by coupling the formation of AMP to NADH production, which is measurable with UV spectroscopy. For our assay to work, the amino acyl-tRNA moiety needs to be recycled, allowing for increased assay sensitivity. We are exploring three different recycling options for the alanyl-tRNA synthetase. The first involves mischarging the tRNA with serine, relying on the editing domain of the enzyme for tRNA recycling. In the second, tRNA is mischarged with glycine and recycled using a second enzyme, D-aminoacyl-tRNA deacylase (DTD). In the third approach, tRNA is charged with alanine and recycled with a mutant of DTD, which may deacylate tRNAs charged with L- as well as D-amino acids.

Apoorva Handigol '19
Summer 2018
Supervisor: Liz Raleigh (Associate Professor of Sociology & Chair of Sociology and Anthropology, Carleton College)
Bill North (Professor of History & Director of Medieval and Renaissance Studies)
Ray Noll (PhD candidate, University of Chicago)

For two centuries, South Asian and Black communities globally have collaborated on liberating themselves from systems of political and socioeconomic subjugation. Examples such as African American Civil Rights Movement and the fight for Indian independence paint a harmonious picture that can lead us to believe that there are strong alliances between Black and Brown communities. However, there is an undercurrent of antiblackness that must be exposed. Brown-Black solidarity has been particularly necessary now as state violence against and surveillance of Black, Brown, immigrant, and Muslim people have heightened. My research South Asian American complicity and extent of solidarity in fighting antiblack racism. Through in-depth interviews with South Asian parents, 18+
youth, and activists, I analyze how antiblackness and Black solidarity manifest across generations of South Asian Americans in Chicago, Illinois. I seek to understand how South Asian Americans and Black Americans are fighting some of the same forces of oppression and how interracial violence is harming our journeys toward freedom.

32. **Testing of improved Cookstoves for Use in Ethiopia**  
**Austin Heuer ’19**  
**Authors/Contributors:** Nick Vetterli ’19, Clarissa Smith ’19, Danayt Abebe, Seblua Abebe, Mayte Aldrett ’19, Rowan Ford ’20, Rihana Jemal, Jack Schill ’21, Trey Stokes ’19, Tsegaye Nega (Associate Professor of Environmental Studies, Carleton College), Deborah Gross (Professor of Chemistry)  
**Supervisor:** Tsegaye Nega (Associate Professor of Environmental Studies, Carleton College) and Deborah Gross (Professor of Chemistry)  

This summer, we continued to develop and test improved cookstoves for distribution in Ethiopia. We conducted a series of cooking tests to determine whether the Mimi-Moto stove emits less harmful particulates than a traditional stove. We measured the concentration of PM2.5 inside of the test kitchen and compared the concentration against the measured ambient concentration of PM2.5. We found that the Mimi-Moto stove emits significantly less particulate matter, which gave us the confidence to move forward with distribution in Ethiopia. We distributed 14 stoves over the course of two weeks in the Merkato neighborhood of Addis Ababa, Ethiopia, and measured PM2.5 concentration for both the Mimi-Moto stove as well as traditional charcoal stoves. Again, we found that the Mimi-Moto stove emitted significantly less particulate matter than the charcoal stove. Testing and feedback from stove users helped us identify putting out the stove flame as an area in need of further innovation due to high levels of PM2.5 measured during the process.

33. **Overall Thermal Efficiency and Pellet Energy Content Measurements for the Ethiopia Cookstove Project**  
**Nick Vetterli ’19**  
**Authors/Contributors:** Austin Heuer ’19, Clarissa Smith ’19, Deborah Gross (Professor of Chemistry, Carleton College), Tsegaye Nega (Associate Professor of Environmental Studies, Carleton College)  
**Supervisor:** Deborah Gross (Professor of Chemistry, Carleton College)  

Improved gasifier style cookstoves burn biomass fuel pellets at high temperature, making them significantly cleaner than traditional open fires or charcoal stoves. Because the Mimi Moto stove selected for use in the Ethiopia stove project requires pellets, multiple pellet types made in Ethiopia were explored for their combustion efficiency. These pellets included a wide range of ingredients from wood chips to spent coffee grounds and coffee husks. The energy density of these materials, pellets, and the resulting charcoal were determined using bomb calorimetry, with appropriate corrections for nitrogen content. It was then determined that spent coffee grounds were a valuable, energy dense candidate for pelletization. Other ingredients, such as bagasse, were found to have poor combustion efficiency and low energy content. Various charcoals were also investigated to determine combustion efficiency. From this information, we were able to determine a thermal efficiency value for the selected cookstove, which was found to be on the order of 60%.

34. **Presence of Insect Herbivore Aphis echinaceae Associated with a Reduction in Predicted Fitness of Purple Coneflower (Echinacea angustifolia)**  
**Andy Hoyt ’19**  
**Authors/Contributors:** Stuart Wagenius (Conservation Scientist at the Chicago Botanic Garden and Adjunct Assistant Professor, Northwestern University)  
**Supervisor:** Stuart Wagenius (Conservation Scientist at the Chicago Botanic Garden and Adjunct Assistant Professor, Northwestern University)  

*Aphis echinaceae* was first identified as a specialist herbivore of *Echinacea angustifolia*, a perennial prairie composite, in 2009. At the time of discovery, the impact of this aphid species on the fitness of Echinacea was unknown. In 2011, researchers at the Echinacea Project in northwestern Minnesota established a long term study on the impact of Aphis on Echinacea fitness. Individual plants were randomly selected from a common garden
experiment for aphid addition and exclusion treatments. Fitness measurements (counts of leaves, rosettes, flowering heads, and seed set) were collected annually. This summer I worked with the Echinacea project to continue this 8-year study. Using a measure of aphid load calculated from data across all 8 years of the study, I found that greater aphid loads were associated with significantly reduced predicted plant fitness. This association has implications for the survival of Echinacea populations, which already suffer from habitat loss and genetic swamping.

35. **Using Spectrally Measured Sodium and Calcium Feature to Characterize M Dwarfs**
   
   **Adam Huang ’21**  
   **Authors/Contributors:** Ryan Terrien (Assistant Professor of Physics and Astronomy, Carleton College)  
   **Summer 2018**  
   **Supervisor:** Ryan Terrien (Assistant Professor of Physics and Astronomy, Carleton College)  
   
   M dwarfs are the most common stars in the Galaxy and present an exciting frontier for exoplanet missions and studies of stellar physics. An array of empirical techniques has been established for approximating the physical properties of M dwarfs, but the precise characterization remains challenging. We consider here potential refinements of these techniques based on the 820nm sodium doublet. Combined with measurements of stellar metallicity and effective temperature, we explored whether the pressure-sensitive sodium doublet could be used to refine the radius predictions of the MIST and Dartmouth isochrones for M dwarfs. We describe here the mixed performance of this potential radius indicator and how it can provide insight into other fundamental properties of M dwarfs.

36. **(U-Th)/He Thermochronologies of the Morton Gneiss and the Wolf River Batholith, northern U.S.A**

   **Natalie Hummel ’20**  
   **Authors/Contributors:** William Guenthner (Assistant Professor of Geology, University of Illinois at Urbana-Champaign), Cameron Davidson (Professor of Geology, Carleton College).  
   **Summer 2018**  
   **Supervisor:** William Guenthner (Assistant Professor of Geology, University of Illinois at Urbana-Champaign).  
   
   The zircon (U-Th)/He system has a significantly lower closure temperature than most systems used for radiometric dating, making (U-Th)/He dates valuable for constraining the low temperature (i.e. near-surface) histories of exhumed plutons. However, it is difficult to interpret (U-Th)/He dates from very old zircons because high radiation damage alters He diffusivity. In this study, we explore the application of (U-Th)/He thermochronometry to extremely old, damaged zircon crystals from several Archean and Proterozoic granites and granitoid gneisses from the North American Craton. The temperature histories of these ancient, relatively stable cratonic rocks have the potential to reflect large-scale episodes of tectonic uplift prior to 1 Ga, such as the formation of the Midcontinent Rift or the breakup of the supercontinent Rodinia.

