Columbia University Undergraduate Research Symposium

ABSTRACTS

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ONLINE EVENT

COLUMBIA UNIVERSITY
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CONTENTS

BETHEL ADIELE CC'23: MEDICINE, LITERATURE AND SOCIETY

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Faculty Mentor(s): Dana March Palmer, Columbia University
Title: COVID-19's Multiplicative Effects on Pre-Existing Racial and Ethnic Health Disparities

Abstract:
The recent outbreak of the Sars-Cov-2 (COVID-19) virus has caused a public health crisis that has infected over 27 million people and taken about 900,000 lives worldwide. Currently, the United States holds the record number of over 200,000 deaths as of September 22nd. We conducted review on epidemiological literature dealing with the social determinants of racial health disparities, fundamental causes of disease, and COVID-19's multiplicative impact on the social determinants of racial health disparities was conducted primarily using PubMed and Science Direct. Data was collected on the racial and ethnic demographics in the front-line industries across the United States. New York City community health profiles were also used to determine which communities and regions were most affected by COVID-19. We also analyzed the models of dispersion of medical innovation to determine what would be the best epidemiological approach to make treatment readily available to those who need it most. Data shows that across the lines of lower SES, disproportionate chronic illness burden, over-representation in front-line industries and incarceration populations, untenable neighborhood living conditions, and lack of proper health service, Blacks and Latinx communities are over-represented. COVID-19's impact on these pre-COVID inequities has been multiplicative on the social determinants of health. Thus, it is necessary that a precise public health approach is used to fundamentally address these racial/ethnic health inequities. Upon the discovery of a vaccine, the priority of treatment must go to these under-resourced communities and the front-line workers.

AROOBA AHMED CC'23: BIOCHEMISTRY

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Faculty Mentor(s): Jean Gautier, Columbia University
Title: Kinetics of SJG-136 Induced Interstrand Crosslink Foci Accumulation and Clustering Analysis

Abstract:
DNA Interstrand Crosslinks (ICLs) covalently link opposite strands of DNA and prevent cells from completing crucial processes such as replication and transcription. This quality makes them functional chemotherapeutics. However, crosslinking agents as common endogenous disruptors to cellular processes have allowed cells to develop processes that bypass them. These experiments studied the mechanisms of repair when cycling U2OS AsiSI cells were treated with the crosslinking agent SJG-136. Comparison of γ-H2AX and RPA foci indicated that γ-H2AX localized to double strand break repair foci before RPA, which is consistent with existing evidence demonstrating that γ-H2AX is phosphorylated before RPA localizes to single stranded DNA that is to be resected. Clustering analysis of foci labelled with RPA showed that SJG-136 induced ICL foci do not cluster and their nuclear distribution is not affected by the Arp 2/3 inhibitor CK-666. This may indicate that these ICL foci have limited mobility in comparison to other ICL foci, such as those created by Neocarzinostatin. Collectively, these results offer insight into repair mechanisms of SJG-136 crosslinks and provide a base on which to build a bigger picture about the fundamentals of crosslink repair.

SOPHIA AHMED CC'21: SUSTAINABLE DEVELOPMENT

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Faculty Mentor(s): Mihir Desu
Title: Electric Vehicle Incentive Models for US Adoption

Abstract:
Transportation is the leading source of greenhouse gas emissions in the United States. Electric vehicles (EVs) provide the only viable pathway to rapidly decarbonize the transportation sector. However, federal policy has not yet solidified its role in the United States' transition to EVs. This project analyzed EV incentive models utilized in International markets and modeled out their application in the United States. Results indicate that many of these incentive structures have been effective in accelerating EV adoption in their respective countries and that the United States is substantially behind peer nations in the ambition and complexity of EV incentives.

JAALA ALSTON CC'22: ETHNIC STUDIES; ECONOMICS

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Faculty Mentor(s): Matt Sandler, Columbia University
Title: Effects of Socioeconomic Heterogeneity on Educational Attainment and Crime Incidence, Evidence from the US

Abstract:
The project begins asking “how and why does racial discrimination persist in non-market economies?” It focused particularly on studying racial discrimination in Cuba because Cuba emancipated its slaves in 1886, later than any other colony or country in the region. Because of insufficient data and the unreliable nature of race-based statistics in Cuba, it was impossible to answer the original question using econometric tools and modes of analysis, therefore, oral history and literature review were employed particularly to understand the relationship between the configuration of race in Latin America, the tension between national mythos and racial identity, and furthermore, understanding the economy as a symbol of national values and ideals. The oral histories that were done among working class Black people in the American south illuminated the narrow scope of the question, and it became apparent that there needed to be a shift in order to consider the micro-level interactions that oppressed people have with individuals in their communities. The study arrived at the conclusion that it would be more fruitful to survey Black radical thought about post-revolutionary struggles, particularly considering what remnants of oppressive thought exist after the abolition of structures that uphold racial capitalism. By becoming steeped in this discourse, it became apparent that the range of ideas spanned across countries and also across identities, considering gender and sexuality as intersections to consider as well. The pivot in question also recognized the agency of Black people as agents of change rather than subjects, and could grapple with the range of lived experiences outside of traditional binaries.

DIOGENE ARTILES CC'22: LATIN AMERICAN AND IBERIAN CULTURES

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Faculty Mentor(s): Ana Paulina Lee, Columbia University
Title: Lances Bahianas: The Sabinada and the Brazilian Slave Trade

Abstract:
Diogene Artiles looked at the separationist movements of early nineteenth century Brazil and analyzed the ways in which race and religion impacted revolutionary thought and potential. Particularly looking at the Sabinada, a separationist movement of the Brazilian northeastern state of Bahia, Diogene found the intersections of the pro-militaristic, anti-Portuguese and segregationist undertones of the movement to be engaging predecessors to the regional politics of the slave trade and which enslaved people were deemed most profitable according to the regional stereotypes that arose due to these separationist rebellions. As a case-study, Diogene looks at Luiz Gama, a notable Brazilian abolitionist who was born into slavery. Gama was born in Salvador, Bahia and his mother was a free African-born woman who was constantly arrested for being accused of planning slave revolts. Gama is sold into slavery, and the stereotype that enslaved people from Bahia are particularly difficult to work with and rebellious impacted his assimilation in carioca culture in southeastern Brazil.

CHARLOTTE ATKINS CC'23: ENGLISH

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Faculty Mentor(s): Alexandra Watson, Barnard College, Columbia University
Title: Timeliness versus Timelessness: How is the Poetry of the Black Lives Matter Movement Categorized?

Abstract:
Inspired by the widespread digital sharing of antiracist reading lists in the wake of the murder of George Floyd and the 2020 nationwide resurgence of civil rights protests, this research project centers on an exploration and categorization of the poetry of the Black Lives Matter movement through the idea of “timeliness” versus “timelessness”. The project focuses on the poetry of the Black Lives Matter movement collected from the two primary catalogs of Black Lives Matter movement poems, one compiled by the Poetry Foundation, and the other by the Academy of American Poets. In investigating how the poetry of the Black Lives Matter movement engages with temporality and relevance, the project defines “timely” poetry as that which is either post-2013 (written after the creation of the Black Lives Matter movement) or which responds to a specific event, often an act of brutality. “Timeless” poems of the movement were either published pre-2013, or are post-2013 poems that do not reference a specific event as their “timely” counterparts do. Through analyzing these categories and the unexpected ways the poetry of the Black Lives Matter movement blurs the lines of category, the project draws conclusions about temporality and relevance applicable not only to the poetry of the movement, but also to the movement itself.

SCARLET AU CC'23: ENVIRONMENTAL BIOLOGY

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Faculty Mentor(s): Prof. Deren Eaton, Columbia University
Title: Biogeography and Dispersal of Viburnum in Taiwan

Abstract:
Islands are often considered “natural laboratories” of evolution, where the order and timing of dispersal of species from mainland communities can significantly influence the establishment, selection pressures, and evolutionary trajectories of island populations. The island of Taiwan has accumulated a rich diversity of plant species over the 5-6 million years since it surfaced, including both tropical lowland and temperate high elevation plant communities composed of species that dispersed from China, Japan, and the Philippines. The plant lineage

Viburnum presents a unique opportunity to investigate the order and timing of island colonization, as it has dispersed to Taiwan at least 11 times independently. With genomic data representative of 125 Viburnum samples and 50+ taxa from 4 regions of interest (Taiwan, China, Philippines and Japan), we applied the multispecies coalescent model (MSC) implemented in the Bayesian Phylogenetics and Phylogeography program (BPP) to infer divergence times and effective population size estimates for 11 clades with divergences between Taiwan and another region. Results were visualized and interpreted with the ipyrad, toytree and NumPy packages in Python and Jupyter. Our results show that dispersal to Taiwan occurred most frequently from mainland China, followed by the Philippines, and then Japan. These results contrast with previous hypotheses about the importance of a middle-late Pleistocene land bridge connecting Taiwan and Japan. Instead, we propose that Viburnum predominantly dispersed to Taiwan much earlier, by bird-mediated dispersal from mainland China.

YASMINE AYMAN CC'21: NEUROSCIENCE AND BEHAVIOR; PHILOSOPHY

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Faculty Mentor(s): Richard Axel, Columbia University
Title: Intergenerational Inheritance of Learned Fear Leads to Phenotypic Changes in the Olfactory Epithelium

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 for the mechanism underlying these epigenetic changes by answering two key questions. Firstly, does fear conditioning extend the OSN lifespan or increase cell proliferation of the specific receptors to the conditioned odor. Secondly, are the receptors to the conditioned odor necessary and/or sufficient for the epigenetic phenotype in F0 and F1. We use 5-ethynyl-20-deoxyuridine (EdU) to birth date OSNs at single cell resolution in the olfactory epithelium, and DREADDS (HM4Di and HM4Dq) to stimulate the OSNs in vivo in order to test the causal relations between the mature OSNs and the increase in OSN expression. Our data indicate a potential mechanism for how environmental signals are conveyed to somatic cells in sensory systems, before being transmitted to germ cells and subsequently to future generations.

JOON BAEK CC'21: COMPUTER SCIENCE; PHYSICS

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Faculty Mentor(s): Mark Taylor, Columbia University
Title: The Professor is In: Using The Professor is Always In - Using Artificial Intelligence for Online Education in Religion

Abstract:
Online learning could be easy for STEM courses, yet for humanities courses that require constant instructor presence, replicating that presence online might be limited. Thus, in order to replicate the instructor's presence online, my independent research attempts to build a chatbot that can communicate with its students regarding specific course-related topics.

Along with Prof. Mark Taylor, the Professor of Religion in Columbia University, I have been working to build a chatbot using natural language processing methods to serve as a teaching assistant to philosophy and religion classes. The intent of the project is to have a chatbot that can not only converse with students on logistical matters (syllabus, exam information, etc) but also on the religious topics of the course.

CHINMAYI BALUSU CC'23: MEDICINE, LITERATURE AND SOCIETY

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Faculty Mentor(s): Anna Delprato, University of Bordeaux
Title: Integrative Genomics Analysis of Gene Expression Patterns in Assessing Comorbidities of Parkinson's Disease and Essential Tremor

Abstract:
According to the National Institute on Aging, Parkinson's disease is a neurodegenerative disorder that leads to "shaking, stiffness, and difficulty with walking, balance, and coordination." The Parkinson's Foundation reports that there are nearly 10 million individuals around the world who are experiencing Parkinson's disease. Essential tremor is a neurological disorder that is often confused with Parkinson's disease due to not being as well known as well as the similar symptoms patients display--individuals with the condition often experience involuntary, rhythmic shaking (e.g. trembling of the hands). In this project, we investigated the expression of genes implicated in Parkinson's disease and essential tremor in three specific brain regions that have been previously demonstrated to be affected by the conditions (the cerebellum, basal ganglia, and substantia nigra). In doing so, we worked to determine the impact of underlying gene expression, pathways, and networks as a basis for comorbidities (both conditions presenting simultaneously in a patient). Additionally, we work to address patients' presentation of symptoms that do not constitute a motor deficit that is highly prevalent in both Parkinson's disease and essential tremor.

EMILIE BIGGS CC'21: COMPARATIVE LITERATURE AND SOCIETY

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Faculty Mentor(s): Christia Mercer, Columbia University
Title: Research Assistant -- Anne Conway and modern philosophy

Abstract:
Because this work was conducted in the context of serving as a research assistant, as opposed to designing a specific project, it follows several different threads as opposed to one set topic. The student worked generally on the history of the modern philosophical era, looking specifically at the works of Anne Conway and trying to identify her scholarly influences. Conway was a British Neoplatonist philosopher known for her Principles of the Most Ancient and Modern Philosophy, a metaphysical and theological text that advances a tripartite division of substance into three categories: God, "creature" (God's creation), and Christ, who serves as an intermediary figure. One central line of inquiry was the influences of Quakerism upon Conway's thought. Similarly, because Conway was in part being studied in relation to the fact of her being a woman philosopher from the 17th century, the role of gender in 17th century Quakerism was also a focal point. This Conway research fit into a larger schema of trying to identify underrepresented voices in the history of philosophy, as well as challenging current narrative surrounding what the history of philosophy is. The student helped work on several papers promoting a more inclusive approach to philosophy, which rejected the traditional, canonical interpretation of Descartes as the

founder of modern philosophy and more deeply explored the multitude of (oftentimes marginalized or deliberately undervalued) sources that informed philosophy's development.

MAKENA BINKER COSEN CC'21: HISTORY

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Faculty Mentor(s): Madeleine Zelin, Columbia University
Title: "America's Greatest Chaos:" Copyright and its Administration at the Library of Congress, 1864-1897

Abstract:
This summer, Makena investigated copyright and its administration at the Library of Congress during the late nineteenth century, prior to the subsequent establishment of the U.S. Copyright Office as one of the Library's departments. Her primary aim was to understand what form copyright law and its management took under the leadership of library clerks. To this end, she consulted the Copyright Office's archives and, from this collection, she studied the Library of Congress's Annual Reports written by the Librarian of Congress, supplementing her primary source analysis with relevant secondary scholarship. Through this exploration, she identified the role of Congress in the decline of copyright's sustainable utility to the Library staff — transforming copyright registration from an incredibly profitable venture into "America's greatest chaos." Moving forward, Makena intends to expand her research into her senior thesis, advancing her examination into the early twentieth century in order to understand how the newly founded Copyright Office's attorneys specialized in intellectual property managed copyright differently than their predecessors.

MARIA BOTERO PINZON CC'22: BIOLOGY

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Faculty Mentor(s): Dalibor Sames, Columbia University
Title: Developing an Image Analysis Workflow for Synaptic Plasticity Assays

Abstract:
Neuroplasticity, or the capacity of the brain to change its structure and function by reorganizing its connections, is essential for brain development and for brain recovery from injury or disease. Many techniques have been developed to study the neuroplasticity of the brain, including morphological, electrophysiological, behavioral, and biochemical approaches; yet, currently not much is known about the signaling cascade within single neurons necessary to induce synaptic plasticity. The brain-derived neurotrophic factor (BDNF) and its high-affinity receptor tropomyosin receptor kinase B (TrkB) play an important role in the survival, differentiation, and plasticity of neurons. Synaptic Plasticity Assays (SyPA) is a method being developed in the Sames lab to quantify molecular signaling associated with the activity of BDNF/TrkB signaling and their long-term effects at the single neuron level. Currently, the greatest challenge in image analysis of SyPA is accurate automated reconstruction of neuron morphology for computational identification. Here, we have developed an automated workflow for SyPA that runs multiple processing steps to effectively classify individual neurons in images so that computational measurements can be conducted on them. The workflow consists of preprocessing (image standardization, illumination correction, denoising), feature extraction (image segmentation using machine learning), postprocessing (refining neuronal reconstructions), and analysis of neuronal images.

ORENNA BRAND CC'21: CLASSICS; COMPUTER SCIENCE

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Faculty Mentor(s): Christia Mercer, Columbia University
Title: A New Edition of Anne Conway's 'Principia'

Abstract:
Anne Conway was a seventeenth-century English philosopher who worked in the tradition of the Cambridge Platonists. A student of Henry More, she learned Latin in order to pursue her interest in philosophy, despite her lot as a woman—that was, exclusion from university education. Her treatise on Platonist metaphysics, 'Principia philosophiae antiquissimae et recentissimae,' was first published in Latin in 1690, and later in English. Despite favorable reception by Leibniz, the text did not receive considerable attention or scholarship until relatively recently. In the past few decades, it has become a priority of many universities and philosophy departments to diversify their syllabi and to acknowledge the early modern women unjustly ignored in the narrative of the history of philosophy. This work was in contribution to a new edition and translation of 'Principia' as a part of the Oxford New Histories of Philosophy series, a hopeful development in the effort to study Conway's deeply original and influential philosophy.

SAMANTHA BRESLAUER CC'23: UNDECIDED

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Faculty Mentor(s): Raj Ragoowansi; Tawfiq Elahi, Royal London Hospital
Title: Hand injuries in climbers – description of various grips and relevant biomechanics, meta-analysis of injuries sustained and combination strategies for treatment.

Abstract:
The aims of the study are to look at the different finger/hand grips used in outdoor and indoor climbing and the frequency of hand injuries along with their recommended management in current literature. We conducted a systematic literature search from the past twenty years of the following databases: PubMed, EMBASE, PsycINFO, AMED, EMCARE, BNI, HMIC, CINAHL, Ovid and Medline. Through looking at various databases, 18 articles were relevant to the meta-analysis on climbing hand injuries. Pulley injuries are the most common with an average of 59.77%, followed by tendon injuries 36.25%, fractures 35.24% and ligamentous injuries 14.47%. For pulley injuries specifically, 59.03% can be treated conservatively, while 40.97% of injuries require surgical treatment. The four most common types of handholds are the closed crimp, open crimp, sloper and pocket. The crimp grip, used by up to 90% of climbers, is associated with an increased incidence of A2 and A4 pulley injuries. We observed Conservative management for Grade I-III pulley injuries and surgical repair for Grade IV. Due to the bulk of injuries being treated conservatively, splinting and taping is a significant part of the management strategy. It is important for hand surgeons to be aware of the complexity and treatment protocols due to growing popularity of the climbing sport.

