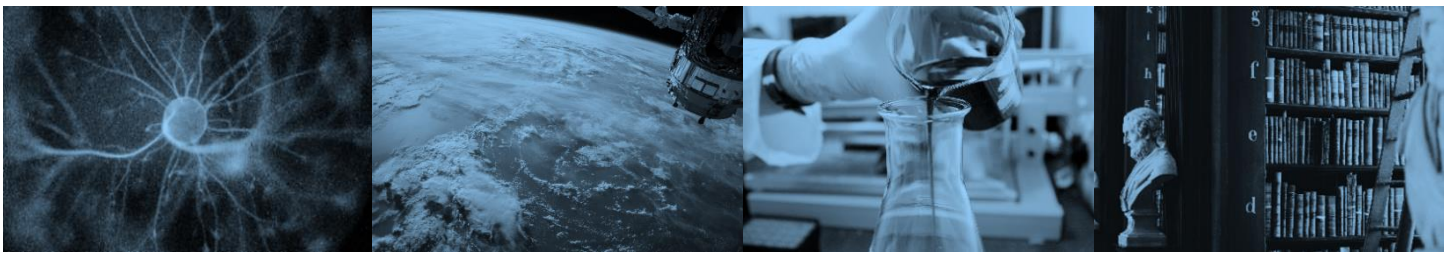
Columbia University Undergraduate Research Symposium

Abstracts

Friday, October 18, 2019
Roone Arledge Auditorium
Lerner Hall



COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

CONTENTS

ABSTRACTS

RAAG AGRAWAL CC'20: BIOLOGY

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Faculty Mentor(s): Dr. Sarah Teichmann, Dr. Martin Hemberg, Wellcome Sanger Institute
Title: Differential Single Cell Development in Crohn's Disease

Abstract:
Single-Cell transcriptomics is a rapidly developing field in computational and developmental biology. It allows researchers to look at gene expression in individual cells, and thus giving deeper insight into the diversity of cell types and developmental pathways cells take. Our goal in this project is to utilize single cell transcriptomics to better understand differential gene expression and cellular makeup of tissue samples taken from Crohn's patients. Here, we explore tissue taken from several Crohn's patients alongside controls - and identify marker genes for known cell types and developmental pathways. Additionally, we annotate cell types in Crohn's tissues using existing literature – and identify putative gene targets for further investigation. We also leverage pseudo-time analysis to discover potential developmental pathway differentiation between control and Crohn's tissues - and find notable differences. We hope this project will better elucidate how differential expression acts on individual cells to produce disease states.

SOPHIA AHMED CC'21: SUSTAINABLE DEVELOPMENT

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Faculty Mentor(s): Mihir Desu, Strategen
Title: Valuation Assessment of Optimized Clean Energy Portfolios in Competition with Existing Coal Generation Facilities

Abstract: Throughout the United States, falling costs for renewable energy generation have increased economic pressures on coal-fired power plants. Despite such progress, there remains skepticism over the economic effectiveness and technical capabilities (namely, capacity and reliability) for clean energy to meet consumer demand at a reasonable cost, compared to coal. This study sheds light on this skepticism with an economic and technical competitive analysis comparing current and projected coal fleets with renewable alternatives in Colorado and Arizona. In particular, this study investigates solar, wind, and storage optimization to develop three viable alternative resource portfolios in replacement of the current coal fleet in each respective state. These three portfolios, in addition to different coal cases are run through valuation analyses on a forty-year time horizon to model levelized costs, social cost, and operational costs. Financing options such as securitization, legislative credit programs, as well as societal benefits are also quantified and included in the valuation analyses.
The valuation analyses indicate promising results that wind, in Colorado, and solar, in Arizona, can produce energy at a lower cost than coal over the next forty years. More specifically, replacing all ten Colorado coal units examined with wind resources would reduce costs by $ $1.7 billion; and retiring all 11 units at the six coal facilities examined in Arizona and replacing them with a solar PV plus storage can save customers upwards of $3.5 billion. Including the modeled societal benefits, these savings reach upwards of $7 billion, demonstrating the inevitable progress to a clean energy transition.

FAITH AJAYI CC'21: ENVIRONMENTAL BIOLOGY

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Faculty Mentor(s): Dustin Rubenstein, Columbia University
Title: Differential methylation in superb starlings due to environmental influences

Abstract: This project focuses on the superb starling, a type of bird native to East Africa. Blood samples from multiple superb starlings were collected and analyzed, and each was found to be genetically altered in different ways based on whether the bird was living in a rainy region or a dry one. In particular, these differences are found in differentially methylated regions (DMRs) of the genes. These are regions of DNA where chemical compounds called methyl groups are attached to the original gene. The addition of a methyl group is like flipping a switch that turns the function of a gene on or off. This project asks the question of which genes are turned on or off in response to a rainy or dry environment, and why. It also investigates which networks of genes seem to be methylated together as a unit, which can give clues as to the overall effect that the methylation has on the individual.

JAALA ALSTON CC'22: ECONOMICS AND MATHEMATICS

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Faculty Mentor(s): Francisco Rivera-Batiz, Columbia University
Title: Economic Analysis of the Puerto Rican Financial Crisis: Stressors and Strategies

Abstract: The research took the form of a literature review conducted to understand the nature of strategic investment in Puerto Rico during the debt crisis, and the ways in which the strategic investment of banks into failing municipal bonds can affect the quality of life among Puerto Ricans on the island. My conclusion was mostly that banks are incentivized to invest in municipal bonds during financial crises because the bonds can be bought for extremely low prices and sold for much higher, which communicates to large returns on investment when failing economies experience upturn. What is interesting about Puerto Rico though, is that, because the island's economy is highly regulated by the United States, the various municipal bonds that are sold are bonds that usually serve the public (primary example is the pension fund), so once the economy begins to recover, the money does not go to Puerto Ricans, but to primary shareholders of the debt, which are most often hedge funds and banks that employ aggressive tactics to ensure that they are paid first. This cycle reinforces poverty in Puerto Rico and provides an enriching view into the nature of poverty, not as a cycle in which money is not entering the system, but in which those funds are not being allocated equivocally throughout the community.
Next steps include considering the ways in which history and racial demographics can affect this, and potentially attempting to formulate an economic experiment that can predict which situations and events will lead to firms employing predatory investment strategies during economic crisis. Additionally, I would like to venture into the study of why various nations experience prolonged economic downturn, do not "bottom-out" when others experience jobless recoveries to economic and financial crises.

DARWIN ARIAS CC'22: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Carmela Alcantara, Columbia University School of Social Work
Title: The Effects of Acculturation and Discrimination Stress on Charlson Comorbidity Index (CCI) Scores Among Latino/as Living in The U.S.

Abstract: There is ongoing research on the effects of stress on the immune system, in particular the effects of stress on sleep, mental health, and cardiovascular health. Yet, the effects of stress are currently understudied among racial/ethnic communities, particularly among Latino/as in the United States that undergo different levels of acculturation and discrimination stress. Such stressors include stress from social inequity, lack of English-language proficiency, low-income status, unemployment, citizenship status, understanding one's rights, etc. It is known that the stress linked to an individual's social position or cultural identity (acculturation and discrimination stress) affects health among Latino/as living in the U.S. in many different ways. Measuring the prevalence of disorders and disabilities through the Charlson Comorbidity Index (CCI) among a healthy population of Latino/as, and measuring their perception of stress from acculturation and discrimination through a variety of measures, we look at the effects of stress on Charlson Comorbidity Index scores in Latino/as. The main goal is to determine a leading source of health disparities between Latino/as and their non-Latino White counterparts, as well as the variation in health among Latino/as living in the U.S. with different backgrounds.

DIOGENE ARTILES CC'22: COMPARATIVE LITERATURE AND LINGUISTICS

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Faculty Mentor(s): Edward Morales, Columbia University
Title: María Moñito: A Brief History of Blackness in the Dominican Republic

Abstract: "I'm not Black, I'm Dominican," is an expression that has gained notoriety in discourse surrounding the intersections of race, Latin American identity, and Dominican identity. The current research project aims to provide light to various Black power movements that have been present on the Spanish speaking side of Quisqueya, the island that shares Haiti and the Dominican Republic, by demonstrating social and political movements that center Black Dominican identity. The research looks at the development of Black identity and struggle from early slave uprisings, to the writings of Black scholar Blas R. Jimenez, to the modern natural hair movement, which draws inspiration from communities across the diaspora, to suggest that Blackness has not only been a driving point in the development of the Dominican identity, but a central and pivotal one. The research also explores the legacy of blackness and its manifestations in modern politics and grassroots social, political, and musical movements.

YASMEEN ASALI CC'20: ASTROPHYSICS

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Faculty Mentor(s): Chris Van Den Broeck, University of Amsterdam
Title: Resonant Modes in Exotic Compact Object Mergers

Abstract: Gravitational waves are caused by accelerating massive objects and have been detected by LIGO. Quasi-normal modes are perturbations in the field that decay over time, and they can be excited during the inspiral of exotic compact objects due to internal resonances. Resonantly excited quasi-normal modes will result in a speeding up of the phasing of the gravitational waveform as energy is absorbed by the resonance. This feature has been shown in binary neutron star mergers, and this work explores similar resonant modes in exotic compact objects in the black hole mass range. We show that resonances with resultant phase shifts or order unity or larger can produce detectable events using a background-foreground approach for Bayesian model selection.

YASMINE AYMAN CC'21: NEUROSCIENCE AND BEHAVIOR; PHILOSOPHY

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Faculty Mentor(s): Richard Axel, Columbia University
Title: The Intergenerational Inheritance of Learned Fear Is Regulated by Neuromodulation and Stem Cell Differentiation

Abstract: The precise mechanism behind epigenetic regulation in the olfactory epithelium is unknown although morphological changes in response to fear conditioning have been observed. Namely, after a chosen odor (acetophenone) is presented, an increase in the specific olfactory sensory neurons (OSNs) is observed in the parental generation (F0) and their offspring (F1) following a 3 day fear conditioning paradigm in which this odor is paired with a foot shock. It has been also shown that more receptors being expressed in response to an odor that is predictive of a shock may make the mice more sensitive to said odor. Here, we provide evidence towards the hypothesis that basal stem cells in the main olfactory epithelium (MOE) receive instructions in the form of small non coding RNAs (sncRNAs) following an environmental stimulus, and then differentiate into more receptors that sense that odor. We used an M71GFP mouse line, where M71 is one of the ~50 receptors to acetophenone. We use BrdU- and PH3 labeling to quantify the number of proliferating M71 cells at a single cell resolution, and we use c-Fos to identify neural activity in the olfactory epithelia, and brain. The ultimate goal of our research is to show that an increase in M71 receptors represents newly differentiated cells and that the differentiation of stem cells in the nose may be informed by neuromodulation from higher order brain regions, such as the ventral tegmental area (VTA), basolateral amygdala (BLA) and locus coeruleus (LC).

JACK BECKER CC'21: CREATIVE WRITING; PSYCHOLOGY

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Faculty Mentor(s): Joscelyn Shawn Ganjhara Jurich, Columbia University
Title: "Like a White Gay": Examining the Role of Whiteness in White Queer Male Cultural Production

Abstract: This project addresses intersecting issues of race and queerness by critically examining whiteness's role in the production of art and media created by white male artists in the queer community. Blending together auto-ethnography, overviews of critical whiteness studies (with a particular focus on the work of Sara Ahmed), and analyses of several works in pop culture (such as HBO's Looking, the Pulitzer Prize-winning novel Less by Andrew Sean Greer, and memoiristic publications such as Isaac Oliver's Intimacy Idiot and Joseph Osmundson's Inside/Out), the project aims to assess how whiteness has affected modern queer male art, and proposes that a nascent, self-critical understanding of whiteness in the queer community is beginning to emerge with the intent, albeit with varying results, to dismantle white supremacy. Additionally, the project includes a large portion of self-inquiry where the researcher—a white queer male-presenting artist themself—questions what it means to be exploring such a topic from their particular positionality, all in the hopes of de-naturalizing the place of the white inquisitor and the role of whiteness in research as a whole. Supplementing the project is a brief inquiry into gay sex parties in New York City, and how these may act as a form of artistic production that can be mined for various insights around race, gender, and class within the queer community.

VIGGO BLOMQUIST CC'21: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Henry Colecraft, Columbia
Title: Synthetic tRNA Mediated Correction of a LQTS Nonsense Mutation in hERG.

Abstract: The human ether-à-go-go related gene (hERG) codes for the pore-forming subunit of the voltage dependent potassium ion channel in cardiac cells. Potassium channels are voltage gated protein channels within the plasma membrane that allow potassium to move down the electrochemical gradient. The channel's central role is to initiate the repolarization of the cardiac action potential. Premature termination codons (PTCs) in hERG result in a hereditary and potentially deadly disease called Long QT Syndrome 2 (LQTS2). The purpose of this investigation was to test if novel codon-edited human tRNAs would be able to recognize the PTC within the mRNA strand and add an amino acid to the growing polypeptide chain, preventing premature termination and, thereby, rescuing hERG. We developed a high-throughput flow cytometry approach to simultaneously assess the capacity of distinct codon-edited human tRNAs to suppress a W1001X PTC in hERG and the efficiency of channel trafficking to the cell surface. We found that individual codon-edited tRNAs successfully suppressed the premature W1001X stop in hERG, albeit with different efficiencies, and that rescued hERG had no trafficking defects. We also confirmed the suppression of the PTC resulted in a gain of function using the whole-cell parameter of the patch clamp technique. Successful suppression of premature stops by using such tRNAs could lead to major medical advances in gene therapy for not only LQTS2, but also for other diseases caused by PTCs.

MATT BOWERS CC'20: CHEMISTRY; COMPUTER SCIENCE

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Faculty Mentor(s): Rafael Gomez-Bombarelli, MIT
Title: Predicting Scalar Coupling Constants for NMR through Graph Convolutional Neural Networks

Abstract: Nuclear Magnetic Resonance (NMR) is an extremely widely used method for analyzing the structure and properties of molecules. The goal of this project was to use machine learning to predict the scalar coupling constant between pairs of atoms in various small molecules, which in turn is useful for understanding the NMR spectra of the molecules. Machine learning is a generic method for solving a huge variety of problems, but only recently has it been applied to chemistry due to the challenge of using a molecular graph as input to a neural network. The bulk of this project was an exploration of different variants of deep neural network architectures that can be used for this problem, with a focus on the relatively new field of graph convolutional neural networks (GCNNs). This work was done in the Gomez-Bombarelli lab in the DMSE department of MIT, and was submitted to the Kaggle competition "Predicting Molecular Properties".

LIAM BRODERICK CC'21: ANTHROPOLOGY; JAZZ STUDIES

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Faculty Mentor(s): Chris Washburne, Columbia University
Title: Jazz in the Modern Global Landscape: A Comparative Ethnographic Study of the Jazz Scenes of Barcelona and Amsterdam

Abstract: Distinctly American in origin, jazz embodies ideals of democracy and freedom with its dual emphasis on collective improvisation and individual expression. The increased global connectivity of the early to mid-20th century, however, introduced jazz into innumerable diverse cultures around the world. This research examines and compares the vibrant jazz scenes of Amsterdam and Barcelona, and, as a result, comments on the processes by which artistic phenomena are exchanged, transformed, and imbued with culturally specific meaning. In order to examine the cultural specificities of the jazz in Amsterdam and Barcelona, the project tackles the following five questions: i) what is the significance of jazz in each musical culture (and how does this differ from the significance of jazz in American culture)?, ii) what are

the similarities and differences in the jazz education of each city?, iii) what is inherently Spanish or Dutch about the jazz being played in the cities of observation?, iv) what is the standard musical repertoire in each scene?, and v) how does the history and lineage of jazz music differ in these two cities?
Through interviews with the leading jazz musicians and educators in Amsterdam and Barcelona, participation in jam sessions at local venues, and participant observation, this project reaches conclusions that engage the critical dialogue surrounding the definition of and globalization of jazz. In addition to the aforementioned research, this project has an artistic component which is intended to serve as a creative entry point into the reflective personal observations made throughout the period of research. The researcher, Liam Broderick, has composed four new tunes--"Viento del Mar", "Lights of Leiden", "Pipa Subterranea", and "Together Alone"-- to reflect on the aforementioned work.

ALAN BURNETT VALVERDE CC'20: ENGLISH

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Faculty Mentor(s): Florent Jakob, Columbia University

Title: tructuralism and Collective Consciousness: Representations of Philosophy in France (1966-1980)

Abstract: Within the study of intellectual history, it is often the case that analyses of philosophical developments are limited to their effect within academic discourse. This is to be expected, as many of the major debates and developments within contemporary Western philosophy have primarily reached their audiences through journals and other scholarly publications. The intellectual generation that is discussed in this paper—often grouped together under the label '(post)structuralists' or 'French theorists'—was met with a similar marginalization since the days of their early publications. It was also a generation of thinkers, however, whose work became most prominent in France during the 60s and 70s, a time when the distribution and consumption of mass media was undergoing expansion and radical transformation. Alan Burnett Valverde's project traces the history of these philosophies within the scope of a broader dissemination, one that takes into account, for example, the growing prominence of television and radio appearances by philosophical thinkers. It is a study of the multiple ways in which thought assumes the form of a cultural commodity and influences its consumers. It is also a study of the mutations that occur when complex ideas are adopted by a broad audience.

KELLY BUTLER CC'20: BIOLOGY; ECONOMICS

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Faculty Mentor(s): Ludmila Prokunina-Olsson, National Institutes of Health (NIH) National Cancer Institute

Title: Evaluating Viral Etiology of Bladder Cancer Through Analysis of FGFR3 Mutations

Abstract: A striking 65% of non-muscle-invasive bladder cancers (NIBCs) harbor an activating somatic mutation in the FGFR3 gene, which encodes fibroblast growth factor receptor 3. The transformative S249C (TCC → TGC) point mutation is the most common FGFR3 mutation in NMIBC and represents 62% of such mutations. S249C is the only recurrent FGFR3 mutation with an APOBEC-type motif and is significantly more common in tumors with high expression of APOBEC3 cytosine deaminases. While APOBEC3s are likely drivers of S249C mutation, the cause of aberrant APOBEC activity in NMIBC remains unclear. To test a hypothesis that host immune responses to virus infection induce APOBEC3 expression and thus cause the S249C mutation, primary bladder cells were infected with Sendai virus, and APOBEC3 expression was quantified using TaqMan assays. Statistically significant induction of APOBEC3A, 3B, and 3G was detected in both HBLAK and BdEC cells, bolstering the biological plausibility that viral infection causes the transformative S249C APOBEC signature mutation in healthy bladder tissue. Moreover,

custom TaqMan genotyping assays are being used to detect S249C and two control mutations in Sendai-infected cells. Observing an enrichment of S249C compared to non-APOBEC-type FGFR3 mutations in infected cells would implicate virus infection as a cause of NMIBC's most common FGFR3 mutation.

TYLER CAMPBELL CC'22: AFRICAN AMERICAN STUDIES; CREATIVE WRITING

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Faculty Mentor(s): Josef Sorett, Columbia University
Title: Physical Discipline in Black American Families

Abstract: Physical Discipline or "Corporal Punishment" as it is commonly referred to, has been a widely used method of reprimanding children for bad behaviors for centuries now. Over the last few decades there has been widespread social push to end this once common method of parenting. Today in 2019, there exists a multitude of research studies on the affects physical discipline has on child development and its lack effectiveness in discipling children. Despite this new wealth of knowledge physical discipline still remains prevalent across many different communities in the United States.
Campbell's research asks the question "Why does physical discipline persist at such a high rate in the black community in America?" He focuses on how physical discipline is represented in media and popular culture as means to understand how specifically in the black familial structure physical discipline functions and the role it has on child development.

HEATHER HSUN CHANG CC'21: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Thomas Clandinin, Stanford University
Title: The Role of Recurrent Computation in Drosophila Visual Motion Detection

Abstract: Despite successful recent applications of recurrent neural networks in machine learning, the computational role of recurrent connectivity and how biological neural systems employ recurrence for computation, is poorly understood. With the connectome of the Drosophila melanogaster visual system highlighting an abundance of recurrent connectivity, we investigate how this recurrence affects visual responses in the Tm3 neurons, two synapses downstream of photoreceptors and directly upstream of T4 neurons, the elementary motion detectors of the fly visual system. This project tests the hypothesis that recurrence has a functional role in shaping the spatiotemporal responses of Tm3 neurons and in maintaining its spatial and temporal dynamics in the motion processing circuit. We inactivated the recurrent output of Tm3 neurons with tetanus toxin while imaging its calcium responses to impulse and noise visual stimuli with a two-photon microscope. We found that the feedback connection from Tm3 to L1 contributes to buffered responses to light of Tm3, ON selectivity of Tm3, and sharper spatial receptive fields. The role of recurrent connectivity discovered through this project will inform not only those investigating visual motion detection but also other neurobiologists seeking general computational role of recurrence and the field of machine learning.

CAROLINE CHEN CC'22: UNDECIDED

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Faculty Mentor(s): Professor Kam Leong, Columbia University
Title: Targeted liposomal delivery of CRISPR/Cas9 against IL1RAP attenuates acute myeloid leukemia stem cell growth

Abstract: Acute myeloid leukemia is the leading cause of leukemic deaths in the United States and is characterized by poor prognosis and a high relapse rate. In recent years, leukemic stem cells (LSCs) have been found to be responsible for AML initiation and relapse, due to their innate chemoresistance and self-renewal capacity. The targeting of the interleukin-1 receptor accessory protein (IL1RAP) in LSCs has shown great therapeutic potential in AML treatment, yet previous methods to target IL1RAP have multiple drawbacks when translated into clinical usage. Herein, liposome-encapsulated Cas9/sgRNA ribonucleoproteins (lipo-RNPs) were utilized to target the IL1RAP gene in LSCs for AML treatment. To further enhance lipo-RNP efficacy, lipo-RNPs were loaded onto mesenchymal stem cell membrane (MSCM)-coated nanofibril (NF) scaffolds that mimic the bone marrow niche in which LSCs reside. CRISPRMAX knockout of the IL1RAP gene reduced IL1RAP protein expression, which led to decreased LSC colony-forming ability, confirming the fidelity of targeting IL1RAP in AML treatment. Further, addition of CXCL12α cytokine enhanced chemoattraction of LSCs to the lipo-RNP MSCM-NF scaffold. Lastly, both free and scaffolded lipo-RNPs induced efficient gene editing of IL1RAP in LSCs, with MSCM-NF scaffolded lipo-RNPs yielding comparable gene cleavage to free lipo-RNP groups. Clearly, IL1RAP gene editing using scaffolded lipo-RNP delivery of Cas9/sgRNA efficiently inhibits LSC ability, demonstrating the potential of a biocompatible liposome-based system to deliver CRISPR/Cas9 for more efficacious AML therapy.

ETHAN CHEN CC'21: BIOCHEMISTRY; STATISTICS

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Faculty Mentor(s): Samuel Sternberg, Columbia University
Title: Mechanistic factors of RNA-guided DNA integration in bacteria

Abstract: Transposons are mobile genetic elements that can move from one genomic location to another. Transposons are important because they have been found in virtually every genome that has been sequenced and their movement causes ongoing genomic rearrangement in prokaryotes. Tn7 is a transposon found in the genome of native E. coli. Recently, type-I-F CRISPR-Cas systems have been found inside Tn7-like transposons. Based on these findings, our lab recently discovered a new programmable, RNA-guided transposase. The system, called INTEGRATE, leverages the CRISPR-Cas effector complex Cascade to direct accompanying transposases to integrate a DNA cargo downstream of a genomic target site complementary to a guide RNA, and allows for higher efficiency genomic engineering applications without the need for double strand breaks. However, many of the parameters that govern its action and the limitations of this tool are unknown. Hence, my project seeks to elucidate the mechanistic factors behind observed off-target long-range DNA integration. We showed that RNA-guided DNA integration into a particular T7 RNAP site was possible for solid media cultures of bacteria. We then designed an array of CRISPR spacers at varying distances from the T7 RNAP site and prepared samples of solid and liquid cultures for next-generation sequencing, which will tell us more about the mechanism and parameters that govern this long-range integration.