37. **Rewiring Mechanism via LGR5/6 Receptors in Squamous Cell Carcinoma**

   **Phuoc Huynh ’19**  
   **Summer 2018**  
   **Supervisor:** Arnaud Jabouille (Post-doctoral Researcher, University of California, San Francisco)  
   
   The Lgr4, Lgr5, Lgr6 proteins are a distinct subset of evolutionarily conserved G-protein-coupled-receptors and known as Wnt signaling mediators (Kumar et al. 2014). Lgr6 has been found to function as a stem cell marker driving carcinogen (DMBA)-induced squamous cell carcinoma development in mice. However, targeting Lgr6 is not sufficient to totally eradicate the appearance of skin tumors. This suggests that some Lgr6+ stem cells are able to rewire the Lgr6 functions, survive and becomes affected by carcinogens. My role during the summer was to validate the effective Lgr5/6 KO using qPCR, immunofluorescence and Sanger sequencing analysis. I also analyzed how mouse fibroblast cell characteristics are affected following Lgr6 loss using PCR Cell Sorting method. Additionally, I evaluated the expression of potential rewiring candidates - Lgr6.

38. **Superheroes as a Source of Psychological Comfort**

   **Abby Ilardi ’19**  
   **Authors/Contributors:** Omri Gillath (Professor of Psychology, University of Kansas)  
   **Summer 2018**  
   **Supervisor:** Omri Gillath (Professor of Psychology, University of Kansas)
The past decade has seen a surge in the popularity of superhero movies and television shows. However, little research has examined the psychology underlying this trend. This preliminary study analyzed psychological factors that may predict superhero fandom. Given the rise of superheroes following 9/11 and the 2008 recession, we hypothesized that fandom can be a coping mechanism for uncertainty and fear, and that participants with more baseline anxiety, such as those with high neuroticism or anxious attachment scores, would be more drawn to superheroes. Our hypothesis was partially supported. In our general sample, higher neuroticism actually predicted lower fandom scores. However, among women, higher neuroticism did predict higher fandom. While attachment style was unrelated to fandom, people who identified strongly with superheroes were more likely to have attachment anxiety. These analyses provide partial support for our hypothesis and will inform our future experimental studies on superhero fandom.

Cullen Irvine ‘19
Authors/Contributors: Javier Vela (Associate Professor of Chemistry, Iowa State University), Carena Daniels (Graduate Student, Iowa State University)
Summer 2018
Supervisor: Prof. Javier Vela (Iowa State University)

Binary intermetallics are atomically ordered two-metal compounds that can possess valuable catalytic, magnetic, super-conductive, and shape-memory properties. One way to synthesize these compounds is by the simultaneous thermal decomposition of two organometallic precursors which contain the metals of interest. A major problem with the concurrent decomposition of two different metal precursors is that a compound might not form if the precursors' rates of decomposition differ greatly when heated at the same temperature. This problem can be avoided by the use of a heterobimetallic single-source precursor, a single organometallic compound that contains both metals needed to form the binary intermetallic. Through a literature search, we found and worked to resynthesize a family of group 10-group 14 heterobimetallic compounds that only differ in which metals they contain (Pd-Sn, Ni-Sn, Pt-Sn, Pd-Ge), providing a single template for us to synthesize several different intermetallic compounds.

40. Frontier: The American West and the Development of Film
Jacob Isaacs ‘20
Authors/Contributors: Laska Jimsen (Associate Professor of Cinema and Media Studies)
Summer 2018
Supervisor: Laska Jimsen (Associate Professor of Cinema and Media Studies)

Laska Jimsen’s Frontier is a forthcoming 60-minute experimental nonfiction film inspired by the end of the American frontier and the beginning of the film medium in mid-1893. As a continuation of the frontier myth, film and later digital media continue to reflect salient and often troubling changes in the American West, especially in California, the world capital of film production. This project documents the conflicts, tensions, power consolidation, fictions, and questions that Western development, on screen and in reality, has brought to the region, with a particular focus on how expansion and development have disenfranchised communities and transformed the environment.

41. Can we observe how DNA is packaged without altering its function?
Alec Jacobson ‘21
Authors/Contributors: Shelby Blythe (Assistant Professor of Biology, Northwestern University)
Summer 2018
Supervisor: Dr. Shelby Blythe (Northwestern University)

Bicoid is a maternal transcription factor essential to the development of Drosophila. Bicoid serves two main roles: one as a transcription factor and another to promote an open chromatin state, so that other transcription factors may access DNA. In this project, I examined mutant flies which had a ParS/ParB system, put in place to provide a readout for chromatin accessibility, seeking to determine whether this system interferes with normal bicoid function. I determined that this system interfered with normal expression of a bicoid target, giant(gt). When the ParS/ParB system is in place, the gt-10 enhancer does not produce a normal expression pattern when driving GAL-4, especially in the posterior end of the drosophila embryo, where bicoid concentration is low. This has important ramifications for both the use of the ParS/ParB system and general understanding of bicoid functionality.
42. **The Out of Time Ordered Correlator as a Measure of Quantum Chaos**

**Charlie Kapsiak ’19**

**Authors/Contributors:** Arjendu Pattanayak, Professor of Physics

Alex Kiral ’20

Summer 2018

**Supervisor:** Arjendu Pattanayak, Professor of Physics

In the study of black holes and information scrambling, the out of time ordered correlator, or OTOC, has found new life as a tool to diagnose quantum chaos, but there has been little analysis into its efficacy. We examine the theoretical rationale for using the OTOC, and its shortcomings. Although the classical correspondence principle does suggest a relationship to the Lyapunov exponent in a space with one stretching dimension, in higher dimensional systems the analogy no longer holds. We create a generalized out of time ordered operator, which has, in the classical limit, the correct structure for a system of canonical variables. We finish by posing several further questions which should be considered before the OTOC can be fully considered a measure of quantum chaos.

43. **Investigating Immune Responses to NMU and IL-25 Induced Allergic Lung Inflammation in B6 and BALB/c Mice Strains**

**Pavana Khan ’19**

Summer 2018

**Supervisor:** Patrick Burkett ’99 (Brigham and Women's Hospital)

Antonia Wallrapp (Brigham and Women's Hospital)

Se-Jin Kim ’17 (Brigham and Women's Hospital)

The increasing prevalence of lung allergies and asthma call for research that focuses on the immune pathways that facilitate the disease. Activation of type 2 innate lymphoid cells (ILC2s) by alarmin cytokines IL-25 and IL-33 can lead to rapid production of the inflammatory cytokines IL-5 and IL-13. In vivo co-administration of the neuropeptide Neuromedin U (NMU) with IL-25, has the potential to strongly amplify allergic inflammation, suggesting an important role for NMU and its receptor Nmur1 in regulating allergic inflammatory responses in lungs. This research investigates the immune responses arising in two strains of mice, after co-administration of NMU and IL-25 to induce allergic lung inflammation. The two strains of mice- B6 and BALB/c have certain immunological variations and BALB/c mice are known to have a more Th2 mediated response to antigen challenges. It is interesting to compare two different mice strains because identifying differences in their immune responses can have implications for how different human respond to lung allergies.

44. **Aldehyde Exposure and Aldehyde-Induced DNA Damage in the Oral Cavity of Falconi Anemia Patients**

**Courtney Kimmell ’20**

**Authors/Contributors:** Alessia Stornetta (Masonic Cancer Center, University of Minnesota) Peter Villalta (Masonic Cancer Center, University of Minnesota) Margaret MacMillan (Department of Pediatrics, University of Minnesota Medical School)

Silvia Balbo (Masonic Cancer Center, University of Minnesota)

Summer 2018

**Supervisor:** Alessia Stornetta (Masonic Cancer Center, University of Minnesota) Peter Villalta (Masonic Cancer Center, University of Minnesota) Margaret MacMillan (Department of Pediatrics, University of Minnesota Medical School)

Silvia Balbo (Masonic Cancer Center, University of Minnesota)

Aldehydes are reactive carbonyl compounds that can bind to DNA and cause DNA adducts, which if not repaired, can interrupt normal cellular processes and lead to the development of cancer. This study focuses on Fanconi Anemia: a rare genetic disease characterized by bone marrow failure and an increased susceptibility to cancer. Fanconi Anemia (FA) patients are deficient in the FA repair pathway, which is involved in neutralizing DNA damage caused by aldehydes. Drawing on the relationship between aldehyde-induced DNA adducts and the FA repair pathway deficiency, liquid chromatography-mass spectrometry approaches were used to investigate if aldehyde exposure and aldehyde-induced DNA damage is greater in the oral cavity of FA patients compared to non-FA patients. In the future, this study aims to shed light on what aspects of FA could contribute to an increased susceptibility to cancer to eventually lead to earlier detection and prevention of cancer in FA patients.
45. Computer-Assisted Proof of Tiling Complexity  
Will Knospe '20, David White '20  
Authors/Contributors: Jed Yang (Visiting Professor of Computer Science), Will Schwarzer '20.  
Summer 2018  
Supervisor: Jed Yang (Visiting Professor of Computer Science)  
A tiling problem seeks to count the number of ways a given set of tiles fit within a region (or to determine whether doing so is possible). It is well known that deciding whether a tileset can tile a region is NP-complete when both the tileset and region are taken as input, but this problem can become easier when the tileset is fixed, e.g., a fixed tileset where the unit tile is present. The standard way to prove that a certain tileset's tileability problem is NP-complete is by creating regions representing "wires" and logical "gadgets" in order to solve the NP-complete problem SAT. The creation of these wires and gadgets must be done individually for each tileset, and can be a highly time-consuming process when done by hand. In this project, we developed two main programs: first, KAST, a general tiling application that uses several algorithmic insights to reduce the number of guesses that must be made while tiling, increasing tiling speed; second, Proofgen, which finds wires and gadgets algorithmically with the goal of independently producing entire tileset NP-completeness proofs.