LIAM BRODERICK CC'21: ANTHROPOLOGY; JAZZ STUDIES

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Faculty Mentor(s): Robert O'Meally, Columbia University
Title: The Interrelation of Jazz and Capoeira: Examinations and Artistic Expansions

Abstract:
Rarely grouped together in academic discourse, Jazz music and the Afro-Brazilian martial art of Capoeira have striking historical, practical, and philosophical similarities. This project implements an intertextual and artistic approach to examining the parallels between these two Afrodiasporic art forms, and, in doing so, develops a comparison which comments on the importance of interpersonal dialogue and provides insight into the relationship between embodied improvisatory practices and the production of philosophical meaning. Tripartite in structure, the first part of the project investigates the histories of each art form and draws connections between the conditions from which they arose; the second part explores the words of practitioners to illustrate the philosophical significance of each discipline; and the final part of the project engages an artistic discussion of the practical similarities between the art forms. The interdisciplinary artistic component of this research project is central with a large part of the work being the production of new jazz compositions inspired by the movements and ideology of Capoeira.

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

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Faculty Mentor(s): Chris Wolfe, Columbia University
Title: "We Not Siblings But We Kinfolk": Community & Neighborhood In Black Poetry

Abstract:
In my research I focus on close reading how ideals of community and neighborhood surface in the writing of contemporary Black poets. Contemporary defined as poetry books published 2012-present aligning with the murder of Trayvon Martin to the present day. In recent poetry anthologies like A Fortune for Your Disaster by Hanif Abdurraquib (2019) and Electric Arches by Eve L. Ewing (2017), these poets unpack moments where their communities have had a profound impact on shaping their lives. These Black poets use personal narratives and acute observations as entrances into larger conversations about survival and kinship amongst Black people in the midst of the over-policing, violence, and rampant gentrification that affects Black communities across the country. This project pursues a deeper understanding of what Black poets stand to gain or lose by politicizing the intimacy of their communities in the modern-day. The research also seeks to parse through the parallels between the Black community at large using personal stories in the literature to humanize themselves under the white gaze. Approach is interdisciplinary, combining methodologies from performance studies, ethnic studies and cultural studies. **Contemporary defined as poetry books published 2012-present aligning with the murder of Trayvon Martin in 2012 to the present day.*

PAYAL CHANDAK CC'21: COMPUTER SCIENCE; NEUROSCIENCE

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Faculty Mentor(s): Marinka Zitnik, Harvard University
Title: Using graph neural networks to find potential treatments for rare diseases

Abstract:
Rare diseases are extremely deadly; 30% of children diagnosed with a rare disease do not live to celebrate their fifth birthday. Only 400 of the 7000 rare diseases in the world have approved treatments. Rare diseases do not have a market large enough to incentivize a long and expensive drug discovery process. However, the strategy of repurposing an existing drug to treat a new disease has found much success. Here we apply graph neural

networks to predict drug repurposing targets for rare diseases. We show that predicting treatments for rare diseases is a hard problem that requires inductive generalization. Current state-of-the-art graph neural network methods perform poorly on this problem. We propose a graph neural network that uses neighborhood routing to achieve inductive generalization.

CAROLINE CHEN CC'22: MEDICINE, LITERATURE AND SOCIETY

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Faculty Mentor(s): Kam Leong, Columbia University
Title: Characterization of a cerebral microphysiological system for modeling neuropsychiatric disorders

Abstract:
Brain organoids recapitulate the architecture and neural network activity of the living human brain, serving as powerful models with which to study physiological and pathological neural development. One critical limitation of the brain organoid model is its lack of vasculature, which is not only necessary for proper oxygenation and nutrient delivery, but also serves a vital function in nerve patterning and development. We propose to integrate brain organoids with 3D vascular culture (termed vessel organoids) to form a cerebral microphysiological system (CMPS) for studying the crosstalk between the central nervous system (CNS) and vasculature. To validate our CMPS, we propose to use DiGeorge Syndrome (or 22q11.2 Deletion Syndrome), one of the most common genetic causes of psychosis that affects both the CNS and vascular system. Using computer-based image analysis methods, we were able to characterize the architecture of our integrated system, improving our understanding of the CMPS structure for further development and applications. Our research may yield insights into a more representative brain organoid system for the screening of drug treatments and modeling of neuropsychiatric disorders.

ETHAN CHEN CC'21: BIOCHEMISTRY; STATISTICS

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Faculty Mentor(s): Sam 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, the Sternberg lab recently discovered a new programmable, RNA-guided transposase. The system 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 RNA11, and allows for higher efficiency genomic engineering applications without the need for double strand breaks. However, many of the parameters that govern its action are unknown. Previous experiments showed that the majority of DNA integration events occur ~50bp downstream of the genomic target site, but rarely, longer-range integration occurs many kilobase pairs away. Specifically, long-range DNA integration into T7 RNA polymerase (RNAP) was observed. Hence, this project seeks to elucidate the mechanistic factors behind this observed off-target long-range DNA integration. An array of CRISPR spacers were designed to experimentally study long-range integration events by next-generation

sequencing. A computational data analysis script was used to analyze sequencing data and plot integration events along the genome. In the future, additional analyses will be conducted to learn more about the mechanism and parameters that govern this long-range integration.

BRENDON CHOY CC'22: BIOCHEMISTRY

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Faculty Mentor(s): Filippo Mancia, Columbia University
Title: Detergents and Membrane Mimetics in Membrane Protein Structural Biology: A 10-Year Meta-Analysis

Abstract:
Membrane proteins are vital to life and serve as essential components of cellular membranes that carry out enzymatic activity, allow cells to communicate and interact with each other, function in intracellular transport, and much more. Determining membrane protein structure helps reveal a mechanistic understanding of their function allows for structure-based drug design. An essential part of finding membrane protein structure is the use of amphipathic detergent molecules or membrane mimetics to stabilize hydrophobic transmembrane domains in solution. However, many different types of detergents must often be screened, and improper detergent choice can significantly affect the protein stability and yield, and structural determination conditions like particle distribution for cryo-EM. Due to the lack of specific rules regarding detergent usage, we have created a database of detergent conditions for all uniquely solved membrane proteins from 2010-2019. Here, using these data, I examined trends regarding detergent usage over time, for different types of proteins, across stages of experiment, and for different structural determination methods. My results visualize the different classes of detergents used over time and based on structural determination method and protein type. They also demonstrate the influence cryo-EM has had on the field over the past through rapid developments in the types of proteins it can solve and the introduction of new detergents and detergent alternatives. In the future, this database will be publicly available for reference and may provide insights into detergent choice for current and future researchers in the field.

HONOR CLEMENTS CC'21: SOCIOLOGY; LATIN AMERICAN AND CARIBBEAN STUDIES

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Faculty Mentor(s): Jonathan Rieder, Barnard College, Columbia University
Title: American or Virgin Islander?: How St. Johnians Feel about their Citizenship

Abstract:
This sociological research study analyzed the way that people who live in St. John in the U.S. Virgin Islands feel about their relationship with the United States. Through interviews with St. Johnians, it was found that many feel forgotten by the United States. Given that Virgin Islanders are citizens of the United States but cannot vote in elections, they are disenfranchised and frustrated. But even on a more daily basis, they feel that life is unnecessarily hard and that the government does little to help. Many cited the difficulty of getting fresh food and water and frequent electrical blackouts as examples. One of the largest complaints from Virgin Islanders was the lack of support after Hurricanes Irma and Maria's devastation in 2017, from which they are still recovering. This study was also affected by the social landscape at the time it was done - in the midst of a pandemic and a national reckoning with racism. The Islands' economic dependence on tourism means that the government has kept the borders open to tourists in the midst of the pandemic, closing only for short periods of time when the infection

rates were extremely high. Most St. Johnians rely on tourism for income, yet most of them also don't have health care. As a result, many of the interview subjects reported that they felt trapped in an impossible decision between making money and risking their health. Many Virgin Islanders also reported racial tensions. Ancestral St. Johnians, descendents of enslaved people whose families have lived in the territory for generations, reported that the legacy of colonialism is a major issue. One example that many interviewees mentioned is the island's national park, a donation from Laurance Rockefeller that takes up 60% of the island, because many ancestral St. Johnians were kicked off their land to make the park. Additionally, the existence of the park means that property values increase steadily in areas where land can be developed, resulting in gentrification. Overall, Virgin Islanders feel forgotten by the U.S. federal government, a feeling that was intensified by the socio-political context at the time this study was done.

SIMON COHEN CC'21: MUSIC

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Faculty Mentor(s): Shamus R. Khan, Columbia University
Title: Miracle Mann: the politics and aesthetics of charismatic leadership in the Philadelphia Orchestra

Abstract:
This article explores the role of personality in negotiating administrative and musical decisions in the Philadelphia Orchestra from the period between 1948 and 1987. It considers the role of patron and impresario Fredric R. Mann, who managed the Robin Hood Dell, the venue of the orchestra's summer concerts, for decades (Mann eventually financed the rebuilding of a new Dell which was called the Mann Music Center in his name). Much attention has already been paid to the role that individual charismatic authority, expressed through strong, unique personality, plays in orchestras through the role of the conductor, who physically shapes the sound of the ensemble, bending the musicians to his (usually) will through an authoritative, sometimes autocratic leadership style. Less consideration, though, has been paid to the extent to which administrators—assumed more peripheral to art-making, but nonetheless with an important ability to respond to and shape public taste—may participate in similar dynamics. This research uncovers the many aspects of Fredric Mann that made him a memorable figure in the circles in which he moved: his distinctive barking voice, the cloud of cigarette smoke that followed him everywhere, and his powerful ability to exert political influence over musicians and city officials alike. It thereby places Mann's mostly-forgotten individual contributions in a context that demonstrates the highly consequential nature of such decisions in determining how music is consumed.

COLUMBIA SPACE INITIATIVE BIOMEDICAL MICROGRAVITY PROJECT

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Faculty Mentor(s): Michael Massimino, Columbia University
Title: Human Spaceflight and Vision Impairment: The Effects of Microgravity on Gene Expression in Retinal Glial Cells

Abstract:
Extended periods of time in space have been known to cause astronauts a multitude of physiological changes in the human body; including but not limited to loss of bone density, muscle atrophy, and diminished organ function. Research shows that about 30% of astronauts on short-term flights and 60% on long-duration missions to the ISS have reported impairment to their vision in one form or another. In this study, it was hypothesized that

short term exposure to microgravity would have a negative effect on the organizational structure within cells from the eye. To examine this, samples of cultured retinal glial cells were sent to outer space on a Blue Origin suborbital rocket for exposure to four minutes of microgravity. An automated payload system was designed to encase the cells and inject cell samples with RNA stabilizing solution at different timepoints during the flight, allowing for comparison of gene expression before and after microgravity exposure. Following payload retrieval, results of a RNA microanalysis demonstrated negative expression of a gene associated with microtubule cytoskeleton organization, successfully corroborating our hypothesis by suggesting a negative impact on the structural integrity of eye cells in response to microgravity. In the future, this newfound knowledge of the effect of microgravity on the structure of eye cells may be used to inform clinical prevention of vision problems in astronauts. Furthermore, the automated payload system that was designed to accomplish this research can be used as a basis for future biological payload experiments in a variety of different contexts.

The five member team of the Columbia Space Initative Biomedical Microgravity Project include Cole Allan SEAS'21, Luke D'Cruz SEAS'21, Sabrina Gjerswold-Selleck SEAS'21, Nathalie Hager SEAS'21 and Christopher Mendell GS'23. Inquiries about this research should be directed to sg3459@columbia.edu or nathalie.hager@columbia.edu.

JOÃO COSTA CC'23: LINGUISTICS

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Faculty Mentor(s): Meredith Landman, Columbia University
Title: A Sketch Grammar for the Balti Language

Abstract:
This project aimed at creating a sketch grammar and an accompanying dictionary for Balti, a Tibetic language of Northern Pakistan with roughly 400,000 speakers. A sketch grammar is a scientific description of a language's grammar and structures based on the way its native speakers talk in their day-to-day lives, not using written or formal varieties as the standard for analysis. For this project, students worked with a native speaker of Balti to describe the variety of the language spoken around the city of Skardu in the Gilgit-Baltistan region Pakistan. Over the course of six weeks, they documented the basic working of the language's sound system (phonology), its parts of speech (morphology) and its ordering of words and phrases (syntax). Along with the grammatical description, students also compiled a word list containing around 600 entries of basic vocabulary that was used during the elicitation interviews, matching them to their closest English translations.

PORTIA CUMMINGS CC'23: BIOLOGY

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Faculty Mentor(s): Jean Gautier, Columbia University
Title: Mutational Signature 3 Enrichment in Pancreatic Adenocarcinoma Tumors with Defects in Homologous Directed Repair Genes

Abstract:
Homologous directed repair (HDR) is one of the mechanisms that eukaryotic cells use to preserve genome stability. HDR repairs double strand breaks, which are lesions on both DNA strands, through sister chromatids that act as homologous templates. HDR is a tumor suppressor mechanism as seen by the significant increase in breast, ovarian, pancreatic, or prostate cancer in patients with germline mutations in BRCA1 or BRCA2, two critical HDR

proteins. Germline or somatic mutations in genes regulating HDR can result in genome-wide accumulation of mutational signatures, with a distinguishable patterns of nucleotide substitutions derived from mutational processes. Enrichment in signature 3 is associated with unrepaired double strand breaks from HDR and can be detected through genomic analysis with the MutationalPatterns package from Bioconductor. These mutational signatures can also aid in treatment selection based on the unique signature for different cancer types. Our research examined signature 3 enrichment in pancreatic adenocarcinoma tumors, which have been shown to contain a high amount of mutations in HDR-related genes. The data confirmed signature 3 enrichment in pancreatic adenocarcinoma tumors with BRCA1 and BRCA2 defects and identified ATM and KMT2D as HDR-related genes with signature 3 enrichment. This examination further elucidates the incidence of HDR defects in pancreatic cancer and moves toward a mutational signature-based treatment selection for pancreatic adenocarcinoma cancers.

JACOB DAHAN CC'21: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Randy Bruno, Columbia University
Title: Training deep neural networks for automated micron-resolution tracking of animal behaviors

Abstract:
As animals navigate through their environment, they must detect and process sensory information to navigate the world around them. Mice rely on their whiskers—analogous to human fingers—to extract detailed information about their environment through active touch. How the brain encodes touch and motor signals, however, remains unclear. Recent research from the Bruno Lab suggests that tactile information processing is modulated in a task-specific manner by somatosensory cortex. Elucidating the relationship between task, motor movement, and somatosensory coding requires a well-characterized behavior assay, precise behavioral tracking, and electrophysiological recordings. Manual behavioral tracking is onerous and susceptible to subjective experimenter bias. To date, automated behavioral tracking is largely limited to macro-scale objects (e.g., tracking whole animals or their limbs) and is far too coarse for tracking mouse whiskers (on the scale of microns). Here, Dahan et al. developed a novel whisker-mediated texture discrimination paradigm for head-fixed mice. Head-fixation permits precise presentation of tactile stimuli, constrains the mice to use their whiskers, and enables high-speed videography of whisker movements. Custom-written data processing algorithms combined with Machine Learning techniques can accurately and consistently track ("label") single whiskers and stimuli. Moreover, high-dimensional outlier labels are reliably identified via a mathematical reduction of the complex data into a limited number of interpretable dimensions. Taken together, Dahan and colleagues demonstrate a new technique for high-throughput, automated preprocessing of traced data. Future work will pair behavioral analysis with electrophysiological data to reveal how somatosensory cortex integrates task design, motor movement, and tactile information to generate behavior.

SINA FAYAZ MONFARED CC'23: HISTORY

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Faculty Mentor(s): Michael Stanislawski, Columbia University
Title: Zionist Pioneers and The Chief Rabbinate

Abstract:

Why did Israel's secular founders opt to retain a modified version of the Ottoman's millet system? The Millet system awarded exclusive jurisdiction on matters of personal status to religious courts of recognized religious communities. Many have argued that Zionist pioneers preserved the Chief Rabbinate's monopoly over personal status in order to secure the ultra-Orthodox support for the establishment of the State. However, I argue that politics was not the sole reason behind this decision. First, Israel's founders created this "Status quo" with the ultra-Orthodox to ensure that Israel would not lose its Jewish character through intermarriage. Second, hoping to bring the Jews of the Arab world to Israel, Zionist leaders sought to accommodate the latter's traditionality by making the Chief Rabbinate the sole marriage register for Israeli Jewry. Third, aspiring to homogenize Israeli Jewry, Israel's founders established the Chief Rabbinate as a monopoly over marriage to enable various Jewish communities to marry each other and overtime generate the Israeli Jewish identity by losing diasporic differences.

ETHAN FENG CC'23: CHEMISTRY; PHILOSOPHY

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Faculty Mentor(s): Ruben Gonzalez, Columbia University
Title: Bayesian Inference: The Comprehensive Approach to Analyzing Single-molecule Experiments

Abstract:
Information about the structure and dynamics of proteins are vital to our understanding of their function in living cells. However, it can be difficult to obtain such information in sufficient detail, since protein molecules are extremely small, and samples contain enormous numbers of them, causing small, transient changes in individual proteins to go unnoticed. To combat this, scientists have pioneered revolutionary biophysical techniques that allow them to isolate single protein molecules to study their behavior. These methods, known simply as single-molecule techniques, have helped provide exceptional insight into the structure and dynamics of proteins. However, these tools are limited by the uncertainty and noisy data inherent to observing a single, miniscule molecule, which can make it difficult to extract meaningful information from the data.
Recently, a probabilistic method known as Bayesian inference has arisen as a powerful tool to tackle these biophysical challenges, and it accounts for the inherent uncertainty of single-molecule experiments. In essence, while traditional techniques yield a conclusion solely based on the experimental data, Bayesian inference takes into account previously known information and allows it to be updated by new data in order to reach a more finely tuned model. This provides a rigorous method to incorporate information from multiple experiments into a single analysis and to find the best model without the risk of overfitting the data. Moreover, Bayesian inference represents the most natural application of the scientific method to the problem of data analysis. These benefits make the Bayesian approach ideal for analyzing single-molecule experiments.