YIBING CHEN SEAS'22: COMPUTER SCIENCE

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Faculty Mentor(s): Shih-Fu Chang and Svebor Karaman, Columbia University
Title: NYCHA Twitter Analysis

Abstract: Yibing Chen worked on collecting and analyzing tweets related to New York City Housing Authority (NYCHA). This project is in place to help the team better understand what challenges NYCHA

residents encounter and empower residents' individual voices. The analysis primarily focuses on applying topic modeling on the text of the tweets, using the Latent Dirichlet Model, a probabilistic natural language processing model, to categorize tweets to reflect major topics.
In interpreting the data, noise words such as "NYCHA", "New York", "NYC" etc. are excluded to improve the relevance of the results. Moreover, each word of the tweets is tagged as different parts of speech, and the model excludes prepositions, articles, and conjunctions to increase the interpretability of the topics. Lastly, this project is in collaboration with Professor Desmond Patton's team at the School of Social Work.

JOSHUA CHOE CC'20: BIOLOGY

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Faculty Mentor(s): Carol Prives, Columbia University
Title: Hyperstability of a LFS-derived Dimer-forming p53 Mutant Elicits a Distinct Metabolic Phenotype and Altered Chemotherapeutic Sensitivity

Abstract: The tetramerization domain (TD) of tumor suppressor p53 facilitates its oligomerization, which is essential for efficient DNA binding, protein-protein interactions, and transactivation of downstream targets. Li-Fraumeni Syndrome (LFS) patients suffer from frequent occurrence of certain cancers at early ages. A subset of LFS mutations is found in the TD and may prevent p53 tetramer formation. Dimer-forming mutations in particular remain poorly characterized, especially in the context of metabolic alteration and chemotherapeutic sensitivity. Here, we utilized CRISPR/Cas9 to generate U2OS clones endogenously expressing either wild-type (WT) p53, null p53, or a LFS dimer forming mutation (A347D) that were either heterozygous (WT/A347D) or homozygous (A347D/A347D). Strikingly, A347D mutant p53 cells exhibit a distinct glycolytic phenotype marked by enhanced glucose influx and antioxidant generation. Despite elevated antioxidant pools, A347D mutant cells display hyperstability due to impaired transcriptional activity, increased basal ROS and morphologically aberrant mitochondria, thereby inducing selective vulnerability to DDR inducers. Therefore, dimer-forming mutant p53 may exert a GOF activity to induce mitochondrial stress, eliciting an upregulation of glycolysis as a survival adaption. These results implicate metabolic reprogramming in overcoming mutant p53-imposed stress during carcinogenesis and suggest a targetable vulnerability in p53 TD-mutant cancers.

STEPHANIE CHOI CC'20: EAST ASIAN LANGUAGES AND CULTURES; POLITICAL SCIENCE

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Faculty Mentor(s): Jungwon Kim, Columbia Unviersity
Title: Intertwining the "Traditional" and the "Foreign": The Evolution of Divorce Rights in Modern South Korea

Abstract: In what ways do foreign states influence the structure and values instilled within the legal institutions of another state? In exploring this question, this research conducts a case study on the evolution of the legal system in South Korea, specifically as it pertains to the rights of women. South Korea had been under continuous foreign occupation throughout its period of "modernization" in the 20th century -- first under Japanese colonial rule (1910-1945), and immediately followed by the United States Army Military Government in Korea (USAMGIK) in the post-WWII era (1945-1948). As such, this study examines the ways in which South Korea's traditional systems and values, Japanese colonial policies, and USAMGIK policies have intertwined with one another to create South Korea's modern constitution and legal codes. More specifically, this study focuses on the evolution of divorce laws as a proxy for

assessing the development of women's rights, as a woman's place within marriage was considered to be the cornerstone of an ordered society within traditional Neo-Confucian thought, and thereby was the principal indicator of a woman's place within the traditional Korean society. This study has collected and analyzed divorce-related decisions issued by the highest court in South Korea -- the Choson High Court (1910-1945) and the Supreme Court (1945-present) -- to assess how the application of divorce laws in South Korean courts have evolved over time. Through in-depth analyses of the rationales provided in these decisions, this study shows how such decisions display an increasing resemblance to the U.S. courts' characteristic emphasis on constitutional rights, with the traditional emphasis on a woman's role within a family increasingly giving way for the protection of her individual right as an independent human being.

BRENDON CHOY CC'22: BIOCHEMISTRY

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Faculty Mentor(s): Filippo Mancia, Columbia University Medical Center
Title: 2B or not 2B: Structural Determination of the Spingosine-1-phosphate exporter MFSD2B

Abstract: Sphingosine-1-phosphate (S1P) is a sphingolipid metabolite with a wide range of biological roles, including the regulation of cell growth, apoptosis, vasculature integrity, and immune cell trafficking. In 2017, Major Facilitator Superfamily transporter 2B (MFSD2B) was found to be the major exporter of S1P from red blood cells and platelets into bloodstream plasma. Despite this recent discovery, further investigation is required to understand the biochemical intricacies and structural mechanisms that MFSD2B employs to export vitally important S1P. The ultimate goal of this research is to obtain a high-resolution structure of MFSD2B through the use of single particle cryo-electron microscopy. All research involving such structural determination begins with overexpression of the target protein. In this study, baculovirus expression systems were used for overexpression of the MFSD2B protein. Various constructs of MFSD2B were cloned and transformed into recombinant bacmid DNA with sequences optimized for transduction of either Spodoptera frugiperda (SF9) insect cells, or human embryonic kidney (HEK) 293S GnTi- cells. Preliminary small-scale expression tests compared the expression of MFSD2B from Bos Taurus (BT) to Homo Sapien (HS). The expression conditions with the most promising gel filtration profiles were scaled up for reconstitution of the target protein into nanodiscs, a phospholipid bilayer that provides a native-like environment for the MFSD2B, ideal for structural determination. The initial conditions reported here underpin the overexpression of MFSD2B and are essential preliminary findings required for its structural characterization. This structure will ultimately provide a better understanding of the mechanism by which MFSD2B exports S1P into the bloodstream.

HAENA CHU CC'20: ART HISTORY; CULTURAL ANTHROPOLOGY

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Faculty Mentor(s): Jonathan Reynolds, Barnard College
Title: Lee Bul's Recent Works: How To Survive History in Modern Korea

Abstract: Lee Bul made her debut in the late 1980s as one of the first post-ideological generation of Korean artists. She earned international recognition for challenging the position prescribed to female bodies in public spaces through monstrous, excessive, and amorphic forms in suspended sculptures Monster and Cyborg series and performance Do You Think I Am a Puppy?. Recently, Lee has transitioned to themes of ideology and history, exploring the fallibility of utopias in her installation series Mon Gran Récit (2005-), architectural models that collage various utopian visions from the past. She often incorporates symbolic references to traumatic events in Korean history such as the Sewol Ferry Incident

in Scale of Tongue (2017-18) and the murder of student protestor Park Chong-Chul under President Park's dictatorship during the 70's in Heaven and Earth (2007).
How does one visualize the unspeakable of trauma? And what role does cultural difference play in structuring this process? This research will highlight Lee Bul's move away from singular bodies towards architectural installations where memory is produced and activated as a strategy to endure, rather than resolve, the gap between individual and historical trauma. Shifting focus to an irreducible sense of lack as the drive behind producing art, both implicit in the psychoanalytical structure of trauma and reinforced by the postcolonial experience of marginality, will answer insufficiencies of characterizing East Asian artists as representation of their immediate cultural backgrounds. Specifically, much of the preexisting literature summarize Lee Bul's recent works as statements of a "stunningly pessimistic belief in progress"(Wayward Tangents: Lee Bul", Artasiapacific, Nov/Dec 2007). To close the reading here, however, only explores this fallibility in the *Abstract* and retrospective, precluding viewers from two important elements that I hope to highlight: first, the particular form through which it is experienced real-time in the presence of Lee's work, including compulsive repetition, heavy references to Western philosophy and literature, and silence; and second, the ongoing process where Lee actively negotiates hr identity against double demands to stabilizing her position within either perceived "Korean-ness" or the universalizing gestures of cyberfeminism.

DONIAN CHYONG CC'21: BIOCHEMISTRY

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Faculty Mentor(s): Sang Geon Kim, Seoul National University
Title: Gα12 regulatesNrf2-lncRNA andmiRNA-122 expression

Abstract: G protein signaling is an important mechanism by which cells interact with their environment. After a ligand attaches to the receptor, a protein cascade activates some response in the cell, often fine tuning the regulation of the cell's activity. One such activity is regulating the cell's metabolism. When cells are in a low energy environment, they signal to break down their stored lipids and other large compounds to create energy and building blocks for other necessary biomolecules. Ga12 signaling has been implicated as critical to this process. Ga12 knock-out mice accumulated fat even during fasting, and their liver cells exhibited nonfunctioning lipid metabolism. A novel long noncoding RNA, named Nrf2-lncRNA, as well as a well studied micro-RNA called miR-122 has also been implicated in this regulatory mechanism in mitochondria. CGS-21680, an adenosine G protein receptor agonist, has been shown to upregulate different proteins, USP22 and SIRT1, also involved in regulating mitochondrial respiration. Treatment with the agonist showed upregulation of miR-122 and Nrf2-lncRNA, thus supporting a connection between G protein signaling and metabolism regulation.

MAKENA BINKER COSEN CC'21: HISTORY

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Faculty Mentor(s): Dana March, Columbia University
Title: Resisting Resistance: Policy Challenges and Triumphs in the Regulation of Antibiotics in Farming

Abstract: Despite concerns regarding antibiotic resistance, by the mid-twentieth century American food producers had become reliant on the use of antibiotic growth promoters (AGP) in farming. Given that AGP usage substantially cheapened food production costs and consumer prices, many farmers were pressured into using them in order to remain competitive in the United States. However, as antibiotic resistance threatens to make treatments for infectious diseases ineffective, there have been continuous

attempts to restrict and substitute AGPs ever since their tentative commercial approval and release. By analyzing two case studies of policy efforts in the United States and the United Kingdom, this paper aims to understand (i) the context that has allowed and encouraged the development and introduction of AGPs in each country and (ii) what challenges persist for American policymakers striving to regulate antibiotic use in farming. Research suggests that such regulations require stronger economic backing in order to attain their approval and implementation. Perhaps it is up to the consumer to use their dollar as their "vote" to support food suppliers that offer products free from harmful chemicals such as AGPs. Moving forward, it would be critical to understand how to effectively educate consumers about food options available to them and how they relate to their health and wellbeing.

AOMENG CUI CC'20: BIOCHEMISTRY; GERMAN LITERATURE

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Faculty Mentor(s): Karl Gegenfurtner, Justus-Liebig-Universität Gießen
Title: The effect of prediction and value on anticipatory eye movements

Abstract: Inherent processing delays during the initiation of foveation cause the eyes to lag behind a moving target. To overcome this delay, anticipatory smooth pursuit eye movements can occur for predictable target movements. The strength of this bottom-up prediction is biased by the probability of target appearance in a certain location. In addition, eye movements can also be affected by top-down factors, like a reward associated with a specific movement. We investigated the interaction between prediction and value through a series of visual paradigms. After an initial step, a target moved continuously into one of two directions. Importantly the target was blanked for 400 ms after the step, allowing us to measure the anticipatory response without any retinal information. In the first experiment, we manipulated prediction, as the motion-direction expectancy reflected the likelihood the target would follow one of two paths. To assess the role of reward, participants were given immediate visual feedback and points which were later converted to monetary reward. In associative reward trials, reward was independent of eye direction; in gaze-contingent reward trials, participants were rewarded depending on their eye direction during the occluded period. Our results suggested that prediction could strongly bias eye direction. Additionally, subjects learned the association of direction with value over many trials, despite a lack of direct reward. When we manipulated prediction and reward in the same trials, congruency between prediction and value further strengthened the eye-direction bias. Interestingly, in the incongruent case, value dominated over the initial bias induced by prediction alone.

TIANYI DAI SEAS'20: ELECTRICAL ENGINEERING

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Faculty Mentor(s): Gil Zussman, Columbia University
Title: 28 GHz Channel Measurements in the COSMOS Testbed Deployment Area

Abstract: Next generation wireless and mobile networks will utilize the widely available spectrum at millimeter- wave (mmWave) frequencies to achieve significantly increased data rates. However, since mmWave radio signals experience high path loss, the operation of mmWave networks will require accurate channel models designed for specific deployment sites. In this poster, extensive 28 GHz channel measurements are reported in the deployment area of the city-scale PAWR COSMOS testbed in West Harlem in New York City. These include over 24 million power measurements collected from over 1,500 links on 13 sidewalks at three different sites and in different settings during March–June, 2019. The three different sites include a fourth-floor balcony at a four-way intersection, a bridge overcrossing a two-way

avenue, and a fourth-floor balcony facing an open-space park within a deep valley. These three sites emulate different deployment scenarios of mmWave base stations in a dense urban environment.
From the measurement results, the 28 GHz channel path gain values and their fitted lines are obtained. Also, the effective azimuth beamforming gain is acquired, which represents the amount of environmental scattering experienced by the wireless signal. The results show that the measured path gains fall within the 3GPP channel model for urban canyon environments, but their values vary significantly between different measurement sites.
Alongside different measurement sites, three other potential impacts of the measurement environments and setup are also studied: (i) the season in which the measurements are conducted, (ii) the height of the measurement equipment, and (iii) swapped transmitter and receiver locations. Based on the results, the effects on the mmWave channel can be evaluated. It is found that for link distances up to 250m, these other impacts have minimal effects on the mmWave channel.
In addition, the link signal-to-noise ratio (SNR) values that can be supported on each measured sidewalk and the corresponding theoretically achievable data rates, are analyzed. It is shown that with typical 28 GHz transmitter and receiver power levels and gains, 15 dB link SNR can be achieved up to around 200m link distance, even on streets without line-of-sight between the transmitter and the receiver.
In conclusion, the measurement results of this study can inform the deployment of the IBM 28 GHz phased array antenna modules in the COSMOS testbed, and can provide a benchmark for other deployment efforts in dense urban areas. Moreover, the results demonstrate the viability of mmWave networks and can open the door to further research at the higher layers of the network.
More details about the measurement equipment, data and results from our work, done in collaboration with researchers at Nokia Bell Labs, Universidad Técnica Federico Santa María, and Columbia University, can be found in the workshop paper "28GHz channel measurements in the COSMOS testbed deployment area," by T. Chen, M. Kohli, T. Dai, A. D. Estigarribia, D. Chizhik, J. Du, R. Feick, R. Valenzuela, and G. Zussman, to appear in Proc. ACM MobiCom'19 Workshop on Millimeter-Wave Networks and Sensing Systems (mmNets), Oct. 2019. The paper is available in: http://wimnet.ee.columbia.edu/wp-content/uploads/2019/08/mmNets2019_COSMOS_28GHz.pdf

MARIYA DELYAKOVA CC'21: MATHEMATICS; COMPUTER SCIENCE

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Faculty Mentor(s): Gail Kaiser, Columbia University
Title: Discovering Metamorphic Properties in Three Routines

Abstract: Software testing is a crucial part of software development which ensures that a certain product has correct functionality, good quality and has no security vulnerabilities. Programs without a "true" test oracle are applications for which we cannot determine beforehand what the correct output result should be for any given input and respectively, traditional test cases cannot be utilized to find potential bugs in such programs. Metamorphic testing is an advanced technique that is used to test such applications that are sometimes called "non-testable" and metamorphic properties lie at the heart of the technique.
A metamorphic property defines a transformation t which can be applied to the input x of a program f, so that we can predict the output of f(t(x)) if we are given the output of f(x). For example, consider a program that computes the sine function – f(x) = sin(x) – and the transformation function t(x) = π - x. Then, if we know the output f(x) = sin(x), we can predict the output f(t(x)) = f(π - x) = sin(π - x) = sin(x) = f(x) without actually running the program for the transformed input. By comparing the expected output and the actually derived output, we can potentially discover bugs in the implementation of programs.
In this project, three routines – Knapsack, TriTyp, and a sorting routine – are tested to discover the metamorphic properties they have. For the purpose, 10 transformation programs – multiplicative,

additive, shuffling and others – were developed to transform the original input the routines take. Once the original input is transformed, there are 8 checkers (identity checker, multiplication checker, and others) that compare the original output of a routine with the newly derived output to discover metamorphic relations in the given programs. Overall, 16 metamorphic properties were found in the project.

LALI DEVADAS CC'20: MATHEMATICS-COMPUTER SCIENCE

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Faculty Mentor(s): Mike Rosulek, Oregon State University
Title: Secure Montgomery multiplication for modular exponentiation using garbled circuits

Abstract: Current state-of-the-art arithmetic circuit garbling allows for ciphertext-free modular addition and the multiplication of private inputs modulo a prime p with only 2(p − 1) ciphertexts. Using these advantages, they constructed a circuit to handle the squaring and multiplication of inputs modulo a large N in a residue number system. They then expanded on the existing techniques for arithmetic modulo p to develop methods to handle arithmetic in a positional, base-p number system. Finally, they evaluated the ciphertext cost of both of these methods to compare their performance for squaring in various large moduli.

EMILY DIAS CC'22: BIOLOGY

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Faculty Mentor(s): Samuel Sternberg, Columbia University
Title: Assessing the impact of target immunity on site specific transposition in the INTEGRATE system

Abstract: Gene editing has revolutionized how scientists interact with nature, specifically improving the research and treatment of cancer, optimization of crops, and elimination of traits from entire species. A novel gene editing tool, INTEGRATE, combines machinery from CRISPR–Cas systems and transposable elements to site-specifically insert donor DNA into the genome. Mechanistic inferences about this system can be made based on its homology to the well-studied Tn7 transposon. Tn7 characteristically shows "target immunity," an occurrence where the presence of one copy of the transposon inhibits additional integration events in the surrounding region, rendering that target site "immune". Using molecular cloning, protein expression, and transposition assays, targeting genomic and plasmid loci alike, we sought to discern whether INTEGRATE similarly displays target immunity, if so, evaluate the strength of that immunity. Understanding the degree of target immunity present in INTEGRATE is crucial to knowing the natural limitations of the tool, and informs future studies.

VANESSA DIPPON CC'21: CHEMISTRY

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Faculty Mentor(s): Tomislav Rovis, Columbia University
Title: Directed Evolution of an Artificial Metalloenzyme to Accelerate Rh(III) Catalysis

Abstract: Directed evolution, pioneered by Frances Arnold, is a method that can be used to engineer a native protein to achieve "new-to-nature" reactivity. In directed evolution, the gene coding for the protein of interest is mutated using random mutagenesis or site saturation mutagenesis to generate a library of random mutants. Reactive mutants are found through a process of either selection or screening; once an active mutant is found, iterative cycles can be performed until the desired reactivity is achieved.

In an artificial metalloenzymes (ArMs), any transition-metal catalyst can be embedded into a protein scaffold; this bestows ArMs with the ultimate variability and versatility. One of the most reliable methods of generating an ArM is by taking advantage of biotin's extremely high affinity for streptavidin (KD = 10-14 M). Previously, I have been involved in the development of an in-vitro monomeric-streptavidin Rh(III) ArM to permit the asymmetric synthesis of α,β-unsaturated-δ-lactams via a tandem C-H activation and [4+2] annulation reaction. However, this semester we aim to dramatically improve the reactivity of this transformation via directed evolution, wish to catalyze a reaction of high synthetic utility with no known equivalent in nature or in the flask, and improve biocompatibility and scalability by enabling in vivo catalysis.

ANASTASIA DMITRIENKO CC'21: COMPUTER SCIENCE

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Faculty Mentor(s): John Cunningham, Columbia University
Title: Investigating the structure of *Abstract*ion in neural networks with population-level hypothesis testing

Abstract: Research in statistical neuroscience focuses on finding structure in large-scale neural recordings. Theoretical models of brain computation are designed to reflect this neural population structure. A methodological bottleneck is generating of surrogate neural data for population-level hypothesis testing. Methods from Elsayed et al. were used to investigate if primary features give rise to geometrical *Abstract*ion (the brain's representation of *Abstract* variables to enable conceptual generalization) in neural networks classifying both magnitude and parity of MNIST digits. Such methods include the tensor maximum entropy (TME), which samples surrogate datasets from a probability distribution that maximizes Shannon entropy with the average primary features of the data. Testing across primary features of the neural readout using surrogate sampling methods suggests that the surrogate datasets do not have the same higher-order structure as the neural network responses. As a result, further research in the project can investigate which non-linear metrics, such as pairwise distances, give rise to *Abstract*ed neural representations.

HAREEM ZAIN SEAS'20, WITOLD DZIEKAN SEAS'20: MECHANICAL ENGINEERING

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Faculty Mentor(s): Adrian Brugger, Columbia University
Title: Automating a 3-Axis Mill with a Variable Frequency Drive System

Abstract: Carleton Laboratory is a Civil Engineering Lab used by staff, students, and professors for undergraduate labs, graduate research, and commercial projects and testing. Subtractive Manufacturing is the process of constructing 3D objects by removing material. The 1964 Bridgeport 3-axis Mill is a Belt-Driven Mill that requires the user to manually switch belt drives to change RPM. A VFD System can be introduced to automate the spindle RPM. Modern Occupational Safety and Health Administration (OSHA) compliant safety features were added to the design. A belt-driven system is both inefficient as a machining tool as well as dangerous and tedious for the operator to change in the middle of a machining project. An automated spindle increases the user's efficiency, allows more users to operate the machine due to easier training, and is much safer than reaching into the belt drive housing to switch gear ratios.

ABIGAIL EDWARDS GS'21: HUMAN RIGHTS

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Title: Interactions Between Memorialization and Reconciliation: a Case-Study of Choeung Ek

Abstract: This research seeks to situate memorialization efforts in ongoing processes of reconciliation in post-conflict Cambodia. Using the case-study of Choeung Ek, this work builds off of and updates existing literature on politicized memorialization in Cambodia. Based on this framework and field research, this research argues that processes of memorialization in the People's Republic of Kampuchea (PRK) created two distinct operating levels of actors: (1) the institutional level of the government and memorial curators and (2) the personal level of the everyday Cambodian and their lived experience. These operating levels are separated according to four main thematic cleavages surrounding the objectives of memorialization: (1) a "will to remember" vs. "a duty not to forget" (Renan, 1882), (2) site privileging, (3) the question of site transformation and dealing with remains, (4) and misaligned notions of reconciliation. The effects of these cleavages on reconciliation and the role of memorials in society are trifold: memorials such as Choeung Ek today are places of a limited truth, constructed memory, and struggle to fulfill their roles as educational conduits. A third operating level can be added to complexify this relationship: the international actor. Next, this paper outlines and evaluates recent changes that have been made the Choeung Ek site/memorial since JC Royal bought rights of operation and development in 2005. Finally, the paper concludes with prescriptive suggestions as to how the memorial site of Choeung Ek might be improved.