Zhi You Koh '19  
Authors/Contributors: Tim Winter-Nelson '20  
Summer 2018  
Supervisor: Professor Charisse Burden-Stelly (Assistant Professor of Africana Studies and Political Science, Carleton College)  
This research seeks to explore the development and construction of Black feminism from 1970-1990 to historicise Black feminism and construct a definition based on the content of Black feminist claims. I suggest that there are distinct strands of Black feminism along lines such as lesbianism and humanism and that Black feminism is distinct from other analyses contextualized to Black women. To legitimize itself, Black feminism constructs competing race-and-gender analyses, especially that of Black nationalism, as racist or misogynistic. Black feminism also constructs a history of Black feminist thought that subsumes paradigms of socialist, race, and gender analysis which are distinct from its 1970-1990s iteration, blurring the scope and definition of Black feminism. This research calls attention to the need to historicise Black feminism and to critically analyse its political project in relation to its use as an analytical paradigm in light of its contemporary dominance in understanding race and gender.

47. Characterizing Complexity in the Dynamics of Chaotic Systems  
Daniel Kupetsky '19  
Authors/Contributors: Andres Aragoneses (Assistant Professor of Physics, Eastern Washington University)  
Summer 2018  
Supervisor: Andres Aragoneses (Assistant Professor of Physics, Eastern Washington University)  
We used a nontraditional statistical analysis technique to characterize the complex behavior of time series generated by 11 chaotic functions. The technique, known as ordinal pattern (OP) analysis, gives a probabilistic description of trends in time series data on a micro scale. We used this OP analysis to generate plots of the functions' complexity and compared the results to more traditional techniques. We found some initial indication that OP complexity analysis produces more information about certain time series than does the traditional analysis, but further study is needed to determine the applicability.

48. Dreams, Secrets, Rumors, and Gossip: How they Shape Social Dynamics and the Minds of the Masses  
Max Lane '19  
Authors/Contributors: Dr. Asuka Sango (Associate Professor of Religion, Chair of Religion, Carleton College).  
Summer 2018  
Supervisor: Dr. Asuka Sango (Associate Professor of Religion, Chair of Religion, Carleton College).  
My research focused on the roles of dreams, secrets, rumors, and gossip in dictating and transforming society at large. The research spanned several different fields, including religious studies, sociology, history, and anthropology, and psychology, with the end goal of providing Dr. Sango with solid background information in these areas to assist in her writing of an article that fused the researched areas with her background in Japanese court society. Discovering how modern research explains the dissemination of rumors and dreams in a historical context
was essential to the project and pertinent to Dr. Sango’s more targeted research. In addition, the research can be applied in a vast variety of contexts and illuminate some of the intricacies of American political discourse, gender theory during the inquisition, and how to deal with (or spread) gossip and rumor in our own lives, a testament to the scope and value of the Humanistic research.

49. A Summer in Norfolk: Examining Archival and Archaeological Records of the Workhouse  
Cece Lasley ’20, Elizabeth Budd ’19, Nicole Connell ’20, Spencer Lekki ’21  
Authors/Contributors: Susannah Ottaway (Professor of History, Carleton College), Austin Mason (Assistant Director of the Humanities Center for the Digital Humanities and Lecturer in History, Carleton College)  
Supervisor: Susannah Ottaway (Professor of History, Carleton College)  
The essence of our research question was how to make the History and Public History of English Houses of Industry as accessible as possible given limited historical records. We attempted to do this through database creation and digitization in the archives, and promotion of newly-created tablet guides in the Museum, as well as the creation of new activities at the Museum that would be engaging for a wide audience. We also spent time turning historical documents into usable demographic data, making the information more easily analyzed for both the public and our supervisor, the museum curator.

50. Comparing Modeling Approaches to Protein Complex Assembly Dynamics in Cell Death Signaling  
Anna Lauko ’19  
Authors/Contributors: Blake A. Wilson (Vanderbilt University), Geena Ildefonso (Vanderbilt University)  
Supervisor: Carlos F. Lopez (Assistant Professor, Vanderbilt University)  
Key mutations found in cancer derail tightly controlled apoptosis (programmed cell suicide) signaling pathways, allowing for rapid cancer cell proliferation. Cell death decisions in the TNF-signaling cascade are controlled by the formation of protein complexes, processes which cannot be directly observed experimentally with current technology. Computer modeling could therefore elucidate requirements that lead to TNF-receptor driven apoptosis, leading to novel methods to induce or avoid cell death in cancer treatments. Three common modeling methods are classical chemical kinetic modeling, stochastic modeling, and spatial stochastic modeling. Each method makes various simplifying assumptions which may not necessarily hold in cells. We evaluated each approach in the context of the TNFR- signaling pathway and found that classical chemical kinetic modeling is the most efficient approach that does not sacrifice prediction accuracy.

51. NMR-Based Photopolymer Gel Point Determination  
Casey Lee-Foss ’19  
Authors/Contributors: Marty Baylor (Associate Professor of Physics, Carleton College), Gretchen Hofmeister (Associate Dean of the College, Professor of Chemistry, Carleton College)  
Supervisor: Marty Baylor (Associate Professor of Physics, Carleton College), Gretchen Hofmeister (Associate Dean of the College, Professor of Chemistry, Carleton College)  
Photopolymers can be used to assemble a variety of analytical devices that include microfluidic and optical features. In order to create microfluidic channels and optical wave guides in a single process, the gel point of the photopolymer, which is the point at which an infinite polymer network has been formed, must be known. The current standard method of determining the gel point is rheometry. However, the process of gelation may be able to be monitored by NMR spectroscopy as well, which is useful for institutions like Carleton that do not possess rheometry equipment. We developed methods to monitor this process by T1 NMR and to use the acquired data to make predictions of the gel point of a photopolymer mixture which correspond to the results of both empirical testing and rheometry.

52. The Role of Anthropogenic Impact on the Białowieska Puszcza and its Cultural Influences on the People of Poland, Lithuania and Belarus.  
Will Loner ’19  
Supervisor: Marty Baylor (Associate Professor of Physics, Carleton College), Gretchen Hofmeister (Associate Dean of the College, Professor of Chemistry, Carleton College)
Bialowieza Forest is an old-growth system on the shared border of Poland and Belarus. In both academic and popular science literature, this forest is lauded as a pristine system, a would-be window into Europe's pre-industrial past. However, much of this system was managed extensively for centuries, and Bialowieza Forest exists today in large part due to this local and regional anthropogenic influence. Due to its stark deviation from the western wilderness narrative, this history of land use is often "swept under the rug" to perpetuate the myth of the last primeval forest. I traveled to Bialowieza to speak with local citizens and experts about how they engage with and think about this forest, seeking to better understand how it plays into concepts of nationalism, conservation and land management, and a sense of place. I considered these ideas through the lens of the recent logging controversy.

53. Synthesis and Reactivity of Iridium Silyl and Silylene Complexes
Joseph Luther '20, Anna Conley '20
Authors/Contributors: Matt Whited (Associate Professor of Chemistry, Carleton College)
Summer 2018
Supervisor: Matt Whited (Associate Professor of Chemistry, Carleton College)
Transition metal silylene complexes containing a Si=M double bond exhibit distinct reactivity with small molecules as diverse as H₂ and CO₂. We have recently prepared a series of iridium complexes supported by multidentate silyl ligands with the goal of enabling new reactivity. Here we report synthetic efforts leading to an unusual base-free iridium silylene as well as preliminary studies of the reactivity of iridium silylenes.