ERRDAISHA FLOYD CC'22: SOCIOLOGY

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Faculty Mentor(s): Geraldine Downey, Columbia University
Title: Tampa Protests: How the Community Understands Social Change

Abstract:
The purpose of the study will be to gauge the specific impact of yet another viral video of an unarmed black man being murdered by the police and the subsequent protests on respondents' understandings of the current state

of racism, the history of the United States, and the process of social change. I am interested in how they make sense of the current state of the country, the recurring uprisings in the past decade, and the future of their community. In other words, I am interested in examining how people's understanding of their past and present, of their community, influence their understanding of social change. This study will take place in one particular community. On the night of May 30th, crowds gathered and looting began in a predominantly black working class neighborhood in Tampa. The night ended with over 40 businesses damaged and 70 people arrested. This is just one of many uprisings that have occurred in the past month and they, along with the viral video, have ignited yet another iteration of the mainstream race conversation in the United States. This involves the recognition that we have been in a similar place before and a discussion of the best ways to create real change given the continued oppression of black people. But this also always involves the critique that “black people shouldn’t destroy their own communities” because that is not how real change is going to happen. When a community goes up in flames, however, no one ever speaks directly with the community about the meaning of the uprising. At best, the media will talk to people in that community a day after but they never receive sustained attention nor are they included in long term discussions about how to make real change, and that has been the case in Tampa.

CINDY GAO CC'23: ECONOMICS; PSYCHOLOGY

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Faculty Mentor(s): Chris Baldassano, Columbia University
Title: Tracking the Process of Memory Segmentation Through Pupillometry

Abstract:
Cindy's research intends to explore whether the change in pupil sizes could be used as a reliable indicator for the occurrence of event boundaries in the memory segmentation process. Our brains process the information from continuous experiences not as complete events, but divide up the experience into separate segments when encoding them into memories. An event boundary is the transition between two different segments. Currently, researchers commonly use fMRI scans to detect the occurrence of event boundaries, which comes with the disadvantages of high experiment costs and limited precision. Thus, this research project aims to offer a more effective and less costly alternative to measure event boundaries. By using an eye-tracking device, the pupil size data of over a hundred subjects were collected as they each respond to three different pre-recorded stories. After data cleaning and processing, Cindy analyzes the pupil size data from over a hundred subjects as they each respond to three different auditory stimulations. She has found significant correlation of pupil size changes across subjects, thus confirming that pupil sizes indeed fluctuate as a result of memory segmentation, and has identified recognizable pupil size patterns at the 1-second time window after the event boundary.

NICK GAUTHIER CC'21: PHILOSOPHY

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Faculty Mentor(s): Christopher Peacocke, Columbia University
Title: How do we feel about our beliefs?

Abstract:
Perception, at a glance, doesn’t seem all that mysterious. There is good reason to think that there is a clear-cut causal relationship between sensory input and our impression of it. We have good evidence suggesting that sensory data interacts with our sensory organs and, by way of a chain of reactions, impresses upon us information

about our external environment. However, given that this basic model is true, there remains the question of how one should think about delusion and hallucination—instances wherein our impression of sensory input is false. For instance, in the Capgras delusion the individual fails to believe their loved ones are, in fact, their loved ones—perceiving them, instead, as identical impostors. For the Cotard delusion, the individual fails to believe that they are alive and, therefore, existing—despite recognizing their own engagement in lifelike activity. It is widely thought that the source of these delusions lies not in lack of recognition but, rather, lack of commensurate affective response towards whoever is recognized. But one might ask: What role, then, does affective response play in belief—if delusions are thought to be idiosyncratic beliefs? And, further: What does the lack of commensurate affective response for those with the Cagras and Cotard delusions suggest about the relationship between access consciousness and recognition? The present work uses research done on these delusions from the cognitive sciences to formulate a view on the way in which affective response bears on access consciousness, belief, and recognition.

SCOTT GENG CC'23: COMPUTER SCIENCE; BIOLOGY

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Faculty Mentor(s): Sheng-Han Kuo, Columbia University
Title: Reading brainwaves: differential cerebellar electrophysiology in patients with ataxia

Abstract:
The cerebellar electroencephalogram (EEG) is a newly pioneered technology in the field of neurology. It allows researchers to take real-time measurements of the electrical activity within the cerebellum, thus giving deeper insight into the physiology of patients with cerebellum-linked neurological disorders. Here, we present a comprehensive computational analysis of raw EEG signal data taken from 19 patients with cerebellar ataxia and 16 age-matched controls. Using Python-implemented Fourier transformations, we investigate the power spectrum densities of each individual, demonstrating that there is a significant decrease in the cerebellar activity within ataxia patients from 4-12 hertz—as compared to control patients—when performing a postural maneuver. Moreover, we also show that this decrease is characteristic across many types of ataxia patients, and is not limited to a particular subset. Finally, we present evidence that the magnitude of a patient's decrease is significantly correlated to clinical scores rating the severity of their disease and tremor, thereby suggesting some underlying link between observed symptoms and measured cerebellar activity. Thus, we conclude that the cerebellar EEG is capable of differentiating ataxia patients from healthy individuals. We hope that this project will lead to further investigation into the mechanisms behind this postural desynchrony, and that we have aptly illustrated the power of the cerebellar EEG.

DEVYANI GOEL CC'22: ECONOMICS; PSYCHOLOGY

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Faculty Mentor(s): Larisa Heiphetz, Columbia University
Title: Examining the Intergenerational Consequences of Perceived Moral Transgression

Abstract:
In the United States, at least five million children have experienced parental incarceration. The current work focused on consequences resulting from parental incarceration, probing the role this factor plays in peers' moral cognition and pro-social behavior. In Study 1, younger (5-to-6- year-olds) and older (7-to 8-year-olds) participants

rated the extent to which peers with or without an incarcerated parent held moral beliefs (e.g., that stealing is wrong). After this, participants indicated the amount of resources they would be willing to share with children with an incarcerated parent as well as without. With age, participants increasingly indicated that children of non-incarcerated (versus incarcerated) parents viewed moral transgressions as wrong. Additionally, older participants were relatively certain that children without, versus with, an incarcerated parent possessed conventional beliefs (e.g., that wearing pajamas to school is wrong). This effect did not emerge among younger participants. Importantly, participants shared fewer resources with children of incarcerated parents than they did children with a non-incarcerated parent. Study 2 will test the extent to which the results in the first study are driven by children's inferences about parental incarceration or parental absence more generally. It will also probe children's inferences about factual beliefs (e.g., that germs are small). Doing so will allow researchers to examine whether the results of Study 1 are specific to normative beliefs or whether they extend to other mental states, such as factual beliefs. This work begins to illuminate the psychological processes (e.g., moral judgment) that may contribute to incarceration-based inequality.

ELIZABETH GONZALEZ CC'23: ASTROPHYSICS

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Faculty Mentor(s): Sarah Ballard, University of Florida
Title: The Radial Velocity Effect of TESS' Hidden Planets

Abstract:
NASA's TESS mission is expected to find thousands of new exoplanets using the transit method of detection. Claims of habitability for these transiting planets hinge on understanding their densities-- are they rocky? Are they gaseous? A density measurement for each planet requires follow-up radius velocity observations to measure the mass. An inaccurate mass or radius may lead to identifying a planet as potentially "habitable" when it is not. This is a real danger, given how precious follow-up resources are to examine the atmospheres of the most promising planets for signs of life. Since the transit method relies on planets having an edge-on orbit to their host star, many additional non-transiting planets may go undetected by TESS. Because these undetected planets will still exert a gravitational pull on their host star, this can lead to miscalculations in mass, and therefore density of known transiting planets. This project investigates the effects those undetected planets have on mass measurements, using simulated radial velocity observations of TESS exoplanetary systems. Upon completion of this project, we should be able to understand how the presence of additional planets to those detected by TESS affect the resulting mass of transiting planets. This will help improve our measurement of exoplanet masses to better determine if an exoplanet can support life.

ISHITA GOVIL CC'23: ECONOMICS-PHILOSOPHY

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Faculty Mentor(s): Inga Winkler, Columbia University
Title: Review of Menstrual Health Policy in India, Kenya, Senegal, and the US

Abstract:
This research was in conjunction with a year-long menstrual health policy study led by Dr. Inga Winkler and Columbia's Institute for the Study of Human Rights. The ongoing project seeks to review policy developments in India, Kenya, Senegal and the US to assess how far-reaching and comprehensive they are, the specific policy

triggers, and which populations they affect. The conversation and movement surrounding menstrual health and hygiene has evolved over the past decade with challenges presented differently in every country. It is important to analyze the effectiveness of the policy and programs developed to assess what more needs to be addressed in the field. By looking through a human rights lens, the policies are evaluated with whether they reach marginalized populations, whether their language is inclusive, and whether the governments are held accountable to follow their commitments. Data was gathered through interview transcripts and policy documents from the four countries (with the documents from Senegal translated from French to English). The data was qualitatively coded through NVivo for further analysis and compiled into policy overviews. The implications of this research is not only to address what's missing from the policies but to inform future policy developments in terms of implementation and accountability for governments and NGOs.

ANASTASIA GRACHEVA GS'21: POLITICAL SCIENCE

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Faculty Mentor(s): Macartan Humphreys, Columbia University
Title: The Energy Cooperation Paradox: Economic Attractiveness vs. Political Barriers

Abstract:
This paper addresses the Japan-Russia energy cooperation paradox that demonstrates the collision of economic advantages and political constraints in cooperation. Furthermore, the analysis of dynamic trends in domestic policies, bilateral political relations, and political risk for Japanese investment in Russia set the stage for predictions of potential scenarios for the future. First, the paper offers an overview of the Japanese energy sector and its extreme dependence on energy imports. Next, the paper focuses on one of the advantageous potential sources in response to Japan's high demand in hydrocarbons, namely Russia. It further explores the structure and dynamic developments in Japan-Russia energy cooperation and addresses critical political constraints and limitations for this cooperation. Considering the uncertainties in the political context for Japan-Russia energy cooperation, the paper constructs several scenarios about future economic collaboration in response to possible shifts in Japan's domestic energy policy and potential changes in political risk for Japanese investments in Russia in response to political developments in the latter country. Overall, the research responds to the question, what are the economic implications of the political context to the potential Japan-Russia cooperation in the energy sector; or in other words, what are possible solutions to the energy cooperation paradox?

ELENA GRIBELYUK CC'22: MATHEMATICS; COMPUTER SCIENCE

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Faculty Mentor(s): Andrew Laine, Columbia University
Title: Association of Airway Morphological Structures with QES

Abstract:
Small-airway destruction in COPD and emphysema is well-described. Specifically, the pruning of the CT-derived airway tree masks has been shown to be predictive of airflow obstructions and measures of small-airways disease. However, one aspect of this airway destruction process that has not yet been studied is how airway morphologic structures may be associated with quantitative emphysema subtypes (QES) defined previously. To that end, we have devised and an automated unsupervised learning pipeline for assigning airway skeletons to clusters with similar structural features. Next, we will work to validate the pipeline to ensure accurate extraction of feature

vectors, branch vectors, valid tree-structure representations in Newick string format, and geodesic distance between airway-tree pairs. Once validation steps are complete, we will move to study any present correlations between QES and airway morphology in the MESA exam 5 cohort.

AMERTI GUDISSA CC'22: ECONOMICS

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Faculty Mentor(s): Tamrat Gashaw, Columbia University
Title: The Effect of Ethiopia's 70:30 Education Policy on Unemployment

Abstract:
In Ethiopia, unemployment has been and is still one of the biggest economic problems the country is struggling to overcome. Although the number of unemployed people is rising in all fields, there seems to be worse among STEM fields, particularly Engineering graduates. A possible explanation for such an increase is the 70:30 education policy adapted a decade ago. The 70:30 policy proposed by Ethiopia's ministry of education targets a 70:30 ratio of STEM fields to Social Sciences. Consequently, the number of engineers has shown a huge increase. In the same years, the number of unemployed engineers has also gone up. This paper examines whether or not this education policy has led engineers to have a larger unemployment rates than other fields, especially compared to social sciences. The results show that following the 70:30 policy, the unemployment rate for engineers has significantly increased while other fields have stayed fairly consistent.

ISABELLA GUILHERME CC'22: PHYSICS; MATHEMATICS

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Faculty Mentor(s): Abhay Pasupathy, Columbia University
Title: Computational modeling of multidimensional quantum wells

Abstract:
Quantum wells are layered structures in which particles are confined between two semiconductor barrier layers, and where we can study a number of quantum mechanical effects as well as investigate the emergence and behavior of quasi-particles, such as excitons. These phenomena tend to be complex, and, in order to better understand them, we built computational models to analyze the probability distribution of the position of an electron and a hydrogen atom in quantum wells of higher dimensions and different shapes, taking into consideration their wavefunction and allowing for different energy values. In particular, we have developed codes that generate graphical and numerical data about the position of these particles in finite and independent triangular and square quantum wells of one, two and three dimensions. In the one-dimensional triangular well case, we have allowed for different values of effective mass, electric field at the semiconductor-insulator interface, depletion charge density and sheet charge density. These graphical representations demonstrate that the greater the quantum number, the greater the energy and curvature. They also illustrate that for a very large quantum number, the probability distribution resembles to be almost uniform, since it is approaching the classical distribution. In contrast to the square wells, the triangular quantum well increases in amplitude before converging to zero near the boundary. The study of quantum wells is significantly relevant today due to the wells' abundant features in telecommunication and technology. Credited to their speedy and economical functions, quantum well devices are replacing most conventional electrical components in modern day's electronic devices, such as laser

diodes and infrared photodetectors. Thus, this research ultimately helps us better understand the impacts of these quantum wells and their applications.

This project was completed in partnership with Emmayrabbi Mohammad BC'22.

MAX DAVID GUPTA CC'21: APPLIED MATHEMATICS

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Faculty Mentor(s): Jerome Nika; Tristan Carsault, IRCAM
Title: Multi-Step Chord Prediction: Generating Time-Separated Chord Progressions with MLP, LSTM and Auto-Encoder Architectures

Abstract:
As the world undergoes a digital revolution, the musical arts are undergoing their own computer revolutions in making and sharing sound. Since the 90's, computers have become increasingly involved in all aspects of musical production. At first, it was the digitization of sound itself, transitioning from analog to digital and vinyl to MP3. Nowadays, most of the revolutions in computerized music are coming from artificial intelligence and machine learning. One of the central goals for artificial intelligence in music is getting a neural network to understand the cadence and pulse of a piece, an attribute that is often mapped by a musical term known as a chord progression. This research develops on state of the art models in this area, known as automatic composition, by improving upon data structures in vanilla MLP, LSTM, and encoder-decoder models in Nika et al. 2019. In this comprehensive report, I begin with a theoretical background on the types of neural network architectures used in our study (some background in maths is required). I go on to introduce the field of automatic composition for chord progressions and provide a review of previous uses of our architecture types applied historically to generate chords. We then look at the real work of the project: improving upon state of the art works of Nika et Al. (2019) to produce better chord accuracies. In this section, we discuss changes made to the previous research and detail the reasons behind these changes (multi-step error propagation, data augmentation, temporal sensitivity). Finally we will discuss the results and suggest areas for further research and improvement in automatic composition with deep learning for real world applications.

ASHLEY GUTIERREZ CC'22: BIOCHEMISTRY

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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 AUA 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 AUA codon significantly attenuates protein expression. However, the expression can be enhanced by replacing AUA with AUC, 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.

HEVEN HAILE CC'21: AMERICAN STUDIES

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Faculty Mentor(s): Deborah Paredez, Columbia University
Title: Beyoncé and the Black feminist existentilaist tradition

Abstract:
The word existentialism usually conjures images of white angsty french men smoking cigars and musing about the painful project of existence. The works of Albert Camus, Jean-Paul Sartre, Simone de Beauvoir, Søren Kierkegaard, Friedrich Nietzsche, Martin Heidegger, Fyodor Mikhailovich Dostoevsky dominate the intellectual history of existentialism. However, Beyoncé has continued the existentialist tradition in her works. However, Beyoncé borrows from a unique Black feminist existentialist tradition that departs from the Black existentialist tradition of W. E. B. Du Bois and Richard Wright. Beyoncé's Black feminist existentialism derives from the works of figures like Toni Morrison, Maya Angelou, Alice Walker, and even the members of the Combahee River Collective. However, the role of capitalism has created tension between these multiple generations of Black feminists. This senior research project investigates how Beyoncé has influenced the way Black women have crafted meaning amidst a global pandemic in a world that devalues and dehumanizes them.

PAUL HANNA CC'23: POLITICAL SCIENCE; FILM AND MEDIA STUDIES

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Faculty Mentor(s): Alexandra Watson; Liza Knapp, Barnard College, Columbia University
Title: Little Napoleons: Napoleon Worship in 19th Century Fiction

Abstract:
A sociopolitical approach to Post-Napoleonic literature, this project explores the political context following Napoleon's rule as represented in the texts Le Rouge et le Noir by Stendhal and War and Peace by Leo Tolstoy. The main characters of both texts, Julien Sorel and Pierre Bezukhov, glorify Napoleon. A common trope defines all three: young men who come from an impoverished provincial background attempting to rise to some form of glory, also known as “The Young Man from the Provinces” as identified by Lionel Trilling. After his reign, Napoleon existed as an unpopular social and political figure across Europe, prompting a shift to reactionary political conservatism throughout European governments, a direct impact of their fear of another Napoleon. Paul examines how Julian and Pierre, both Napoleon-wannabes, are led to failure in their respective journeys because the geopolitical context in which their lives take place will not accommodate the rise of another Napoleonic figure. Thus, he concludes it is a battle of their intrinsic political identity and the populist society which ensures they are not successful rather than simply their own ineptitude.