JAKE FISHER CC'22: ECONOMICS - POLITICAL SCIENCE

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Faculty Mentor(s): Rebecca Kobrin, Columbia University
Title: Capturing America's Hearts and Minds: Andrew Carnegie's International Mind Alcoves

Abstract: After the utter destruction of the First World War, philanthropists across the world began to pour resources toward preventing such global chaos from recurring. The Carnegie Endowment for International Peace, coined America's first think tank, made global cooperation and wide-scale internationalism its main priority. One of its flagship programs, the International Mind Alcoves, which consisted of a syllabus of about 100 books focused on cultures from around the world and important works in international affairs were donated to public libraries across the rural United States and around the globe. The Alcoves came at no cost to libraries and, in some cases, became a library's most prized collection. During the interwar era, the Alcoves reached a large portion of rural readers and worked to change attitudes in favor of global friendship and understanding over conflict. Nonprofits have always played a prominent role in shaping American life. But historians disagree as to what the impact of such philanthropy really is on the structure of our government and society. While some claim that nonprofits have and can continue to make necessary and positive change, others argue that the charitable contributions of these organizations have ultimately only masked and normalized growing inequity. The International Mind Alcoves demonstrate that nonprofits have the capability to make change, but in many cases, they are unable to create sweeping structural reforms that can fundamentally challenge the inequality that exists in the status quo.

SUPRIYA MAKAM CC'22, NICHOLAS GANEK GS'22, DEAN FOSKETT GS'24: NEUROSCIENCE

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Faculty Mentor(s): Lisa Rosen-Metsch and Rachel Shelton, Columbia University
Title: Student Perspectives: Investigating the Dissemination and Implementation of Opioid Education and Naloxone Training at Columbia University

Abstract: College campuses are an important, yet understudied context for opioid education and Naloxone training. This pilot study investigates the acceptability, feasibility, and initial adoption and implementation of an evidence-based opioid education and Naloxone training program at Columbia University. After an environmental scan among research and community experts, focus groups were conducted among staff, leadership, and priority student groups, with the goal of identifying barriers and facilitators to the implementation of opioid education and Naloxone training. Based on the information obtained from the groups, a comprehensive curriculum was piloted for students and staff.
Cited barriers to adoption and implementation included opioid-related stigma, low self-efficacy once trained, and decentralized campus communication, while facilitators included low cost and ease of training. Currently, over 200 students and staff have been trained, with close to 95% choosing to take a kit at the end of the session. Groups trained so far include, but are not limited to, orientation leaders, resident advisors, and BWOG. Trainings are scheduled to occur with SVR volunteers, GS Students, and Alpha Chi Omega. Campus clubs have also displayed an interest in participating, including American Medical Students Association, and Peer Health Exchange. Findings suggest there is strong interest and demand for opioid education and naloxone training at Columbia, and this pilot study has broader implications for applications to other universities. With over 100 people dying every day from an opioid overdose--and increasing numbers of non-opioid users fatally overdose from drugs secretly laced with fentanyl--the need for thorough substance abuse education and naloxone dissemination in schools and universities is dire and necessary.

LILY FRIEDLAND CC'22: SUSTAINABLE DEVELOPMENT; PUBLIC HEALTH

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Faculty Mentor(s): Ursula Staudinger, Columbia University
Title: Age Plasticity Research as a Possible Solution for China's Demographic Crisis

Abstract: Lily Friedland is a sophomore and Laidlaw scholar in Columbia College. This past summer, Lily began her research into the environmental and cultural factors affecting how well elders age in rural and urban communities in China. Lily studied under Professor Ursula Staudinger of the Mailman School of Public Health, a specialist in aging research. Next summer, Lily is planning on traveling to China to conduct elder time use surveys and interviews in rural and urban settings in order to observe how well elder communities currently function as a part of their larger community. Lily's longterm goal is to use her gained knowledge of age plasticity (how well an individual ages) and her observations in China next summer to create culturally sensitive suggestions for China's current demographic crisis as a result of their one-child policy and underdeveloped elder health care system.

MICAH GAY CC'20: MATHEMATICS

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Faculty Mentor(s): Travis Schedler, Imperial College London
Title: Regular Holonomic D-Modules

Abstract: The Beilinson-Bernstein correspondence is one of the foundational theorems in geometric representation theory. It tells us that D-modules over the flag variety of a reductive group correspond to modules over the universal enveloping algebra U(g) of the corresponding Lie algebra g. Requiring D-modules to be regular and holonomic further allows us to realise them as perverse sheaves through the Riemann-Hilbert correspondence. In this project, we attempt to characterise the locus of regular

singularities for irreducible sl2-representations in terms of the representation theory of U(sl2), and also to generalise the notion of regular singularities to more general symplectic resolutions.

BEATRIX GEAGHAN-BREINER CC'22: HISTORY; POLITICAL SCIENCE

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Faculty Mentor(s): Jack L. Snyder, Columbia University and George A. Lopez, Notre Dame
Title: The Economic Strangulation of a Nation: Anti-Humanitarian Effects of Unilateral Sanctions On Venezuela

Abstract: As a Laidlaw Scholar, Beatrix Geaghan-Breiner studied the humanitarian effects of sanctions in Venezuela. Specifically, she researched the ways in which the economic blockade imposed by the United States is restricting Venezuelan civilians' access to healthcare, food, water, sanitation, and general wellness. To set the foundation for her project, she began by researching historical examples of sanctions such as the United Nations sanctions on Iraq during the 1990s. Reviewing previous scholarly work allowed her to focus on the causal chains between economic sanctions and humanitarian effects such as mortality rates, water accessibility, and healthcare.
After studying the far-reaching effects of sanctions in other countries, Beatrix delved into recent data on Venezuela's humanitarian situation. Because national statistics are sparse, she focused on data from humanitarian organizations within and outside of Venezuela. Beatrix analyzed statistics on health such as medicine scarcity, epidemics, and water sanitation, and economic data regarding imports and exports. She discovered that shipments and transactions for medicine and food have been blocked from entering the country due to US sanctions. Additionally, the conditions of healthcare facilities in Venezuela are worsening each consecutive year of sanctions. The American economic blockade is essentially strangling the Venezuelan economy by isolating it from the international trade market. As a result, it is increasingly difficult for the Venezuelan government to provide the basic social services that its civilians need. Ultimately, Beatrix's project contributes to mounting evidence that economic sanctions have a staggering human cost, risking the lives of innocent civilians and destroying state infrastructure.

BRYANNA GEIGER SEAS'21: COMPUTER SCIENCE

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Faculty Mentor(s): Katherine Reuther, Columbia University
Title: Shoulder Biomechanics

Abstract: Scapular dyskinesis is an abnormal position and motion of the scapula and is associated with many shoulder injuries including but not limited to rotator cuff tears. Due to its prevalence in shoulder injuries, the global objective of the research is to develop strategies to improve clinical outcomes following shoulder injury and following surgical and non-surgical treatments for shoulder injury. In previous clinical studies, the methods used to identify scapular dyskinesis required expensive equipment not easily accessible in a clinical setting. Therefore, the goal of the study was to develop a cost-effective and quantitative method to test for scapular dyskinesis in a clinical setting. To map out the surface of the human body into a topographic map, the Moiré phenomenon, which uses interference of images very similar in design, was used. Our objective was to optimize and then validate the method being used to test for scapular dyskinesis through data collection and analysis.

DAHLIA GHOSHAL SEAS'21: APPLIED PHYSICS

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Faculty Mentor(s): Alexander Gaeta, Columbia University
Title: Dispersion-managed passive similariton fiber laser

Abstract: Optics researchers are investigating lasers that can be used to produce stable "frequency combs" – in which the color spectrum has evenly spaced teeth, like a hair comb. In this work, we present a ytterbium-doped mode-locked fiber laser that can be stabilized to generate an optical frequency comb. The laser is "mode-locked", so the oscillating electromagnetic fields of all the colors maximize simultaneously, thus creating high energy, ultrashort pulses. To achieve mode-locking and short pulse generation in the cavity, we implement saturable absorption and dispersion management. Saturable absorption is critical for pulse formation and, in this laser, we use nonlinear polarization with a series of waveplates. Dispersion management is critical for both high power and broadband pulse formation, and a pair of diffraction gratings is used for managing the overall dispersion of the cavity. The laser successfully outputs infrared pulses with a duration < 100 femtoseconds (10^-13 seconds) every 18 nanoseconds. Near-future work includes using a nonlinear medium to achieve coherent supercontinuum generation, which is critical for full-stabilization of the laser, and electro-optic and optomechanical elements in the cavity to allow for frequency stabilization of the mode-locked laser. Frequency comb technology can be used for wide range of applications, including bridging the optical and microwave domains in high-precision optical clocks and calibrating astronomical spectrographs for exoplanet searching.

DIMITRI GODUR CC'20: PSYCHOLOGY

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Faculty Mentor(s): Dr. Ashutosh Agarwal, University of Miami
Title: Optimization of Culture Conditions for Recapitulating Patient-Specific Neuromuscular Junction Diseases on a Dish

Abstract: Charcot-Marie-Tooth (CMT) is a disease that leads to peripheral neuropathies in 1 out of 2,500 people, and results from a mutation in any of 70 affiliated genes. Using neurospheres derived from induced pluripotent stem cells of CMT patients and mouse skeletal muscle cells (C2C12), Agarwal lab has devised an in vitro model of neuromuscular junctions using a gelatin-laminin hydrogel platform. These models are designed to further the understanding of axonal dysfunction in CMT patients. C2C12 myoblasts differentiate into multinucleated myotubes and twitch when cultured. The twitching has been attributed to the supplements in the Dulbecco's Modified Eagle Medium/Nutrient Mixture F-12 (DMEM/F12) maturation media and introduces variability in the neuromuscular junction model. By redesigning the media composition, we can eliminate the twitching and make it specific to stimulation through neuronal firing; leading to a more faithful recapitulation of neuromuscular junction activity.
DMEM/F12 maturation media was supplemented with dorsomorphine, a differentiation promoter, retinoic acid, SAG, and three neurotropic factors. To test the affects of the media on the C2C12 culture, 50 gelatin-laminin hydrogels were created to run 10 experimental groups of 5 samples. Each group contained media without each supplement respectively, DMEM/F12 with no supplements, negative control differentiation media, and positive control DMEM/F12 with all supplements. 100,000 cells were seeded on each of the 50 hydrogels, and the cells were cultured for 14 days, being fed on days 3, 6, 9, and 12 post-seeding. Cell morphology and twitching characteristics were studied under a microscope and recorded.
The maturation media project and overarching CMT study will continue beyond the term, as all samples expressed a degree of twitching by later observation. Preliminary observations indicate that wells fed with media without GDNF neurotropic factor expressed the least amount of twitching, with early myotube development but no perceivable twitching on days 3 and 6, and increased twitching activity on days 9

and 12. Concern arose when sample wells fed with differentiation media, our negative control with no anticipated twitching, began to express twitching on day 6, which increased thereafter. Because of confounding results with the negative control, this experiment will be repeated to standardize the results, and validate the quality and function of engineered CMT neuromuscular junctions.

DEVYANI GOEL CC'22: ECONOMICS; POLITICAL SCIENCE

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Faculty Mentor(s): Larisa Heiphetz, Columbia University

Title: Moral and Conventional Knowledge

Abstract: Essentialism is the idea that all objects and individuals have an inherent, underlying "essence" that is crucial to their existence as it is. To "essentialize" a quality in a human being is to imagine that feature of their personality as being immutable and often hereditary. There exists a substantive body of previous research suggesting that young children tend to "essentialize" certain qualities in themselves and in other people. This research project aimed to study whether children "essentialize" criminality; i.e. if they think that a child with an incarcerated parent is more or less likely to engage in rule or norm-breaking behavior. To do so, the researchers told children stories about characters that have a parent who is currently in jail or has never gone to jail—then asked questions about which characters understand certain rules. After that, the child played a sharing game where they were given stickers to share with the characters in the story. The study was conducted with kids between 5 to 8 years old because this time represents a critical window in reasoning about why people should be punished. The study differentiated between moral and conventional norms. The larger aim of the research project remains policy oriented – figuring out the best way to reform the criminal justice system in order to prioritize the well being of those involved.

BENJAMIN GOLDSTEIN CC'20: HISTORY

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Faculty Mentor(s): Jose Moya, Barnard College

Title: "A Fighting Pacifist": An American Interwar Non-Interventionist Foreign Correspondent Navigating Fascism at Home and Abroad

Abstract: This study examines a forgotten foreign correspondent (Karl H. von Wiegand) from the 1930s and his failed attempts to keep America out of World War 2 through a mix of informal diplomacy, journalism and propaganda. Through his reporting in Nazi Germany during the early 1930s, he became very familiar with the brutal violence and anti-Semitism of the regime. However, by the mid-1930s he concluded that maintaining peace in Europe, and especially keeping America out of any brewing conflict, took precedence over the "sins" of Germany. Through backdoor transnational diplomacy, often in conjunction with journalistic and interviewing techniques, he tried to proactively smooth over geopolitical tensions as a "fighting pacifist". His articles – which confusingly mixed an objective sounding reportorial style with a more subjective sounding and opinionated columnist voice – also tried to promote non-interventionism at home. However, as American public opinion soured against Nazi Germany in the late 1930s, von Wiegand's journalistic efforts for non-interventionism became increasingly suspect as pro-Nazi. His blurred roles between journalist, correspondent and diplomat caused confusion and suspicion at home, ultimately damaged his ability to influence public opinion. In addition to failing at his political goal, he also fell under surveillance from both British and American intelligence organizations. This

research documents the multipurpose nature of the interwar foreign correspondent, and the power of American non-interventionism's fascist wing.

FRANCESCO GRECHI CC'20: MATHEMATICS; COMPUTER SCIENCE

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Faculty Mentor(s): Michael Woodford, Columbia University

Title: Efficient Encoding Schemes

Abstract: In recent years, behavioral economists have worked to understand the cognitive processes by which the human brain is able to interpret psychophysical stimuli. One of the most convincing models proposes that outside stimuli are noisily encoded to generate internal mental representation. These internal representations are then processed by the nervous system to decide upon a response. In this poster session, we present a computational model for efficient encoding schemes of psychophysical stimuli. We operate under the assumption that the brain has limited cognitive resources. We aim to extend recent work by Robson and Whitehead (2018) by developing a learning process more closely aligned with empirical evidence of how encoding occurs in the brain. To do so, we make use of an inference model and an information theoretic objective function recently proposed by Alemi et. al (2017). The result is a machine learning system which predicts results about psychophysical perception thresholds that coincide, in specific situations, with existing literature results. We first present meta-statistics of the model concerning training time, parameter tuning, and other computational information. We then present preliminary results, discuss the merits of the model, and conclude with possible future investigations.

ELENA GRIBELYUK CC'22: MATHEMATICS; COMPUTER SCIENCE

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Faculty Mentor(s): Andrew Laine, Columbia University

Title: Spatial Association of Airway Morphological Changes with Quantitative Emphysema Subtypes

Abstract: Small-airway destruction in COPD and emphysema is well-described. Previously, the pruning of the CT-derived airway tree masks has been shown to be predictive of airflow obstructions and measures of small-airways disease. One aspect of this airway destruction process that has not yet been studied is how these changes to airway morphology are distributed throughout the lung, and how they associate spatially with quantitative emphysema subtypes (QES). To that end, we have devised and automated approximative method for assigning each segment of the airway tree to the lung parenchyma it supplies. Running this algorithm on a sample (n = 2,101) of MESA exam 5 cohort, we found that in the senile and diffuse QES, a decrease in areas supplied by high branching generations was observed. Moreover, both a local and global decrease in areas supplied by high branching generations was observed in the Apical (smoking related) QES with a larger effect size in the local measure.

ASHLEY GUTIERREZ CC'22: BIOLOGY

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Faculty Mentor(s): John Hunt, Columbia University

Title: Codon Influence on Protein Expression in E. coli: Understanding the Role of ATA Codons

Abstract: Redundancy in the genetic code allows multiple, synonymous, codons to produce the same amino acid. Over the past couple of decades, there has been a rising interest in how variation in

synonymous codons influences mRNA translation and ultimately gene expression. Previous studies have shown that non-canonical codons influence gene expression in E. coli and enhance protein expression when their respective tRNA cognate are increased. The majority of these studies have targeted the rarest codons in E. coli AGA and AGG, which encode an arginine residue. However, from our generated codon-influence metric, we discovered that the ATA codon, which encodes for an isoleucine, has the greatest impact on the rate of translation in E. coli. Here, we tested to see if synonymous codons for isoleucine can be used to increase protein expression in genes. Through a series of biochemical studies, we show that the ATA codon significantly perturbs protein expression. However, the expression can be enhanced by replacing ATA with ATC, a synonymous codon for isoleucine. These results change our current understanding of biochemical processes underlying translational efficiency in E. coli and may facilitate development of biotechnological techniques that improves protein production.

Blaise Haddad CC'20: English; Art History

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Faculty Mentor(s): James Schamus, Columbia University
Title: History of Film Noir

Abstract: Blaise Haddad spent his summer researching the critical history of film noir. For his project, Blaise combed through film noir's vast academic literature, reading various essays that uniquely pertained to one of film noir's many themes. These themes included: masculinity, existentialism, visual style, the question of genre, B-picture studio history, the hard-boiled literary school, queerness, and women in film noir. For each theme, Blaise boiled down the essence of an author's central argument to essential quotes or passages. Such quotes highlight the key pillars of each author's argument, from their opening framework and foundational observations to the main critical thrust of their writing. In addition to being roadmaps to the literature of these different film noir themes, Blaise's documents also allowed for crucial connections to be drawn between the various themes. For example, Blaise underscored the essential thematic overlaps between a theme like masculinity and other themes such as existentialism, the hard-boiled literary tradition, and post-war disillusionment. He specifically highlighted particular films that bring such themes together in fascinating and often jarring ways. The layered thematic resonance of this film category reveals not only the importance of history to our understanding of film noir but, perhaps more tellingly, the importance of film noir to our understanding of history.

Abigail Hickman CC'21: Anthropology

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Faculty Mentor(s): Ariella Lang and Frank Guridy, Columbia University
Title: "Cherokees Love Space": Exploring Settler Colonialism Across Space and Time

Abstract: It is no secret that there is a lack of representation of minority voices, particularly Indigenous voices, in science fiction and discussions about space. There is a plethora of scholarly literature on the topic, with most reaching the conclusion that science fiction film and literature as well as those officials involved in space travel enterprises, must "decolonize" and listen to and/or include Indigenous voices. Despite most Indigenous activists and scholars agreeing that Indigenous voices are critical to discourses about time and space, not many have considered why mainstream perceptions of future remains seemingly purposefully excluding of Indigenous people and epistemologies. What is it about the fabric of space that causes it to possess a noticeable gap in Indigenous knowledge, especially when there is no evidence to suggest that Indigenous people are any less invested in it, and in fact may be more invested?

HUNTER HOLLAND CC'22: ASTROPHYSICS

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Faculty Mentor(s): Frits Paerels, Columbia University

Title: Determining the Composition of Dense Molecular Clouds Using Scattered Extragalactic X-rays

Abstract: Interstellar dust has long been a lens through which we view our universe, but when it isn't the subject of our observations, it is, more often than not, a nuisance. However, through examining the photons of extragalactic X-ray sources that get scattered by this dust, we can use special properties of the clouds to further characterize it. Certain dense molecular clouds exhibit "coreshine," a property which has led to the conclusion that these clouds contain a significant population of large dust particles with icy mantles. Even so, the particles' exact densities and compositions are presently unknown. Recognizing that these particles should scatter X-rays efficiently, and using coincident X-ray and infrared data from Chandra and Spitzer, we have begun an attempt to detect this scattered light and use it to get a firmer grasp on both of these properties. Upon completion of this project, we should be able to confirm the presence of ices in these shining cores, places which are speculated to be formation sites of complex molecules fundamental to the origin of life.

HUCK JUN HONG CC'22: BIOLOGY

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Title: Dissecting the role of SMARCAL1 in the regulation of cell-intrinsic immune response mediated by cGAS-STING

Abstract: SMARCAL1 is a SWI/SNF2-family DNA translocase involved in fork remodeling and double-strand-break repair, and its activity is crucial in maintaining genome stability during both normal and aberrant replication. Several studies have demonstrated that genomic instability results in the accumulation of micronuclei, which activates the cell-intrinsic immune response pathway when detected by cGAS. Namely, the cGAS-STING pathway promotes type I IFN upregulation and the induction of IFN-stimulated genes (ISGs). In this study, we evaluated whether genomic instability caused by SMARCAL1 inhibition may lead to micronuclei formation that triggers the cGAS-STING pathway and promote higher expression of ISGs. To address this question, we employed CRISPR-Cas9 technology to knock-out the SMARCAL1 gene in MDA-MB-436 human breast cancer cells and evaluated the expression levels of ISGs and micronuclei using qRT-PCR and immunofluorescence. Obtained results showed that the deficiency of SMARCAL1 caused significantly higher numbers of micronuclei, which in turn activated cGAS and induced higher expressions of ISGs, notably IL6 and CXCL10. This study showed that SMARCAL1 function is critical to linking genomic instability, micronuclei formation, and cGAS-STING activation with intrinsic immunity.

MIDORI HOSODA CC'21: COMPARATIVE LITERATURE AND SOCIETY; BIOLOGY

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Faculty Mentor(s): Alejandro Adler, Columbia University

Title: Perceptions and Usage of Modern, Traditional (Sowa Rigpa), and Local Medicine: A Qualitative Study with Bhutanese Patients

Abstract: Modern society has seen a rapid shift toward biomedicalization. However, there is now an increasing trend of using complementary and alternative medicine for holistic treatment. Bhutan promotes the physical, mental, and spiritual well-being of its citizens through its universal healthcare system, production of herbal medicines, Buddhist practices, and governmental policy of Gross National Happiness. Patients can choose one or a combination of modern, traditional (Sowa Rigpa), and local healing practices for treatment. For this study, in-depth, semi-structured interviews were conducted among 20 randomly-selected patients. Interviewees were categorized based on demographics, past medical experiences, upbringings, and expectations for medical care providers. The study identified patients' perceptions of the strengths and limitations of each healing practice. To this end, the participants' reasoning for relying on certain practices over others for particular ailments were investigated. A notable finding was that patients believe flexibility in the reliance of one or multiple treatment types optimize their health and facilitate access to medical resources. Additional collaborations between modern medical practitioners and complementary and alternative medical care providers are necessary to advance the integration of these three practices and ensure patient well-being.

DIANE HUANG CC'21: ECONOMICS-MATHEMATICS

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Faculty Mentor(s): Douglas Almond, Columbia University
Title: Investigating the Relationship Between Indoor Infrasound and Wind Turbines

Abstract: While wind energy offers great potential for reducing dependence on fossil fuels and their contribution to greenhouse gases, controversy exists as to whether wind turbines impair the health of those living nearby. One causal mechanism that has been proposed for compromised health is that infrasound generated by wind turbines may disrupt sleep. Infrasound is very low frequency sound (<20 Hz) which can be generated by natural disasters and machinery, such as wind turbines. As a preliminary test, a sound level meter capable of detecting infrasound was placed indoors in Northfield, MN where there are three utility-grade wind turbines. Analyses were run on the recorded decibel levels and wind speed over time. Raw regressions with wind speed and sound levels show a weak and positive correlation between wind speed and both infra- and audible sound. Fixed effects based on a hypothetical additional mechanical contributor to infrasound (a "machine") result in a strong correlation (R2 = 0.8046) but small and negative contribution from wind speed.

GREG HUMPHRIES CC'20: POLITICAL SCIENCE; ENGLISH

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Faculty Mentor(s): Justin Phillips, Columbia University
Title: Representation and Responsiveness in the European Parliament

Abstract: The UK's decision to leave the European Union (EU) reflected a number of disenchantments with the EU, not least the feeling that citizens' interests were not properly represented by the EU's legislative bodies. Since June 23rd, 2016, both UK and EU politicians have come under fire from UK voters for a perceived lack of responsiveness to voters' opinions. As people continue to question representation in the EU, it becomes increasingly important to ask just how responsive EU politicians are to the preferences of those whom they represent. Looking specifically at policy decisions on immigration, and public perception on pertinent issues, this work analyses if Members of the European Parliament actively, and intentionally, respond to the political preferences of those whom they represent. By comparing the votes of MEPs and preferences of constituents at multiple times – throughout the seventy-three UK

constituencies of the European Parliament – this study quantifies the democratic legitimacy of the EU's largest legislative chamber using the lens of policy responsiveness.