54. Cation Motion in Zeolites: A Molecular Dynamics Study
Brody Lynch '20, Adam Nijhawan '19
Authors/Contributors: Daniela Kohen (Professor of Chemistry, Carleton College)
Summer, 2018
Supervisor: Daniela Kohen (Professor of Chemistry, Carleton College)
Zeolites are naturally occurring minerals with microscopic pores. These pores allow for zeolites to act as sieves for gases. Specifically, some zeolites trap CO₂ in much greater quantities than other gases. Thus, there is potential in using zeolites to filter out greenhouse gases from fossil fuel emissions. We used computational models to study the process by which zeolites trap CO₂ because they allow us to better understand the movement of atoms on a molecular level. We also evaluated the accuracy and speed of different computational models. We used the model we found to be the best on zeolites RHO and MFI to analyze the interactions between molecules and gain insight into the filtration mechanism.

55. Detecting and characterizing submarine groundwater discharge (SGD) on an arid island in the North Pacific
Eliza Malakoff '19
Authors/Contributors: Samantha Levi ('20, University of Southern California)
Mitsuyo Tsudo (Masters Student, California State University Long Beach)
Merik Ruane ('18, California State University Long Beach)
Jillian Malone ('20, California State University Long Beach)
SuJin Lee (Associate Professor at the Spatial Sciences Institute, University of Southern California)
Doug Hammond (Associate Professor of Earth Sciences, University of Southern California)
Benjamin Hagedorn (Associate Professor Geology, California State University Long Beach)
Lynn Dodd (Associate Professor of Archeology, University of Southern California)
Summer 2018
Supervisor: Lynn Dodd (Associate Professor of Archeology, University of Southern California)
SuJin Lee (Associate Professor at the Spatial Sciences Institute, University of Southern California)
Submarine groundwater discharge (SGD) occurs when fresh groundwater or recirculated saltwater into the ocean at or below sea level. The location and quantity of SGD seeps can be used to understand the effects of drought on groundwater systems, but no standard methodology exists for locating and characterizing SGD. We utilized two methods of detecting and characterizing SGD along the coastline of Santa Catalina Island (CA), an arid island subject to severe drought conditions since at least 2007, including systematic surveys of the coastline were conducted using (1) portable instruments capable of radon-isotope counting; and (2) salinity probes suspended from a small motorboat. We found significant radon concentrations along the coastline and a clear influence of tidal height, suggesting the presence of recirculated seawater is more common than fresh SGD. Our salinity probes were also able to detect several areas of consistently lowered salinity, which may indicate coastal upwelling.
56. **Pathogenic Mutations in a Human Mitochondrial Enzyme**  
**Clara McCurdy '19, Hannah Kennicott '20**  
**Authors/Contributors:** Joe Chihade (Professor of Chemistry, Carleton College)  
Summer 2018  
**Supervisor:** Joe Chihade (Professor of Chemistry, Carleton College)  
Previous work has identified mutations in human mitochondrial alanyl tRNA-synthetase that lead to infantile cardiomyopathy and leukodystrophy. We have recreated those mutations in a bacterial expression system in order to study their effect on protein stability. We identified several mutations that rendered the protein insoluble and therefore impossible to assay. One project this summer was to finish constructing plasmids that encoded for all known pathogenic mutant proteins. A second goal was to create plasmid constructs encoding hybrid proteins, where solubility enhancing tags were added to aid protein folding. Two types of these were made. The final project utilized Western Blotting to identify how a mutation affects the fate of the mitochondrial alanyl-tRNA synthetase in regards to solubility and resistance to proteolysis.

57. **Investigating the Active Sites of the Succinyltransferases DapD and TabB**  
**Eric McGregor '19**  
**Authors/Contributors:** Chris Calderone (Assistant Professor of Chemistry, Carleton College)  
Summer 2018  
**Supervisor:** Chris Calderone (Assistant Professor of Chemistry, Carleton College)  
Tabtoxin is the causative agent of wildfire disease in tobacco plants and is produced by the bacterium Pseudomonas syringae pv. tabaci. Tabtoxin is structurally homologous to the amino acid lysine. Prior research has discovered numerous enzymes along the biosynthetic pathway of tabtoxin that are homologous to those along the lysine pathway. Two of these enzymes are DapD (in the lysine pathway) and TabB (tabtoxin pathway). These enzymes both function as succinyltransferases and have the same three-dimensional structure. Although these enzymes function similarly, their active sites contain different amino acids that interact with the substrate. We attempted to interconvert these amino acids between the two enzymes through mutagenesis. Spectrophotometric assays were conducted in order to determine activity, but no activity was observed in the mutants. This suggests that despite the similar three-dimensional structure, the precise position of amino acids in the active site is essential for activity.

58. **Is the Amino-Terminal Domain all you really need?**  
**Quinn McVeigh '20**  
**Authors/Contributors:** Rou-Jia Sung (Assistant Professor of Biology)  
Quinn Johnson '19  
Anna Lauriello '20  
Summer 2018  
**Supervisor:** Rou-Jia Sung (Assistant Professor of Biology)  
The LY6 family of proteins is made up of prototoxin-like molecules endogenous to mammals, with similar structures to alpha-neurotoxins found in various snake venoms. Two membrane-attached members of this family, LY6G6D and LYPD2, are potential regulators of AMPA receptors. AMPARs are tetrameric receptors with three domains: the amino-terminal (NTD), the ligand binding, and the transmembrane. We hypothesize that LYPD2 and LY6G6D interact with AMPARs at the interface between the NTDs of two subunits. We created two constructs derived from the full-length GluR2Q AMPAR: NTDStop, in which only the amino-terminal domain is expressed, and NoNTD, in which the NTD is not expressed but the other two domains are. Both constructs have a GFP tag inserted. Immunofluorescence experiments show colocalization of the AMPAR constructs at the cell surface with LY6G6D. Co-immunoprecipitation experiments to determine whether the NTD is important for interaction with LY6G6D are currently being developed.

59. **Optimizing the Harvesting Efficiency of a Piezoelectric Vibrational Energy Harvester**  
**Matthew Mikos '19**  
**Authors/Contributors:** Arjendu Pattanayak (Professor of Physics, Chair of Physics and Astronomy, Carleton College), Andre Ribeiro de Carvalho (Centre for Quantum Dynamics, Griffith University), Andres Aragoneses (Visiting Professor of Physics, Carleton College), and Sacha Greenfield '19  
Summer 2018  
**Supervisor:** Arjendu Pattanayak (Professor of Physics, Chair of Physics and Astronomy, Carleton College)
The optimization of the harvesting efficiency of a coupled piezoelectric vibrational energy harvester modeled as a double well Duffing oscillator is explored. Using XMDS software for solving coupled differential equations we find maximized harvesting efficiency corresponds with the maximization of the electromechanical coupling constants. Additionally, peak harvesting efficiency is found when the dimensionless time constant is such that it matches the driving frequency and results in impedance matching. We use ordinal analysis and permutation entropy to examine harvester time series. Finally, we speculate that there is a direct link between the time-averaged distributions of the orbits in position-momentum phase space and harvesting efficiency.

60. Searching for Lorentz Violation with Multi-messenger Gravitational Astronomy  
Tim Mikulski ’21  
Authors/Contributors: Jay Tasson (Assistant Professor of Physics, Carleton College)  
Summer 2018  
Supervisor: Jay Tasson (Assistant Professor of Physics, Carleton College)  
Violations of relativity (Lorentz violation), if detected, could provide experimental evidence of the long-sought unified theory of physics that combines quantum physics and General Relativity. Gravitational waves, ripples in spacetime that travel to us from distance collisions of star-like objects, provide a new tool in the ongoing search for Lorentz violation. Recently Earth-based gravitational-wave detectors observed gravitational waves and light from the same astrophysical event, making a sensitive comparison of the speeds of these waves possible. The speed comparison and the sky position of the event can be used to significantly extend the depth of the Lorentz-violation search, because a difference in the speeds of the signals implies a Lorentz violation. A linear programming optimization approach can refine the search further once a sufficient number of multi-messenger events have been observed. We have assembled a codebase to automate these calculations.

61. Stoplist Optimization for Topic Modeling  
Malcolm Mitchell ’20  
Authors/Contributors: Eric Alexander (Professor of Computer Science, Carleton College)  
Summer 2018  
Supervisor: Eric Alexander (Professor of Computer Science, Carleton College)  
Topic modeling, a method of uncovering the semantic meaning hidden within text, can be inaccessible to the domain experts who may most effectively employ its results. With the goal of supporting its accessibility to such scholars, we have focused on one aspect of topic model-creation: stoplisting. Stoplisting, or the removal of certain words before text-processing, is a simple concept which entails endless decisions. We advocate the selection of domain- and task-specific stoplists and introduce a set of categorizations by which stopwords can be identified. Motivated by these findings, we implement Stopifu, a web-based tool which structures stoplist creation and refinement.