ELLIE HANSEN CC'22: PSYCHOLOGY

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Faculty Mentor(s): Nim Tottenham, Columbia University
Title: Meta-Analysis of Early Life Adversity and Children's Brain Structure

Abstract:
Children's brains are greatly affected by early childhood adversity, and many studies examine associations between adversity and brain structure using MRI. However, most necessarily involve small sample sizes. Further, existing reviews of the literature are largely qualitative. Therefore, we conducted a systematic, quantitative meta-analysis of all existing studies measuring the association between early childhood adversity and brain structure in children, from ages birth to 18. Researchers identified (n = 6,906) potential studies using a search algorithm. Abstracts were independently screened based on several criteria (i.e., human children, psychosocial adversity, structural MRI, and sufficient data); 581 studies remained eligible for inclusion. Interrater reliability for abstract screening was very high (95% agreement across researchers, kappa = .71). Extraction of study data from selected abstracts is currently in progress. Analyses will collapse imaging data across studies, and examine differences between adversity/no adversity groups, and additional moderators, e.g. adversity type. Variables of interest will include mean and SD of brain regions, and Activation Likelihood Estimate scores. By pooling sample data and analyzing across studies, our study seeks to clarify existing child neuroimaging work, be an invaluable resource for future research, and further our understanding of adversity and the developing brain.

HUNTER HOLLAND CC'22: ASTROPHYSICS

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Faculty Mentor(s): Frits Paerels, Columbia University
Title: Finding X-ray Halos to Determine the Compositions of Dense Molecular Clouds

Abstract:
Certain dense molecular clouds exhibit "coreshine," a specific class of infrared emission which leads us to conclude that these clouds contain a significant population of large dust particles with icy mantles. Even so, the exact densities and compositions of these particles are presently unknown. To get a firmer grasp on both of these properties, we present a study grounded in the notion that these particles should efficiently scatter X-rays. By viewing an X-ray point source located behind a cloud with coreshine, we can observe how the source's light interacts with it, and we intend to use this information to set bounds on various parameters of the cloud, including their densities and compositions. By utilizing custom image processing algorithms on coincident fields of X-ray and infrared data, 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.

JENNY JIN CC'21: BIOCHEMISTRY

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Faculty Mentor(s): Brent Stockwell, Columbia University
Title: Identification and Validation of Transferrin Receptor 1 as a Ferroptosis Marker

Abstract:
Cells are the fundamental units of life, and just as relevant to living systems and disease is the regulation, occurrence, and impact of cell death. Ferroptosis is a recently-discovered type 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 had not yet been developed that could be used to identify the presence of ferroptosis in animal models of disease or patient samples. Recently, a potential marker has been identified: 3F3 Anti-Ferroptotic Membrane Antibody (3F3-FMA). The antigen of 3F3-FMA was identified as transferrin receptor 1 (TfR1). 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 staining studies, 3F3-FMA showed an increase in cell membrane fluorescence specific to cells undergoing ferroptosis; this pattern was not observed in cells undergoing apoptosis, another form of cell death, or general non-ferroptotic oxidative damage. A commercial TfR1 antibody was also found to effectively identify ferroptosis in a tissue context. This development of a ferroptosis marker may help guide disease treatment through the ability to identify ferroptosis in patient samples. Furthermore, the identification of TfR1 as a ferroptosis marker opens new avenues of exploration into the mechanisms underlying ferroptotic cell death.

NICK KATHIOS CC'21: PSYCHOLOGY; MUSIC

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Faculty Mentor(s): Nim Tottenham, Columbia University
Title: Popular Music & Self-Reported Emotion Valence: Pilot Exploration

Abstract:
Music's ability to evoke emotions is a well-studied phenomenon (Juslin & Vastfjall, 2008; Lundquist et al., 2009; Huron, 2006). Particularly, music in a major mode is more likely to produce a positively valenced emotion, and the opposite is true for music in a minor mode (Gomez & Danuser, 2007). However, much of the work done to understand this relationship has used only Western Classical music. This means it is unclear whether these parameters have predictive power in music-evoked emotions in other musical genres. As such, this pilot study of participants ages 65-80 (N=6) looked to see whether "Classical" parameters have a relationship with participants' self-reported emotion, or if other parameters that are more relevant to popular music play a bigger role in emotional responses to this kind of music. To explore alternative parameters, five measures generated by Spotify (acousticness, danceability, valence, speechiness, and energy) were used. Participants' ratings of familiarity of individual songs as having a possible relationship with affective responses was also considered. It was hypothesized that the "Classical" parameters would not have a relationship with self-reported evoked emotion (i.e. responses on a scale from 1-7 to the question "how did the clip you just heard make you feel?") in response to a 30 second music clip, whereas both familiarity and "Spotify" parameters would. A correlation matrix provided evidence for parts of the hypothesis; namely, that familiarity seems to be positively associated with self-reported emotion valence, and that "Classical" parameters do not seem to be related to these self-reports.

ARIEL KATZ GS'22: PSYCHOLOGY

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Faculty Mentor(s): Nim Tottenham, Columbia University
Title: Role of Developmental Timing of Early Caregiving Adversity in Later Life Anxiety Symptoms During Childhood

Abstract:
Caregiving-related adversities (crEAs) (e.g., disrupted caregiving, abandonment, institutionalization, caregiver-perpetrated maltreatment) are thought to have a profound impact on children's early emotional development; however, little is known about the effects of crEA timing on child psychopathology. The objective of the current study was to examine the relationship between crEA timing variables and later life anxiety symptoms in children. Data were drawn from wave 1 of a longitudinal study of neurobehavioral development. Participants included 255 children aged 6-12. Linear regression models estimated associations between crEA age of onset, duration, and recency, respectively, and later childhood anxiety symptoms. Covariates included age at testing, gender, and cumulative crEA score. Linear regression models indicated that there was a significant, positive association between crEA duration and total anxiety, along with a significant, negative association between crEA recency and anxiety. However, crEA age of onset was unrelated to anxiety. Findings suggest that children with longer crEA durations and more recent crEA experiences demonstrate higher anxiety symptoms during childhood. Additional studies should investigate the moderating effects of specific adversity types, such as abuse, neglect, and disrupted caregiving, on later life anxiety. These findings suggest the importance of considering the effects of adverse experiences, particularly those that are enduring and more recently present, when studying or assessing the presence of anxiety symptoms in childhood.

JACOB KIM-SHERMAN CC'23: ECONOMICS-MATHEMATICS

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Faculty Mentor(s): Brendan O'Flaherty, Columbia University
Title: COVID-19 and Energy: Modeling the Impact of an Exogenous Demand Shock on the Energy Transition

Abstract:
Climate change poses a tremendous threat to life on earth as it exists now, and the decisions made by firms in the energy sector are a crucial determinant of greenhouse gas emissions. The COVID-19 pandemic has drastically changed lives in the United States since March of 2020 and has led to a substantial decline in economic activity and energy consumption, but it is unclear how long this reduction of energy consumption will persist. This project develops a theoretical framework for considering the impact of an exogenous demand shock and future demand uncertainty on the investment decisions of an energy firm. This model aims to capture the choices that a profit-maximizing monopolist energy firm would make between building or demolishing renewable and fossil fuel energy plants. In this model, the firm must generate a set amount of energy from the existing infrastructure in the present before making an investment decision based on an uncertain prediction about energy demand in the future. By solving the constrained optimization problem for the first-order conditions and adopting a number of simplifying assumptions, the model suggests that while the use of renewable energy sources might appear to increase in the present, the increased uncertainty of future consumer energy demand acts to slow the retirement of fossil fuel plants. In practice, therefore, the model suggests that the pandemic is unlikely to lead to a permanent increase in the share of renewable energy in the future, and is, in fact, uncertainty may delay the transition.

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

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Faculty Mentor(s): Peter A. Sims, Columbia University

Title: Elongation inhibitors do not prevent the release of puromycylated nascent polypeptide chains from ribosomes

Abstract:
Tracking the generation of new proteins is integral to the study of cellular function. One of the most widely used tools to track protein translation is puromycin. Puromycin is an analog to amino-acyl transfer RNA and can thus be incorporated into newly forming polypeptide chains. Upon incorporation, puromycin causes the polypeptide chain to be ejected from the host ribosome. Using staining techniques, the location of puromycin can then be determined within the cell, serving as a marker for newly synthesized proteins. In recent years, an assumption that has become widely accepted is that if ribosomes are treated with elongation inhibitors prior to puromycylation, the puromycylated polypeptide chains will remain complexed to the ribosomes. According to this model, known as ribopuromycylation, puromycin can then serve as a marker for sites of active protein translation rather than only for newly synthesized proteins.
However, when a proximity ligation assay was implemented to detect ribosome-puromycin complexes, no evidence was found to support the notion that puromycylated chains remain associated with ribosomes. To further investigate the viability of ribopuromycylation, additional biochemical assays and live cell imaging of polypeptides were utilized to attempt to detect such complexes. However, it was observed that puromycylated polypeptide chains quickly dissociated from ribosomes even in the presence of elongation inhibitors. These results suggest that elongation inhibitors are not sufficient to prevent the release of puromycylated polypeptide chains from ribosomes and that attempts to precisely characterize sites of active translation with elongation inhibitors may be confounded due to such behavior.

NIKITA KUPKO SEAS'21: BIOMEDICAL ENGINEERING

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Faculty Mentor(s): Alexander Sobolevsky, Columbia University
Title: Processing of cryo-EM data for TRP ion channels: introduction to computational techniques and data analysis

Abstract:
Transient receptor potential (TRP) ion channels, which are widely present in the plasma membranes of mammalian cells, play a crucial role in temperature sensation, nerve signal propagation and many other physiological activities. TRPV3, a member of the vanilloid subfamily of TRP ion channels that is expressed in skin keratinocytes, participates in the maintenance of a healthy skin barrier and hair formation. Mutations in TRPV3 can lead to cancer and various skin-related diseases, including Olmsted syndrome. This study presents the cryo-electron microscopy map of the wild type mouse TRPV3 reconstituted in a lipid nanodisc in the closed state at 2.10 Å resolution. Lipid densities are clearly observable on the surface of voltage sensor-like and pore domains of the ion channel. The obtained TRPV3 cryo-EM map, currently the highest resolution among reported density maps for TRP channels, will serve as a tool for future studies of lipid binding and channel gating mechanisms.

ALQAIM ALY LALANI CC'23: ECONOMICS; HISTORY

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Faculty Mentor(s): Jeff Tan, The Aga Khan University
Title: The Economic and Sociopolitical Impacts of Oil Rentierism in the Middle East

Abstract:
The discovery of oil has been a highly consequential factor in the modern history of the Middle East. Oil concessions in the Arab world can be traced back to the D'Arcy Concession of 1901, signed by William Knox D'Arcy and the Qajar King of Persia, Mozaffar ad-Din Shah. However, it was only after May 1908 when Burmah Oil discovered the Masjed Soleyman oil field–the largest known oil field at the time–that significant foreign exploration followed. This included the formation of the Anglo-Persian Oil Company in 1909, as well as the establishment of the California-Arabian Standard Oil Company in 1933 and its eventual nationalization into Saudi Aramco in 1988. While the commercialization of oil brought prominence to the Middle East on the global stage, this was at the expense of rentierism and political instability. Even so, two antithetical historical perspectives prevail; either the discovery of oil was a 'curse' that made the Middle East prone to foreign interventionism, or a 'blessing' that turned barren deserts into booming economies. Rather than determining how oil affected the entire region, this project takes the form of various case studies that seek to understand how select rentier states in the Middle East were distinctly implicated by oil. Furthermore, this project emphasizes the dissimilar experiences of various stakeholders, including political leadership versus the wider civil society. The project concludes that while the Middle East remains more progressive than ever before, oil acts as a barrier which hinders regional development into the twenty-first century.

NICO LAQUA CC'21: NEUROSCIENCE

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Faculty Mentor(s): Aaron Neely; Oleg Nikolaev; Linda Hill; Tom Marcotte, UCSD and Birdhouse
Title: Evaluating the Eyes as a Biomarker for Cannabis Impairment

Abstract:
Impaired and intoxicated driving is a matter of public safety and national concern. The Governors Highway Safety Association (GHSA) and the National Highway Traffic Safety Administration (Drug Impaired Driving: A Guide for States, 2015) have both identified the inability to adequately detect drug-impaired drivers as a critical and urgent matter. The GHSA has reported that 43% of fatally injured drivers tested positive for drugs while 29% of all fatalities involved a drunk driver. Marijuana was the most commonly identified drug among illicit substances detected. The eyes are the most accurate indicators for the detection of drug and alcohol impairment (Tennant, 1988). Birdhouse's new device, the EyeAlyzer, innovatively administers proven eye tests in virtual reality and utilizes artificial intelligence to achieve new levels of accuracy and precision. Acting in concert, these features help eliminate human error and bias. Our study incorporated computer vision, more specifically, image recognition, to read the recorded video output for each eye and locate the subject's pupil in a probabilistic region of interest. We accordingly developed a preliminary model that assessed impairment levels.

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 Non-Diplomatic Policy Proposals in Israel through Computational Text Analysis

Abstract:
Much research has been written about increasing stratification and differential support for non-diplomatic solutions among Israel's Arab and Jewish populations. The frequent usage of the term "annexation" in national security discourse is not only a proxy for the salience of the issue, but also for the success of its underlying framing. Google Trends for the Hebrew "סיפוח " ("annexation") can be analyzed across the North, Jerusalem, Haifa, Tel Aviv, Center, and South Districts to assess determinants of pro-annexation rhetoric. This study draws on a difference-in-difference estimation to evaluate whether searches for annexation correspond to the ethnic and religious composition of each district. The relative search volume for סיפוח surged to a national average of 66.8 points from 2013-2015, overlapping and coinciding with the 2014 Israel–Gaza conflict. Despite Israeli-Palestianian de-escalations in violence, the search volume for סיפוח across Israel's six districts reached a fever pitch from 2019 on at 82.2 points, an increase that was not stratified upon ethnic lines. The post-2014 rise casts doubt upon research suggesting that shifts away from diplomatic policies are collinear with heightened exogenous tensions. This research suggests that party elites may play an outsized role in framing discourse compared to that of the public. Even after the recent Abraham Accords Peace Agreement, Likud MK Shlomo Karhi has declared West Bank annexation to be still "on the table". Further study can help determine whether the electoral decline of left-wing two-state-solution proponents (Meretz) is explained by the escalation of the incumbent party's hardline national security discourse.

ELAINE LEE CC'23: NEUROSCIENCE; COMPUTER SCIENCE

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Faculty Mentor(s): Jaeseung Hahn, Columbia University
Title: Wearing is Caring: A public health outreach initiative about COVID-19 and mask-use

Abstract:
In April 2020, the CDC recommended universal masking to slow the spread of COVID-19. This differed from their previous policy of only masking symptomatic people, and resulted in much confusion. Many details to mask-wearing remained unanswered. What did it mean to have a properly fitting mask? How could masks be reused safely? What were the best mask materials? To combat misinformation, Elaine joined Wearing is Caring, a group of Columbia researchers creating accessible science-based guidelines about mask-wearing and COVID-19. First, she conducted a literature review about mask material and sanitization techniques. From this information-gathering, she made 12 different infographics addressing various mask-use tips. With her team, she translated them into 8 different languages. Because infographics inevitably lacked the nuance of a scientific study, she also wrote short summaries of papers she used to make the graphics. Written in layman's terms, the summaries explained additional details about studies' experimental designs, results, and implications. She also made a website that presented the results of her research: WearingPPEisCaring.org. Finally, Wearing is Caring's infographics were posted on Instagram, Twitter, Facebook, where they have been seen by more than 500K people. A perfect storm of uncertainty, sickness, misinformation, and isolation, the pandemic is testing the

mental health of millions of Americans like never before. In the fall, Elaine hopes to address these struggles. Her work with Wearing is Caring continues.

EMMA LEE CC'22: BIOLOGY

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Faculty Mentor(s): Attila Losonczy; Adrian Negrean, Columbia University
Title: The Role of Dendritic Spines in the Place Tuning of Mouse Hippocampal CA1 Pyramidal Cells

Abstract:
Alzheimer's disease patients often have impaired spatial navigation and spatial memory due to neurodegeneration in the hippocampus, primarily the Cornu Ammonis (CA) 1 region. Proper spatial function is dependent on a subset of hippocampal cells, called place cells. Each place cell is activated preferentially when an organism encounters a specific location in space. This associative process, called place tuning, is dependent on the integration of synaptic input to the cell at the dendritic spines. Previous studies have shown evidence for place tuning at the soma and individual dendritic branches, but there has been limited research regarding the role of dendritic spines in the place tuning of pyramidal cells. Here we show evidence of in vivo place tuning in individual hippocampal CA1 pyramidal cell dendritic branches and spines using two-photon microscopy to trace calcium and glutamate signals within a single cell over time as a mouse runs on a cued belt. Additionally, we observed co-tuning between a dendritic branch segment and connected dendritic spine, as well as co-tuning between individual spines within a single scanfield, across multiple scanfields of a dendritic branch, and across multiple scanfields of a single cell. These results provide critical information for future CA1 place cell modeling and investigatory studies.

NICOLE LIBERMAN CC'21: BIOLOGY

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Faculty Mentor(s): Erin Barnhart, Columbia University
Title: Maintaining Uniform Mitochondrial Distributions Within Asymmetrically Branched Dendritic Arbors

Abstract:
Dendritic arborization is a central determinant of neuronal activity, connectivity, and plasticity. A dendrite's morphology shapes the biophysical properties of the dendrite, thus impacting synaptic integration and computation. Dendritic function also depends on the localization and transport of mitochondria. Mitochondria are dynamic organelles that move, stall, and change direction and speed throughout a dendritic arbor. It remains unclear how these local mitochondrial motility mechanisms are integrated over several orders of magnitude to reach uniform, global mitochondrial distribution patterns in elaborately branched dendrites. We systematically correlated dendritic architecture with mitochondrial movement using publicly available HS reconstructions and in vivo confocal images of mitochondrially-targeted GFP in HS neurons of the Drosophila visual system. We found that dendritic subtree length and mitochondrial transport rates scale with dendritic branch thickness, with proportionally more mitochondria moving into thicker branches. We propose that this scaling allows highly branched dendrites to maintain stable, steady-state mitochondrial distributions over time.