ALLISON HUNG CC'20: BIOLOGICAL SCIENCES

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Faculty Mentor(s): Alexandre Persat, Swiss Federal Institute of Technology
Title: Characterizing antibacterial resistance upon surface attachment

Abstract: Pseudomonas aeruginosa is an opportunistic bacterial pathogen that causes severe infection in immunocompromised patients. During colonization of its host, P. aeruginosa frequently transitions between planktonic and surface-associated states. This surface-association via type IV pili has been linked to increased virulence in P. aeruginosa strain PA01 -- specifically, an RNA-seq study suggests an upregulation in the mexCD-oprJ antibiotic efflux pump, which confers resistance to fluoroquinolone antibiotics.
We used RT-qPCR to confirm the upregulation of the mexCD-oprJ operon, in both PA01 and the virulent strain PA14. However, we noticed a consistent downregulation upon surface attachment, along with an upregulation in the pilus sensing gene pilA, which was used as a positive control. We then visualized a transcriptional reporter for mexCD-oprJ following surface attachment. We observed an increase in fluorescence following attachment, which suggests that promoter activity increases upon surface contact. Lastly, we visualized cell death in the transcriptional reporter following addition of fluoroquinolones in order to further characterize the mexCD-oprJ activity. Taken together, these results confirm that surface attachment is able to influence expression of the mexCD-oprJ efflux pump in P. aeruginosa. However, further experiments are necessary to understand how such expression changes influence the efflux pump activity, and more broadly, the advantages in fitness that are conferred by these changes.

NAAY IDRISS CC'20: ANTHROPOLOGY; COMPARATIVE LITERATURE

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Faculty Mentor(s): Audra Simpson, Columbia University
Title: Readers and Resisters: The Daily Life of Resistance Literature Amongst Palestinians in Lebanon

Abstract: I seek to study the different uses and uptakes of resistance literature. As Barbara Harlow shows, texts by, about, and for the colonized or formerly may reshape culture and identity. Yet neither resistance literature itself nor scholarly treatment of it reveals its reception. Accordingly I ask what actual use people make of resistance literature in society: Who reads it? When? How do they incorporate it into daily life? I am especially interested in how resistant cultural productions are applied and taught, and how this differs across contexts. In the absence of state support for the right of return, for example, how do Palestinian refugees teach resistance across generations, at a remove from personal experience of Palestine? I think about literature and stories as a pedagogical issue. How do people become committed to resistance and imagine it? Do they seek to transfer experiences cultivating resistance in one context to another? How does their work contrast with that of NGOs and Human Rights organizations in Lebanon that attempt to institutionalize resistance? Instead of assuming an extant pedagogy of resistance, I want to study its emergence, what informs its formation and how this varies based on positionality. Methodologically, I combine comparative literature and ethnographic methods to examine not just how society affects and produces literature, but also how this literature produces society (cultural identity, practice, etc.) as audiences engage it. Literature provides a texture to imagination, but what life do the readers bring to the text? My field work was primarily focused on research at the Ghassan Kanafani Cultural Centers in the

Palestinians camps in Lebanon; reading, reading with, interviewing students, teachers, principles, and leading a reading group on resistance literature. This anthropology -- what I have termed 'a literary anthropology of alterity' -- takes seriously the imaginative power of people's worlds and thoughts as they emerge out of one's self. In this sense, my research hopes to treat people's literature, and their thoughts, reflections, affective responses, and experiences, as the 'archives.'

AMY JANG SEAS'22: BIOMEDICAL ENGINEERING

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Faculty Mentor(s): Russell Rockne, City of Hope Comprehensive Cancer Center
Title: Analysis of cell state transitions from multiple time point single cell sequencing data

Abstract: Single-cell RNA-sequencing (scRNA-seq) has become popular in recent years as it provides transcriptional profile at single-cell resolution. This granularity allows for new levels of transcriptomics analysis. scRNA-seq analysis was used to find the effect of a potential treatment for leukemia on the cell state-transition trajectory on mouse progenitor cells. Cells from different time points were collected and sequenced from both the treated cells and control cells undergoing normal differentiation to compare the change in the gene expression profiles and the cellular identities across a linear timeline. Caf1 is an important protein in the cellular plasticity modulation. This cell state plasticity can be utilized to change the differentiation state of normal and leukemic cells.
This dataset is unique in that it is one of the few that has scRNA-seq data at discrete time points. To deal with the high dimensionality of scRNA-seq data, multiple projections were used to portray the data in a more intuitive and lower dimension space. The Leiden algorithm was used to cluster cells and differential gene expression analysis was used to identify cell types. RNA velocity analysis was conducted to estimate the trajectories and potential landscapes of the cells for each time point. Lowering levels of Caf1 caused cells to deviate from the standard hematopoietic differentiation as cells were more likely to head towards a stem-like state. There were more progenitors at later time points and cells were less likely to differentiate. Unexpected cell types were discovered as well, potentially signaling a crossing of branches within the hematopoietic differentiation tree with the reduction of Caf1 levels.

JULIENNE JEONG CC'21: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Attila Losonczy, Columbia University
Title: In-vivo optical imaging of dendritic synaptic activity during place cell formation

Abstract: Spatial memory is a fundamental capacity that allows for all living animals to recall, retain, and create a cognitive map of our surrounding environment. This faculty allows for humans to not only remember where certain events occur and where objects lie in relation to another, but also orient ourselves along the familiar paths in our daily lives. The mechanism of spatial memory is largely attributed to the formation and activation of place cells, located in the hippocampus. While this ability is particularly important, the way in which place cells form is still not known.
Knowing that there is a significant amount of synaptic activity and electrical signals at the level of the dendrites, we propose that dendritic synaptic activity actually drives place cell formation. We can study the signals at the dendrites by performing two-photon optical imaging experiments on neurons with genetically encoded voltage sensors, which we can inject into the cell, a process known as electroporation. Voltage sensors are useful when measuring membrane potentials in cells because they allow a cell to emit light and show fluorescence according to their changes in voltage or membrane

potential. We can then image a single dendrite and extract the changes in membrane potential according to the changes in fluorescence. This two-photon microscopy is performed in-vivo, allowing us to better understand place cell formation in real time, on an awake animal running on a treadmill containing different spatial cues. Thus, by discovering the relationship between place cell formation and dendritic activity, we report on the mechanism of spatial memory.

HELEN JIN CC'20: MATHEMATICS; COMPUTER SCIENCE

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Faculty Mentor(s): Tian Zheng, Columbia University
Title: Enriching Artificial Perceptron Learning: Image Categorization with Weak Supervision

Abstract: While supervised learning has achieved great success in recent years, given that well-annotated training samples are hard to come by in real life, there is a need to solve the problem of automatically identifying correct labels for a large volume of unlabeled data with weak supervision, especially with images in the field of computer vision. The ultimate goal of this project is to construct a novel and effective data-science workflow, Artificial Perceptron Learning (APL), based on machine learning models. The initial dataset under examination here is used to carry out a "virtual" ecological survey to an unprecedented scale. With disasters happening more frequently than ever (in this case cyclonic storms in Puerto Rico's El Yunque rainforest) due to climate change, to be able to understand an ecosystem's vulnerability to them as best as possible, without physically being there or assessing by inefficient ground-based observation is important. Further contributions were pursued to enrich and further the original results this project by trying new pre-trained models to extract better features that could then determine the species (in particular palm and cecropia) of trees in the aerial images, trying classification by texture using the Describable Textures Dataset (DTD) and also a Deep Convolutional Generative Adversarial Network (DCGAN) model approach.

JENNY JIN CC'21: BIOCHEMISTRY

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Faculty Mentor(s): Brent Stockwell, Columbia University
Title: Identification and Validation of a Ferroptosis-Specific Antibody

Abstract: Ferroptosis is a recently-discovered, non-apoptotic form of cell death that is characterized by iron-dependent lipid peroxidation. Studies have found that ferroptosis may play a key role in various degenerative diseases (Alzheimer's, Parkinson's, etc). Inducing ferroptosis may also be a potential therapeutic strategy against several cancers. However, a specific molecular marker of ferroptosis has not yet been developed that can be used to stain cells or tissue samples for the occurrence of ferroptosis. Recently, a potential marker has been identified: 3F3 Anti-Ferroptotic Membrane Antibody (3F3 FMA). The aim of this project was to confirm the applicability and ferroptotic specificity of 3F3 FMA, as well as other potential antibodies for detecting ferroptosis. From immunofluorescence studies, 3F3 FMA showed an increase in cell membrane fluorescence specific to cells undergoing ferroptosis. This membrane localization pattern was not observed in cells undergoing apoptosis, suggesting that 3F3 FMA may be an effective and specific marker of ferroptosis in cell culture. Further development of a ferroptosis marker may in the future help guide disease treatment through the ability to identify ferroptosis in patient samples. Additionally, the identification of the antigen of 3F3 FMA may suggest unexplored mechanisms underlying ferroptosis.

ZACH KAHN CC'20: HISPANIC STUDIES

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Faculty Mentor(s): Bruno Bosteels, Columbia University
Title: Institutional and Individual: Changing Landscape of Movies in Cuban

Abstract: Along with other industries in Cuba, movie watching is becoming a largely private enterprise as the state can not accommodate the industry on its own. Data-shops called "paquetes" sell movies, TV and music to download, serving as the primary medium for Cubans from the comfort of home.
While the film institute ICAIC maintains the best cinemas in Havana, the theater network in the capital and throughout the country has fallen into disrepair. Bad conditions in theaters and the new option to watch any content, any time, anywhere bring attendance down. My research explores the varied reactions across the population, with interviews of movie theater and paquete employees, and the movie public (at home and at the movie theater). Among ICAIC personnel, I interviewed sociological researchers and the heads of programming.
Opinion varies from those who wish to see more commercial, current film in the theaters to those who depend on the programming for their whole social lives. However, nearly everyone agrees on disappointment in the conditions of the theaters, ubiquity and ease of data-sharing movies, excitement for the traditional film festivals, and hunger for new Cuban films. I also focus on the institutional response to this changing landscape of film. The solution to the decline of Cuban film exhibition is closely tied to that of film production, seen in ICAIC's Decree-Law 373 which legalizes independent film production. Today's independent and institutional exhibition, production and opinions will define the future of Cine Cubano.

LINGHAO KONG CC'22: NEUROSCIENCE AND BEHAVIOR; COMPUTER SCIENCE

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Faculty Mentor(s): Peter Sims, Columbia University
Title: Toward Visualization of Active Translation in Dopaminergic Neurons

Abstract: Dopaminergic neurons perform critical functions in the mammalian brain, including regulation of movement, reward, and cognition. Translation of mRNA into proteins is key to proper cellular function, but the distribution of mRNA translation sites within dopaminergic neurons remains unclear. Current techniques to study local mRNA translation in neurons include fluorescence in situ hybridization (FISH), in which specific mRNAs are fluorescently labeled, and ribopuromycylation (RPM), in which actively translating ribosomes incorporate puromycin into nascent peptide chains. While these techniques are powerful, they have limitations. FISH visualizes mRNA location but cannot determine whether the mRNA is being actively translated, while RPM labels all ribosomes and is therefore not cell type-specific. These limitations prevent the visualization of active protein translation specifically in dopaminergic neurons.
This research involves a novel method that overcomes these limitations and achieves "dual specificity": visualizing actively translating ribosomes specifically in dopaminergic neurons. This dual specificity is achieved through a proximity ligation assay (PLA), which detects the proximity of two targets. The first target is the HA tag on ribosomes in genetically engineered RiboTag mice, where an HA-tagged ribosomal protein L22 is specifically expressed only in dopaminergic neurons. The second target is puromycin that has been incorporated into nascent peptide chains of actively translating ribosomes after RPM. Combining RPM with RiboTag mice, this PLA assay forms a powerful visualization tool to study sites of active translation in dopaminergic neurons. Ongoing studies using this technique will accelerate the understanding of subcellular translation in health and disease.

NICO LAQUA CC'22: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Caroline Arout, Columbia University
Title: Eye Movement to Assess Impairment in Virtual Reality

Abstract: Biomarkers of recent drug use and intoxication have societal relevance, in that they are used by law enforcement and other agencies to detect drug impairment. For instance, a breathalyzer can quickly and accurately detect blood alcohol content (BAC) to indicate if a person is under the influence of alcohol; however, there is currently no similar way to quickly detect if a person is under the influence of cannabis. In light of increasing cannabis use, it is important to define a quantitative, objective method of determining recent use and intoxication.
The link between changes in eye characteristics (e.g. movement, pupil dilation) and cannabis use is documented (Peragallo et al. 2013), but insufficiently characterized. Certain outcomes of eye behavior are known to be affected by recent cannabis use (e.g. the eyes' ability to converge on a target; Stapleton et al 1986), while findings are mixed regarding other outcomes (e.g. the eyes' ability to smoothly follow a target; Fant et al. 1998). Thus, the goal of this study is to identify a characteristic pattern of eye behavior, defined by performance on a battery of four eye tasks, as a function of recent cannabis use (7% vs. 0% THC).

SEAN LE VAN CC'22: POLITICAL SCIENCE; STATISTICS

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Faculty Mentor(s): Alberto Spektorowski, Tel Aviv University
Title: Analyzing the Rise of the Far-right in Israel through Computational Text Analysis

Abstract: The purpose of this study is to analyze the determinants of the recent rise of right-wing ideology in Israel and the collapse of the left-wing party Meretz through a quantitative text analysis. Analyzing term usage in Knesset legislative transcripts and Twitter communications of centrist Israeli political parties Kadima and Yesh Atid allows one to track shifts in mainstream Israeli policy positions. Natural language processing techniques have been applied to political communications in order to score document political positions. Some of these precedents in the current state of academic literature include the "Wordscores" and "Wordfish" procedures. The former weights each word equally, while the latter in terms of its frequency. Most current text-as-data methods are geared towards political party platforms and are typically trained to perform well on classifying formal speech rather than social media postings. Thus, the statistical model used in the study is the first to take into account term specificity (differential word frequency) into its classifier, which helps determine the ideology of political text more accurately. Additionally, this study is the first to apply natural language processing techniques to ideologically score political text in Hebrew. Incorporating NLP methods to the Israeli political situation can generate findings applicable to understanding the marked rise in support for the far-right in recent years. Finally, the development of a more accurate text classifier to categorize political texts can be useful in analyzing the surge of far-right parties (and rightward shifts in party policy preferences) in other political contexts.

CHRISTINA LEE CC'21: BIOPHYSICS

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Faculty Mentor(s): Justin L.P. Benesch, University of Oxford
Title: Understanding the evolution of polydispersity in small heat-shock proteins

Abstract: In response to disease or cellular stressors, small heat-shock proteins (sHSPs) are deployed to prevent protein aggregation by assisting in the refolding of aggregated proteins. The dynamic nature of sHSPs results in an array of oligomeric conformations, ranging from monodisperse to highly polydisperse proteins. The degree to which an sHSP is polydisperse has been thought to relate to its function as a molecular chaperone. This study traced the evolution of polydispersity by expressing and purifying vertebral analogs of the human heat-shock protein B1 (HSPB1) along with reconstructions of ancestral proteins. A combination of native mass spectrometry and mass photometry was utilized to characterize the oligomeric states of the expressed proteins. These techniques were used in order to locate the window in evolution during which sHSPs became polydisperse and to begin to understand what characteristics of a protein lead to its polydispersity.

GAYOUNG J. LEE CC'21: COMPARATIVE LITERATURE AND SOCIETY; COMPUTER SCIENCE

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Faculty Mentor(s): Alexandra Watson, Barnard College
Title: 언어, 그 이후: Korean diasporic formations

Abstract: This project examines Korean diasporic identity-formation as it is shaped by language, migration, and citizenship. It focuses on how experiences are shaped by the languages in which they happen (English, Korean, Japanese etc.) and the sociopolitical relationships between languages, arguing for creative writing as a medium through which to bridge comparative Korean diasporic experiences overlooked by traditional areas of study (area/East Asian studies and ethnic/Asian American studies). In doing so, it draws broadly from literature, critical race theory, psychology, studies on the origins of area and ethnic studies, and field work in Japan to weave a narrative arc of coming to understand the self as navigating spaces within, between, and wholly outside of both language and academic visibility. In asking where we turn to when languages fail us because of the social contexts in which they are defined, this project proposes new beginnings: self-expression through dance; through code-switching; through reconnecting with heritage languages and learning new vocabularies for understanding the self.

YOUNGWEON LEE CC'20: FRENCH; CLASSICS

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Faculty Mentor(s): Pierre Force, Columbia University
Title: Les femmes et la poésie au XVIIe siècle: une analyse à partir d 'Antoinette Deshoulières

Abstract: Youngweon spent her summer in Paris through the Beesen Global Research Fellowship, working on her French senior thesis about women and poetry in the first half of the 17th century in France. In particular, she looked at the social norms and conventions that created barriers between women and poetry, and looked at one successful female poet of the era, Antoinette Deshoulieres, and closely studied her poetry using databases such as the Bibliothèque nationale de France and various French and European thesis databases. In addition, Youngweon looked at why Deshoulières and some other female poets were more accepted in educated societies than others, attempting to untangle the complex societal rules of the 17th century French aristocracy that closely affected the literary scene. Youngweon worked closely with her thesis advisor, Professor Pierre Force from the Department of French and Romance Philology, as her summer research advisor.

LEXIE LEHMANN CC'20: URBAN STUDIES

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Faculty Mentor(s): Frank Guridy, Columbia University
Title: CityWalk BHAM: Reparations for injustice through urban placemaking

Abstract: In 2015, eight plaintiffs filed a complaint against the Alabama Department of Transportation (ALDOT) and the Federal Highway Administration, attempting to reverse a decision to "authorize, fund, and otherwise advance construction" of improvements to Interstate 59/Subsection 20 (I-59/20), which runs directly through Birmingham, Alabama. The Interstate was built in the 1960s in the center of a segregated black neighborhood, resulting in the displacement of thousands of residents. Following the lawsuit, ALDOT enlisted consultant support to reclaim the area underneath the underpass as dedicated public park space. The space was also subject to a comprehensive re-branding campaign entitled, "CityWalk BHAM: Where Birmingham Connects." The goals of this research were twofold: first, to uncover primary evidence on Interstate 59-20's construction and controversy, and second, to use ethnographic methods to assess the likelihood that a public space in the underpass will be a successful and lively gathering point for this community. The research concludes with the proposal that community-driven urban placemaking be used as a useful strategy of empowerment for urban centers.

DEBBIE LEUNG CC'21: ENVIRONMENTAL BIOLOGY; COMPUTER SCIENCE

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Faculty Mentor(s): Stephen Palumbi, Stanford University
Title: Cobbling Together Patterns of Biodiversity within Kelp Forest Ecosystems

Abstract: Kelp forests are arguably one of the most diverse ecosystems on the planet dominating 150,000 km of global temperate coastline that rival the coastal occurrence of coral reefs. However, in recent years, ecological disturbances led to elevated recruitment of sea urchins which resulted in destructive grazing of kelp forests, thereby negatively affecting the recruitment of commercially important species such as abalone. To this end, we employ "Wild Reef Monitoring System" (WRMS) that incorporates DNA metabarcoding of bulk material to sample cobbles covered with crustose coralline algae within kelp forests along the Californian coast to 1) examine cobble community composition along a latitudinal gradient within kelp forest ecosystems inside and outside marine reserves and 2) survey for the presence of abalone species that have faced a population decline during the 2014-2016 warming event across the Pacific North coast of America. This study provides an opportunity to examine species composition at a small scale and detect larval settlement of commercially important species. With this baseline of species diversity and community composition along the Californian coast, the findings can be used to assess species trajectories when exposed to anthropogenic disturbances and climate change to better inform monitoring practices of multi-species assemblages within kelp forests.

THOMAS M. LI CC'20: BIOCHEMISTRY

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Faculty Mentor(s): Theresa T. Lu, Hospital for Special Surgery
Title: Type I interferon regulates Langerhans cell ADAM17 activity in lupus

Abstract: Photosensitivity is a hallmark feature of systemic lupus erythematosus (SLE), among other dermatological conditions, which leaves SLE patients with not only disfiguring skin lesions but also systemic disease flares, renal complications, and lymphadenopathy after exposure to ultraviolet radiation

(UVR) (1-4). Our lab has shown that a Langerhans cell (LC)-keratinocyte axis limits UVR-induced keratinocyte apoptosis and skin injury via keratinocyte epidermal growth factor (EGF) receptor stimulation (5). This mechanism is dependent on LC ADAM17, a metalloprotease that cleaves LC EGF ligands, activates keratinocyte EGF receptor (EGFR), and protects the skin. Transgenic mice lacking LC ADAM17 and photosensitive lupus mice have weakened epidermal barrier function, retain lower LC numbers, and have reduced Adam17 mRNA compared to wildtype mice (5). Yet the mechanistic underpinnings that regulate ADAM17 activity and expression at homeostasis and disease are not well understood. In the present study, we show that IFN-I is necessary to decrease LC ADAM17 activity in vitro and in vivo and sufficient to rescue ADAM17 activity in lupus mouse models. We also show that lupus mouse models have an interferon signature, suggesting that anti-IFN α/β receptor 1 (anti-IFNAR1) treatment may alleviate photosensitivity. Together, our data may provide an explanation of how IFN-I can contribute to LC ADAM17 dysfunction in lupus.

GRACE LIM CC'22: SOCIOLOGY

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Faculty Mentor(s): Yao Lu, Columbia University
Title: Asian American Studies: Then and Now

Abstract: The purpose of this research project is to study the legacy of Asian American student activism on college campuses during the 1960s and 1970s. The first step of this project involved studying the history of Asian American student activism, and more specifically, Third World Liberation Strikes of 1969 that united Black, Asian American, and Chicano students at the University of California Berkeley and San Francisco State University for the development of an Ethnic Studies program at the two campuses. The second step aimed at comparing and contrasting the goals and outcomes of the Third World Liberation Strikes with the Ethnic Studies departments at modern-day institutions of higher learning, which were studied through interviews with faculty members at the University of California Berkeley, University of California Los Angeles, and San Francisco State University who were participants of the strikes of 1969 and are now professors of Asian American Studies at their respective institutions.

TINA LIN CC'22: MATHEMATICS

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Faculty Mentor(s): Darcy Kelley, Columbia University
Title: Underwater Acoustics Locoalization

Abstract: The objective of this research is to illustrate and determine, within meters, the localization of sound generated by a source underwater. In this case, the team has developed a system to localize the calls of an aquatic frog, Xenopus laevis (X. laevis). The purpose of this work is to support research by the Kelley Lab of Columbia University in the City of New York in the study of animal behavior for the genus Xenopus and the hybridization of the species of that genus. The team conducted the research through the use of free software and commercially available, off-the-shelf hardware at a nonman-made pond approximately 50 by 80 meters in dimension located in Hyde Park, NY. At this pond, the team developed and deployed an array of hydrophones, square in shape with 4.3 m sides, which enabled us to record the calls. To localize the sound source, the recordings produced were processed in order to estimate the Time Difference of Arrival (TDOA). Once this was determined, a second algorithm would locate the source using a linearized multilateration method.