62. Detecting astrophysical events with gravitational and electromagnetic waves  
Geoffrey Mo ’19  
Authors/Contributors: Erik Katsavounidis (Senior Research Scientist, LIGO Lab, Massachusetts Institute of Technology)  
Summer 2018  
Supervisor: Erik Katsavounidis (Senior Research Scientist, LIGO Lab, Massachusetts Institute of Technology)  
A new era of multi-messenger astronomy started with the simultaneous gravitational-wave (GW) and electromagnetic (EM) detection of the binary neutron-star merger GW170817. As the sensitivity of GW detectors such as LIGO and Virgo continue to improve, an increasing number of GW events are expected. To ensure prompt EM observational follow-up of such events, efficient channels of communication need to be established between GW and EM astronomers, the fastest of which must function on a minutes-long timescale. We present gwcelery, an automated method to process gravitational-wave information before it is passed to EM astronomers. One such piece of information is a suite of detector characterization checks, which act as a first line of defense against noise or injected signals being misidentified as real GW events.

63. The Adoption Tax Credit: Past, Present, and Future  
Alec Morrissey ’21  
Authors/Contributors: Liz Raleigh (Associate Professor of Sociology, Carleton College)  
Summer, 2018  
Supervisor: Liz Raleigh (Associate Professor of Sociology, Carleton College)
The Adoption Tax Credit provides $13,810 to subsidize the cost of adoption. While its broad legislative history is known, uncertainty regarding the events resulting in its enactment in 1996 remains. Through an analysis of the congressional record and media sources, this research sought to locate a moment of transition when the policy language expanded to include domestic private and transnational adoptions following an original objective to incentivize foster care adoption. While no precise moment could be located, this research revealed greater context for the credit’s 1) legislative origins, 2) near-repeal in 2017, and 3) federal tax credit policy.

64. **Searching for an Excess of Gravitational Waves from the Milky Way Galaxy**  
**Serena Moseley ’20**  
**Summer 2018**  
**Supervisor:** Thomas Callister (California Institute of Technology)  
The Laser Interferometer Gravitational-Wave Observatory (LIGO) is a highly-sensitive, large-scale observatory designed to detect disturbances in spacetime known as gravitational waves. No known object in the Milky Way galaxy produces detectable gravitational waves, however, it is possible that an unknown galactic source is emitting gravitational radiation at frequencies accessible to current detectors. Thus, we develop a method of mapping the sky distribution of transient gravitational waves, known as bursts, to determine whether there exists a galactic excess of gravitational waves in the LIGO frequency band. To test our method, we simulate both an isotropic population and a galactically-distributed population of unmodeled gravitational-wave bursts and conduct parameter estimation on these two sets in order to generate sky localizations for each simulated signal. We combine these into probability distributions of source locations for the two populations and demonstrate that we can correctly classify our two distributions based on their recovered localizations.

65. **Two-Locus Model Predicts Asymmetric Reinforcement by Concordant Selections.**  
**Alief Moulana ’19**  
**Authors/ Contributors:** Yaniv Brandvain (Assistant Professor of Evolution, Ecology, and Behavior, University of Minnesota-Twin Cities)  
**Winter 2017 - Present**  
**Supervisor:** Yaniv Brandvain (Assistant Professor of Evolution, Ecology, and Behavior, University of Minnesota-Twin Cities)  
During reinforcement, it has been shown that the fitnesses of hybrids of two populations differ between the two reciprocal matings (asymmetric). Previous model have shown reinforcement more likely happens under a concordant, rather than discordant, asymmetric scheme, such that both prezygotic and postzygotic selections favor a population in the same direction. Here we develop a model involving a selection and a mating preference loci under asymmetrical selection (s), mating (d), and migration (m) environments. Our model predicts the ability of invasion by mating allele at high mating cost only when there is a concordant selection. Moreover, we observe the failure of spread when d < 0.1. When m between two populations is asymmetric, we observe discordant selection resulting in reinforcement when s is weakly asymmetric. This suggests that discordant selection does happen under nearly symmetric selection, which fits previous observations in model organisms.

66. **Determining the Effect of Genetic Background on the Evolvability of Natural Yeast Isolates using Molecular Barcodes**  
**Alief Moulana ’19**  
**Authors/ Contributors:** Monica Sanchez (Postdoctoral Fellow, Stanford University), Dmitri Petrov (Professor of Biology, Stanford University)  
**Summer 2018**  
**Supervisor:** Monica Sanchez (Postdoctoral Fellow, Stanford University)  
The genetic background in the microbial genomes have been shown to affect the evolvability of the individuals. Here, we applied CRISPR based strategy to incorporate a diverse set of barcode sequences to track natural isolates of yeast evolution. These strains represent a rich diversity in term of phenotypes, genotype, ecological and geographical niches and provided with us a great opportunity to study how traits and evolvability depend on the genetic background. 13 out of 15 colonies successfully grew with introgressed barcodes, and 11 out of 15% had a PEASY efficiency values of greater than 0.85. These libraries were then subsequently prepared for the first step of experimental evolution. Moreover, during a study that compares the haploid and diploid yeast cells, we successfully tracked adaptive strains that showed predominant mutations in the metabolic pathways. This suggests
the enhanced fitness of more efficient metabolism.

67. Finding Potential Anisotropies in the Cosmic Ray Spectrum
Lucas Mueller ’21
Authors/ Contributors: Frank McNally (Visiting Professor, Carleton College), James Yuan
Summer 2018
Supervisor: Frank McNally (Visiting Professor, Carleton College)
Cosmic rays are high energy particles of unknown origin that routinely strike the Earth. Using data from the IceCube research center at the south pole, we attempt to reconstruct potential sources for these particles. Numerous statistical tests were performed upon the cosmic ray spectrum in order to isolate potential anisotropies. The majority of the tests provide p < 10^-33 validation of a low-energy dipole structure, but higher energy tests remained inconclusive. Furthermore, fits of zenith angle against energy were performed in order to better establish an energy spectrum for incident cosmic rays. A reasonable fit was found to be a spline fit with power law 3.

68. Reduction of Epileptiform Frequency by 1A-Adrenergic Receptor Agonists
Maxime Munyeshyaka ’21
Authors/ Contributors: J.P Biggane(University of North Dakota School of Medicine & Health Sciences), J.A Power( University of North Dakota School of Medicine & Health Sciences), Z.O Dent (University of North Dakota)
Summer 2018
Supervisor: Dr. Van Doze, University of North Dakota
Norepinephrine is a neurotransmitter with strong influences on brain excitability and seizures. Norepinephrine signals via interactions with the adrenergic receptors(AR). Previous studies have shown that selective activation of the alpha-1A-AR results in less seizures and an increase in brain function. The goal of this study is to determine variability in response to alpha-1A AR activation, measured as the modulation of epileptiform event frequency, in the mouse hippocampal slice. We hypothesized that the alpha-1A-AR-mediated antiepileptic response would exhibit higher efficacy when activated by imidazoline-type agonists, such as cirazoline. Dose-response curves were generated in hippocampal slices which exhibited epileptiform activity in an artificial cerebrospinal fluid devoid of magnesium. Epileptiform events were detected by measuring local field potential using field electrophysiological methods. Our results suggest that different classes of -AR agonists do have variable capacities to confer an antiepileptic effect. We found that epinephrine exhibits a decrease of about 15% in epileptiform frequency, while cirazoline mediated about 60% decrease in epileptiform frequency. This study establishes possible strategies and insights for the translatable potential of an 1A-AR antiepileptic drug.

69. Squished Rocks: Creating Deformation Bands in Sandstones Using Triaxial Apparatus
Kate Nootenboom ’20
Authors/ Contributors: Sarah Titus (Professor of Geology, Carleton College), and Peter Lindquist ’18
Summer 2018
Supervisor: Melodie French (Assistant Professor of Geology, Rice University)
Deformation bands are planar structures that typically localize in porous, granular rocks subjected to tectonic stress. In sandstones of the Etchegoin Formation in central California, northeast of the San Andreas fault, deformation bands are commonly observed in the field. When these structures are used to infer local stress directions, the angles are typically 60°-70° from the San Andreas fault strike. This finding is at odds with the World Stress Map. To investigate this discrepancy, I conducted rock mechanic experiments using a triaxial deformation apparatus to subject samples of the Etchegoin Sandstone to known stress directions and strain rates. The goal of these experiments is to create deformation bands in a controlled lab setting, explore the relationship between stress direction and deformation band angle, and extrapolate experimental results to the observed patterns in the field to better understand the region’s tectonic and deformation history.