ASTRID LIDEN CC'23: HUMAN RIGHTS; LATIN AMERICAN AND CARIBBEAN STUDIES

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Faculty Mentor(s): Jose Moya, Barnard College, Columbia University
Title: Migration in the Time of COVID-19: The Experience of Venezuelan Migrants and Their Forced Return

Abstract:
The Venezuelan migration crisis has been labeled the second-largest mass migration crisis in recent history, second only to that of Syria. From a country of immigrants, it has become a country of emigrants. Over 5 million Venezuelans, almost 15%, of the population, have fled Venezuela by foot, bus, and plane primarily for other nations in Latin America, Western Europe, and the United States due to human rights abuses in the country as well as socioeconomic challenges. The impact of COVID-19 on Latin America, the new "epicenter" of the pandemic, has had a direct effect on Venezuelan migrants who find themselves in every aspect of society, especially in informal labor. Migrants were some of the hardest hit both by the pandemic itself as well as its economic, social, and political repercussions. The concern of legal status has also raised issues of migrants being able to receive necessary resources and rights in their arrival countries. Through discussions with other researchers, professors, and Venezuelan humanitarian activists in the region, this research and the culminating paper discuss the acute vulnerability of this migrant population due to the pandemic. Mass returns to Venezuela during a time of pandemic, an unusual sight in migration patterns, have escalated the crisis for migrants, as Venezuela has had severe underreporting and lack of testing for a nation with an already-crumbling infrastructure. Migrants returning to Venezuela are experiencing hate and xenophobia, with President Maduro blaming migrants for COVID-19 in the country despite encouraging them to return. This also drove this research to dive more into the effects that COVID-19 is not just having on those that have fled, but also on those left behind.

SIMONE LIU CC'22: ENGLISH; RACE AND ETHNICITY STUDIES

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Faculty Mentor(s): Deborah Paredez, Columbia University
Title: Research Assistance on Deborah Paredez's American Diva Project

Abstract:
This summer, Simone served as a research assistant for Dr Deborah Paredez's book-length project about American 'diva' figures. Blending memoir and narrative with scholarship, Dr Paredez's project examines the role of the the diva in American culture and imagination. Simone focused on Dr Paredez's chapter on divas and girlhood, spending time sourcing interlocutors in girlhood and media studies, annotating and summarizing scholarship, and compiling detailed descriptions of diva-related products and media. Through reading a wide array of primary sources, criticism, and analysis surrounding girlhood, 1990s-2010s pop culture, and the Walt Disney Corporation in order to best supply Dr Paredez with relevant sources to consult, she developed a strong understanding of these scholarly landscapes. In reading all of this, she found herself asking questions about the cultural and political contexts of narrative trends in children's and teen media and how cultural appetites shift in the way they do. While Dr Paredez works with the materials she sourced, Simone is considering writing independently on youth-marketed media in the Obama era, with particular attention to purity/virginity discourse, teen pregnancy storylines, the popularization of country-pop aesthetics, and a proliferation of girl-singer narratives and TV-to-music career trajectories for young women celebrities.

HELEN LIU CC'21: BIOLOGY

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Faculty Mentor(s): Tristan Shuman, Icahn School of Medicine at Mount Sinai
Title: Quantification of Phase Locking in Hippocampal Interneurons

Abstract:
In order to process spatial cues in the environment and form spatial memories, the hippocampus requires precise synchronization and firing between diverse groups of interneurons in the brain. Specifically, the firing of interneurons in the CA1 and the dentate gyrus (DG) in normal, healthy brains is tightly phase-locked using theta oscillations, where interneurons fire preferentially during particular phases of theta waves. Recent research from our lab demonstrates that in mouse models of temporal lobe epilepsy, interneuron cell death and changes in hippocampal circuitry lead to reduced phase locking of CA1 and DG interneurons, likely contributing to spatial memory deficits and seizures in the epileptic brain. With this in mind, my mentor Dr. Tristan Shuman and I designed and wrote an analysis package that quantifies and visualizes phase locking of diverse groups of interneurons recorded during 128-channel silicon probe in vivo electrophysiological recordings. Probes were inserted into the hippocampus of non-epileptic naive mice to span both the CA1 and DG, and measured local field potentials (LFPs) and interneuron firing while mice navigated a virtual reality linear track. This LFP and firing data was run through the Python package written by me and Dr. Shuman to measure the phase locking of single neuronal cells. We calculated the modulation index (r, measures the strength of phase locking) and the mean preferred firing phase of the cell (mu) in order to determine how cells fire during spatial processing and understand how they phase lock during theta oscillations. Our initial analysis was performed in non-epileptic naive mice, but in the future we hope to apply this analysis to electrophysiological recordings performed in epileptic mice such that we can compare phase locking dynamics between a diseased and non-diseased brain state.

LEO LO CC'22: PHYSICS

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Faculty Mentor(s): Hoi Chun Po, Massachusettes Institute of Technology (MIT)
Title: Topological Nodes in Superconducting Twisted Bilayer Graphene

Abstract:
Room-temperature superconductivity, if realized, would drastically improve energy efficiency in electronics and reduce our energy footprint. Magic-angle twisted bilayer graphene (TBG) was recently shown to be a promising superconductor at low temperature, in addition to being a versatile 2D platform for building 2D circuitry. Nonetheless, TBG superconducting mechanism is not well-understood, hindering the full utilization of TBG for energy applications. Since the topological nodal features in the band structure of TBG may distinguish between different mechanisms experimentally, the goal of this project is to understand such topological nodes, both numerically and analytically. Two pairing mechanisms were investigated: spin-singlet/onsite pairing and spin-singlet/inter-sublattice pairing. For spin-singlet/onsite pairing, the band structure is fully gapped numerically, consistent with the analytic calculation of a zero winding number. For spin-singlet/inter-sublattice pairing, nodal features are observed numerically and confirmed analytically. This serves as theoretical predictions of topological nodes that may be confirmed experimentally via spectroscopic measurement techniques, improving current

understanding on the superconducting mechanisms of TBG and enabling the full utilization of TBG as an energy-efficient platform for 2D electronics.

ILINA LOGANI CC'22: ECONOMICS

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Faculty Mentor(s): Aharon Levy, Columbia University
Title: Hypodescent, The Color "Brown", and the Transnational “Coloured Solidarity" of W.E.B. Du Bois and Cedric Dover

Abstract:
This research blends recent research in psychology with literary analysis to explore how the social science theory of hypodescent can be employed as a framework through which to view the interwar works of W.E.B. Du Bois and Cedric Dover. This research interrogates the role that the authors’ multiracial identities played in their writings supporting “coloured unity”—the joining of non-white intellectual forces across ethnic, national, and racial lines to combat white nationalism and oppressive political structures. The theory of hypodescent establishes that a mixed-race individual is societally associated with the race of the “lower-status” parent through the following mechanisms: the “socially dominant” racial group (e.g., White) over-excludes when determining individuals belonging to their ingroup (evidenced by the “one-drop rule” in American history) to protect the hierarchical status quo, while the “socially subordinate” racial group is overly inclusive in determining which members belong due to a sense of shared oppression. Through a literature review of psychological research around intergroup relations and a literary analysis of the use of the generic terms “brown”, “coloured”, and “dark” as racial descriptors in Du Bois’ novel Dark Princess and in Dover’s poetry collection Brown Phoenix and essay “Notes on Coloured Writing”, this research argues that both Dover and Du Bois were uniquely positioned, by nature of their multiracial identities and tendency towards hypodescent, to use the language of color to conceptualize and advocate for a world with a broadened, transnational definition of what it means to be “coloured”.

JORDAN LU CC'22: COMPUTER SCIENCE; NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Christine Chio, Columbia University
Title: Identifying Altered Lipid Metabolic Enzymes and Pathways in Pancreatic Ductal Adenocarcinoma (PDAC)

Abstract:
Pancreatic Ductal Adenocarcinoma (PDAC) is among the deadliest cancer cell types with no major therapeutic improvements in the past few decades. The increased energy supply necessary to sustain abnormal cell proliferation has revealed that altered metabolic pathways support PDAC tumorigenesis. These alternative pathways that PDAC tumor cells use may reveal biomarkers that help combat its late stage diagnosis or the mechanisms that support resistance to therapies. Previous studies show altered lipid composition and metabolism are characteristic of PDAC tumorigenesis, possibly contributing to membrane remodeling and resistance to drug uptake, synthesis of abnormal signaling molecules or an additional energy source. However, specific upregulated or downregulated lipid metabolism enzymes and pathways are yet undiscovered. Here we identify that the ACOT2 gene is significantly downregulated in both premalignant and malignant PDAC tumors and is involved with biosynthesis of unsaturated fatty acids. This indicates that tumor cells upregulate incorporation of

saturated or monounsaturated phospholipids into their membrane lipid bilayer. Further investigation into the ACOT2 gene and its downstream pathway may reveal possible therapeutic targets against PDAC.

IAN MACLEOD CC'23: COMPUTER SCIENCE

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Faculty Mentor(s): Larisa Heiphetz, Columbia University
Title: Intergenerational Punishment: Examining Moral Attribution Towards Children of Incarcerated Parents

Abstract:
This project addresses issues of prosocial behavior, attachment theory and cognitive development in children by creating a concise literature review that analyzes how and why children behave with other-oriented behaviors. This project was conceived as a comparative review between the literature that exists on adults' cognitive conceptions of others and how adults express prejudice/acceptance and the literature that exists for children's behaviors on the same topics. This project takes a special focus towards the types of attachments that children develop as infants (along the secure/insecure paradigm), examining potential correlations between attachments and prosocial nature. While past studies have shown that adults with secure attachments exhibit prosocial behaviors with very clear real-world ramifications (less outgroup prejudice, greater willingness to volunteer in their communities, etc.), these correlations have not been exhibited clearly in experiments with children and provide ground for future research to better understand the moral motivations of children.

MULAN MADDEN CC'22: ASTRONOMY

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Faculty Mentor(s): Adwin Boogert, University of Hawai'i at Manoa
Title: The Onset of Dust Coagulation and Ice Formation in the Perseus and Serpens Molecular Clouds

Abstract:
Dense clouds in the interstellar medium are the sites of star and planet formation. These clouds are rich in gas phase molecules and dust grains composed of silicates and carbon. Shielded from the interstellar radiation field, atoms and molecules freeze out onto cold dust grains, forming ice mantles, rich in species, such as H2O and CH3OH. It is expected that the ice-coated grains stick together. This coagulated mixture of dust and ices can be considered the first step in comet and planet formation. To study the relation between grain coagulation and ice mantle growth, we have taken infrared spectra of 28 stars located behind the Perseus Molecular Cloud and 21 behind the Serpens Molecular Cloud with the NASA Infrared Telescope Facility (IRTF) and the Spitzer Space Telescope. Absorption by H2O ice (3.0μm) and silicate dust (9.7μm) is clearly detected in many lines of sight. The continuum emission of the stars is also reddened as a result of extinction by dust grains. We find that H2O ices are formed at extinctions above 0.327 +/- 0.133 and 0.315 +/- 0.084 magnitudes at 2.2μm in Perseus and Serpens, respectively. In agreement with other clouds, we find that the depth of the silicate band is commonly suppressed relative to the continuum extinction. This is likely a result of grain growth. Some sightlines, however, do not follow this trend, particularly near the cloud edge. We have investigated whether the presence or absence of H2O ice is responsible for this.

SUPRIYA MAKAM CC'22: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Adam Bisaga, Columbia University
Title: Pharmacogenetics of Extended-Release Naltrexone in Patients with Opioid Use Disorder

Abstract:
It is no question that the American addiction epidemic is a public health emergency. Vivitrol, one of the primary forms of Medication Assisted Treatment for opioid use disorder, is a formulation of extended-release naltrexone, administered monthly via injection. Unlike other treatments, naltrexone is not an opioid, posing no abuse potential, and is a mu-opioid receptor antagonist, blocking the rewarding effects of opioid agonists in the brain for up to four weeks. It is known that there is significant variability among individual naltrexone metabolism, however, there are mixed results as to whether the need for stratifying treatment based on demographic factors is necessary. This analysis examines how the pharmacogenetic factors of race, gender, age, and weight affect Vivitrol metabolism. This dataset was compiled from four different studies, totaling 115 patients, and 331 blood draws. The amount of time since injection, in days, was recorded and added to the dataset. Several tests of significance were used to determine whether there was a difference in blood naltrexone levels over time, compared across the demographic groups. Our results showed that while there was large variation among individual Vivitrol metabolism, the differences were not statistically significant across the aforementioned groups. Additionally, close to twenty percent of patients consistently had blood levels below the therapeutic level of 1 ng/mL, before their next injection. This may indicate the need for a more frequent injection, rather than a monthly occurrence. Ultimately, this data supports the notion that treatment for addiction is not a one-size-fits-all mechanism.

KATE MARSH CC'23: POLITICAL SCIENCE-STATISTICS

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Faculty Mentor(s): Michael Gerrard, Columbia University
Title: Compilation of Recommendations to Reduce Greenhouse Gases in New York State

Abstract:
This project examines the spectrum of recommendations to reduce greenhouse gas emissions in New York State and how to implement wide-ranging climate laws. Under the Climate Leadership and Community Protection Act (2019) or CLCPA, Governor Andrew Cuomo announced plans to cut greenhouse gas emissions by 85% by 2050. Despite the CLCPA's passing in 2019, the law has yet to be implemented, leaving the goals set by the governor unreached and uncertain. Using 130+ articles, papers, and reports from government agencies, industries, and think tanks, this project compiles 400 pages of recommendations for how the Climate Action Council, established by the CLCPA to implement the law, might go about regulating and taxing greenhouse gas emissions. With help from the work of the Sabin Climate Change Law Center, this report also includes past actions that New York State has taken to combat climate change. This project is both extensive, covering industries from Buildings to Agriculture, and specific to the needs and interests of New York State. Unlike other reports, it presents an objective take on all the recommendations available, often arguing against itself for action items like implementing a carbon tax. Depending on national politics, there may be no federal climate action in the near future, which makes action taken on the state level much more important. New York often acts as a model for progressive legal action for other states around the country. Policies implemented in New York successfully are

likely to gain popularity in other states and around the world. This makes the implementation of this law integral in the fight against climate change.

CAROLYN MARTINEZ CC'23: MEDICINE, LITERATURE AND SOCIETY; PUBLIC HEALTH

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Faculty Mentor(s): Anindita Dasgupta, Columbia University
Title: Systematic review: Healthcare provider perspectives on performing abortions in Latin America & Caribbean

Abstract:
Healthcare providers play instrumental roles in the enforcement of legal abortion bans, which result in unsafe abortions, and are associated negative health sexual and reproductive health complications for women. As a result, it is vital to understand providers' perspectives on implementing abortion bans in order to understand, and reduce harms associated with unsafe abortion. In the Dominican Republic incidence of unsafe abortion increased by 48% following criminalization of abortions in 1999; and similar bans exist in other parts of Latin America and the Caribbean. This review examines the empirical literature on healthcare providers' attitudes towards abortions and other contraceptive services in Latin America and the Caribbean. The studies included in the review were identified using a combination of search terms in four databases (PubMed, JSTOR, Wiley, Contraception Journal, EBSCO). Many papers highlighted the conflict between providers' perspectives on abortion, and their willingness to provide them. Few studies examined how abortion stigma from providers exist within the broader gendered cultural context (ex. "machismo"). Understanding the greater context in which providers deliver SRH services is essential to ensuring the safe provision of abortion. Greater understanding of how provider perspectives are informed by the cultural context is vital to ensuring safe access to women's reproductive healthcare.

NATHAN MARTIN CC'21: PSYCHOLOGY

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Faculty Mentor(s): Nim Tottenham, Columbia University
Title: Depressive and anxiety symptoms in late adolescents correlate with greater affective sensitivity to emotional schema acquisition

Abstract:
Emotional schemas are theorized to cause and maintain biased, maladaptive beliefs of oneself and the world, which leads to psychopathology, particularly internalizing problems. Prior research in fear conditioning and reward learning have also linked depressive and anxiety symptoms to emotional processes. However the relationships between internalizing symptoms and emotional schema learning have yet to be evaluated. The current study aimed to examine whether depressive or anxiety symptoms were related to emotional schema acquisition among late adolescents. 29 undergraduate students that enrolled in an introductory psych course participated in this pilot study. They completed a novel computerized emotional schema acquisition task in which they were presented with fribbles, made-up animal-like figures that made positive, neutral, or negative sounds based on body type. Participants had to predict what sounds fribbles made until they reached 90% accuracy. In addition, 6 pilot participants completed affect ratings of fribbles before and after the task to assess their acquisition of the affective component of the emotional schema. The findings suggested that late adolescents with higher internalizing symptoms had a more robust acquisition of the affective component of newly learned emotional schemas despite similar learning rates. This pattern was especially striking for anxiety. Greater

knowledge for the heightened intensity in which people with higher anxiety and depressive symptoms process emotional stimuli may help inform treatment for these symptoms.

NEELY MCKEE CC'23: URBAN STUDIES

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Faculty Mentor(s): Michael Gerrard, Columbia University
Title: The Implementation of the Climate Leadership and Community Protection Act in New York

Abstract:
The New York state Climate Leadership and Community Protection Act—often referred to as the "CLCPA"—is one of the most ambitious environmental regulations in the country. Upon its passage by the state legislature in July 2019, the newly created Climate Action Council set out to determine exactly how to implement the CLCPA in New York. This research takes the form of a report that details specific policy recommendations for the Climate Action Council on behalf of the Sabin Center for Climate Change Law at Columbia University. Organized by section outlined in the CLCPA, the document details a wide array of measures the Climate Action Council can use in the process of drafting a scoping plan. In the creation of this document, numerous reports, policy papers, case studies, and resources from local environmental organizations were analyzed and compiled. With both extensive recommendations and successful examples from other cities, states and countries, this report was sent to members of the Climate Action Council in August but remains a living document. This report and the research that went into it highlights the complexities of implementing comprehensive environmental laws like the CLCPA while emphasizing the role of such legislation in our planet's very survival.