LEO LO CC'22: PHYSICS; MATHEMATICS

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Faculty Mentor(s): Dmitri Basov, Columbia University
Title: Hyperbolic plasmonic waveguide modes in BSCCO(2212) heterostructures

Abstract: Room-temperature superconductors, if realized, would drastically reduce energy consumption in today's electricity-driven world. Unconventional superconductors, such as Bi2Sr2CaCu2O8+δ (BSCCO), have to date the highest superconducting temperatures at ambient pressure, promising a path towards room-temperature superconductivity. However, there is no consensus on the underlying mechanism for unconventional superconductivity; in particular, the optical properties of superconductors are underexplored. In this work, the optical responses of optimally doped BSCCO heterostructures, at 10 K (superconducting phase) and 100 K (strange metal phase) at the far-infrared and terahertz (THz) range (100-2000 cm-1), is studied numerically. Graphene is included in the heterostructure to probe the plasmonic response of BSCCO. The frequency- and in-plane-momentum-dependent reflection coefficient (rp) is calculated using the transfer matrix method. For thin BSCCO slabs, rp dispersion plot confirms the existence of hyperbolic waveguide modes. For BSCCO heterostructures with graphene, rp dispersion demonstrates that graphene plasmon enhances BSCCO waveguide modes. Such enhancement is most prominent beyond a threshold separation distance between the graphene and BSCCO surface. Using the lightning rod model developed by McCleod et al. (2014), scattering-type scanning near-field optical microscopy (s-SNOM) signal is calculated and confirms that graphene enhances BSCCO waveguide mode. Furthermore, s-SNOM signal reveals an observable difference between the superconducting and strange metal phase. Therefore, this work identifies s-SNOM signal as a clear experimental probe to systematically investigate BSCCO's far-infrared and THz optical behaviors for future experimental studies of high-temperature superconductors, catalyzing the eventual realization of room-temperature superconductors.

MULAN MADDEN CC'22: ASTRONOMY

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Faculty Mentor(s): Brian Svoboda, National Radio Astronomy Observatory
Title: Observing CH3OH in the Hot Corino NGC 1333 IRAS 4B1 with the Very Large Array

Abstract: Hot corinos are very hot, small, low-mass protostars that heat their surrounding material. That material consists of interstellar gas and dust grains that have interacted with each other to form ices. Before a hot corino forms, there was a colder starless core. When gaseous molecules landed on dust grains, they froze around temperatures ranging 10 - 20 K. The ices reacted with one another to create more complex molecules that couldn't form otherwise. Hot corinos caused these ices to sublimate, which is how hot corinos are also known to have high abundances of complex molecules. Methanol (CH3OH) is the "simplest" complex organic molecule (COM), which makes its molecular structure easier to observe than other COMs. We looked at ten CH3OH transitions using the Very Large Array (VLA) in C configuration with a beam size of 0.3". We aimed to extract the spectra and plot a rotation diagram, from which we could estimate excitation temperatures and calculate total molecular column densities of the gas. Excitation temperature dictates the population of atoms' energy levels, and total molecular column density is the number of molecules per unit area along the line of sight. Future and ongoing work involves the seven inverse transitions of ammonia (NH3) that were observed at the same time as the CH3OH data.

CAROLINE MAGALHAES DE TOLEDO CC'21: BIOLOGY

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Faculty Mentor(s): Clarissa Waites, Columbia University

Title: The effects of Rab35 on Exosome Release in Cortical Neurons

Abstract: Alzheimer's Disease (AD) is the most prevalent cause of dementia and the 6th leading cause of death in the United States. The most prominent clinical features of AD are cognitive impairment, memory loss and behavioral changes. Its pathophysiology is marked by the presence of agglomerates of amyloid beta and the microtubule associated protein Tau. Neurons are known to release exosomes, small extracellular vesicles 30-150 nm in diameter. These vesicles are of interest to the study of how protein aggregates spread between neurons. Exosome secretion relies on protein trafficking pathways within the cell. Studies on other neuronal cell lines suggest a role of Rab GTPases, a class of proteins involved in protein trafficking, in exosome biogenesis. The central aim of this study is to determine the effects of Rab35 overexpression and knockdown on exosome release and size in cortical neurons, astrocytes and N2a (mouse neuroblastoma) cells. Although it has been shown that Rab35 is involved in exosome release in oligodendrocytes, it is relevant to know whether this finding is cell specific or it holds for other neuronal cell lines. Preliminary findings suggest that Rab35 overexpression and knockdown do not have a clear effect on exosome release or size in cortical neurons or N2a cells.

ALEXANDRIA MALILAY CC'22: ENVIRONMENTAL BIOLOGY

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Faculty Mentor(s): Cherie Motti, Australian Institute of Marine Science

Title: Monitoring the Crown of Thorns Starfish and Giant Triton Snail

Abstract: The crown-of-thorns seastar (COTS) is a starfish with up to 23 arms and spanning two to three feet. These massive animals are one of the main contributors to the destruction of the coral reef. They feed on nearly all types of corals and can eat their own body surface area worth of coral in a single night. The giant triton snail is one of COTS' few predators that is resistant to the toxins produced by COTS. However, the sea snails are few in number due to overfishing, and there is not much knowledge on their behavior or larval stages.
Alexandria worked on a couple of different projects at the Australian Institute of Marine Science in order to lessen the devastating impact of COTS on the Great Barrier Reef. She reared giant triton larvae with an array of feeding treatments, analyzed video data to understand the interactions between COTS and giant tritons, and tested the impact of triton toxins on COTS. Alexandria also extracted COTS toxins from seawater and used 3D imaging software to quantify the toxins produced per animal.

VAIBHAV MANGIPUDY CC'22: BIOLOGY; COMPUTER SCIENCE

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Faculty Mentor(s): Chao Lu, Columbia University

Title: Designing and Evaluating the Potential of Novel Classes of Epigenome Editing Tools

Abstract: Beyond the sequences of base pairs in DNA, several complex regulatory mechanisms exist that modulate the expression of genes. Given that two meters of DNA must fit into a nucleus smaller than a pin-head, the accessibility of genes and the storage of genetic material in our cells is specifically regulated. DNA is coiled around proteins called histones, and groups of those histones are referred to as the nucleosome. Together, histones and DNA wrapped around them compose chromatin. Each histone

possesses amino acid tails that can be modified by the topological addition of chemical groups. These modifications serve as binding sites for chromatin remodeling proteins that read, write, or erase these chemical marks, subsequently changing genome accessibility. Together, these histone chemical modifications, and modifications of the DNA, comprise the so-called epigenome. The onset of several human diseases including certain cancers can be traced to mutated histone tails or chromatin remodeling proteins, which subsequently lead to an aberrant state of the epigenome and inappropriate gene expression.
Discoveries of CRISPR systems have led to increased discussion regarding their use in genome editing, but their use in epigenome editing is less well known. In this project, the potential of fusing certain chromatin remodeling proteins and metabolic enzymes to nuclease-deficient CRISPR systems in an effort to locally modify the epigenetic landscape was explored. This technical development may be a potent way to study molecular mechanisms underlying chromatin related disease models and perhaps even offer avenues for correcting abnormal chromatin states in associated human diseases.

ANDREW MATHEWS GS: POSTBACCALAUREATE PREMEDICAL STUDIES

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Faculty Mentor(s): N/A
Title: coffee talk

Abstract: Over 50% of a coffee cherry is wasted in the process of getting to the bean that we roast and grind to brew a cup of coffee. Most of the time it is spread over crops or used for animal feed. However, this waste could be used to produce many sustainable disposable products first.
I am working to develop a coffee cup that is made from 100% coffee. The wax in the cherries will be used to create a liner for the cups. The fiber and cellulose will be used to make the paper for the cup. The sugars will be used to make the glue for the seam of the cup. Alternatively, other viable products that could be made are disposable paper plates, napkins, utensils, paper towels, cardboard, bubble wrap, etc. The waxy liner currently used in coffee cups is really a polyethylene plastic that is not truly biodegradable. This research hopes to help change that. It also hopes to change a large portion of the disposable products and packaging industries.

FRANCESCA MERRICK CC'20: PHILOSOPHY

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Faculty Mentor(s): Christia Mercer, Columbia University
Title: Epistemic Authority and Civil Displacement: How denial of epistemic authority affects conceptions of self-agency, space and belonging, and modes of expression within marginalized and underserved communities

Abstract: Epistemology is the study of knowledge: how we come to know what we know, what knowledges are considered valuable, and who or what grants authority to certain knowledges. Francesca Merrick, in her work "Epistemic Authority and Civil Displacement", contemplates these issues with regard to social systems of knowledge that grant epistemic authority (power) to certain groups of privileged peoples, while denying that authority to certain marginalized communities.
Merrick draws on contemporary thinker Sally Haslanger to explore issues of how epistemic injustice and authority are juxtaposed onto structural systems of knowledge. Specifically, Merrick uses Haslanger's commitment to normative epistemology (with justice-orientated action, rather than comprehensive theory, as its goal) as an as an intellectual road-map for identifying social schemas of knowledge in

communities silenced via systems of carceral control. Issues of mass incarnation and epistemic authority are inseparable: 75% of incarcerated adults are functionality illiterate. How do communities denied formal education come to see themselves as knowers? What knowledges are hidden or even silenced in those denied the epistemic authority to be taken seriously? Finally, what consequences should the undeniable relationship between epistemic injustice and overly-incarcerated communities have on policy surrounding prison and education reform? Merrick proposes a systematic approach to identifying paradoxes in truth conditions (i.e. when different conclusions are reached about a subject, both satisfying truth conditions) within our legal system as a way of investigating knowledge schemas that may be hidden or oppressed. These areas of confusion, she argues, are ideal starting places for direct action and policy implementation.

ELIZABETH MERRIGAN CC'20: POLITICAL SCIENCE

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Faculty Mentor(s): Andrew Nathan, Columbia University
Title: Assessing the frames of press coverage of Huawei between 2017 and 2019 in the US, UK, Canada, and Australia

Abstract: Huawei, the Chinese multinational ICT manufacturer, has emerged as a controversial frontrunner in the market for cheap, efficient smartphones and the world's largest supplier of telecommunications network equipment. On the one hand, Huawei and its success represents China's rise to economic and technological prominence in recent decades, as well as its rapidly growing eminence as a major player in the race to implement next-generation 5G networks. On the other, countries are divided over the degree to which Huawei's technology poses a threat to national security. This study, based on previous studies on media visibility, attempted to better understand the narratives that have taken shape around Huawei over the last two years, how prominently they appear in publications of different countries, and the extent to which those findings correlate with the technological and geopolitical priorities of those countries. Scholars have argued that the volume of stories in news media dedicated to particular topics or issues has an effect on public awareness of those topics. Moreover, prominent publications have "inter-media agenda-setting power" that influences the reporting approaches and narratives of other sources and audiences. Thus, this study used content analysis to identify and visually represent the hierarchy of major, mid-level, and sub-frames of Huawei coverage in the United States, the United Kingdom, Canada, and Australia.

COLLINS MOKUA CC'21: NEUROSCIENCE

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Faculty Mentor(s): Kathleen Pike, Columbia University Medical Center
Title: Mental Health in Kenya; A desk review on the current state of metal health in Kenya

Abstract: Majority of Kenyans live in rural areas yet majority of health facilities are in urban areas. Use of health care services is inequitable as hospital services are increasingly pro-rich. As a consequence, poor and disadvantaged communities suffer more from common mental disorders and their consequences.
Research methods included a desk review using Google Scholar, CLIO, and JSTOR to identify potential articles, papers and government documents. Identified sources were narrowed down by reading the abstract and selecting the most relevant and applicable for inclusion.There exists a severe shortage of mental health facilities and health professionals. Public psychiatric patients are attended by the 600-bed Mathari psychiatric hospital also in Nairobi and seven provincial and six district hospitals with about 20 beds each across the country. Prevalence of depressive disorders is 4.4% and Anxiety disorders at 3.1%

and these attributed to 8.3% and 2.9% of total YLD respectively. Yet, mental health only accounts for less than 1% of the health budget. Prevalence of mental illness in Kenya is similar, and higher in some cases, to high-income countries. However, there are strong competing priorities such as infectious disease, malnutrition, unsafe drinking water, malaria, and increasing rates of chronic diseases. A systemic focus on psychosis has led to signs of depression of anxiety not to be recognized as mental illness and negatively affected care seeking behaviour. Non-profit organizations are the most promising stakeholders making moves to improve mental health.

CHRISTINA MONNEN CC'20: ENVIRONMENTAL BIOLOGY

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Faculty Mentor(s): Sarah M. N. Woolley, Columbia University
Title: Effects of Long-Tailed Finch (Poephila acuticauda) Cross-Tutoring on Juvenile Bengalese Finch (Lonchura striata domestica) Song Development

Abstract: Acoustic communication requires agreement between parties on the significance of an auditory stimulus as well as coordinated specialization of mechanisms for vocal production and auditory perception. Among finches of family Estrildidae, song learning is a complex process in which adults tutor young birds on species-typical songs. Existing literature suggests song syllables and syntax may be coded neuronally by separate circuits, with syllable copying being accomplished during development and influenced by exposure to tutors but syntax being predetermined for the species regardless of tutor exposure. This study explores whether juvenile Bengalese finches (Lonchura striata domestica, BF) cross-tutored by adult long-tailed finches (Poephila acuticauda, LF) develop songs with BF-typical syllables arranged in BF-typical probabilistic or LF-typical deterministic syntax. One group of BF nestlings was transferred into an LF nest to be raised and tutored by foster LF parents while a second group remained in the natal BF nest to be raised and tutored by conspecifics. Individuals of both were recorded weekly from approximately 50 to 120 days post-hatch. Recordings were analyzed for similarity, transitions, frequency power spectra, and modulation power spectra to determine how cross-tutored BF songs differed from those of the tutor, genetic father, or normal-reared counterparts. Ultimately, cross-tutored male BFs attempted to incorporate LF-typical upsweeps into a fundamentally BF-typical song with a more stereotyped syntax than that of a normal-reared BF, suggesting that both syllables and syntax are affected by learning. This project hopes to shed light on the mechanisms underlying BF song development and the extent to which finch song may be genetically coded or learned.

CHANDLER MORRIS CC'22: ENVIRONMENTAL SCIENCE

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Faculty Mentor(s): Roisin Commane, Columbia University
Title: Calculating the Whole Ecosystem Methane Flux in Harvard Forest, MA

Abstract: Understanding and quantifying sources and sinks of methane (CH4), a potent greenhouse gas, is essential in order to create a global methane budget. Recently published papers identify forests as a significant source of methane. However, these findings do not account for the methane flux through the forest and, therefore, are not representative of the net ecosystem. The main goals of this project are to develop an understanding of the whole ecosystem methane fluxes, the functional relationship between methane uptake by soils, and environmental drivers, as well as to put an upper limit on forest canopy emission of methane.

I used flux-gradient methods with methane data from Harvard Forest, MA to calculate the whole ecosystem methane flux. Data was taken from eight levels of a 28 meter tower in Harvard Forest, the lowest level being closest to the forest floor and the highest at the top of the canopy. The data indicates that methane concentration rises with height, showing that there is a large intake by soil. Comparing methane concentration to time of year shows that there is a hysteresis to the methane flux. I compared the methane data to soil temperature and moisture data from Harvard Forest and found that environmental drivers impact soil uptake of methane. Using differences in methane concentration between the top and bottom levels of the tower, I found that forest canopy emission of methane would be of the same order of magnitude as soil uptake, making the methane flux out of the canopy approximately zero.

RACHAEL MOW CC'22: CHEMISTRY

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Faculty Mentor(s): Colin Nuckolls, Columbia University
Title: Tuning the Electronics of Organic Perylene Dimer Dyes

Abstract: This project describes methods to synthetically create novel materials for high performance in solar cells and molecular wires as future electronic components. The components being varied have highly electron withdrawing properties as a method to modulate the different electronic states of the molecules. This project explores synthesizing different molecular groups to modulate these energy levels for optimal electronic performance. Because these electronic groups have varying associated sizes, there is also interest in the resulting overall shape of the molecule. Investigation into the properties of these withdrawing compounds through collaborations with other group members has revealed a successful lowering of the LUMO electronic level with increasing withdrawing strength, as well as influences on the mobility of the molecule and effective use in organic photovoltaic applications. Ongoing research is drawing from the data found in this project and utilizing the results to expand on the synthesized compounds to make new molecular structures and look further into their properties and applications.

NICHOLAS O'BRIEN CC'20: BIOCHEMISTRY

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Faculty Mentor(s): Carol Prives, Columbia University
Title: PPARα activity is modulated by the MDM2-X complex in ferroptosis

Abstract: Ferroptosis is a recently discovered type of iron-dependent, non-apoptotic cell death that results from uncontrolled lipid peroxidation. While several drugs have been shown to have the ability to induce ferroptosis, the molecular regulators involved are still being studied. The Prives lab has previously shown that the MDM2-MDMX (MDM2-X) complex is necessary for ferroptosis to occur, and that the role the MDM2-X complex plays is independent of its well-known role in p53 regulation. The target of the complex that mediates its activity in ferroptosis, however, is yet to be discovered. In this study, the nuclear receptor PPARα was evaluated as a potential downstream target of the MDM2-X complex in ferroptosis. He observed that cellular sensitivity to ferroptosis can be modulated by altering the activity of PPARα. Most significantly, while blocking the activity of the MDM2-X complex blocks ferroptosis, simultaneously blocking PPARα activity suppresses this blocking of ferroptosis. Further, using downstream targets of PPARα as a proxy for its activity, blocking the activity of the MDM2-X complex was shown to upregulate PPARα activity basally. He postulates that PPARα is modulated by the MDM2-X complex in ferroptosis, and that the resistance to ferroptosis observed by blocking the MDM2-X complex is a result of increased

PPARα activity. The exact mechanism by which the MDM2-X complex can modulate PPARα activity is a subject of ongoing studies.

JEREMY ORLOFF GS: POSTBACCALAUREATE PREMEDICAL STUDIES

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Faculty Mentor(s): Victoria Rosner, Columbia University
Title: On the Frontlines: Nursing Leadership in Pandemics

Abstract: On the Frontlines: Nursing Leadership in Pandemics is a faculty working group in the Center for the Study of Social Difference. Jeremy Orloff serves as the group's coordinator and joined a delegation of nurses who traveled to Sierra Leone and Liberia in August 2019. The goal was to record oral histories from nurses and midwives who were active during the 2014-2016 Ebola crisis. 39 interviews were collected and each level of the healthcare system was represented. Among those interviewed were administrators from the ministries of health and frontline workers who cared for the sick and dying in Ebola Treatment Units. Two of the nurses interviewed were themselves survivors of Ebola and nearly every person the group encountered had a story of personal loss and heroism.
A team of specialists in sociology, nursing and oral history collaborated to create a framework for interview questions. Areas of inquiry included Ebola clinical experience, community experience, and communication with local and global health authorities. Of particular interest to the group were the role of gender, the training available to nurses and midwives before and during the crisis, and local customs around illness and death. While systematic analysis of these oral histories continues, a number of themes have emerged. Common among these healthcare workers is a sense that their sacrifices during that time were never compensated, honored or memorialized. In addition, many of the nurses spoke of the stigma they faced during the crisis, as they were ostracized from their families and communities.

CHERYL PAN CC'21: NEUROSCIENCE

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Faculty Mentor(s): Tracy Young-Pearse, Harvard Medical School/Brigham & Women's Hospital
Title: Characterizing Astrocytes Derived from HiPSCs to Study Alzheimer's Disease

Abstract: Alzheimer's disease (AD) is a progressive neurodegenerative disease that currently affects more than 5 million people in America, and this statistic is expected to nearly triple by 2050. AD is characterized by the destruction of healthy neurons in the brain due to extracellular amyloid plaques and intracellular neurofibrillary tangles. The exact cause of the pathogenesis of AD, however, is still unknown and there is no cure. Recently, there has been a growing interest in examining the role that astrocytes play in underlying molecular pathways contributing to AD. Therefore, it is essential to develop a robust experimental system of human iPSC-derived astrocytes to study how astrocytes can serve as a therapeutic target for AD. This project utilizes astrocyte reporter lines and AD patient- derived iPSCs to compare two differentiation protocols for culturing hiPSC-derived astrocytes: one based on dual SMAD inhibition (DSEB) and one based on overexpression of Sox9 and NFIB (iAST). Immunofluorescent staining and protein expression characterization for astrocyte-specific markers demonstrated that compared to DSEB astrocytes, iAST astrocytes show more biologically relevant morphology of cytoplasmic processes and stellate cell shapes, as well as more consistent protein expression across lines with different genetic background. The iAST differentiation protocol successfully established iPSC-derived astrocytes from both astrocyte reporter lines (ALDH1L1-GFP iPSCs) and AD- patient samples, demonstrating great potential

as a novel tool for further investigation and modeling of AD-specific phenotypes in iPSC-derived astrocytes.

JULIA PARSLEY CC'22: BIOCHEMISTRY

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Faculty Mentor(s): Virginia Cornish, Columbia University
Title: Peptide Containing Hydrobead Based Biosensor for Physical Force

Abstract: As the field of living materials grows, an easily implemented method for interfacing physical force and biological response on a macroscopic level becomes increasingly necessary in order to make possible a generation of living materials with engineered responses to physical stimuli, including the ability to self heal. Therefore, it is of interest to create an easily produced and scalable macroscopic biosensor for physical force. Such a biosensor must rely on the physically induced release of a stimulus that can incite a biological response. Consistent stimuli across biological domains are peptide hormones and pheromones. Hydrobeads, spherical materials able to absorb much water, have been used for peptide entrapment, and bursting leads to propulsion of contents. Thus peptide containing hydrobeads are an attractive candidate for macroscopic communication of stimulus.
The purpose of this study is to develop a hydrobead based biosensor in which bursting of the hydrobead leads to release of peptide, which is sensed by surrounding cells. Saccharomyces cerevisiae alpha factor (ScPep) was the peptide chosen for entrapment in beads, and yeast derived from BY4741 with pheromone response pathway engineered for fluorescence output upon ScPep detection were employed for sensing. Chitosan-PPA ScPep beads were formed via extrusion dropping and placed in soft agar containing yeast, beads were popped, fluorescence was quantified over several days. Yeast exposed to popped beads exhibited generally higher, occasionally significant fluorescence compared to yeast exposed to intact beads depending on formulation. Future efforts will focus on improving consistency of bead performance to ensure reproducibility of biosensor function.

RADHIKA PATEL CC'22: MEDICINE, LITERATURE AND SOCIETY

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Faculty Mentor(s): Daniel Salzman, Columbia University
Title: How crucial is the basolateral amygdala in cue-induced eating?

Abstract: Feeding behavior is influenced by a multitude of internal states, such as hunger and thirst. However, there are many external cues including visual and auditory senses that also trigger similar behaviors. Therefore, it is important to study such external cues that contribute to overeating behaviors and could eventually lead to weight gain and obesity. It has been suggested that the brain's basolateral amygdala (BLA) is involved in this behavior. This study aims at exploring how crucial the BLA is in cue-induced eating (CIE).
The Salzman Lab has developed a paradigm of CIE in mice and has begun to analyze the role of the BLA in this eating behavior. Using this paradigm, the BLA was inactivated using chemo-genetics. With a bilateral injection surgery, hM4Di was injected into the BLA and behavioral tests will be performed to observe whether this behavior of CIE continues in the absence of a functional BLA. Additionally, a paradigm of CIE that is outcome-specific is being developed. The experiment questions whether mice engage in similar feeding behavior when presented different food rewards. Lastly, it has been suggested that other parts of the brain may also be involved in CIE. For example, it is unclear how downstream brain regions are influenced by neuronal activity in the BLA. Specifically, the projection from the BLA to the

nucleus accumbens is a target of study because this pathway is known for its involvement in reward seeking behavior. Recently, the central amygdala has also been hypothesized to have a role in CIE.

SANJAY PAUL CC'20: HISTORY

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Faculty Mentor(s): Elizabeth Blackmar, Columbia University

Title: Of Lecturers and Lodges: Populism, Coalition, and Schism in Late 19th Century American Politics, 1880-1896

Abstract: In the mid-1870s just north of Austin, Texas, a group of farmers assembled in a small town called Lampasas to found what would become the largest Third Party movement in United States history. Since the collapse of the People's Party, the papers and remembrances of the populists of the Farmers Alliance and the People's Party have been collected in Austin. This past August Sanjay travelled to Austin, Texas to look at the various materials in the Briscoe Center for American history. He saw and studied official newspapers, county log books, Alliance ledgers, and personal letters. All of these materials will help him to better understand the origins of the Farmers Alliance and the concept of populism.