70. Teaching Teachers: The Relationship Between Teacher Behavior and Teacher Credibility
Morgan Ross ’19
Summer 2018
Supervisor: Stephanie Wassenburg (Carnegie Mellon University)
Chinmay Kulkarnie (Carnegie Mellon University)
Recent technological advancements in the classroom have largely focused on helping students rather than teachers. The largest factor that determines a teacher’s influence on student achievement is teacher credibility (Hattie, 2018). Teacher credibility is a combination of competence, trustworthiness, and caring (McCroskey & Teven, 1999). Research has linked teacher credibility to broad attributes. However, the specific behaviors underlying teacher credibility remain unknown. The current study aimed to articulate the specific behaviors that affect students’ perceptions of credibility. Students rated their teacher’s credibility, the frequency of specific behaviors, and the ideal frequency of these behaviors. The perceptions of several behaviors were found to be correlated to their perceptions of teacher credibility, largely agreed upon by the students, and often lacking when compared to the ideal frequency of those behaviors. Based on these findings, guidelines for a technical intervention, which would increase teacher credibility and in turn student achievement, were discussed.

71. The Role of STAT3 in Schistosomiasis Associated Bladder Cancer in Humans
Thomas Rubino ’21
Summer 2018
Supervisor: Dr. David Tweepary, MD (MD Anderson), Dr. Prema Robinson, PhD (MD Anderson), Kris Eckols (MD Anderson), Dr. Moses Kasembeli, PhD (MD Anderson)

Schistosomiasis, or Bilharzia, is a parasitic worm that affects 200 million people in Africa, Asia, and the Caribbean. Nearly 600 million people living in rural areas are currently at risk. Carcinoma of the urinary bladder is the most common malignancy in the Middle East and parts of Africa where schistosomiasis is a widespread problem. Major evidence suggests an association between schistosomiasis and bladder cancer, however, not much is known about the mechanism behind this link. Eggs deposited in the bladder become lodged into the connective tissue, or Lamina Propria. This initiates a chronic inflammatory response that can last for years. Transcription factor STAT3 has emerged as a key player in this crosstalk between inflammation and cancer. Although STAT3 signaling is known to be activated in human urothelial bladder carcinoma, there are no studies that have determined the relation between STAT3 and Schistosoma associated bladder cancer.

72. Ways of Being Home
Fernando Saldivia Yanez ’20
Authors/Contributors: Cecilia Cornejo (Instructor in Cinema and Media Studies, Carleton College)
Summer 2018
Supervisor: Cecilia Cornejo (Instructor in Cinema and Media Studies, Carleton College)

My work this summer is part of the larger project encompassing the production of the documentary Ways of Being Home, which explores the sense of belonging of Mexican immigrants within the Northfield community through the audiovisual documentation of their testimonies and daily experiences. For this phase, I created an archive containing news articles and media footage covering the Trump administration measures regarding immigration and the public’s response to them. This helps us understand local testimonies and events in a national context and is therefore key in the development of the documentary film.

73. Exploring Upper Bounds of Graph Proper Diameters
Nathanial Sauerberg ’20
Authors/Contributors: Grant Fickes ’19 (Kutztown University). Dylan Green ’19 (Trevecca Nazarene University). Jill Stifano ’19 (Fairfield University). Karen McCready (Assistant Professor of Mathematics, King’s College). Kathleen M. Ryan (Assistant Professor of Mathematics, DeSales University)
Summer 2018
Supervisor: Karen McCready (Assistant Professor of Mathematics, King’s College) and Kathleen M. Ryan (Assistant Professor of Mathematics, DeSales University).

Graph theory is the mathematical study of relationships between objects. We represent each of the objects we are studying as a dot called a vertex. Then, we draw lines called edges between pairs of vertices that bear whatever
relationship we are studying. Two vertices not directly joined by an edge can still be connected by a sequence of edges called a path. One way to study multiple interdependent types of relationships is by giving each relationship a color and then coloring the edges accordingly. This research focuses on paths whose edges alternate colors. When the only such path between a pair of vertices travels the entire graph, the distance between the vertices is maximal. Looking at graphs containing such vertices leads to the construction of the graph family. We show that the graph family encompasses all graphs with this property and has a number of other interesting properties.

74. **In-Situ Method for Characterization of Two-Stage Photopolymer Phase Structures**  
**Emily Schwartz ’19**  
**Authors/Contributors:** John E. Hergert (Materials Science and Engineering Program, Univ. of Colorado, Boulder), Charles M. Rackson (Department of Electrical, Computer, and Energy Engineering, Univ. of Colorado, Boulder), David J. Glugla (Apple, Inc.), Amy C. Sullivan (Department of Electrical, Computer, and Energy Engineering, Univ. of Colorado, Boulder), and Robert R. McLeod (Materials Science and Engineering Program and (Department of Electrical, Computer, and Energy Engineering, Univ. of Colorado, Boulder)  
**Summer 2018**  
**Supervisor:** Robert R. McLeod (Materials Science and Engineering Program and (Department of Electrical, Computer, and Energy Engineering, Univ. of Colorado, Boulder)  
The characterization of the refractive index contrast in two-stage photopolymers, $\Delta n$, is essential for optical device design. We present an in-situ imaging technique using confocal reflection microscopy and quantitative phase imaging that captures the full spatial frequency spectrum and $\Delta n$ of 2D photo-structured phase elements.

75. **Relativity Research**  
**Eric Shao ’21**  
**Authors/Contributors:** Jay Tasson (Professor of Physics, Carleton College)  
**Summer 2018**  
**Supervisor:** Jay Tasson (Professor of Physics, Carleton College)  
General Relativity and quantum physics are two separate theories, which, taken together, describe the physics world as we know it. However, most physicists find this patchwork unsatisfactory. By conventional thinking, unfeasibly high energies are required to search for a unified theory. An alternative approach involves precise experiments looking for violations of Lorentz symmetry, which is the idea that experimental results do not depend on the orientation or velocity of the experiment. A large number of such experiments have been done under a general test framework known as Standard-Model Extension. This project aims to take advantage of additional changes in the velocity of experiments due to the rotation of the Earth on its axis, which most experiments ignore. Since this velocity is latitude dependent, we combine data from several existing experiments done at different latitudes on Earth to search for additional sources of Lorentz violation not sought in the original tests.

76. **Measurement back-action to control the energy dynamics of semiclassical system**  
**Yueheng Shi ’21**  
**Authors/Contributors:** Sacha Greenfield ’18  
J.K. Eastman (Phd student, Australian National University)  
A.R.R. Carvalho (Senior Researcher, Griffith University)  
Arjendu Pattanayak (Professor and Chair of Physics, Carleton College)  
**Summer 2018**  
**Supervisor:** A.R.R. Carvalho (Senior Researcher, Griffith University)  
Arjendu Pattanayak (Professor and Chair of Physics, Carleton College)  
In previous work, it has been shown that the measurement parameter choice, the scale of the system and the measurement angle could greatly affect the energy dynamics of semiclassical dynamics. Through decoupling the five equation system to four, we devised an adaptive control strategy through measurement angle. Our work has shown adaptive control of measurement angle could even dramatically increase the effect without changing the scale of the system. Further connection with energy harvesting and quantum thermodynamics has been discussed.

77. **Investigating catalase activity as a method of coping with oxidative stress in Weddell seals**  
**Eliza Skoler ’19**  
**Summer, 2018**  
**Supervisor:** Dr. Allyson Hindle (Massachusetts General Hospital)
The Weddell Seal regularly holds its breath for 30 minutes at a time while diving in frigid Antarctic waters. To avoid running out of oxygen during this long dive, the seal restricts blood to only essential organs. In other mammals, the process of cutting off blood flow and the supply of oxygen to a tissue, only to reoxygenate those tissues at a later point generates reactive oxygen species which cause oxidative stress. This summer we studied some of the physiological adaptations that enable Weddell seals to avoid the detrimental effects of oxidative stress at a cellular level. I focused on the activity of antioxidants, specifically an enzyme called catalase, as a protective mechanism in seal tissues (as compared to sheep tissues). Results showed that tissues undergoing the most severe oxidative stress in seals have higher levels of catalase activity and catalase gene expression.