AARON MCKEEVER CC'23: COMPUTER SCIENCE

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Faculty Mentor(s): Annie Pfeifer, Columbia University
Title: Linguistic features of Germany's far-right nationalist party

Abstract:
Since the rise of the nationalist movement in the early 20th century, far-right-wing parties in Germany have used propaganda and tactical linguistic practices to spread their ideas and influence massive audiences. In the age of social media, this has reached all-new proportions; however, it is now possible to better understand these vast agglomerations of textual data by utilizing the processing power of computational linguistic technology. Using the Twitter developer module and natural language processing libraries, including CoreNLP and NLTK, tremendous amounts of information can be derived from a corpus of tweets. Using a pseudo-random sampling of representatives from the 19th German Parliament, algorithms were run over large pulls of historical tweet data to obtain a deeper understanding of the linguistic features occurring within the different parties and determine whether or not certain features are explicitly unique to right-wing parties. By analyzing word frequency, sentence structure, and sentiment scores, this research suggests that far-right politicians on social media have distinct linguistic practices. Additional word-relationship visualizations, based on graph theory, highlight the more abstract practices such as specific word choices in the form of collocations, most common bi-grams, and topical groupings.

STEFANIE MCKENZIE CC'23: ASTROPHYSICS

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Faculty Mentor(s): Joe Patterson, Columbia University
Title: Time Series Photometry of Cataclysmic Variable Stars

Abstract:
This research reviews the properties of Nova Scorpii 1437, a cataclysmic variable (CV) which contains a red dwarf (secondary star) in close orbit with a magnetic, accreting and rapidly rotating white dwarf (primary star) characterized by bright stellar outbursts, with a view to measure the precise orbital and spin period, and see how these periods are changing over time. Most CV's exhibit an accretion disk occurrence distinguished by mass transfer of stellar material from the secondary to the primary star that causes loss of angular momentum creating intrinsic instability in the accretion disk and thus varying the orbital periods of CVs. This phenomenon is observed in the light curves plotted from the real-time Nova Sco data collected from two observatories located in Western Australia and South Africa, a strategy for increasing precision. CV's also display eclipses, and the analysis of the eclipses is important in determining the orbital inclinations of the CV's. The team's analysis of Nova Sco's eclipses reveals it as an intermediate polar with a period ~30 minutes.

ANNA MISHCHENKO CC'23: ECONOMICS - POLITICAL SCIENCE

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Faculty Mentor(s): Judith Russell, Columbia University
Title: AI and Judicial Decision-Making: The Impact of Risk Assessment Technology on Racial Bias in the U.S. Criminal Justice System

Abstract:
Bias is often considered a shortcoming in judicial decision making within the U.S. criminal justice system. Risk assessment instruments are a type of evidence-based strategy to inform sentencing and parole by predicting an offender's risk of recidivism based on socioeconomic factors and previous criminal involvement; in general, we expect that such artificial intelligence will mitigate human error and ensure greater consistency across judicial decisions, thus creating a fairer system. But my study applies a statistical analysis with multiple performance indicators, challenging the utility of such instruments in relation to racial bias. It considers the rationale that the inclusion of certain socioeconomic factors (e.g. level of education) creates embedded bias in the data used to develop risk assessments and thereby generates a disparate impact across racial groups, in which minority offenders are disproportionately targeted. The study focuses on the recently implemented tool "PATTERN," mandated by the First Step Act of 2018 for U.S. criminal justice reform, and uses data on recidivism rates across BOP sites and prisoner demographic characteristics made available by the National Prisoner Statistics Program. The analysis not only illuminates the reciprocal effects of risk assessment instruments and their predictive utility, but also sheds light on the intrinsic biases within the criminal justice system. If, with such instruments as PATTERN, is racial bias perpetuated rather than reduced, the application of artificial intelligence to judicial decision-making is to be placed into even deeper scrutiny.

EMMA MOHAMMAD BC'22: PHYSICS

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Faculty Mentor(s): Abhay Pasupathy, Columbia University

Title: Representation of 1D-3D quantum square wells and 1D quantum triangular well

Abstract:
Quantum wells are layered structures in which particles are confined between two semiconductor barrier layers, and where we can study a number of quantum mechanical effects as well as investigate the emergence and behavior of quasi-particles, such as excitons. These phenomena tend to be complex, and, in order to better understand them, we built computational models to analyze the probability distribution of the position of an electron and a hydrogen atom in quantum wells of higher dimensions and different shapes, taking into consideration their wavefunction and allowing for different energy values. In particular, we have developed codes that generate graphical and numerical data about the position of these particles in finite and independent triangular and square quantum wells of one, two and three dimensions. In the one-dimensional triangular well case, we have allowed for different values of effective mass, electric field at the semiconductor-insulator interface, depletion charge density and sheet charge density. These graphical representations demonstrate that the greater the quantum number, the greater the energy and curvature. They also illustrate that for a very large quantum number, the probability distribution resembles to be almost uniform, since it is approaching the classical distribution. In contrast to the square wells, the triangular quantum well increases in amplitude before converging to zero near the boundary. The study of quantum wells is significantly relevant today due to the wells' abundant features in telecommunication and technology. Credited to their speedy and economical functions, quantum well devices are replacing most conventional electrical components in modern day's electronic devices, such as laser diodes and infrared photodetectors. Thus, this research ultimately helps us better understand the impacts of these quantum wells and their applications.

This project was completed in partnership with Isabella Guilherme CC'22.

DEBORAH MORENO ORNELAS CC'23: ART HISTORY; FINANCIAL ECONOMICS

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Faculty Mentor(s): Lisa Trever, Columbia University
Title: The representation of gender-based violence against women in contemporary Latin American and Latinx art

Abstract:
Feminicide and gender-based violence against women are two of the most pressing issues Latin America has been facing for the past thirty years. Despite more than two decades of activist and legal efforts, the situation has only worsened and been exacerbated by the impunity allowed by governments and incompetent police investigations. This research project explores this issue in the context of contemporary art and how artists of Latin American origin have approached it through different mediums. What do these artworks have to say about the problem? What is their role in the larger political conversation about violence against women? How does art play a part in activism and does it contribute to the ongoing fight for justice? The project aims to provide a framework to think about these questions by examining how two different contemporary artists of Latin American origin, Judithe Hernández and Lorena Wolffer, approach the issue of gender-based violence and feminicide through their artworks. The first part of the project consists of an annotated bibliography that provides context to the research topic and informs the analysis of the artists' works. The second part includes the formal description of pastel works by former Chicana muralist Judithe Hernández and a selection of performances by Mexican contemporary artist Lorena Wolffer; all works chosen relate to the overarching theme of gender-based violence against women.

A personal interview with Judithe Hernández was conducted to close the project and serve as a testimony to art-making in the name of justice and gender equality.

EILEEN MOUDOU CC'21: CHEMISTRY

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Faculty Mentor(s): Milan Delor, Columbia University
Title: Excitons transporting energy in atom-thin materials: a random walk simulation

Abstract:
In semiconductors, electrons transport energy through the conducting material by pairing up with the positively charged hole it leaves behind, creating a boson quasiparticle called an exciton. As semiconducting materials are excited with a laser, many excitons are propagated and transport energy throughout the material on the timescale of picoseconds (over several nanometers). The movement without interference is radial and quadratic, but as most materials have tiny defects throughout the landscape, each exciton's path is disrupted and deflected, making the overall diffusion close to linear (relative to time). This can be frustrating for the technology that relies on the efficient transport of semiconductors, such as solar cells. Frustration specifically arises from the inability of current technology to image what causes such defects on a similar picosecond/nanometer scale. This project was therefore to create a Monte Carlo random walk program (using Python) to simulate the diffusion of excitons in known materials with known parameters, to obtain diffusion coefficients that agree with recent literature values. By using known parameters, the effects of lesser known parameters or less-rigorously investigated values were manipulated to extrapolate particular deviations in anticipated transport mechanisms. It is expected that the results of this project may supplement future experiments by providing a general expectation of how similar parameters/testing conditions may affect materials used in vivo.

FRANCK BUHENDWA MUGISHO CC'23: COMPUTER SCIENCE

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Faculty Mentor(s): Christopher Baldassano, Columbia University
Title: Neuroimaging Research

Abstract:
My summer 2020 consisted of two main projects. The first consists of object-oriented coding and the second was about Data Management. For the former, the goal was to design the user interface for an experiment that uses complex artificial intelligence models such as NGram Models, Recurrent Neural Networks, and Transformers to predict which ones are close to the human brain. Its findings can be useful in software programs like Grammarly because if we know which models are close to the human brain, we can use them to make better human-like suggestions and predictions of sentences in the case of Grammarly. The models can also be a way to improve virtual assistants like Siri or Alexa. The second project was about organizing participants' data, filtering out careless ones by tracking their inputs, and paying them for an experiment that explores how the activation of schemas influences the perception of a story.

ELIZABETH MYRUS CC'21: BIOLOGY

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Faculty Mentor(s): Kimara Targoff, Columbia University
Title: Imaris9.5.1 Software Enhances Visualization and Quantitative Analysis of the Zebrafish Cardiac Outflow Tract

Abstract:
Congenital heart defects (CHD) account for the majority of birth defects worldwide and result from morphogenetic and functional errors during fetal heart development. Cardiomyocyte specification and differentiation are transcriptionally regulated processes, and previous research has demonstrated a link between mutations in cardiac transcription factors and CHDs. The Targoff Labratory previously found nkx genes to be essential regulators of ventricular cardiac identity maintenance, yet little is known about the downstream effectors responsible for the differentiation of cardiomyocyte subpopulations. One effector that was recently identified from cardiac-specific RNA-sequencing analysis is cystine-rich intestinal protein 2 (crip2). Here, we used CRISPR/Cas 9 (clustered, regularly interspaced, short palindromic repeats) mutagenesis to generate crip2/3 double mutant embryos in which we observed outflow tract (OFT) defects. We then used SCAPE (Swept, Confocally-Aligned, Planar Excitation) microscopy to study OFT morphogenesis in wild- type and crip2-/-;crip3-/- zebrafish. Our research demonstrates the benefits of translation-less, 4-D microscopy to cardiac research and identifies effective methods for SCAPE data visualization. Using Imaris9.5.1 software, we successfully processed a number of videos of live wild-type and crip knockout zebrafish embryos. We determined that Imaris software can be used to generate quantitative and morphological data about the OFT regions and blood flow patterns in the fish. Our findings highlight the intersection of biomedical engineering and biological research and will enable more precise imaging and analysis of organs and tissues in a wide range of developing organisms.

KYLE NEARY CC'22: DATA SCIENCE; ECONOMICS-MATHEMATICS

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Faculty Mentor(s): Frits Paerels, Columbia University
Title: Searching for X-ray Counterparts to Binary Black Hole Mergers behind the Galactic Plane

Abstract:
When two black holes merged, they emit detectable gravitational waves. It is further theorized they will briefly exhibit an episode of X-ray emission. This flash of X-rays will leave an “echo” in the sky as photons hit dust particles and scatter off of them. If the gravitational wave event happened behind the Galactic plane, as seen from Earth, this echo can linger for years. This research includes searching X-ray telescope photos of the sky for electromagnetic counterparts to those gravitational wave events that may have been located behind the plane. The a priori probability of success for at least one such alignment is now approximately 20%. In order to search for these X-Ray counterparts, it is necessary to model their expected shape. Given the X-rays passed through the galactic plane, we expect to see an anulus-shaped “halo” of light from scattered photons, growing in size with time. In addition to searching for gravitational wave event counterparts already caught on telescope, this research considers optimal strategies to search for a potential halo after gravitational wave detectors find probable binary black hole mergers.

THEO NELSON CC'24: BIOMEDICAL SCIENCES; COMPUTER SCIENCE

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Faculty Mentor(s): Thomas Postler, Columbia University
Title: Uncovering the Role of lnc173 Mouse-Ortholog in T-Cell Biology

Abstract:
T-cell activation is a crucial step in the adaptive immune response. Recent studies in T-cell lines have hinted at lnc173, a long non-coding RNA, as having a role in regulating cytokine production- signaling proteins that can either activate or suppress immune responses. Genomic analysis has been run for a wide range of publicly available RNA-seq data including both human and mouse T-cell data. Both lnc173 and its mouse ortholog are expressed to varying degrees within many T-cell datasets. Work is ongoing to integrate more datasets into this analysis and apply meta-analysis techniques to compare between-experiment results.

ANA CAROLINA OLIVEIRA CC'23: PHYSICS

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Faculty Mentor(s): Zsuzsanna Márka; Szabolcs Márka, Columbia University
Title: Low-Latency Algorithm for Multimessenger Astrophysics with Gravitational-Wave Bursts and Neutrinos

Abstract:
Gravitational-wave (GW) emission from cosmic sources can be accompanied by other messengers across the electromagnetic spectrum, as well as by particles such as high-energy neutrinos (HENs). Joint gravitational-wave -- high-energy neutrino source can be discovered via searching subthreshold events in both data streams as time and spatially coincident GW+HEN candidate may rise above the detection threshold. Moreover, the use of neutrinos as counterparts can significantly improve the localization of the GW detection and thus enhance electromagnetic follow-up campaigns. Here we present studies with the Low-Latency Algorithm for Multimessenger Astrophysics (LLAMA), a pipeline used for joint searches for common sources of gravitational waves and high-energy neutrinos. We extended the LLAMA infrastructure to digest triggers from cWB, an unmodeled gravitational-wave detection pipeline and conducted several case tests using the open public unmodeled GW burst candidate alert, S200114. The case tests are organized as follows: for injected high-energy neutrinos running the analysis with the GW chosen, we perform the analysis in a modified version of the neutrino, shifting its right-ascension, declination, energy, or its time difference to GW trigger in each run. The goal of the test is to observe the behavior of the odds-ratio (statistical test that determines whether detection is a real signal or background) for each set of changes, allowing us to understand the functioning of the pipeline for joint searches using unmodeled detection pipelines. This is a first step towards the discovery of joint GWHEN events from unmodelled sources, as well as a much-needed enhancement of the analysis pipeline.

CHERYL PAN CC'21: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Vilas Menon, Columbia University
Title: Analyzing Postmortem and iPSC-derived Glial Cell Types to Study the Transcriptomic Profile of the Alzheimer Brain

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 AD is still unknown, and no effective therapies exist. This project analyzed single-cell RNA-Seq datasets with the computational tool Seurat. These included postmortem prefrontal cortex samples from individuals enrolled in the Religious Order Studies (ROS) and Memory and Aging Project (MAP) studies, and various iPSC-derived glial cells. The aim of this project was two-fold: to study AD-related differential gene expression across cell type and origin, and to evaluate how iPSC-derived brain cells can serve as a robust model for studying AD. Expression profiles of microglia in the AD brain showed more upregulated protein-coding genes related to inflammatory processes, when compared to iPSC-derived microglia. The iPSC-derived astrocytes were developed by two differentiation protocols: dual SMAD inhibition (DSEB) and overexpression of Sox9 and NFIB (iAstro). Compared to DSEB astrocytes, iAstro astrocytes expressed more similar levels of mature astrocyte markers as the postmortem samples. However, the extent to which the datasets integrated was lower than expected. Immunoregulatory protein markers such as CLU, IFITM3, and IL17D separated all three datasets into distinct clusters. Ultimately, this project demonstrated the potential of both iPSC-derived glial cells and computational software like Seurat as tools for further investigation and modeling of AD-specific phenotypes in vitro.

JULIA PARSLEY CC'22: BIOCHEMISTRY

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Faculty Mentor(s): Jim Manley, Columbia University
Title: Modulation of 3' UTR Length in Stem Cell Differentiation via Coordinated FIP1L1 and CPSF4 Splice Isoform Expression

Abstract:
Alternative polyadenylation (APA), carried out by the cleavage and polyadenylation complex, describes the differential termination, or cleavage, of the mRNA transcript and subsequent addition of the 3' poly-A tail; where cleavage and polyadenylation at specific sites in an mRNA transcript can influence subsequent alternative splicing of the RNA as well as RNA stability. Interestingly, APA has been implicated in stem cell differentiation several times over the past decade, as 3'UTR length for transcripts with multiple polyadenylation sites has been shown to globally increase upon embryonic stem cell differentiation and conversely globally decrease upon iPSC reprogramming of differentiated cells. Despite this, however, the mechanism of differentiation-related APA profile changes is largely unknown.
Recent developments in RNAseq technology have revealed several protein components (polyadenylation factors) of the cleavage and polyadenylation complex to have multiple isoforms generated by alternative splicing, suggesting changes in polyadenylation factor isoform ratios as a possible mechanism of APA regulation. However, these isoforms have not yet been characterized in the literature. Therefore, the goal of this study is to characterize any changes in polyadenylation isoform expression upon stem cell differentiation in an effort to elucidate functional roles for these isoforms in APA regulation. DTU analysis of hESC, neural progenitor, trophoblast, and human tissue RNAseq data revealed consistent and coordinated changes in splice isoform ratios for two polyadenylation factors directly involved in polyadenylation site recognition, CPSF4 and FIP1L1, suggesting a central and cooperative role for these polyadenylation factors in APA, as well as providing evidence for functions of several uncharacterized isoforms.

SAPNA PATEL CC'22: BIOLOGY

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Faculty Mentor(s): Anna Vannucci, Columbia University
Title: Childhood Caregiving Unpredictability and Emotional Schema-based Learning and Adaptation

Abstract:
Childhood unpredictability in the home environment is a promising dimension through which to conceptualize adverse caregiving experiences (Smith & Pollak, 2020). This study examines the relationship between childhood caregiving unpredictability and emotional schema (conceptualization tool) based learning and adaptation. On day 1, participants completed the Questionnaire of Unpredictability in Childhood and a novel emotional schema acquisition task. On day 2, they completed an emotional schema-based learning task that assessed their ability to adapt their preexisting day 1 schemas when confronted with new conflicting affective information. Most day 2 stimuli (objects called fribbles, with an associated valence) were congruent with the day 1 schema, while 37% were incongruent. Results use pilot data from 9 undergraduate students. For congruent stimuli, greater childhood caregiving unpredictability was associated with higher accuracy (neg-neg: r = .34; neu-neu: r = .49; pos-pos: r = .49). In all incongruent conditions in which the fribble valence shifted to being more negative, greater childhood caregiving unpredictability was associated with lower accuracy (pos-neg: r = -.20; pos-neu: r = -.16; neu-neg: r = -.19). Montecarlo simulations (N=1,000) suggest that a sample of 50 participants would have 90% power to detect a significant childhood unpredictability x d1-d2 valence interaction. Higher levels of childhood caregiving unpredictability may be associated with alterations in emotional schema-based learning, differing by the nature of affective valence shifts. The observed inflexibility in shifting away from positive schemas may reflect an adaptation promoted by growing up in unpredictable caregiving environments.