JESSICA PENG SEAS'22: COMPUTER SCIECE

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Faculty Mentor(s): Shih-Fu Chang, Ishaan Jhaveri, Svebor Karaman, and Xu Zhang, Columbia University, Berkeley University

Title: Political Visual Literacy Project

Abstract: Introduction. With recent events and the 2020 election, the resurgence of far-winged political groups and other extremist groups have become prevalent. A problem for photojournalists in the field is often a lack of information to identify these groups in the midst of protests and rallies. Symbols of the group could be as tattoos, on hats, shirts, flags, etc. The goal of the research is to create an application that allows photojournalists to have an updated tool in order to be able to correctly identify these groups through symbols and give an accurate representation of events. Methods. Data was collected through google crawl images and the team reached out to photographers who recorded political rallies. Blender was also used to augment and render flag data with different wind speeds, lighting, and camera angle of flags with symbols. Google's object detection Faster RCNN model was used to detect objects such as flags, shirts, cars, people, etc; in pictures and the object annotation tool was used to highlight ground-truth borders of symbols. Python's PIL imaging library was used to paste augmented images into training data. Results. Sift-based matching was successfully able identify different symbols. A model for identifying flag symbols is currently being developed and trained with augmented data. Future Steps. For the future, the lab will be working on extending the application to identify individual symbols above high risk objects, improve the detection of 5 symbols in particular, and present the application to the NYC Media Lab in September.

DUDA PENTEADO CC'21: FILM AND MEDIA STUDIES

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Faculty Mentor(s): Alan Stewart, Columbia University

Title: A Shakespearean Re-Imagination: Unravelling Inclusive Production Practices and Artist of Color Experiences at the Globe

Abstract: This project is centered around understanding Shakespeare's Globe re-imagination of Shakespearean theatre as an inclusive art form for creatives of different ethnic and racial backgrounds. The project takes into account how creatives are fostering a new view of Shakespeare, moving away from crystallized notions of Shakespearean Theatre as an exclusive white British patrimony. Data was gathered from different interviews available through the Globe's Such Stuff podcast and from archival recordings of events at the Globe. Common themes throughout the interviews included discussions around casting practices, staging elements, the multicultural nature of Britain, and social engagement in the theatre. The aim of the research was, firstly, to understand the experiences of actors and other creatives of color working with Shakespearean text and performance, and, secondly, to unravel the different production mechanisms and practices that enable a conversation about Shakespeare and race in different contexts, fostering an atmosphere of true inclusion, dialogue and change. Understanding the Globe's successful inclusive programming can help understand how other organizations may foster inclusion in their practices.

KLARA POKRZYWA CC'21: ENGLISH AND CREATIVE WRITING

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Faculty Mentor(s): James Cetkovski, University of Oxford
Title: The Astral Moment: Poetic Mysticism in T.S. Eliot and H.D.

Abstract: During World War II, T.S. Eliot and H.D. were both living in England, and bore witness to the devastation the war wrought on the country they had chosen to make their home. This experience prompted them to reevaluate their relationship with art, religion, and community. The resulting works are Four Quartets and Trilogy, major modernist poems that engage with mystical traditions in very similar ways. This project examines the poets' search for religious and poetic clarity, giving particular attention to the relationship of language with the unknown and the divine. There are few critical works that put these poems in conversation together, especially in this way—understandably, as Eliot's Anglo-Catholic beliefs and H.D.'s arcane occultism do not present as practices that share much ground. Reading these poems together with a focus on several large ideas, however, results in a rich spectrum of overlap that elucidates the aim and structure of both works. The conclusion of this project is that Four Quartets and Trilogy share a common mythological and religious ancestry that allows them to particularize the broad traditions with which they both engage in the concrete details of their idiosyncratic mystic practices.

ISAAC POPE CC'22: PHYSICS

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Faculty Mentor(s): Charles J. Hailey, Columbia University
Title: GAPS Module Hermeticity Assessment

Abstract: The General AntiParticle Spectrometer (GAPS) experiment aims to detect cosmic ray antinuclei produced in the annihilation or decay of dark particles. GAPS uses an array of lithium-drifted silicon (Si(Li)) detectors to track incoming antinuclei and outgoing annihilation products. GAPS is scheduled for a long duration balloon (LDB) flight in late 2021. The detectors are prone to humidity and environmental contamination and so are enclosed in modules that are pressurized and purged with nitrogen gas. For this project, a pressurized module was tested and examined to find leaks which would expose the detectors to contaminants in the ambient environment. Module design issues were noted for the future production of flight modules and changes to the module construction were made. The differential pressure in the module was measured and fitted in order to find the time constant for pressure loss in the

module before and after each successive change in order to test the effectiveness of those changes. The time constant, which was under ten seconds before any changes to the module construction were made, was recently measured to be approximately 240 minutes. Tests are currently being done to confirm the current time constant.

ARYA RAO CC'22: BIOCHEMISTRY

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Faculty Mentor(s): Peter Andolfatto, Columbia University
Title: Parallel Molecular Evolution of Cardenolide Resistance in D. melanogaster

Abstract: A significant number of unrelated herbivorous insects have repeatedly and independently evolved the ability to feed on plants that produce toxic secondary compounds called cardenolides. Cardenolides inhibit the function of Na+,K+-ATPase, a medically important enzyme necessary for many processes including neural function and muscle contraction. This evolved insensitivity, which occurs via a small subset of adaptive substitutions, is of interest in understanding the mechanisms of adaptive evolution. The frequently observed adaptive substitutions at two sites, 111 and 122, were evaluated using genome engineering of Drosophila melanogaster (the common fruit fly). After the homozygous lethality of adaptive substitutions at these two sites was realized, a phylogenetically correlated substitution, A119S, was identified and was then found to ameliorate the deleterious effects of substitutions at 111 and 122. Further genome engineering and related experimentation revealed that despite A119S's lack of contribution to cardiac glycoside-insensitivity in vitro, it, like 111 and 122, increases cardenolide insensitivity. Thus, the general importance of epistasis in constraining the paths of adaptive evolution is underscored. In addition, these results yield insight into the development of drugs to treat a number of Na+,K+-ATPase-associated neurological and physiological disorders in humans.

SWATI RAVI CC'22: PHYSICS

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Faculty Mentor(s): Melissa Ness, Columbia University
Title: Data-Driven Modeling of MaNGA Galaxies with Milky Way Spectra

Abstract: Synthetic stellar population modeling can be used to determine ages, metallicities, and star formation histories from galaxy spectra by matching best-fit stellar population samples with observed galaxy spectra. With the large volume of high-quality and well-calibrated empirical stellar spectra available from the SDSS MaStar stellar library, modeling of MaNGA galaxy spectra is feasible with stellar populations derived from MaStar. The Milky Way, with its high-quality spectra for individual stars, serves as an ideal near field cosmology experiment. Of primary interest is the question of whether such modeling of external galaxies yields spectra similar to the MaNGA galaxies, enabling understanding of the Milky Way properties in the context of the larger ecosystem of spiral galaxies. The most-likely ensemble of stellar candidates can be utilized to infer properties of MaNGA galaxies with similar precision to that of Milky Way kinematic and metallicity maps. A sigma removal operation is employed to correct MaNGA data's low signal-to-noise ratio and then a stellar model is created from 10 velocity-shifted MaStar spectra with constrained parameters Teff, velocity, and spectral amplitude. Similar spectral features are observed between the MaNGA data and the stellar models, supporting the use of near-field stellar candidates to build synthetic galaxy models. Further optimization of the stellar model parameters with an MCMC maximum likelihood estimation will generate the most-likely constituent populations of the MaNGA galaxies. This data-driven model allows for supplementing the low-quality MaNGA spectra with relevant

high fidelity MaStar measurements, thereby providing additional insights into the properties of the MaNGA galaxies.

HERBERT RIMERMAN CC'22: CLASSICS

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Faculty Mentor(s): John Ma, Columbia University
Title: Written Greek in Hellenistic Palestine

Abstract: Evidence for written Greek on a wide scale in Palestine (an administrative and cultural region in the ancient world consisting of all the land west of the Jordan River between modern-day Lebanon and the Sinai desert) appears remarkably late; such evidence is not until the late second century BCE, almost 200 years after the region had been conquered by kingdoms with Greek-speaking administrations. This fact seems especially odd given that Aramaic, an administrative language previously imposed on Palestine by the Achaemenid Persian Empire, was adopted at all levels of literate society extremely quickly. Moreover, Greek was finally adopted as a written language in Palestine during a time when the self-identified relationship between the Jews, the area's main inhabitants, and the Greeks, as well as ethno-religious and political relations between Jews and other groups in the land were greatly contested. Herbert's work demonstrates a preliminary investigation of the beginnings of Greek-language writing produced by Palestinian Jews, attempting to present a methodological framework for answering the questions of who, what, where, and why this literature was being produced, as well as what these answers tell us about how the Jews of Palestine viewed themselves in the context of the broader Mediterranean world.

HELEN RUGER CC'22: CLASSICS

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Faculty Mentor(s): Katharina Volk, Columbia University
Title: Graceful Giving: The Role of the Female in Seneca's "De Beneficiis"

Abstract: This manuscript considers the role of women in De Beneficiis, the presence of the female in Seneca's theory of gift exchange. It asserts that female examples are fertile ground for understanding the framework that Seneca presents for Roman men. It argues that Seneca's gift exchange reflects--assumed and argued to be masculine--an ideal of gift exchange as a feminine and thus natural, emotive, and private concept, marking an important tension between Roman social practice and theory. While prior work on De Beneficiis has focused on masculine and antagonistic elements of exchange, namely obligation and reputation, little attention has been paid to the impact of women, although Seneca refers to women or uses feminine language, explicitly or implicitly, approximately 65 times. Gift exchange in Seneca has been viewed as a masculine and public phenomenon, functioning within the Roman public sphere as a project in deriving male reputation or relationships. However, further analysis suggests elements of Seneca's exchange divert from male reciprocity, and can instead be read as a graceful process involving "sweet (dulce)," "precious (pretiosum)" and "beautiful (pulcrius)" benefits (2.6;3.7). This paper argues that the female complicates claims that classify Seneca's work as an obligatory, reciprocal exchange designed for elite men: women are integral to the gift-giving ideal, and critical in illuminating the tension between internal ideology of gift exchange and public social practice. This examination injects nuance into the binaries of exchange, emphasizing the process of giving that arises in Seneca's Rome – and in our own time as well.

PETER RUTKOWSKI CC'21: FINANCIAL ECONOMICS

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Faculty Mentor(s): Damon Phillips, Columbia University

Title: From Practice to Patronage: how Young Visual Artists transition from Study to the Global Art Marketplace

Abstract: In this study, a variety of methodologies and data visualization techniques are used to present a thorough perspective on how young artists -- particularly visual artists -- have both historically and currently transitioned from being students to 'commercial' artists at least partially immersed in the arts marketplace. A literature review, selecting studies from the 'beginning' of the European art marketplace (often determined by many scholars to have occurred in the mid-18th Century, centered around Paris and London) is presented and analyzed to show historical background. Two case studies, London and New York, then are presented, and mapping visualization tools are used to show the rise of artistic hubs both over time and over geographic space, analyzing the most prominent arts education institutions and emerging artist-focused galleries in each location. Perspectives from current young artists, galleries, and arts professors/artistic mentors are shared, in addition, to provide a more nuanced backdrop to this study. Lastly, multiple sources of data are quantitatively analyzed, allowing a generalized understanding of modern factors, including self-promotion and marketing, networking, arts education, and the impact of gallery representation, and their impact on artists' initial commercial success.

LORENZO SAMPSON CC'21: SUSTAINABLE DEVELOPMENT

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Faculty Mentor(s): Joan Grimalt, Institute of Environmental Assessment and Water Research - CSIC

Title: Mercury in the Mediteranean

Abstract: This project aimed to collect data to generate a spatial profile of the mercury content in the Mediterranean by collecting fish from local markets in Alicante, Spain; Marseille, France; Genoa, Italy; Civitavecchia, Italy; and Alghero, Italy. The current thought is that the Mediterranean has relatively high levels of mercury when compared to the rest of the ocean because of geologic formations that slowly release mercury into this sea, but this project aims to show that the mercury in the Mediterranean could actually be caused by pollution, specifically from industrial chemical plants. This project has shown that there are several species of fish being sold in local markets which exceed the maximum permitted levels of mercury by the European Union, but there is no efficient way to test mercury levels of fish on site. This is especially concerning because mercury is a known neurotoxin and certain populations, such as pregnant women, children, and the elderly are more susceptible to negative effects from this metal. In a place where seafood is so commonly consumed, this project is an attempt at cataloging where the mercury levels are especially high, in what fish, and why that is.

ISAAC SCHOTT-ROSENFIELD CC'21: ENGLISH; CLASSICS

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Title: The Quality of the Affection: Paradisal Alignment of Confucius and Cavalcanti in The Cantos of Ezra Pound

Abstract: It is in the Pisan Cantos that The Cantos of Ezra Pound begin to face up to the "demands of a 'Paradiso.'" This paper examines the method of that paradisal approach by outlining the convergence, in

the critical Canto LXXVI, of two of the poem's most prominent figures: Cavalcanti and Confucius. Following these characters' pedigree in Pound's literary and critical production, it traces in the close structuring of the canto the intellectual scheme by which Pound came to arrange them, a scheme conditioned by his taste for Neoplatonism, Spinoza, and the theory of Social Credit. This is, in the severest reduction, that a noetic body superior to man, making contact with him, assists to illuminate and clarify forms and affects within him, which clarity impresses not only a spiritual wonder and a scientific precision, but guides the mind and body into action. Alongside exegesis of Canto LXXVI, this plan offers context for Pound's poetry within a coherent ethic, constructed out of that grand intellectual syncretism upon which The Cantos' critical verdict and poetic life depends.

DAKOTA SCHRAMM CC'21: BIOPHYSICS

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Faculty Mentor(s): Kenda Wallace, University of Mississippi
Title: Determining the effects of circulating factors on cerebral vessel permeability during pregnancy

Abstract: HELLP (Hemolysis Elevated Liver enzymes Low Platelets) syndrome is a complication of preeclampsia that occurs in the late third trimester or in the immediate post-partum period. HELLP results in liver and blood damage that can be fatal both to the mother and the unborn child. This project looks closely at recent results stating that HELLP results in higher blood brain barrier permeability and tries to connect this impairment to circulating factors in the blood. This is done by isolating the posterior cerebral artery of non-pregnant female rats and infusing them with blood from non-pregnant and HELLP rats. These vessels were then tested in a permeability and tone experiment in order to determine whether circulating factors in the plasma from HELLP rats leads to impairment of cerebral vessels. Though these tests are preliminary in nature, they show the ability to infuse plasma from pregnant rats into posterior cerebral vessels from non-pregnant virgin rats.

RALEY SCHWEINFURTH CC'22: ENVIRONMENTAL CHEMISTRY; MUSIC

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Faculty Mentor(s): Avraham Rosenberg, Regeneron Pharmaceuticals, Inc.
Title: Automation of Glycan Sample Preparation with the Biomek i5 Automated Workstation

Abstract: Asparagine (N)-linked glycosylation is a complex post-translational protein modification that is highly variable. Although glycans can be found in all organisms, a specific glycan can have various roles within different proteins in multiple environmental contexts. Using a Biomek i5 Automated Workstation, an automated liquid-handling workflow was developed to optimize the release and RapiFluor-MS labeling of N-linked glycans in preparation for hydrophilic interaction liquid chromatography (HILIC) with online fluorescence (FLR) and mass spectrometry (MS) detections. With the automated protocol, glycan preparation time for HILIC-FLR-MS analysis was reduced 61% (90 minutes using a manual preparation compared to 35 minutes with automation). Subsequently, two methods for N-linked glycan profiling were developed: a normal method for both IgG1 and IgG4 monoclonal antibodies (mAbs) and a "harsh" method for highly glycosylated proteins. Stabilization of the hydrophilic mannose 8 glycan peak was achieved through the addition of dimethylformamide (DMF). Temperature and time were optimized for the deglycosylation and labeling steps, and complete deglycosylation was confirmed through intact mass analysis for both methods.

KHYBER SEN CC'22: COMPUTER SCIENCE

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Faculty Mentor(s): Junfeng Yang, Columbia University
Title: Smart Neural Fuzzer using LLVM Branch Coverage

Abstract: As the need for hardened security in software systems becomes increasingly apparent, we need to evolve the way we automatically test software to root out the most obscure and yet most dangerous bugs. Currently, automated software testing has evolved in two primary directions. On one hand, static analysis automatically reasons about the semantic structure of a program, either to prove them correct or to eliminate common patterns of bugs. But static analysis misses many subtle cases in complex programs and is very slow and doesn't scale well. On the other hand, randomized testing, called fuzzing, feeds random inputs to a program to try and cause a crash or memory leak in order to uncover a bug. However, fuzzers are fundamentally random and thus extremely inefficient: they aimlessly explore a vast search space mostly in vain, only rarely finding a bug, usually by luck.
Instead, our Smart Neural Fuzzer combines the best of both testing paradigms, initially testing a program randomly, similar to fuzzing, but then honing in on data and control flow dependencies it discovers in an intelligent, targeted way. By instrumenting a program to record all the control flow (every "if" statement), we can associate inputs with their resultant control flow and feed this to a neural net, which can predict the input of a new control flow path that we want to extensively test and uncover hidden data dependencies between parts of the program. This can drastically improve current fuzzers by selectively targeting untested parts of the program. Or it can be used for taint analysis, determining if the input data is able to influence what data is passed to a privileged function. It can also enable advanced optimizations, and as an added bonus, it can also be used as a sophisticated record-replay system of the control flow of a program, allowing for a new level of time-travel debugging.

ABHISHEK SHAH CC'21: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Denis David, Paris-Sud University
Title: The Anti-Depressant and Anti-Relapse Action of the Type 3 Serotonin Receptor

Abstract: Depression is the leading cause of disability worldwide. Current pharmacological approaches to treating depression (conventional antidepressants) are slow to act and effective in only about two thirds of patients. As a result, there is a need to develop and understand the mechanisms of novel antidepressants.
Vortioxetine, an unconventional, recently developed drug, has been shown to have potent antidepressant effects. Furthermore, in a mouse model of depression and anxiety, vortioxetine was shown to protect against the relapse of depressive-like symptoms after cessation of treatment to a greater degree when compared to conventional antidepressants. While it is not known how vortioxetine exerts this anti-relapse effect, it is known that antagonism of the type 3 serotonin receptor (5-HT3-R) is involved in vortioxetine's antidepressant effect. Thus, the 5-HT3-R was targeted as a potential mediator of protection against relapse and long-term stress resilience.
To test whether 5-HT3-R antagonism was sufficient to prevent relapse, the drug ondansetron was used to blockade the 5-HT3-R, and a battery of behavioral tests were performed. Blocking the 5-HT3-R prevented depressive-like and stress-induced anxiety symptoms, but did not prevent all anxious behavior. Once drug treatment ceased, mice that had endured blockade of the 5-HT3-R retained protection against depressive-like symptoms. Furthermore, these mice had lowered rates of stress-induced anxiety, just as they did during drug treatment. Together, these results suggest that the 5-HT3-R can be targeted to

prevent the relapse of depressive-like symptoms, and that it plays an important role in protecting against future stress, potentially opening up possibilities for novel treatments.

MANASI SHARMA CC'21: PHYSICS; COMPUTER SCIENCE

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Faculty Mentor(s): Mansi Kasliwal, California Institute of Technology

Title: Real/Bogus Classification for the Palomar Gattini-IR Telescope using Deep Learning

Abstract: Palomar Gattini-IR is a new, wide-field infrared survey telescope that is accomplishing the first all-sky time domain survey of the dynamic infrared sky in J-band. The survey produces tens of thousands of alerts each night for transients such as variable stars, dwarf novae and supernovae; however, numerous false positive, or bogus, detections appear due to issues such as poor subtraction in the image analysis pipeline or defects in the detector, which reduce efficiency for the researchers who must manually classify these sources. Thus, we present a deep-learning, real/bogus classifier that separates bonafide transients from the false candidates through deep learning on a training sample. We first describe the software used by the GROWTH collaboration for classification and labeling of the transients, as well as the set-up of a Zooniverse classification scheme to build our training sample. We then describe the neural network architecture, which is a two-layer Convolutional Neural Network, implemented using the high-level Keras API and TensorFlow. We describe the results of performance tests which show a 97.5% classification accuracy from K-fold Cross-Validation. A sub-sample of these classified real transients were followed up with infrared spectroscopy at Palomar Observatory in California, including a confirmed supernova and a flaring brown dwarf.

SABRINA SHIH CC'22: DATA SCIENCE; HUMAN RIGHTS

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Faculty Mentor(s): Michael Gerrard, Columbia University

Title: Opening Doors in the Pacific: Inclusive Migration with Dignity through Labor Shortages

Abstract: Pacific Atoll States, especially the island groups of Kiribati and Tuvalu, are currently suffering from accelerating environmental dangers, including sea-level rise, king tides, storm surges, flooding, and increased ocean acidification that will degrade coral reefs, exacerbate erosion, and salinize arable land and freshwater resources—all of which may be intensified by climate change. In response to the atolls' already limited access to land, water, and food systems, many have proposed international migration as an adaptation measure alongside efforts to reduce greenhouse emissions and invest in sustainable, protective infrastructure. One possible strategy called "migration with dignity," first promoted by the former president of Kiribati, Anote Tong, details an effort to help I-Kiribati migrate with self-determination, usually into appropriate jobs in neighboring states like Australia and New Zealand.
However, visas for permanent or long-term residency like New Zealand's Pacific Access Category (PAC) are not accessible for many who are unskilled, have poor English, and/or are not below 45—the exact people who are most exposed to the lack of resources and environmental impacts. In an effort to make migration with dignity inclusive of the most vulnerable, this paper examines the utility of labor shortages in low-skilled, long-term occupations in Australia and New Zealand as possible migration pathways. Using a method to identify occupational labor shortages outlined by the United Kingdom Migration Advisory Committee, this paper quantifies the proportion of I-Kiribati and Tuvaluans who do not have access to permanent migration and identifies the extent of shortages in the qualifying occupations.

BEATRICE SHLANSKY CC'22: HISTORY
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Faculty Mentor(s): Nicholas Bartlett, Barnard College
Title: Chinese American Reactions to Japanese Internment

Abstract: The Asian identity incorporates everyone from Asiatic countries, including Koreans, Japanese, and Chinese people. While these people may similarly be "Asian," this does not mean that these groups necessarily get along, nor support each other. This project investigates how Chinese Americans reacted to Japanese internment in the United States during World War II. While many perhaps assume that Chinese Americans would have supported Japanese people in America due to facing similar racial struggles and discrimination in America, the opposite was true. For many Chinese Americans, the Sino-Japanese Wars (1894-1895 and 1937-1935 respectively) and Rape of Nanking (1937-1938) stood as events that collectively traumatized and motivated Chinese Americans against the Japanese. Further, many Chinese Americans perceived Japanese people as competition to their businesses and pathways to gaining status in the United States. Thus, many Chinese American communities mobilized against the Japanese, advocating for Japanese internment. This project explores the methods by which Chinese Americans asserted their identity during this period, and how they used this concept of identity to assert power over the Japanese in America. Through the staging of different protests and boycotts against Japanese, as well as the self-identification of "Chinese" through flags, buttons, and homemade signs, Chinese Americans claimed themselves as the "Good Asians." By openly embracing their Chinese identity, Chinese Americans were able to signal support with the United States and establish status in society.