78. Gender and Sexuality in Spanish Children’s Literature
James Smith ’19
Summer 2018
Supervisor: Anita Chikkatur (Associate Professor of Educational Studies, Chair of Educational Studies)

Although themes of gender and sexuality are becoming more prevalent in children’s literature, formal research on this area remains sparse, particularly outside of the Anglosphere. This study examines 48 books for children ages 6- through 9-years-old on the 2017 Muestra de libros infantiles y juveniles to understand the ways they challenge or reinforce existing expectations around gender and sexuality in Spain. Through three case studies, I exemplify how this list presents both limiting and creative gender models. I conclude that although both Madrid’s community and its Public Library System have specific goals and values centered on being LGBT inclusive, the books they identify as “good” largely fail to include non-normative versions of gender and sexuality, especially in regards to masculinity. I put forward three suggestions for future research that must be conducted to better understand the reasons for this gap in representation.

79. Chinese Illustration and the Three Perfections
Florence Solomon ’20
Summer 2018

Chinese Literati painting is perhaps most commonly identified by its loose, minimalist style, and especially by its calligraphic characters. Why all the words? Last year, I was introduced to the Chinese artistic theory of the “Three Perfections” - painting, poetry, and calligraphy - which together serve to create a work which is both a visual poem and a verbal painting. This philosophy of visual communication is the best articulation of the idea of illustration that I have ever encountered. On this program, I sought to study and to personally implement the tradition, the philosophy, and the art-forms which were born from this idea.

80. Examining the Effects of Surface Tension on Photopolymer Lens Shape in Water Substrate
Sam Stevenson ’19
Authors/Contributors: Martha Elizabeth Baylor-Reed (Associate Professor of Physics, Carleton College department of Physics and Astronomy)
Summer 2018
Supervisor: Martha Elizabeth Baylor-Reed (Associate Professor of Physics, Carleton College department of Physics and Astronomy)

Lenses fabricated from polymer resins are cheaper to manufacture than lenses made from glass, but are not sufficient when high surface quality is necessary. We fabricate macro-sized polymer lenses by dropping photo-curable resins into a water based substrate in order to ensure much smoother surfaces than other manufacturing processes. We analyze the differences in lens shape that result from altering the hydrophobicity of the resin compared to water, which controls the shape of the lens. We find that we can alter the height of the lenses by an average factor of 2 by altering the surface tension of the resin with only a 2% additive by mass. By understanding the relationship between the surface tension and the lens shape, we can predict the shapes of lenses and customize lenses for specific applications.

81. In my Blood: Contextualizing Intergenerational Trauma within the Police Brutality Phenomenon
Jamonte Strawder ’19
Summer 2018
Supervisor: Alford Young Jr. (Profesor of Sociology, University of Michigan)

How do interactions with police differ between Black and White Americans as a result of racial socialization? What generational implications can be observed in Black American socialization patterns as a result of adverse interaction
and exposure with police officers? To uncover the climate surrounding police brutality two years after the Philando Castile shooting in Minneapolis, MN, a focus group will be conducted comprised of concerned community members who believe their community falls victim to police brutality. The sample will include approximately 20 to 30 African American men and women ages 18 to 60. Following this focus group, I will conduct in-depth interviews centered on uncovering the resulting effect on that community. The interviews will then be coded for thematic consistencies in hopes of identifying common trends in the retelling of the participants’ experiences with law enforcement officers. Though results are forthcoming, the expected thematic patterns will be consistent with the ideas of mistrust of police, intentional changes in child-rearing practices, and explicit fear of adverse interactions with police officers.

82. Returning Home: Printing the Story of Shiro Kashino
Justine Szafran ’19
Authors/ Contributors: Fred Hagstrom (Rae Schupack Nathan Professor of Art, Carleton College)
Summer 2018
Supervisor: Fred Hagstrom (Rae Schupack Nathan Professor of Art, Carleton College)
This wasn’t a research project, but I helped to screen print a book about Shiro Kashino, a Japanese-American WWII veteran who served in the US army during Japanese internment. He was not recognized for his major contributions during the war due to his Japanese heritage and faced quite a bit of mistreatment.

83. Using Mitochondrial DNA Sequence Alignments to Estimate Genetic Diversity in a Population of Captive Black Milk Snakes (Lampropeltis triangulum gaigeae)
Maddie Talamantes ’19
Authors/ Contributors: Stephan Zweifel (Professor of Biology, Carleton College), and Matt Rand (Professor of Biology, Carleton College)
Summer, 2018
Supervisor: Stephan Zweifel (Professor of Biology, Carleton College), and Matt Rand (Professor of Biology, Carleton College)
The nonvenomous black milk snake (Lampropeltis Triangulum gaigeae), endemic to the mountains of Costa Rica and Panama, is a popular pet trade species. We have observed an anomaly on the stomach scales that we hypothesize is due to inbreeding in the captive population. In order to demonstrate that this population does have reduced genetic diversity, we examined the DNA sequences from three regions of the mitochondrial genome: the two control regions (CR1 and CR2), and cytochrome c oxidase subunit 1 (CO1). In addition, a captive population of bullsnakes (Pituophis catenifer sayi) was analyzed for these mitochondrial regions. DNA was isolated from shed skins, PCR amplified using primers for the three regions, and then sequenced. The DNA sequences for each of the three regions were aligned and analyzed for single nucleotide polymorphisms (SNPs). Our findings show that the black milk snake population has significantly less genetic variation in comparison to the bullsnake population.

84. Inferring Tumor Phylogeny from Noisy Sequencing Data
Kiran Tomlinson ’19
Authors/ Contributors: Layla Oesper (Assistant Professor of Computer Science, Carleton College)
Summer 2018
Supervisor: Layla Oesper (Assistant Professor of Computer Science, Carleton College)
A number of methods have recently been proposed to reconstruct the evolutionary history of a tumor from noisy DNA sequencing data. We investigate when and how well these histories can be reconstructed from multi-sample bulk sequencing data when considering only single nucleotide variants (SNVs). We formalize this as the Enumeration Variant Allele Frequency Factorization Problem. We propose and assess two methods for increasing the robustness and performance of an existing graph based phylogenetic inference method. We apply our approaches to noisy simulated data and find that low coverage and high noise make it more difficult to identify phylogenies. We also apply our methods to both chronic lymphocytic leukemia and clear cell renal cell carcinoma datasets.

85. Narrowing Down Hox Responsive Regulatory Region to Determine Expression in Male Ventral Nerve Cord in C. Elegans
Kevin Tran ’20
Authors/ Contributors: Jennifer Wolff (Associate Professor of Biology, Carleton College)
Estee Emlen ’20
Emma Ferrer ’20
The ventral nerve cord (VNC) in C. elegans is sexually dimorphic: males have sex specific neurons, including 9 CP neurons that are the focus of our study. CP neuron fates can be divided into 3 anterior-posterior zones, defined by Hox transcription factors. The goal of this project is to determine how the Hox transcription factors LIN-39 and MAB-5 interact with the regulatory regions of the neurotransmitter genes flp-21 and flp-22 to regulate their zone-specific expression in CPs. Deletion analysis of the flp-22 and flp-21 regulatory regions in GFP reporter transgenes revealed that 226 (flp-22) and 1300 (flp-22) base pair regulatory elements are sufficient to drive zone-specific expression in the CPs. We also explored expression of LIN-39, and found that a 250 base pair regulatory element confers expression in the VNC. Future work includes further deletion analysis of flp-21 and flp-22, and ectopic expression of MAB-5 in neurons normally defined by LIN-39.

86. Characterization of a run-off initiated debris flow Western Cascades, OR
Sara Wall '19
Authors/ Contributors: Josh Roering, Professor of Geomorphology and Earth Surface Processes, University of Oregon
Summer 2018
Supervisor: Josh Roering, University of Oregon
Wildfires are increasing in frequency and intensity across the Western United States, changing the landscape’s response to rainfall. Post-fire debris flows are among the most destructive consequences of wildfire. In the Pacific Northwest, debris flows have historically resulted from soil saturation (unrelated to fire), but as fires increase, post-fire debris generated from overland flow are becoming more frequent. Such debris flows normally characterize the interior mountains of the Rockies and in Southern California and have not been reported in the Coastal and Cascade Mountains of the Pacific Northwest. On June 20, 2018 however, a run-off initiated debris flow occurred on the Western side of the Cascades in Oregon. This summer I examined the debris flow to understand why it occurred in this region and to determine the implications for the Pacific Northwest if this type of debris flow occurs more often.