HENRY PAUL CC'22: HISTORY

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Faculty Mentor(s): Christopher Washburne, Columbia University
Title: Joe Henderson: Radical Sounds and Radical Politics

Abstract:
In his 1926 essay “Criteria of Negro Art,” W.E.B DuBois makes the argument that “all art is propaganda and ever must be”. This research project explored the necessarily political dimensions of art through study and analysis of the music of Joe Henderson. Henderson was a prolific yet often overlooked saxophonist of the post-bop era. Throughout his long and diverse career, he was a torchbearer of modernist jazz from its 1960s Blue Note heyday to its resurgence in the 90s. This research explores a string of Henderson albums in the 1970s that were explicitly and radically political in message. Through his music, Henderson expressed his ideological alignment with the radical left, the Black Panther Party, and afrocentrism. This project sought to document and explore this intersection of ideology and music through a number of relevant questions. First, what were the social and historical contexts that drove Henderson to put out this political music? Further, what factors kept him from releasing politicized music before and after this period in his career? Second, and perhaps most important, how did the music itself relate to the ideologies expressed? How was Henderson able to create a radical sound to carry his message? And what do these formal elements and techniques reveal about the political nature of art?

GIANCARLO PEREIRA CC'21: PHYSICS

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Faculty Mentor(s): Abhay Pasupathy, Columbia University
Title: Unveiling Diverse Metallic Phases in Twisted Transition Metal Dichalcogenides

Abstract:
The field of 'twistronics' ('twist' + 'electronics') studies how twist angles between two atomically thin crystal layers change electronic properties of materials and has offered many insights into fundamental questions of quantum mechanics and the nature of electron behavior. We have studied the uniqueness of quantum phases that arise from twist angles (4º - 5.1º) on samples of two atomically thin layers of WSe2, a transition metal dichalcogenide, stacked on top of each other. By twisting two layers of WSe2, the band structure from the top layer hybridizes with that of the bottom layer, creating flat energy bands -- these flat bands have been used to study superconductivity in twisted bilayer graphene in a range of 'magic angles.' In our findings, we observed a linear-in-temperature behavior for the longitudinal resistivity in our 2D samples around quantum critical points, i.e. in the boundaries between metal and correlated insulator regions. There is very little understanding as to what mechanism is responsible for pushing the dissipation into a quantum limit, the Planckian limit. Our current system provides advantages in the study of such metallic regimes due to the easy tunability of the number of electrons in our system, which can unveil both linear-in-temperature and quadratic-in-temperature resistivity, the latter being well understood in simple Fermi liquid theory. Our system has the potential to rule out trivial explanations for the observed dissipation limit such as phonon coupling, which is strongly present in magic angle graphene and makes it difficult to separate exotic phenomenology from trivial ones.

JENNIFFER PROFITT CC'23: PHYSICS; MATHEMATICS

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Faculty Mentor(s): Paolo Desiati, Wisconsin IceCube Particle Astrophysics Center; Elena D'Onghia, University of Wisconsin-Madison
Title: Protection for a New Generation of Spacecraft: Evaluating the feasibility of active shielding systems using magnetic fields

Abstract:
Long-term spaceflight and space-based instruments require protection from cosmic radiation, and active shielding could reduce the mass, consolidate the radiation deflection system, and provide higher efficiency than passive shielding using bulk materials. Multiple magnetic field geometries were tested and 9 proton energies (spread over a logarithmic scale) were simulated for each geometry to determine which is most efficient at protecting a small, central region of 3D space from varying levels of cosmic radiation. To determine the efficiency, proton particle trajectories for each energy from 0.1 MeV to 1 GeV were generated; the distance from each coordinate to the center was calculated for every particle in the trajectory; and from these distances, a minimum distance was determined. If this distance did not reach the target region, the shielding efficiency was incremented. The results showed that the solenoid magnetic field of 11 coils and 10 meter radius provided the weakest overall shielding; the geomagnetic dipole proved strongest for a central region of 1 meter radius and for central regions of 3 meter and 5 meter radii for low proton energies (at or below ~30 MeV); and the circular coil wire field was strongest for central regions of 3 meter and 5 meter radii for high proton energies (at or above ~100 MeV). This research is important for near-future aerospace engineering applications (especially for long-term, reusable crewed landers)

as well as for providing a simulation of the behavior of cosmic rays along field lines of various magnetic field geometries.

PHILIP RAFTOPOULOS CC'22: BIOCHEMISTRY

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Faculty Mentor(s): Benjamin Bechand, Columbia University
Title: Synthesis on Non-Bridged Ibogaine Derivatives

Abstract:
Ibogaine, a natural product of Tabernanthe iboga, has historically been used to treat addiction from various drugs, including cocaine, nicotine, alcohol, and opioids. Currently, the compound has received Schedule I classification by the DEA due to its psychedelic side-effects. Potential derivatives could have the ability to selectively bind to the kappa-opioid receptor, which would ameliorate side-effects and still allow for the retention of non-addictive properties. This could have huge implications in both addiction treatment and analgesic treatment. Dr. Andrew Kreugel has previously synthesized a benzofuran series of ibogaine derivatives; among the most promising is ACK-676. Unfortunately, these compounds bind to hERG, which means they would have long-term heart effects if used in any way. This project seeks to reduce heart-related side effects through the synthesis of non-bridged derivatives of ACK-676 and similar compounds. These compounds can be made by reacting an aromatic grignard reagent with an isoquinuclidine ketone. The synthesis of both starting materials was performed, but the final reaction was not able to be completed. Results were confirmed through NMR and mass spectrometry analysis. The starting materials were deemed as ready to undergo further reactions. One future goal of this project is to fully complete the synthesis and to analyze the effects of the compound in mouse models. This can be accomplished in the near future.

ARYA RAO CC'22: BIOCHEMISTRY; COMPUTER SCIENCE

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Faculty Mentor(s): Peter Andolfatto, Columbia University
Title: Intra- and Inter-species Adaptive Evolution of Cardiac Glycoside Resistance

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 cardiac glycosides (CGs). CGs inhibit the function of Na+,K+-ATPase, a medically important enzyme necessary for many processes including neural function and muscle contraction. This evolved toxin insensitivity, which occurs via a small subset of adaptive substitutions, is of interest in understanding the mechanisms of adaptive evolution. We used this case of parallel evolution in the alpha subunit of Na+,K+-ATPase to show that computationally identified adaptive amino acid substitutions at sites 111 and 122 actually produce deleterious effects in vivo. We further showed that these effects can be partially ameliorated by a “permissive” substitution (a substitution that is not implicated in CG- resistance but nevertheless is necessary for CG-resistance), A119S. To our surprise, we found that negative pleiotropic effects result from these substitutions, indicating that genetic background has importance in adaptation. A preliminary GWAS of wild-type D. melanogaster populations supports this idea. We expect this work to reveal information about genetic determinants of CG-sensitivity that we can then use to predict targets of adaptation in diverse CG-

tolerant taxa. 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.

AIDA RAZAVILAR CC'23: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Peter Canoll, Columbia University
Title: Phenotypic Characterization of Retrovirus-Induced Glioma to Model Notch-Driven, Slow-Cycling Tumors

Abstract:
Glioblastoma (GBM) is the most common malignant primary brain tumor, and even with the availability of chemo-radio therapeutics, GBM patients are known to have one of the lowest survival rates of any cancer. Intratumoral heterogeneity is a major challenge to treating GBM, and post-treatment recurrence, which is observed in virtually all cases of GBM, is due to the failure of therapies to effectively target both proliferative, fast-cycling cells, as well as more quiescent glioma cell populations. We hypothesize that the Notch signaling pathway is a key moderator in the transition between fast-cycling and slow-cycling glioma cell states. The same mechanisms that allow Notch signaling to modulate cellular transitions help fast proliferating cells, the target of traditional therapeutics, evade these therapies by reverting to a slow-cycling cell (SCC) state. The role of SCCs in recurrence and malignancy makes them a key target for GBM treatment. Notably, these SCCs have distinct metabolic pathways and are especially sensitive to therapies inducing ferroptosis, cell death by the accumulation of lipid peroxides. In this study, we used a genetically-engineered mouse glioma model that expresses a constitutively active form of Notch to test its phenotypic properties and the efficacy of ferroptosis-inducing therapies. Here, we show that our model exhibits significantly less oligodendrocyte progenitor-like features, acquiring features of multiple other lineages, including neural progenitors and astrocytes, while also showing trends towards a less proliferative tumor. Additionally, cells derived from the tumor model were significantly more responsive to RSL3, a ferroptosis inducer acting via GPX4 inhibition. Together, these results validate the potential for our retroviral-induced primary GBM tumor to model a Notch driven slow-cycling tumor, and to use this model for pre-clinical testing of new therapeutic approaches to target glioma cells that are resistant to current forms of therapy. Ultimately, these data may lead to the development of better, more efficacious treatments for GBM.

HERBERT RIMERMAN CC'21: CLASSICS

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Faculty Mentor(s): Paul Kosmin, Harvard University
Title: I Will Make of Them One Nation: The Covenantal Ἰουδαῖος and the Hasmonean Incorporation of Idumea

Abstract:
The Hasmonean state established the sovereignty of Ἰουδαῖοι (commonly translated as "Jews") over Judea for the first time in human history. Gaining autonomy after centuries of Persian and Hellenistic rule required the Hasmoneans to define of what a state of Ἰουδαῖοι looked like, and consequently which characteristics defined the subjects of the state, in a way that was both effective for them and intelligible to neighboring powers.
Their incorporation of Idumea frequently features in studies of the Hasmoneans, but previous treatments have left the means by which Hyrcanus attempted to tackle this task as an afterthought, passing it by to ask questions such as whether ‘conversion’ is an applicable term or whether the annexation was forced or voluntary, based on the supposed attractiveness of Judaism or of affiliation with the Hasmonean state. However, the Hasmonean

expansion into Idumea provides an early test case of the Hasmonean platform that can provide insight into these unresolved questions. Employing information from new archaeology and delving into the late Hellenistic context of the period, this paper investigates how Hyrcanus defined the Hasmonean state and used its expansion into Idumea to project his definition of the new Ἰουδαῖος.

LILLIAN ROUNTREE CC'23: FRENCH; STATISTICS

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Faculty Mentor(s): Inga Winkler, Columbia University
Title: Review of Menstrual Health Policy in India, Kenya, Senegal, and the United States

Abstract:
In the past decade, more and more countries have created policies designed to address issues of menstrual health, menstrual hygiene, and the taboos surrounding menstruation. However, due in part to the newness of these policies, a critical examination of their efficacy has been largely absent, and thus these policies run the risk of incompletely tackling the issues of menstrual health and hygiene they seek to address. This ongoing project, sponsored by the UN Water Supply and Sanitation Collaborative Council, examines menstrual health policy in four countries—India, Kenya, Senegal, and the United States—in three stages of the policy cycle: triggers, policy development, and implementation. This project delves into the origins and details of menstrual health policy in the aforementioned countries at a federal, state, and regional level to understand central questions such as: Who is driving this policy change? Who is being included and excluded when creating this policy? What does implementation look like, and are those mechanisms effective? Through interviews with stakeholders, policy document retrieval, and the qualitative coding and analysis of these key texts, this project assesses the current state of menstrual health policy within its four countries, using a human rights lens to understand effective and ineffective tactics for change and offer a roadmap for future policy developments in these countries and beyond.

HELEN RUGER CC'22: CLASSICS

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Faculty Mentor(s): Brook Holmes, Princeton University
Title: Reproductive Agency and the Role of the Female Psyche in Soranus' Gynaecology

Abstract:
This paper considers the impact of female psychical action in relation to female agency in Soranus' Gynaecology. It asserts that the female psyche's capacity to interfere with the reproduction process reflects an agency – often assumed to be absent from female patients – that registers as resistance to regulation from the reproductive imperative or as self-regulation. While prior work on female volition (or lack thereof) in ancient Greek medical literature has focused on the absence of female agency within the Hippocratic corpus or on the expansive male subjectivity in the late-antique period, little attention has been paid to the impact of the female psyche or presence of female volition within Soranus. However, further analysis of Soranus' work reveals that the female psyche and mind are referenced throughout as forces with the ability to disrupt each stage of reproduction. Indeed, an unregulated psyche can dispel the seed, cause difficult labor, and misshape the fetus (1.34, 1.39, 4.54). This paper investigates such impact at stages within the reproduction process but does not conclude that simply the presence of the psyche inherently suggests more female autonomy. Rather, it focuses on psychical action because it hypothesizes that degrees of female autonomy can be measured through analyzing the psyche's

relation to reproduction, medical regulation, nature, and health. This examination reevaluates prior denial of female volition and reveals the moments of agentic choice that position the female in medical literature in a liminal space between a solely physiologically motivated being and an agent of psychical intervention and self-regulation.

AMESH SARECHA CC'22: BIOCHEMISTRY

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Faculty Mentor(s): Christoph Buettner, Icahn School of Medicine at Mount Sinai
Title: The Role of Hepatic Stellate Cells (HSC) on Metabolic Diseases

Abstract:
As the global population of the world continues to rise, the already existing burden for healthcare providers is expected to increase as the non-communicable, chronic metabolic disorder Diabetes Mellitus (DM) is increasing steadily all over the world. For a long time now, we have been able to characterize the vast majority of cases of diabetes into two broad etiopathogenetic categories that center around impaired metabolic regulation and insulin action/secretion. As there have been vast technological improvements in the last decade, the research efforts in understanding the physiology of the disease have increased as well. Plenty of studies have been done on how three of the four major liver cell types- hepatocytes (HCs), Kupffer cells (KCs), and liver sinusoidal endothelial cells (LSECs) play a role in the progression of DM. However, our research focuses on the current gaps revolving how paracrine communication is alerted when you remove the hepatic stellate cells (HSCs) and thus the effect this would have on metabolism. We worked with transgenic (Tg) HSC KO mice to assess how hepatic de novo lipogenesis (DNL) will be altered. What we saw was key enzymes of DNL decreased including FAS, ACC, p-ACC, ATPCL, p-ATPCL, and ChREBP when normalized to b-actin. Additionally, we were able to see a significant difference in the levels of p-ERK/ERK from the WT to the HSC KO. As more work still needs to be done, our current position points in a direction that may serve to play a role in the cure of fatty liver diseases including NAFLD, NASH, alcoholic hepatitis, and alcoholic cirrhosis.

ISAAC SCHOTT-ROSENFIELD CC'21: ENGLISH; CLASSICS

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Faculty Mentor(s): Ronald Bush, Oxford University
Title: Affective Perception and Value-order in the Pisan Cantos

Abstract:
This paper examines the intellectual schema of the Pisan Cantos of Ezra Pound, in terms of which the “progress” of the poem may be defined. Charting the overform produced at the start of the Pisan Cantos through the alignment of Cavalcanti’s “Donna mi prega” and the Confucian stone-classics, it illuminates Pound’s plan for a “paradisal” approach, and explains its initial failure. Weighing Pound’s treatment of scholastic views on knowledge and his endorsement of Mencian ethics, it considers the criteria for the approach’s success, leaning on the phenomenology of Max Scheler to demonstrate the modernity and viability of Pound’s project, despite its more ancient components. Finally, the paper considers the realization of these criteria at the end of the Pisan Cantos, reflecting on the role of the poem itself in its effort towards a robust anti-dualism and the recovery of an holistic weltanschauung.

RALEY SCHWEINFURTH CC'22: ENVIRONMENTAL CHEMISTRY; MUSIC

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Faculty Mentor(s): Bevin Daglen
Title: Detection and Removal of Dinotefuran from the Environment

Abstract:
Maintaining a healthy bee population is of vital importance to the sustainability of our planet, as bees are essential for the future of agriculture and the stability of the Earth's food supply. With a growing number of bee species protected under the Endangered Species Act, the urgency for action to halt the disappearance of these pollinating insects is paramount. One theory for the reduction in bee population relates to the increased use of insecticides globally, especially neonicotinoid insecticides. After a single insecticide spraying of the neonicotinoid dinotefuran killed more than 50,000 bees in Oregon, this 3-year investigation using liquid chromatography tandem mass spectrometry (LC-MS/MS) assessed local honey samples to determine whether or not it was possible for bees to return to their hives and contaminate honey with dinotefuran. Subsequent to Oregon's ban on dinotefuran, tree and soil samples from affected sites also were examined for dinotefuran. Results reveal that dinotefuran can linger in honey and soil samples for at least 3 years following insecticide application. Moreover, this study provides data to support the effectiveness of phytoremediation and bioremediation, the in situ cultivations of greenery and bacteria respectively, for removing dinotefuran from contaminated sites.

ABHISHEK SHAH CC'21: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Christine Denny, Columbia University
Title: Prophylactic administration of 5-HT4R agonists alters brain-wide neural activity networks

Abstract:
Stress is a critical risk factor for both major depressive disorder (MDD) and post-traumatic stress disorder (PTSD). While current treatments address the symptoms of these illnesses, there is a need for treatments that address the root causes, for instance by increasing resilience to stress. It was recently shown that the drugs (R,S)-ketamine and the type 5-serotonin receptor (5-HT4R) agonist prucalopride can protect against stress-induced behavioral despair. Although both drugs target different receptors, both elicited similar changes in neural activity within the hippocampus, suggesting that common changes in brain activity may underlie resilience to stress. In order to study these changes at a brain-wide scale, the expression of the activity marker c-Fos was measured across the entire brain following administration of either (R,S)-ketamine or prucalopride. Both drugs influenced brain-wide connectivity as compared to saline-administered controls, and that this change accompanied reduced fear behavior. These data provide a novel mechanism by which to understand stress-resilience, and provide regional targets for further treatment development.