MALIA SIMON CC'22: PSYCHOLOGY
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Faculty Mentor(s): Meredith Landman, Columbia University
Title: Applause as Delicacy and Debauchery: Examining Uninvited Applause in the Audiences of Donald Trump vs Hillary Clinton During the 2016 General Election

Abstract: Political applause marks the point at which moral assent and aesthetic pleasure coincide — Roger Gilbert
Applause is perhaps commonly held as one of the most trivial of human behaviors—it might be thought of as a simple tradition executed on autopilot with occasional bursts of genuine excitement. Some philosophers have described it as something as lowly as a literal secretion of sound. Or perhaps it is not thought of at all. This research project exploits precisely this perceived trivial nature of applause: the researcher conducted a retrospective study which compared the applause in Donald Trump and Hillary Clinton's campaign speeches throughout the 2016 general election until Trump's victory. This study taps into the "hidden data" that applause can prove to be—that is, previously overlooked natural data that provides insight into the appeal of Donald Trump as a speaker in the speaker-audience conversation. Indeed, in such conversation, applause can either serve as an obligatory act of decorum invoked by intentional rhetorical setups ("invited applause") or as an autonomous outburst ("uninvited applause"). Using a previously-established typology for identifying invited applause in political speeches, the researcher compared which candidate received more uninvited applause, how each speaker responded to such applause, and the effect this may have had on the ultimately effective appeal of Donald Trump.

ERIIFE ADELUSIMO CC'22, UGOCHINYERE NDUKWE CC'22, RILEY SMITH CC'22: NEUROSCIENCE

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Faculty Mentor(s): Darcy Kelley, Dustin Rubenstein, and Szabolcs Marka, Columbia University
Title: Neural & Genomic Correlates of Vocal Behavior

Abstract: This project analyzed the calling patterns of various different combinations of male and female frogs within the genus Xenopus in order to determine if female Xenopus have a preference for the call of a conspecific or heterospecific male. Also of interest was whether the F1 generation of a cross between Xenopus laevis and Xenopus petersii would show a preference for another hybrid or for either parental species. Male Xenopus are known to produce an advertisement call meant to attract sexually receptive females in order to enter amplexus and reproduce. A sexually receptive female will produce a rapping call that is longer than the ticking call that a sexually unreceptive female produces when clasped. Utilizing PRAAT to analyze the audio recordings of the pairings, CSV files were generated that indicated the intervals when males called, females called, and the duration of the calls, enabling determination of the type of calling. These CSV files were then pipelined through R in order to create ethograms, allowing graphical visualization of any overlap between male and female calling. After analyzing the call overlap as well as the duration of the female calls, it was determined that the data did not indicate a preference for males of a specific species (conspecific or heterospecific), suggesting that sexually receptive female Xenopus prioritize fertilization of their eggs over specific mate choice.

KRISTOFF SMITH CC'22: THEATRE

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Faculty Mentor(s): Jessica Merrill, University of California
Title: Turn Your Back on Mother Nature: The Reclamation of Monsters in Trans Folklore

Abstract: This research project explores the concept and figures of monstrosity in relation to transgender folklore and narratives with a particular emphasis on the idea and implications of reclaiming such figures. Extensive academic research has been published on the connections between monsters and queerness, but with an overwhelming focus on sexuality and little to no attention to transgender narratives. This project began by conducting a survey of zines as a modern method of folklore transmission and their strong ties to the queer community. It expanded to include other forms of art and material culture with a strong emphasis on collecting trans-created media in order to reflect the vast difference in narratives when self-told, versus the overwhelmingly cisgender-produced trans stories in mass media. It takes and gleans transgender symbolism from popular creatures such as Frankenstein to lycanthropes, cryptids, and various other creatures across folklore. It seeks to explore how these monsters, used across time as social tools, trouble the line between desire and fear, horror and reverence, dysphoria and euphoria. It includes explorations into the politics and symbolics of visibility and the body, depiction, what it means to exist (or not exist) within a culture, bodies and their materiality (or immateriality), transformation, resistance versus assimilation and more. It ultimately seeks to reveal the potential power in self-reclamation of monstrous figures for transgender individuals, and to provide more challenges than answers in a current climate that still seeks to relegate trans existence to the shadows.

TOMMY SONG CC'20: HISTORY; POLITICAL SCIENCE

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Faculty Mentor(s): Karl Jacoby, Columbia University
Title: Columbia University Historical Justice Initiative Version 2.0

Abstract: Tommy Song's research focused on the marginalized narratives of Columbia University that form the expanded tours offered by the Columbia University Historical Justice Initiative (CUHJI), which Song launched in fall of 2018. Created by using archival documents in various repositories in and beyond Columbia as well as student research from the Columbia University and Slavery Project, the second version of CUHJI's alternative walking tour—now available through the Initiative's website—includes historical narratives that cover the campuses of Barnard College, Teachers' College, Columbia Law School, and the Fu Foundation School of Engineering and Applied Sciences. Moreover, the original tour that covered the lower half of the Morningside Campus now has additional information from further research, including the history of the Lenni-Lenape's connection to Wall Street and the troubled heritage of the Core Curriculum. Other highlights of the second tour include: Earl Hall's connections to gay rights activism as well as Reconstruction in the South, Barnard Hall's mixed legacy of political activism and Protestant-androcentrism, the Political Science Department's link to white supremacy in Hawaii thanks to John W. Burgesss, Havemeyer Hall's connection to the NYC sugar industry and plantation slavery, and more.

PALLAVI SREEDHAR CC'21: HISTORY; ECONOMICS

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Faculty Mentor(s): Clément Godbarge, Columbia University
Title: Arguments from the Political Left and Right Regarding the Nation-Wide Voucher System and Educational Policy in Chile

Abstract: From 1973-1990, Chile was ruled by the military dictator Augusto Pinochet. During this period, which was characterized by the suppression of political parties and persecution of dissidents, Pinochet made sweeping economic policy reforms under the guidance of Chilean economists that trained under Milton Friedman. One aspect of the reforms instituted during Pinochet's dictatorship was the introduction of a universal educational voucher system, which meant that parents could use government vouchers to help pay the tuition of a private school. The nation-wide voucher system in Chile is a radical social experiment that has since been reformed drastically. However, the voucher system and education policy is still highly politicized in Chile. To get a better sense of the range of political opinions on the voucher system and education policy in Chile, Pallavi spent three weeks in Santiago this summer interviewing professors, researchers, and government officials about their opinions. Pallavi made sure to get a diverse range of opinions from the political left to the right and took note of the different rhetorical arguments made by each side. While no easy conclusions can be made from this rhetorical study, Pallavi is interested in comparing the arguments made about the Chilean voucher system to those made about a potential voucher system in The United States.

ARJUN SRIVATSA CC'20: DATA SCIENCE

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Faculty Mentor(s): Itsik Pe'er, Columbia University
Title: Protein Tertiary Structure Prediction through Deep and Reinforcement Learning methods

Abstract: The protein folding problem is a biological problem with significant repercussions in pharmacology and the treatment of diseases. Proteins are the building blocks of DNA and their unique

3D shapes dictate their function in the human body. Predicting protein tertiary structure from both the original amino acid chain or secondary structure would have a significant impact in drug design and delivery. In this project, we accurately predict tertiary protein structure as measured by global roots mean square distance on the critical assessment of protein structure prediction contest dataset. Our method includes an ensemble of various deep learning methods inspired by encoder-decoder architectures from natural language processing. Moreover, progress has been made to refine our predictions using reinforcement-learning methods.

JOHN STAUNTON CC'20: PHYSICS

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Faculty Mentor(s): Dmitri Basov, Columbia University
Title: Extending the Lightning Rod Model to Terahertz Frequencies

Abstract: Taking a photograph involves the reflection of light on an object and the absorption of colors into the camera. This is easy enough to accomplish since light waves are small compared to the object we are imaging. However, once objects we attempt to image are the same size, or even smaller, that the wavelength of light, we must deduce properties of the material through its interaction with light. Experiments that deal with this type of scattering of light are called "s-SNOM microscopy." At infrared scales, which are slightly longer than light we see every day, we accurately predict the interaction through the Lightning Rod Model (McLeod, 2014), which models the back-reaction of the imaging tip and the material itself. At even longer wavelengths, in Terahertz (THz), there are three nontrivial interactions that must be accounted for. First, there are certain wavelengths that are the same size of the tip and increase the corresponding signal. Second, light can interact with the edge of the material introducing an extra spatial dimension in need of analysis. Third, observations indicate that the imaged edge is fuzzier than it is in real life. All three factors can be accounted for via resonances and unequal transfer of momentum in scattering. As such, the aim is to model such corrections to the Lightning Rod Model and demonstrate its effectiveness by comparing to signal data obtained at the Basov Infrared Laboratory. The model extension agrees with the data both qualitatively and quantitatively as shown by statistical fits.

EMMIE STRICKLAND GS'23: ENVIRONMENTAL BIOLOGY

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Faculty Mentor(s): Suzanne Macey, Columbia University
Title: Grazing Behavior of Cape Buffalo and Plains Zebra: Niche Separation and Feeding Preferences of Two Successful Ungulate Populations at Lewa Wildlife Conservancy

Abstract: As climatic variability in equatorial regions increases with climate change, resource availability and competition between large herding mammals is less predictable. East Africa is already experiencing these phenomena. The white rhino (Ceratotherium simum), Cape buffalo (Syncerus caffer), and plains zebra (Equus quagga) are three Kenyan species that both herd and intake energy primarily from eating grass. As droughts become more frequent with climate change though, this intraspecific competition is heightened, threatening the already endangered white rhino's survival further, as well as the success of the buffalo and zebra. The feeding behavior and distribution of two of these three species, Cape buffalo and plains zebra, were examined at Lewa Wildlife Conservancy, a multi-use conservancy in central Kenya to understand these animals' relationship to the land and to one another. The researchers analyzed historical animal distribution and climate data spanning the last five years to give a comprehensive spaciotemporal picture of these variables. A current distribution survey of the herds' grazing locations

was conducted using GPS and scan sampling. The team finally conducted a grass survey in the areas at which the two species feed, to identify the exact grass species for which they are competing. Results displayed that with heightened climatic variability came more distribution overlap of the two species, and that currently, the buffalo and zebra are utilizing the same grass species for nutrition. Understanding relationships like this between climate, animals, and land will allow for more informed conservation plans to be implemented as the anthropogenic impact on nature deepens.

DAEUN SUNG CC'21: BIOCHEMISTRY

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Faculty Mentor(s): Douglas Kondo, University of Utah
Title: Localized and Lateralized In Vivo Brain Phosphocreatine Changes during Acute Hypoxia

Abstract: Neuroimaging research has revealed lateralized brain abnormalities in mood disorders. For instance, decreased activity in the left dorsolateral prefrontal cortex is associated with depression and is a target of transcranial magnetic stimulation. Previous studies have suggested that such altered brain chemistry may be caused or exacerbated by hypoxia. However, it is unknown whether acute hypoxia can induce in-vivo changes, namely in high-energy phosphorus neurometabolites, which are indicators of high-energy stores and buffering capacity.Thirteen phosphorus-31 magnetic resonance spectroscopy (31P-MRS) scans were acquired from healthy volunteers. During a single scan session, subjects were exposed to 16% hypoxia, and 25% hyperoxia conditions. Four regions of interest (bilateral fronto-basal ganglia and bilateral parieto-occipital lobes) were analyzed to evaluate dynamic, localized and lateralized changes in brain phosphocreatine (PCr), an indicator of high-energy stores and buffering capacity.
Acute hypoxia decreased brain PCr levels in the left fronto-basal ganglia (z=-2.22, p=0.03). Other regions had non-significant changes (right fronto-basal ganglia (z=-0.77, p=0.44), right parietooccipital (z=-1.23, p=0.22) and left parieto-occipital (z=+0.11, p=0.91)). Pairwise comparisons revealed that the left fronto-basal ganglia displayed the largest regional difference, as compared to the left parieto-occipital region (p=0.02). These findings suggest that during acute hypoxic stress, the human brain expresses regional differences in high-energy neurochemistry. These lateralized PCr alterations may be implicated in disorders such as depression, which has been associated with oxidative stress vulnerability and hypometabolism in the LDLPLC through PET studies. Further study of mood-disordered subjects is warranted, using our novel method of oxygen manipulation in the MR scanner, to comprehensively establish the relationship between mood disorders, hypoxia and brain mitochondrial dysfunction.

DAIKI TAGAMI CC'22: BIOLOGY; STATISTICS

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Faculty Mentor(s): Minoree Kohwi, Columbia University
Title: Corto/Psc regulate neural progenitor competence restriction by promoting timely genome reorganization

Abstract: Neural stem cells generate a large variety of neuronal and glial cells that lose competence to generate early-born neurons through unknown mechanisms. Drosophila embryonic neural progenitors (neuroblasts) sequentially express distinct temporal transcription factors, beginning with Hunchback (Hb), which is a necessary and sufficient component that specifies early-born neuronal identity. For several divisions after Hb repression, the neuroblasts remain competent to specify early-born identity until the Hb gene locus relocates to the nuclear lamina during mid-embryogenesis. Here, we discovered that Corto, an enhancer of trithorax and polycomb, and Posterior sex combs (Psc), a Polycomb group (PcG)

protein, are required for this mid-embryogenic Hb gene relocation and competence termination. Even though PcG proteins are well known in maintaining gene repression, both Corto and Psc mutants show reduced Hb gene-lamina association without Hb de-repression. Our data support that Corto/Psc are required for timely genome reorganization to close the early competence window after Hb is repressed. In addition, we also developed a 3D neuron detection tool using the latest advancement in artificial intelligence. By training a deep learning technique called deep convolutional generative adversarial networks, we were able to develop a training set from the original 3D microscopic images. Here, we demonstrate the advantages of using these training set instead of the original image to train the machine learning model for image classification.

MAYA TALUKDAR CC'20: COMPUTER SCIENCE; BIOLOGY

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Faculty Mentor(s): Peter Kharchenko, Harvard University
Title: Of Mice and Men: Assessing Schizophrenia Drug Success in the Context of Human-Mouse Brain Homology

Abstract: Mouse models are commonly used to mimic the symptoms of neuropsychiatric disorders like schizophrenia in order to facilitate the development of effective medication. However, the increased use of single-cell genomic technologies to probe the transcriptomes of the human and mouse brain has led to the repeated finding that even homologous human and mouse brain cell types have marked biological differences. In this study, we align data from the human medial temporal gyrus (MTG) and mouse primary visual cortex (VisP) at the single-cell resolution. Additionally, we benchmarked several related integration methods and related hyperparameters. We then utilize this integrated dataset to identify cell-type specific differentially expressed genes between the mouse and human brain and their relationship to genes targeted by successful and unsuccessful schizophrenia drugs brought to human clinical trials. Intriguingly, we find significant cell-type specific differences between the mouse and human brain but no association between differentially expressed genes and unsuccessful schizophrenia drug targets.

SERENA TAM CC'21: COMPUTER SCIENCE

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Faculty Mentor(s): Junfeng Yang, Columbia University
Title: Voice Next Page: Voice Automation for Android Devices

Abstract: Voice input is an increasingly popular means of interacting with mobile devices, with 20% of Android searches already voice-based. While many users simply enjoy the fast hands-free convenience, voice input is essential for those with health considerations that impede the use of touch input. In this project, we develop a framework for creating full voice automation of Android apps, along with a demonstration app called Voice Next Page (available on the Play Store) which makes existing ebook reader apps voice-accessible. The existing Android AccessibilityService API has shortcomings that prevent easy automation of actions without explicit widgets (e.g. swiping or zooming in on ereaders); our technique is to provide a "virtual finger" which can perform any action a user might do. We borrow techniques from the heavy, voice-reliant task of voice coding, including command chaining, to provide an interface that a user might feasibly use for all of their device interactions. Our system is built on a simple open source speech recognition engine (Kaldi), ensuring the lowest possible barrier to entry for new developers embracing voice accessibility. We also conduct a user study to test the accuracy of voice commands in different volume backgrounds, as well as the app's overall ease-of-use.

ARNAV TANDON CC'21: CLASSICS

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Faculty Mentor(s): Katharina Volk, Columbia University

Title: Gabii through the Archaeological Record

Abstract: The ancient Latin city of Gabii has been under active excavations for the past ten years, during which time archaeologists have uncovered quite a bit of information about the ancient city and its environs. The primary factor that first motivated archaeological interest in Gabii revolved around the city's grid layout, an urban format which had not been detected in Italy outside of a pocket of Greek settlements. Now, however, archaeologists have become fascinated with the abundance of archaeological evidence from different occupation phases.

The goal of this project was to gain familiarity with the archaeological record at Gabii as an avenue for understanding the city's complicated history more clearly. Notably, its proximity to Rome encouraged association between the two cities, especially as Rome grew in size and in regional influence. An example of such a linkage between the two neighbors is the foedus Gabinum (tr. Gabine treaty) from the end of the Roman monarchy: a treaty which established a lawful equality between citizens of Gabii and their Roman counterparts. Of course, Gabii undergoes significant changes in later phases, ranging from further development featuring monumental public and private structures to a quarrying phase, when the city depopulates and becomes one of the largest suppliers of stone for the numerous construction projects ongoing at Rome. Ultimately, the Gabine archaeological record has proved to be extremely fruitful in diagnosing the history of Latium as a region as well as the intricacies of the complex relationship between Gabii and Rome.

NAZ PINAR TASKIRAN SEAS'22: UNDECIDED

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Faculty Mentor(s): Emlyn Hughes, Columbia University

Title: Quantifying Lung Microstructure in COPD using Hyperpolarized Noble Gas Imaging

Abstract: Chronic obstructive pulmonary disease (COPD) is the third leading cause of death in the US. The disease is not well understood because current methods are insensitive to local changes associated with the disease. Using hyperpolarized (HP) gas MRI and perfusion measurements, we can extract information about lung microstructure damage with sensitivity to the ~10 μm level.

We analyzed the diffusion weighted image of a patient with mild COPD to generate a map of the apparent diffusion coefficients (ADC) using hyperpolarized helium-3. As the disease progresses, the walls of the airways get destroyed, and as such ADC approaches the free diffusion coefficient, and the outer and inner radii of the alveoli increase in size. For the future, we plan to apply the equations relating the MRI signal of anisotropic gas diffusion to lung microstructure in scans from ~60 patients from the multi-ethnic study of atherosclerosis (MESA) COPD study collected at New York-Presbyterian Hospital.

We are planning to submit a proposal to NIH this fall to use hyperpolarized xenon-129 to perform MRI studies on 100 patients in order to study lung microstructure using ADC measurements and measure the dissolved-phase to gas-phase polarized xenon ratio, which characterizes gas uptake efficiency.

KARLY TEGANG GS'22: BIOLOGICAL SCIENCES

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Faculty Mentor(s): Gerard Karsenty, Columbia University

Title: Glast Promotes Osteocalcin Endocrine Functions

Abstract: Osteocalcin (OCN) is a hormone made by bone, which controls glucose homeostasis, energy expenditure, male fertility, brain development, cognition and mediates the acute stress response. In mice, rats, horses, and humans, OCN levels decline precipitously with age. Studies in mice indicate that replenishing OCN levels in aged mice to that present in young mice can reverse several manifestations of aging. In vivo, OCN is carboxylated by a gamma-carboxylase (GGCX) in osteoblasts, a post-translational modification that inactivates the hormone. Hence, we asked whether bioactive uncarboxylated OCN could be artificially increased in order to treat manifestations of aging. Specifically, we tested whether overexpressing Glast, a glutamate transporter in osteoblasts, could increase the release of bioactive OCN by inhibiting the activity of GGCX. We observed that Glast overexpression in osteoblasts does increase the release of bioactive OCN. This results in an increase in circulating insulin and testosterone levels, and a slight decrease in visceral fat deposit. These data establish that Glast is required for the release of bioactive OCN by osteoblasts and reveals that targeting glutamate transport in bone may be a viable method to increase OCN levels in patients.

JACK TREANOR CC'20: URBAN STUDIES

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Faculty Mentor(s): Mary Rocco, Barnard College
Title: Redevelopment in the London Docklands

Abstract: This project examines the changing typology of redevelopment project in the Docklands of East London, focusing on how industrial land and infrastructure were repurposed in the decades following the widescale shuttering of shipping facilities. Between 1960 and 1980 the shipping facilities that had served London for hundreds of years closed in favor of more efficient deep-water container ports further down the Thames River leaving over eight square miles of unused industrial land in close proximity to central London. From the initial light industry and family-focused residential developments to the gleaming office towers of Canary Wharf, these redevelopment projects, spread over four decades and initiated by both government and private interests, reflect the political and economic moments that they were built in as well as the changing philosophy of urban design. This project asks how these developments play into and reflect the larger story of redevelopment and gentrification of East London.

LIZKA VAINTROB CC'21: MATHEMATICS

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Faculty Mentor(s): Aliakbar Daemi, Stony Brook University
Title: Studying exotic structures on manifolds using techniques from knot theory and computers

Abstract: Manifolds are geometric objects that locally look like the usual Euclidean space of a given dimension. They are among the most classical and well-understood objects of study in topology (the area of mathematics that deals with properties of spaces preserved under continuous deformations).
In recent years, there has been enormous progress in our understanding of manifolds of low dimensions (the most famous event was the proof of the Poincaré conjecture in dimension three), but many important unresolved questions remain. One such question is whether certain "exotic smooth structures" exist on some low-dimensional manifolds. A manifold with an exotic structure is a manifold which is topologically but not smoothly equivalent (or diffeomorphic) to a given manifold. This project explored exotic structures on certain four-dimensional manifolds using techniques from knot theory (the part of topology that

studies different ways of embedding circles and spheres into the Euclidean spaces of dimensions three and four). Knot-theoretical constructions (so-called "surgeries") were used to obtain new manifolds from the given ones. To compare the resulting manifolds, their topological invariants were evaluated using specialized computer programs (in particular, SnapPy and KLO).

MICHAEL VAN DUINEN CC'21: CHEMISTRY; MATHEMATICS

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Faculty Mentor(s): Latha Venkataraman, Columbia University
Title: Use of Silver in Ionic Solvents in the STM-BJ Method of Single Molecule Electrical Conductance

Abstract: The electrical conductance of single molecules is important as electronics become smaller and smaller, an advance important economically and environmentally. Researching such electrical conductance can be done with a variety of methods; the type of method used in my lab typically takes advantage of the electrical properties of a junction between two gold atoms. Much of the work in this project involves working instead with the junction between a silver atom and a gold atom. This project is not the first to work with such junctions, but it is one of the first if not the first to work with such a junction in an environment of electrically charged solvent. Electrically charged solvents can work with a larger variety of molecules than the solvents typically used in this field of research, and they have better potential to host and/or catalyze reactions than non-charged solvents. Since silver is a better chemical catalyst than gold, the success of this project can spur interesting reaction electrochemistry research for future projects.

NAAZANENE VATAN CC'20: BIOLOGY; MEDICINE, LITERATURE AND SOCIETY

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Faculty Mentor(s): Kavita Sivaramakrishnan, Columbia University
Title: Understanding Older Adults' Experiences and Intergenerational Support Networks in Mumbai's Deprived Urban Contexts

Abstract: This project investigated intergenerational relations between Mumbai's young and old populations in deprived urban contexts through both field interviews and literature review. Specifically, the project focused on populations in Dharavi, Mumbai's largest informal settlement community. The work built on a two-day workshop held at the Columbia Global Center in Mumbai, which hosted local NGO directors and gerontologists. During the group discussion portion of the workshop, participants were asked to discuss six questions relating to generativity and the interactions between young and old populations. Participants highlighted lack of age-friendly environments, lack of engagement in social and public activities, and lack of physical and psychological well-being as the primary challenges facing Mumbai's elderly. During interviews and home visits in Dharavi, older residents echoed concerns of limited social relationships, in addition to abandonment by their families; this was particularly relevant for older women. Resident interviews and an analysis of current literature revealed that while there is existing support for elderly populations by way of local NGOs, social and government support can and should be further leveraged. Furthermore, women face specific challenges, including lack of sustainable income and increased discrimination and ostracism from younger family members, that make old age at once a state of isolation from and dependence on their younger counterparts.