87. Probing the Magnetic Characteristics of Magnetic Nanodots
Spencer Weeden '20
Authors/ Contributors: Barry Costanzi (Visiting Assistant Professor of Physics)
Summer 2018
Supervisor: Barry Costanzi (Visiting Assistant Professor of Physics)
Understanding the mechanisms governing magnetic states on the mesoscale (~100s of nm) is of interest both technologically, since this length scale approaches that of individual magnetic hard drive bits, and fundamentally, given these length scales place the system squarely in a semi-classical regime. Our research investigated the magnetic characteristics of square permalloy (Ni80Fe20) dots by performing transport measurements to measure their magnetic state through the anisotropic magnetoresistance (AMR). Previous optical experiments have sought to characterize the magnetic ground state of such dots, but always on arrays of hundreds of dots rather than individuals. In contrast, our technique allows probing single dot’s magnetic energy landscapes through the AMR. Our results suggest a phase transition from a magnetic ground state in which the net magnetization points along the dot edge (the so-called “buckle” state) to one where net magnetization points along the dot diagonals (the “leaf” state), in agreement with theoretical predictions.

88. Using EEG to Examine the Neural Basis for Spatial Attention
Janna Wennberg '19
Authors/ Contributors: Joshua Foster (Doctoral Student, University of Chicago)
Summer 2018
Supervisor: Edward Awh (Professor of Psychology, University of Chicago)
We are constantly bombarded with visual stimuli, and we cannot possibly notice everything. Thus, spatial attention is necessary for us to direct our brain’s limited resources towards the most relevant information. While scientists have established that brain activity is higher for attended stimuli than for unattended stimuli, we do not know how this difference varies with the intensity of the stimulus. Using electroencephalography (EEG), we examined how brain activity varies as a function of stimulus intensity and as a function of attention. EEG is a particularly good method for studying attention because it measures the rhythmic neural activity that can track spatial attention. We
hypothesize that the difference in brain activity for unattended and attended stimuli increases with stimulus intensity. This experiment will give us a better understanding of how neural activity and everyday cognitive processes are connected.

89. **Progress Toward the Synthesis of Carbon-Nitrogen Bonds with Earth-Abundant Metals**  
**Luke Westawker '20**  
**Authors/ Contributors:** Matt Whited (Associate Professor of Chemistry, Carleton College), and Claire Shugart '20  
**Summer 2018**  
**Supervisor:** Matt Whited (Associate Professor of Chemistry, Carleton College)  
Carbon-nitrogen bonds are common in many pharmaceutical drugs, however, the current synthetic pathways employ expensive metal catalysts and unsustainable organic halogens. This project focuses on establishing sustainable synthetic routes for carbon-nitrogen bonds using cheap and earth-abundant nickel and cobalt catalysts. Here we present studies on redox transformations of bisp(phosphine)-supported cobalt and nickel with the goal of synthesizing and characterizing amido (M-NR2) and imido (M=NR) complexes relevant to C-N bond formation. We have established a route for Ni(I) amido (Ni-NR2) complexes and are exploring new proposed pathways to Co(I) amido and Co(II) imido complexes by targeting a bisp(phosphine)-supported Co(I) or Co(0).

90. **Microbial Colonization of Land and Associated Genes**  
**Alex Whitis '20**  
**Authors/ Contributors:** Rika Anderson (Assistant Professor of Biology, Carleton College)  
Dr. Eva Stueeken (University Research Fellow, University of St Andrews)  
**Summer 2018**  
**Supervisor:** Rika Anderson (Assistant Professor of Biology, Carleton College)  
Ancient life is thought to have originated in marine environments. In this study, we investigate the transition of microbial life from marine to terrestrial settings, as this could have impacts on microbial metabolic diversity and, consequently, global biogeochemical cycles. Using publicly available microbial metagenomes from various aquatic and terrestrial locations, we sought to determine which genes had an important role in microbial survival on land. With the use of molecular clocks, we determined timings of the genes' births, duplications, and horizontal transfer events across microbial genomes, the latter of which is thought to indicate ecological relevance. Our results suggest that the investigated genes did not proliferate with the original wave of terrestrial pioneers; instead, the genes found in this study spread during some secondary event ~1.6 billion years ago. Future analyses will look into a wider range of genes, as well as refine the methods used to estimate evolutionary timings.

91. **Opening a Miraculous Window Into the Middle Ages**  
**Read Wilder '20**  
**Authors/ Contributors:** William North (Professor of History, Carleton College)  
**Summer 2018**  
**Supervisor:** William North (Professor of History, Carleton College)  
Stemming from a translation project begun in the Medieval Latin class of 2018, Professor William North and I worked on the first English translation of De miraculis libri duo, or The Two Books of Miracles, a collection of miracle accounts, written by the French monk and abbot, Peter the Venerable of Cluny. Peter was a major figure of the 12th century, ruling over Cluny at the height of its power, corresponding with such prominent figures as Bernard of Clairvaux and Peter Abelard, and leading the first effort to translate the Quran into Latin. Peter's text brings a lot to the table: demons, ghosts, murder mysteries, institutional history, eucharistic miracles, biography, and much more.

92. **Documenting Dakota: From Data Collection to the Structure of Noun Phrases**  
**Kyra Wilson '20**  
**Authors/ Contributors:** Catherine Fortin (Associate Professor of Linguistics, Carleton College)  
**Summer 2018**  
**Supervisor:** Catherine Fortin (Associate Professor of Linguistics, Carleton College)  
Dakota is a language that is rich for study but so far has been very under-described. The Linguistics department has begun a long-term project to change that, and I worked on it this summer. Specifically, I investigated the structure of noun phrases in Dakota and transcribed Dakota language data from handwritten notes, as well as creating a system of organization for any resources and information relating to the project. The work was very successful, and we anticipate submitting an abstract about it to a Native American languages conference occurring in May 2019.
93. **Causal Transfer: Challenges for Causal Learning and Reinforcement Learning**  
*Kaixing Wu ’19*  
**Authors/Contributors:** Mark Edmonds (Phd Student, UCLA), Yixin Zhu (Postdoctoral Scholar, UCLA)  
*Summer 2018*  
**Supervisor:** Chengfanfu Jiang (Assistant Professor of Computer Science, University of Pennsylvania)  
Discovery and application of causal knowledge in novel problem contexts is a prime example of human intelligence. As new information is obtained from the environment during interactions, people develop and refine causal schemas to establish a parsimonious explanation of underlying problem constraints. The aim of the current study is to systematically examine human ability to discover causal schemas by exploring the environment and transferring knowledge to new situations with greater or different structural complexity. We developed a novel OpenLock task, in which participants or Reinforcement Learning agents explored a virtual Sescape room environment by moving levers that served as Slocks to open a door. Our goal is to test the ability of deep Reinforcement Learning.

94. **Reconstructing Cosmic Ray Shower with DNN**  
*James Yan ’21*  
**Authors/Contributors:** Frank McNally (Assistant Professor of Physics, Mercer University)  
*Summer 2018*  
**Supervisor:** Frank McNally (Assistant Professor of Physics, Mercer University)  
Cosmic rays are high-energy radiations. Most of them which arrive earth are from the outside of solar system. By studying cosmic rays, we can learn about the events outside the solar system such as supernovae. My research focused on the reconstruction of cosmic rays. In the past, a range of methods was used for reconstruction including Boosted Decision Tree. I tried deep neural network (DNN) to reconstruct the energy range and component of cosmic rays from the geometry of the using the simulated data generated by IceCube. With tensorflow, I was able to construct a DNN which takes the signal and geometry of the detectors and predicts the energy or the compositions of the simulated cosmic rays. The prediction of the compositions using the DNN showed a more than 70% accuracy.

95. **Diagnostics of Probabilistic Topic Models**  
*James Yang ’19*  
**Authors/Contributors:** Eric Alexander (Assistant Professor of Computer Science, Carleton College)  
*Summer 2018*  
**Supervisor:** Eric Alexander (Assistant Professor of Computer Science, Carleton College)  
We set out to explore and visualize the relationship between topic models, a method for understanding large corpora by discovering hidden semantic structures, and sentiment analysis, which helps classify the opinion polarity of a text. We were particularly interested in the Joint Sentiment Model (JST), an algorithm seeking to combine these two techniques. However, we found that the quality of topic models matters significantly in the study of these combined applications, which directed us to a new objective. We developed a graphical approach to study the various diagnostic metrics of topic models, and came up with adjustments on some existing metrics. As part of our approach, we studied the performance and validity of existing metrics. Our approach is additionally valuable as an intuitive process for researchers to properly explore the parameter space of a topic model. As next steps, we wish to extend our study back to JST if applicable.