NICK VAUGHAN CC'22: NEUROSCIENCE

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Faculty Mentor(s): Christine Denny, Columbia University

Title: Identifying and manipulating brain-wide fear memory traces following extinction training

Abstract: Exposure therapy, which involves repeated exposure over time to a fearful stimulus in the absence of threat, is a widely used behavioral treatment for Post Traumatic Stress Disorder, however, it is not always effective. Fear can relapse after fear extinction, a part of exposure therapy, and the neural mechanisms governing competition between the fear and extinction memories are not well understood. The researchers utilized an activity dependent transgenic mouse line that allows for the indelible labeling of memory traces, or engrams, across the entire brain. This system enables a comparison of memories labeled at two separate time points, between the individual cells that are activated during fear encoding with those that are activated during memory retrieval, in order to investigate how extinction alters fear memories across the whole brain. They created a software pipeline of registering brain sections using WholeBrain in R to quantify the cells and then to map the cell counts to corresponding brain regions within each section to a mouse atlas. The normalized cell counts were analyzed for regional activity correlations between the two markers for neuronal activity and the mice that underwent extinction training versus the mice that did not. The researchers' results replicate prior findings that fear extinction training decreases the reactivation of fear memories in the Dentate Gyrus.

LUIS VELASQUEZ GS'24: POLITICAL SCIENCE

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Faculty Mentor(s): Jose Moya, Columbia University
Title: The Current Venezuelan 'Diaspora' from a Political and Humanitarian Perspective in Venezuela and Peru

Abstract: Recognized historically as an open-door country, Venezuela received numerous population flows composed of both Europeans and Latin Americans. By the 1960s one of the wealthiest economies in Latin American and by 1970 the richest one and Top 20 worldwide. Ironically, the 1970s marks also the start of the downfall in the economic spectrum. It is estimated by the government, that about 28,000 people arrived between 1936 and 1940. Now, it faces the most significant crisis not only of its history, but worldwide surpassing the Peruvian hyperinflation of 1990 and following the steps of the Zimbabwe Crisis of 2000. With shortages all around the country, indiscriminate privatizations and an opposition that has been stuck in an endless internal conflict people had begun a modern day 'diaspora' as a way to protect the safety and future of their families and, in many cases, escape a political/military persecution.
Since South America has never experienced migration at this rate, there are no long-term plans for migrants and refugees as well as national laws to protect them, the only one being the Cartagena Agreements about refugees. Countries like Ecuador, Peru and Colombia have been forced to shut down their frontiers and change their historical perspective about migrants and refugees, while Peru is still voting whether a quota or a total closure should be made. This has only led to diaspora type conditions and a painful journey by feet by hostile territory without the minimum requirements to live and without the certainty that the next country will receive them. Currently, it presents an entirely different migration pattern, motivated by a national crisis under a context of institutional deterioration, economic recession and social decomposition, a situation that has worsened during the last 17 years in great measure due to the 'resource curse.' hypothesis. In this framework, the paper purpose is to analyze the evolution of the migratory phenomenon in Venezuela, as well as the political, humanitarian and social context as possible causes of migration. In the same way, it intends to approach the perceptions that some Venezuelan immigrants have in Peru, regarding their prospects of change in the country of origin and their expectations of return through the use of an exclusive interview with a Venezuelan refugee in Peru.

SHIVALI VERMA CC'22: BIOLOGY
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Faculty Mentor(s): Michael M. Shen, Columbia University
Title: Investigating Cripto Function in Early Mammalian Development Using A Novel Gastruloid System

Abstract: In the mammalian embryo, gastrulation represents a crucial stage in which the pluripotent epiblast breaks symmetry and differentiates forming the three primary germ layers. During this stage, accurate patterning or positioning of germ layer tissues is critical for normal organ placement and development, and to specify the primary body axes. Previously, direct morphological and molecular analyses of the epiblast have been difficult due to its small size, thus the recent development of 'gastruloids' derived from embryonic stem cells (ESCs) that specify all major embryonic axes in a temporally coordinated manner offer a novel and innovative method to circumvent this problem and study early developmental stages. This study aims at using the gastruloid system (Beccari et. al. 2018) in order to study the function of Cripto, a ligand and coreceptor that our earlier studies have shown to be a regulator of the Nodal signaling pathway essential for mesoderm differentiation, visceral endoderm movement, and the specification of Anteroposterior and Left-Right axes. The gastruloid protocol was established using two wild type mESC lines as controls. Initial elongation of embryoid bodies seen suggests gastruloids can be generated reproducibly from controls pending further optimization and streamlining. Two additional Cripto null mutant ESC lines were also established, from which gastruloids will be generated to characterize and compare morphology and elucidate Cripto function more directly using in situ hybridization and immunofluorescence techniques.

DAVID WANG CC'22: BIOLOGY; DATA SCIENCE
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Faculty Mentor(s): Chao Lu, Columbia University
Title: Impact of H3K36 Methylation on 3D Genome Organization

Abstract: Head and neck squamous cell carcinomas (HNSCCs) are an especially widespread cancer, affecting millions of people globally. A recent genomic study uncovered a previously unappreciated subgroup of HNSCC patients characterized by epigenomic dysregulation. Specifically, these patients—which comprise of approximately 13% of all HNSCC cases—possess defects with histone H3 lysine 36 methylation (H3K36). Of these patients, the majority suffer from mutations in the NSD1 gene in particular, which encodes for a methyltransferase that normally di-methylates H3K36. While NSD1 has been linked to HNSCCs and shown to alter the chromatin modification landscape, how aberrant H3K36 methylation mechanistically results in tumorigenesis is unclear. Here, we reveal a link between the chromatin modification landscape and chromatin structure. In mouse embryonic stem cells (mESC), we show that H3K36me2 domains are a sufficient predictor of compartment A regions of the genome. Furthermore, contact frequencies that we calculated from global Hi-C data spike at the boundaries of H3K36me2 domains. Our ongoing experiment will test the hypothesis that H3K36me2 domains and contact frequency measurements deviate completely in NSD knock out cells. Further investigation of chromatin structures changes due to NSD1 mutation and development of HNSCCs is necessary to establish the mechanistic link between NSD1 and HNSCC tumorigenesis.

JOHN WANG CC'21: NEUROSCIENCE AND BEHAVIOR; COMPUTER SCIENCE
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Faculty Mentor(s): Kira Poskanzer, University of California-San Francisco

Title: Characterizing the Heterogeneity of Cortical Astrocytes for GABAergic and Glutamatergic Signals

Abstract: With increasing evidence that astrocytes have the capacity to regulate excitatory-inhibitory balance in the CNS, it is crucial to understand how these non-neuronal cells are specialized for glutamatergic and GABAergic signaling in neural circuits. Here, we explored the functional heterogeneity of cortical astrocytes using two-photon calcium imaging in acute slices of mouse primary visual cortex (V1), followed by event-detection to extract features of astrocyte calcium activity. Clustering analysis of glutamate and GABA event features via t-SNE delineated two distinct patterns of activity, and the discreteness of the two patterns were confirmed using ANOVA. Administration of glutamate and GABA switched the activity patterns of individual astrocytes from their baseline condition. Such a change in modality is unique to each neurotransmitter stimulus. In parallel, immunohistochemistry was used to identify the distribution of glutamate transporter 1 (GLT-1)+ and GABA transporter 3 (GAT-3)+ astrocytes throughout the six layers of V1. While astrocytes were found to be most dense in middle layers, expression of both GLT-1 and GAT-3 was higher in superficial layers and lower in deeper layers. The majority of astrocytes showed no co-localization for both GLT-1 and GAT-3 within their cell bodies. Although this may explain the differential calcium responses of individual astrocytes to GABA and glutamate, further investigations are needed to quantify the co-localization of GLT-1 and GAT-3 in astrocytic processes. Future studies will also elucidate the mechanisms underpinning the observed heterogeneous physiology of cortical astrocytes, which may extend our knowledge on the functional and structural organization of diverse cortical circuits.

MICHAEL WANG CC'21: ECONOMICS

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Faculty Mentor(s): Anindita Dasgupta, Columbia University
Title: Social Network Support For Syrian Refugee Women In Jordan

Abstract: The Syrian refugee crisis is the largest humanitarian crisis of this era. Despite that, there exists large gaps in the specific understanding of the needs of those affected. The goal of this program is to identify the needs of Syrian refugees and promote the use of evidence-based practices, specifically focusing on the health of Syrian refugee women. The research group has already conducted surveys amongst health providers in Turkey and Syrian women in Jordan. The group is partnering with universities in the Middle East as well, including the University of Jordan's medical school. Interventions and policy often ignore the specific, real needs that refugees have, and policies that do not account for these needs will not be effective. The research group is currently in the process of analyzing data and writing papers, as well as disseminating information to actors involved in refugee policy.

WILLIAM WANG CC'21: COMPUTER SCIENCE; MATHEMATICS

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Faculty Mentor(s): Yi Zhang, Columbia University
Title: Bitcoin: The Role Different Cryptocurrency Exchanges Perform in Price Discovery

Abstract: Bitcoin is traded on many different (100+) exchanges through many different instruments, including spot, futures, swaps, and options. The ecosystem of cryptocurrency exchanges is not perfectly efficient, but operates efficiently enough to make simple arbitrage difficult. In this research, the correlation of Bitcoin price between the different exchanges is examined. Of particular interest is the notion of "price discovery", which is how traders settle on a general price for a security even though it

may be traded through different channels. This is further complicated in Bitcoin because exchanges that trade swaps take their indices from other spot exchanges, further integrating price communication between exchanges. In a previous paper, it was discovered that swaps on BitMex, the largest Bitcoin derivative exchange, lead price discovery on the 3 largest spot exchanges. The paper aims to examine if this is still true, and if it can be generalised to futures products on other derivatives exchanges.

EMILY WOODER CC'21: BIOLOGY

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Faculty Mentor(s): Mimi Shirasu-Hiza, Columbia University
Title: Dietary Restriction Partially Rescues Injury Induced Neurodegeneration in Drosophila.

Abstract: Traumatic brain injury (TBI) causes protein aggregation and loss of tissue in the brain along with impaired neurological function. These phenotypes are also observed in neurodegenerative disease. Thus, a TBI model in Drosophila was used to study the molecular processes underlying neurodegeneration.
The lab had previously found that TBI leads to metabolic dysfunction, specifically resulting in misregulation of the TOR pathway, a central metabolic regulator. Knowing that TBI impacts the activity of the TOR pathway, they set out to examine if manipulating the TOR pathway can alter the severity of the neurodegenerative phenotypes resulting from TBI. Specifically, the impact of FOXO overexpression and dietary restriction (DR) on climbing ability and protein aggregation in the brain in post-TBI flies was examined. Overexpression of FOXO, a stress response transcription factor that regulates TOR pathway activity, resulted in decreased climbing ability and increased protein aggregation in both injured and uninjured flies. Thus, FOXO overexpression seems to increase neurodegeneration, but does not appear to interact with TBI itself. In contrast, DR through a reduced protein diet was found to significantly increase the climbing ability of flies post TBI without changing the climbing ability of uninjured flies, suggesting a partial rescue.

SERENA WU CC'20: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Christoph Anacker, Columbia University
Title: Serotonin 1A Receptor-Dependent Regulation of Ventral Dentate Gyrus Activity in Response to Stress

Abstract: Selective Serotonin Reuptake Inhibitors (SSRIs) are popular antidepressant treatments, yet their underlying mechanisms are unknown. Hippocampal neurogenesis in the dentate gyrus (DG) has been found to mediate SSRI responses, as adult-born granule cells are necessary for some behavioral effects of fluoxetine and to induce stress resilience. Using transgenic mouse lines with either no 5HT1ARs anywhere in the brain (1AKO) or limited to the dentate gyrus (DG1A+), we show that chronic administration of 5HT1AR agonist, 8-OH-DPAT produces notable behavioral relief. After analyzing expression of the immediate early gene, C-fos, a proxy measure for neuronal activity in mature granule cells, we found that specific 5HT1AR activation by agonist 8-OH-DPAT in DG1A+ mice protected them from chronic stress-induced anxiety-like behavior. Analysis of neurogenesis through the young neuron marker doublecortin (Dcx) revealed no effect of 5HT1AR activation on neurogenesis. These results suggest that inhibition of mature granule cells by 5HT1ARs may be underlying the behavioral responses to 8-OH-DPAT. This work has the potential to bring about improved antidepressant treatments that may inhibit the DG, potentially by directly activating 5HT1ARs.

LIHAO XIAO GS'20: MATHEMATICS-STATISTICS

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Faculty Mentor(s): Tian Zheng, Columbia University
Title: Diagnostics of Dynamic Interaction data from an Email Network

Abstract: We introduce and briefly analyze the interaction data in a large email network first described in Kossinets and Watts (2006). The email network consists of over 10000 users and 2 million temporal data. We describe the data collected, perform some exploratory analyses and finally fit some point process models to a selection of this data. Especially, I performed residual analysis on the Community Hawkes Independent Pairs Model(CHIP) to analyze the email network. We develop model fitting techniques including residuals analysis and matrix structure scores to detect community-structure of email users. We also use different visualization tools in Gephi to visualize the network structures. The research aims to perform diagnostics for point process models and to better capture the interaction intensity within or between social groups and how different social groups are linked together.

DINGWEN XIE SEAS'20: OPERATIONS RESEARCH

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Faculty Mentor(s): Sharon Di, Columbia University
Title: Understanding the relationship between NYC bikesharing and public transit

Abstract: Citibike has been introduced to New York City since 2013. More and more New Yorkers travel by Citibikes, but does it mean people become less likely to take the subway? This project focuses on the relationship between bikeshare system and public transit, especially in Manhattan, whether it's competition or complement. We gathered actual travel information through Citibike May trip data, MTA subway turnstile data and MTA static data including schedule and geo locations. Bike trips were divided into different categories: not only differentiate time and location, but also different combinations of bikeshare start or end, subway enter or exit. Also, we defined horizontal and vertical trips by their start and end locations. Then we calculated correlation score of each group. Current results could tell that Citibike trips in lower Manhattan had higher correlation with subway in general. Next step we will further cluster bike stations and subway stops to make more rigorous analysis.

KOHTARO YAMAKAWA CC'20: PHYSICS; MATHEMATICS

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Faculty Mentor(s): Yasutomo Uemura, Columbia University
Title: Muon Spin Rotation Studies of LaSrVO3

Abstract: Using a novel, spatially-local probing technique called "Muon Spin Rotation Spectroscopy", the magnetic structure of the crystal La Sr V O 3 is studied. In this process, muons are beamed into a small sample crystal, and allowed to decay into pions inside the crystal. Detection of such pions allow information about the muon's spin, their precession, and decay there-of to be transmitted. Through this technique, it is shown that lower dopings have an additional magnetic structure that was unable to be detected by other methods. It is also shown that previous data on the phase transition taken via current measurements is consistent with the taken data. Particular interest is held in the crystal's phase transitions from a metal to insulating state and how this transition relates to the internal interactions between the atoms inside the crystal. This allows one to understand more in depth about the nature of so called "orbital physics" and how charge, spin, and orbital degrees of freedom interact with one another.

ANGELA YE SEAS'22: CHEMICAL ENGINEERING

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Faculty Mentor(s): Alan West, Columbia University
Title: Measuring Transference Number of Battery Membranes as a Function of State of Charge

Abstract: Many sources of renewable energy, like solar and wind, are intermittent, and thus require energy storage. One promising energy storage technology is the vanadium redox flow battery (VRFB), which has large energy capacity and is resistant to degradation. VRFBs contain V4+ and V5+ in the positive half-cell and V2+ and V3+ in the negative half-cell. A membrane is required to separate the two redox couples, but vanadium ions may cross the membrane, causing efficiency loss. The membrane's selectivity for ion crossover is quantified by transference number. However, current techniques to measure transference number are imprecise, time-intensive, and complex. An accurate transference number measurement can be used to understand efficiency loss in the VRFB for both currently used and newly designed membranes.

In this study, transference numbers of vanadium in the VRFB membrane were measured for varying states of battery charge. An experimental setup was designed to allow accurate measurements of vanadium crossover. Transference number was obtained by comparing experimental data to a numerical simulated model of the setup. At high current densities, experimental data and model are in good agreement. This allowed for calculations of transference number with minimal uncertainty. Transference number decreased linearly as battery state of charge increased. These results confirm that this methodology can be applied to VRFBs, which can help estimate VRFB performance and to measure transference number of other membranes. In the future, generating and testing with V2+ and V3+ ions will give a complete understanding of crossover behavior in these batteries.

STEVEN ZELDIN CC'22: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Nicole Vo, Columbia University
Title: A Tool Against Dementia: Evidence that CD33 Can be Safely Targeted in Future Alzheimer's Disease Therapies

Abstract: CD33 is a cell-surface receptor protein that significantly increases Alzheimer's Disease risk by lessening the ability of the brain's resident white blood cells (microglia) to destroy toxic Amyloid-Beta proteins. A non-harmful mutant form of CD33, known as D2-CD33, has recently been identified—yet it is not clear whether D2-CD33 is beneficial because it has gained an Alzheimer's-protective property (gain-of-function mutation) or because it has merely lost one of typical CD33's harmful properties (loss-of-function mutation). In his study, Steven Zeldin supports the claim that a loss-of-function mutation is responsible for D2-CD33's Alzheimer's-protective nature by providing evidence that D2-CD33 experiences a shift in localization from the cellular surface to the cellular interior, thus removing its access to the ligands responsible for activating CD33. By so providing evidence that the Alzheimer's-protective D2-CD33 is merely a disabled form of CD33, Steven supports the idea that CD33 can be safely and effectively made a drug target in future Alzheimer's therapies. Steven's work also highlights the need to conduct further studies on D2-CD33 and its properties, as its reasons for migrating away from the cell membrane and its possible intracellular roles are not yet understood and of potential relevance to Alzheimer's Disease research and future therapies.

ALENA ZHANG CC'21: SUSTAINABLE DEVELOPMENT

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Faculty Mentor(s): Kanako Iuchi, Tohoku University
Title: Coffee and Quinoa: Economic Adaptation After Natural Disasters in Japan and Taiwan

Abstract: Economic adaptation to natural disasters is essential for vulnerable coastal communities facing threats to traditional livelihoods in the form of globalization and/or climate change. Two indigenous villages in south Taiwan, Rinari and Ulaluzi, have adapted their economy to tourism-driven, single-crop enterprises to increase economic capital after the destruction of Typhoon Morakot in 2009. Rinari grows, refines and sells high-end quinoa-based products; Ulaluzi, coffee. Both are marketed as a combination of modern technology and traditional indigenous practices. However, these businesses only minimally retain traditional indigenous practices of farming. They face major challenges in shifting the culture of a previously self-subsistent, isolated community to one heavily influenced by the global market. Research is needed to demonstrate if these recovery efforts provide true resilience, or if they are destructive coping mechanisms that may lead to loss of culture, land, and livelihood. I propose to modify the Sustainable Livelihoods Approach, which qualitatively measures the livelihood of a community as the culmination of 5 capitals: natural, physical, financial, human, social, to include a sixth capital, cultural, as based on community development theories. My research aims to illuminate the neo-cash crop businesses in Rinari and Ulaluzi as either a livelihood resilience measure or a coping mechanism, thus filling a gap in the literature about the increasing presence of such enterprises in rural, disaster-prone areas. Future research could link the quinoa and coffee enterprises in Taiwan with the new strawberry enterprise in the rural village of Yamamoto, Japan, which was destroyed by the 2011 tsunami.

EMILY ZHANG CC'21: ASTROPHYSICS

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Faculty Mentor(s): Murray Brightman, California Institute of Technology
Title: Searching the Chandra Source Catalog for High-Redshift AGN

Abstract: Active galactic nuclei (AGN) are the most constant, luminous emitters in the Universe, which makes them uniquely visible at large distances and capable of probing the earliest periods of the cosmos. Previous searches for high-redshift AGN have focused on finding unobscured AGN through infrared and optical analysis. However, most AGN in the Universe are actually obscured, so these studies overlook a significant portion of high-redshift candidates. To uncover new candidates, we searched for sources in the Chandra Source Catalog following hardness ratios given by the Brightman & Nandra (2011) torus model as well as other characteristic parameters of high-redshift AGN. We then fit each selected source's spectrum with the torus model in order to find the best-fit redshift and its confidence, keeping any sources with a confident best-fit redshift > 6. Moving forward, we will add further observations from Chandra and XMM to improve these candidates' spectra and visually check for spectral features like the iron line, iron edge, and Compton hump. We will confirm our final sources by chasing them in the traditional optical and infrared bands.

HARRISON ZHANG CC'22: BIOLOGY

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Faculty Mentor(s): Minoree Kohwi, Columbia University
Title: Drosophila Neuroblast Fate Specification and Competence with Hunchback Intron Deletion

Abstract: Neuroblasts have limited competence to generate specific cell fates, and a series of developmentally regulated molecular mechanisms are thought to tightly control their resulting progeny. In Drosophila neuroblasts, the hunchback (hb) gene produces the Hunchback (Hb) protein, a vital transcription factor that specifies early born neurons. After chromatin accessibility mapping (ATAC-sequencing) revealed the hb gene intron's accessibility to potential regulatory factors during neuroblast development, we deleted the hb intron to assess its role in the regulation of a neuroblast's competence to produce early born neurons. Transgenic flies with the hb intron deletion were assayed with CQ-gal4, en-gal4, sca-gal4, and 1407-gal4 gene drivers to characterize neuroblast fate specification and competence in the context of the intron deletion. We discovered that while post-mitotic U motor neurons do not change fates in response to overexpression of Hunchback (Hb) protein, they exhibit a striking extension of competence to produce early born cell fates when Hb is overexpressed in neuroblasts, GMCs, and neurons. When Hb is overexpressed in neuroblasts only, we also observe an extension of competence to produce early born cell fates, and thus confirmed that only overexpression of Hb in neuroblasts is needed to extend the competence window when the hb intron is deleted. Through these assays, we confirmed that the hb intron is not required for proper Hb expression in the central nervous system and that the hb intron region plays a vital role in the termination of a neuroblast's competence to produce early born neurons in Drosophila.

SUSAN ZHOU CC'22: ECONOMICS - MATHAMATICS

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Faculty Mentor(s): Douglas Almond, Columbia University
Title: The Impacts of the California Paid Family Leave Policy on Pregnancy-Associated Hypertension

Abstract: Chronic maternal stress has been associated with low infant birth weights and poorer infant health, and economic strains can be one of the primary contributors to maternal stress. The United States currently does not have a nationwide policy for paid family leave, although individual states have enacted their own policies. A statewide Paid Family Leave policy was introduced in California in 2004, and the implementation of the program increased between 2004 and 2014. Databases of natality information were examined in order to study the relationship between the paid family leave policy and pregnancy-associated hypertension, which was used as a proxy for maternal stress. In particular, San Bernardino County in California and Washoe County in Nevada were compared, as they are neighboring counties subject to differing paid family leave policies. The proportions of pregnancy-associated hypertension in the two counties over time were calculated and plotted. However, any projections currently drawn would still need to be tested for statistical significance. Moreover, further background research is required to ensure that there are no other confounding factors. Nevertheless, chronic maternal stress been associated with negative health repercussions for the mother and the infant, and further research on paid family leave policies could reveal some important effects of public policy on health outcomes during this critical period.