SOPHIE SHAN CC'22: DATA SCIENCE

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Faculty Mentor(s): Hanrui Zhang, Columbia University
Title: Single-Cell Transcriptome Profiling in Atherosclerosis

Abstract:
Atherosclerotic cardiovascular disease is one of the main sources of death in the world. Macrophages are the most abundant immune cells in atherosclerotic plaques. The objective of this project is to determine the macrophages heterogeneity and master regulators in atherosclerosis using single cell RNA-seq data. To achieve this goal, we apply the PISCES (Protein Activity Inference in Single Cells) pipeline in order to pinpoint master regulator proteins within murine atherosclerosis plaques in during plaque regression. PISCES is a technique for examining the gene expression profiles of single cells based on regulatory networks. Running PISCES involves the construction of a regulatory network using ARACNe-AP on scRNA-seq data. ARACNe-AP utilizes irreducible statistical dependencies in gene expression profiles to determine explicit regulatory relationships among genes. First, ARACNE-AP is run separately for all regulator sets, then, protein activity is used to create clusters. Next, cluster-specific network generation is executed. Then, one by one the clusters are compared against the other parts of the data to determine which proteins are the most specific to that cluster. In summary, we have identified three distinct sets of macrophages in atherosclerosis regression. Further analysis will determine the function of cells within these three clusters. Top master regulators within these clusters include: Elp2, Znrf2, Ubap1, Ccdc88a, Atrn, and Gle1. Future studies will determine the potential role of these master regulators in atherosclerosis protection.

MANASI SHARMA CC'21: COMPUTER SCIENCE; PHYSICS

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Faculty Mentor(s): Anima Anandkumar, Caltech
Title: Disentangling Observed Causal Effects from Latent Confounders using Method of Moments

Abstract:
Causal Inference is an important domain in Machine Learning that focuses on the discovery of the causal relationships between variables, and it has wide applications in medicine, online recommendation systems, etc. Two algorithms have been designed to for this purpose; one is the Structural Equation Model (SEM) model that models the relationships between the observed variables, using observational data, and the other is the Independent Component Analysis (ICA), which is a tensor decomposition method that models the relationships between latent and observed variables, using interventional data. The two algorithms were combined by the TensorLab team at Caltech in order to uniquely identify causal relations from both observational and interventional data, since historically only observational data was used. We aimed to optimize the initial implementation of the algorithm by altering various hyper-parameters in the code (such as the learning rate, dimensions of the variables, etc.). We also looked into finding other ways to make the algorithm implementation more efficient (such as seeing if we can reduce the number of “interventions”, or changes made to the data in order to determine causal relations). We are now looking to move on to trying a non-linear approach to the model (to better model the intricacies of causal relations).

SUNJAE SHIM CC'21: PSYCHOLOGY

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Faculty Mentor(s): Chris Baldassano, Columbia University
Title: Event Perception Based On Working Memory Demand

Abstract:
The way that people divide up an experience into separate events can have long-term impacts on the way that this experience is remembered. According to the event segmentation theory, an event boundary is perceived when an individual makes an error in their prediction about what will happen next. However, recent studies have raised doubts about whether an event boundary is created only when a prediction error occurs. In this study, we tested whether event boundaries can be triggered even without prediction error by manipulating working memory demands. In our task, participants were shown a series of random images, presented in segments, along with an image of a clock. The beginning of a segment was indicated with the clock hand pointing up (12 o'clock position). Participants were instructed to detect image repetitions within each segment, but to ignore any repetitions across segments. The clock images either had specific ticks that the hand moved along, making the beginning of a new segment predictable (experimental condition) or did not have ticks in between to create a prediction error (control condition). The participants then completed a temporal memory task to indicate which of two images was presented first. Previous research has shown that temporal memory judgements can be used to identify event boundaries in long-term memory, since order judgements can be made with higher accuracy for pairs of items within the same event. We found that this boundary-related memory effect will be present in both the predictable and unpredictable event boundary conditions, suggesting that event boundaries can be successfully formed by resetting working memory load.

EDOARDO SPOLAORE CC'21: NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Yueqing Peng, Columbia University
Title: Optogenetic activation of glutamatergic neurons in the medulla induces transition from wakefulness to NREM sleep

Abstract:
Sleep is fundamental for cognitive and behavioral performance, immune function, and general health, but the neural circuits that initiate and maintain sleep states continue to be poorly understood. When falling asleep, the brain transitions from wakefulness to non-rapid eye movement (NREM) sleep. How this transition occurs and which neural circuits are involved in promoting NREM sleep remain open questions. This study addresses these questions using optogenetic activation, a neuromodulation method that employs light to manipulate neuronal activity in vivo via genetically-encoded light-sensitive ion channels. Optogenetic activation was applied in mice in order to stimulate the glutamatergic neurons located in the medulla. Such stimulation caused mice to transition from wakefulness to NREM sleep at a significantly higher rate than without stimulation. Specifically, the average percentage of transition from wakefulness to NREM sleep was 50% with light stimulation versus 6% in the absence of light stimulation. The stimulation had a larger effect on the transition from wakefulness to NREM at higher frequencies: 67% at 20 Hz, 31% at 10 Hz, and 14% at 5 Hz. In contrast to previous research that has mainly focused on the role of the hypothalamus in the transition from wakefulness to NREM, these results implicate a novel role for the medulla in the transition from wakefulness to NREM. Moreover, while previous research has concentrated on GABAergic neurons, this study shows an important role for glutamatergic neurons. Therefore, glutamatergic agonists may have a role in treating sleep disorders, such as insomnia.

ANNA 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:
Geography of residence has been implicated in the development and course of mental disorders1 and is associated with adverse alterations in mood and cognitive performance, including memory and vigilance2. Regions of altitude in the U.S., such as the Intermountain West, as well as in other countries, correspond with higher rates of suicide, drug abuse, and mental disorders such as depression and attention-deficit hyperactivity disorder, which may be attributed to hypoxic effects. Although high altitude is known to cause significant impairment of reasoning and performance, the mechanisms behind the neurochemical basis for these behavioral and mental impairments is largely unknown. For patients with bipolar disorder (BD), magnetic resonance spectroscopic neuroimaging (MRS) studies have found abnormal lactate and phosphocreatine (PCr) levels, in addition to alterations of intracellular pH and choline-containing metabolites13. We hypothesize that chronic hypobaric hypoxia may result in similar changes in brain bioenergetics, specifically in regional phosphocreatine levels, which is a high energy phosphate involved in oxidative phosphorylation. Using spectroscopic neuroimaging with appropriate pulse sequences, the effects of altitude on the brain will be comprehensively studied in order to develop a deeper understanding of the correlation between mental health and altitude.

ASWATH SURYANARAYANAN CC'23: PHYSICS

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Faculty Mentor(s): Frits Paerels, Columbia University
Title: High Resolution X-ray Spectroscopy of Cygnus X-3 with Chandra

Abstract:
The Iron (Fe) spectrum of the high mass X-ray binary Cygnus X-3 is analyzed using the highest resolution data available, obtained with the High Energy Transmission Grating Spectrometer on the Chandra X-ray Observatory, taking advantage of diffraction into high spectral order. The Fe XXV He-alpha complex and the Fe XXVI Ly-alpha lines are fully resolved, and the narrow radiative recombination continuum features from highly ionized Fe are detected. This is the first resolved Helium-like Fe XXV ion emission spectrum from a source driven by photoionization and radiative transfer and the unique features of this spectrum which are characteristic of these conditions are identified and described. A preliminary analysis of the Fe XXV recombination continuum at 8.828 keV suggests a maximum gas temperature (in the highest Fe ionization zone) of the order of the instrument resolution, or 30 eV. Finally, the Doppler shifts of individual lines in the Fe XXVI and Fe XXV complexes are estimated. Using the fact that significant orbital Doppler shifts are not detected in the emission lines from the highest ionization zones of the companion stellar wind, a lower limit to the compact object mass is obtained, providing evidence for a black hole.

DAIKI TAGAMI CC'22: STATISTICS

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Faculty Mentor(s): Liam Paninski, Columbia University
Title: Deep Graph Pose: a semi-supervised deep graphical model for improved animal pose tracking

Abstract:
Animal pose tracking is crucial for many scientific investigations, with applications in ethology, psychology, neuroscience, and other fields. State of the art methods such as Deep Lab Cut and DeepPoseKit have opened up an exciting array of new applications in the area of animal behavior tracking, but hundreds of labels may still be needed to achieve tracking at the desired level of precision and reliability. Here, we propose Deep Graph Pose, which is a probabilistic graphical model built on top of deep neural networks, and develop an efficient structured variational approach to perform inference with this model. Deep Graph Pose models the targets as continuous random variables, resulting in a semi-supervised model that make use of both labeled and unlabeled frames of animals to achieve significantly higher accuracy while requiring fewer labeled training frames.
Many animal tracking tasks are taking frames from multiple views, and there are many occlusions and missing body parts per frame. While some existing algorithms are doing post-hoc 3D reconstruction, there still exists some issues with creating a model that can completely perform the tracking process in 3D. Here, we try to integrate both the multi view constraint and 3D body reconstruction into Deep Graph Pose, so that the entire tracking model will be 3D.

ARNAV TANDON CC'21: CLASSICS

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Faculty Mentor(s): Katharina Volk, Columbia University
Title: Poetic Self-Consciousness and the Imperial Elite

Abstract:
Many long poems or collections of poems contain epilogues written in the first person to imply the poet's presence and voice. Such instances of poetic self-consciousness, in which poets offer their own voices to reflect on the creation and completion of their works, occur in a number of ancient texts. In Horace's Odes and Ovid's Metamorphoses, each author utilizes the first-person voice firstly as an emphatic conclusion to his work of literature, but the content of these sections also suggests a proclivity on the author's part to align himself with and to insert himself physically into the highest echelons of Roman society. Several of the poems within the larger Odes collection function to morph Horace into an entity, be it a star or a bird, through which he can ascend above the earth and thus divulge his own poetry to the ends of the empire. In this way, Horace seems to take on a certain power otherwise reserved for the highest members of the imperial family. In Ovid's case, the reference to imperial power is much more direct: Ovid fashions himself as the emperor at the end of his Metamorphoses. The implication here is that Ovid, whose extensive work the reader has just finished, possesses a certain power that is also generally inaccessible to others. Through different methods, both writers essentially liken themselves to those who possess the most power at Rome.

MARIA TRIFAS CC'21: BIOCHEMISTRY

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Faculty Mentor(s): Anton Henssen, Charité-Universitätsmedizin Berlin

Title: Single-cell RNA sequencing analysis of ecDNA-containing neuroblastoma cells reveals pathway-level differences between CHP-212 cells with varied MYCN expression

Abstract:
Human cells normally have 23 pairs of linear chromosomes. However, in numerous cancers, oncogenes have been found to be amplified on circular extrachromosomal DNA (ecDNA). The expression of these genes on ecDNA can drive tumor evolution and cellular heterogeneity within a tumor. Currently, the relationship between increased ecDNA copy numbers and changes in overall gene expression are poorly characterized. In this study, we analyze transcriptional differences between cells of the CHP-212 cell line, a neuroblastoma sample known to amplify characteristic oncogenes, including MYCN, on ecDNA. We utilize SMART-seq single-cell RNA sequencing to obtain a transcriptional snapshot of the tumor cells, and we cluster the cells to identify significant differences between different groups. Additionally, we report the transcriptional differences between cells with high and low MYCN expression, a proxy measure for ecDNA expression. We then perform pathway-level analyses to search for alterations between MYCN-high and MYCN-low groups. We find that MYCNhigh cells are characterized by high mitotic activity and ribosomal biogenesis, while MYCNlow cells are enriched in extracellular matrix organization, developmental, and tumor suppressive pathways. This analysis reveals the unique pathways that differ between cancer cells with high ecDNA-mediated MYCN expression and those with low MYCN expression levels.

PANAGIOTIS TSIMPOS CC'23: PHYSICS; MATHEMATICS

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Faculty Mentor(s): Brian Cole, Columbia University
Title: Longitudinal flow decorrelations in heavy-ion collisions studied with the ATLAS detector at the Large Hadron Collider

Abstract:
Quark Gluon Plasma (QGP) is a state of matter in which quarks and gluons, the constituents of protons and neutrons, are deconfined; shortly after the Big-Bang all matter existed in QGP form. Relativistic (i.e. v≈c) heavy ion collisions produce QGP. We study measurements of colliding lead nuclei performed at ATLAS, the largest general purpose detector of the Large Hadron Collider, housed at the European Organization for Nuclear Research. After QGP formation, extreme pressure and temperature drive an explosive expansion during which it behaves as a (relativistic) liquid. We study its flow via flow harmonics (vn), i.e. coefficients of the Fourier series expansion of the distribution of particles in the azimuthal direction (polar direction on a cross-section of the accelerator). We study the dependence of vn on the particles' transverse momentum (pt ,momentum component normal to the beam axis) and the event's centrality class (distance of colliding nuclei centers). The flow vector (q) quantifies the "bulk flow" of particles. We divide particles in pseudorapidity (η, measure of angle with beam axis) classes and assign a flow vector qi to each class. We create distributions of dot products in all (i,j) pairs against the change in η; we fit them with Gaussian and quadratic curves. We lastly plot the fit parameters against the sum of eta. We repeat with events of different centralities and particles within different pt bounds. We observe a monotonic relationship between pt and the fit parameters; we do not observe sensitivity on the centrality classes.

LIZKA VAINTROB CC'21: MATHEMATICS; COMPARATIVE LITERATURE AND SOCIETY

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Faculty Mentor(s): Peter Ralph, University of Oregon
Title: The mathematics of antagonistic alleles

Abstract:
Population genetics is a field of biology that studies the genetic composition of biological populations as well as the changes in genetic composition that result from the operation of various factors, including natural selection. The mathematical methods of population genetics theory quantitatively characterize the gene distribution dynamics in evolving populations. The goal of this project was to learn the basic mathematical tools of population genetics, like discrete dynamical systems (the changes in a given system, like genetic characteristics of a population, measured over time-steps) and phase portrait analysis (reading relevant information about dynamical systems from geometric data), to apply them to a description of the dynamics of allele frequencies in populations under natural selection and genetic drift (changes in the genetic composition of a population over time that result from chance irregularities in gene inheritance). The project also analyzed some elements of population-genetics literature. For instance, some papers describe the conditions for when sexually antagonistic selection (when certain alleles increase fitness for one sex, and decrease it for another) might maintain genetic diversity among sexes (in particular, the recent Kasimatis et al paper, "Limits to Genomic Divergence Under Sexually Antagonistic Selection" demonstrates that it might be easier to interpret the relevant data as statistical error than as the result of sexually antagonistic selection, because this would require many low-probability conditions to be true to remain stable).

SHIVALI VERMA CC'22: BIOLOGY

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Faculty Mentor(s): Donna L. Farber, Columbia University
Title: Transcriptomic analysis of human NK cells and T lymphocytes in tissue sites over age

Abstract:
T lymphocytes direct all aspects of the adaptive immune response that are essential for mediating protection to pathogens and tumor clearance. T cells are found in the blood, but the majority localize in tissue sites, dubbed Tissue Resident Memory (TRM) cells, where they accelerate pathogen clearance by providing a first response against infections re-encountered at body surfaces. Generated in response to site-specific vaccinations or infections by diverse pathogens (viral, bacterial, parasites), TRM cells exhibit distinct functional, transcriptional and phenotypic capacities that vary critically between specific tissue site and age - a phenomenon also observed in human Natural Killer (NK) cells. Recently, their heterogenous populations from different tissue types have been better characterized individually, but not comparatively analyzed. An analysis of existing whole transcriptome RNA sequencing data of NK cells from different human tissues (lungs, intestines, lymphoid sites, spleen)was performed to identify markers for T lymphocyte data analysis. Obtained from organ donors from infancy to adults, the analyses reveal site- and age-specific differential gene expression suggesting distinct pathways for maintenance of T cell subset homeostasis, and providing insights into differential T cell aging by site.

YASNA VISMALE CC'22: SUSTAINABLE DEVELOPMENT; PHILOSOPHY

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Faculty Mentor(s): James Valentini, Columbia University
Title: Reducing Columbia's Carbon Emissions

Abstract:
Yasna is currently conducting research to produce a survey which is projected to be facilitated throughout the university this Fall of 2020 in partnership with the School of Climate Change at Columbia. She began working under Dean Valentini starting Fall of 2019 her sophomore year to conduct this research project during the time she began a literature review with the help of Dean Rosen-Metsch. The next semester, she began drafting her survey which she has been refining throughout the summer.
The research focuses on learning about student sentiment and behavioral patterns towards Columbia's and their own carbon emissions. This summer of 2020 while her original plan was to continue her research in Paris at Reid Hall to learn about the effects of nuclear energy, Yasna spent her summer in Seattle. During this time, she collaborated with Dean Valentini, Dean Rosen-Metsch, Margaret Pereyra to further develop questions and facilitated a test survey of 55 volunteers from Columbia's to refine the questions. She also continued to conduct informational interviews with professionals within the sustainable development field, financial services, and government, to refine the content within her survey.

CHARLIE WALLACE CC'23: POLITICAL SCIENCE; EAST ASIAN STUDIES

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Faculty Mentor(s): Andrew J. Nathan, Columbia University
Title: Wealth Disparity in Xinjiang, China

Abstract:
Charles Wallace through the Laidlaw Fellowship researched wealth disparity in Xinjiang Uyghur Autonomous Region (XUAR). Xinjiang, China's largest province in terms of area, is a Muslim majority region in Western China. XUAR is having an economic boom with its GDP growth topping the charts by being the fastest growing economy in China in many fiscal quarters. However, he looked at exactly which members of the populace were benefiting from this economic boom. He investigated this topic through an urban versus rural lense, comparing development between members of the Han ethnic group versus members of the Uyghur ethnic group, as well as contrasting two different regions named Dzungaria versus Tarim Basin in Xinjiang. Through anecdotal accounts, limited Chinese government statistics, and published university research, Charles Wallace saw the massive disparity in infrastructure, healthcare, and disposable income in Xinjiang. Specifically he looked at how Dzungaria, the Uyghur majority region of Xinjiang had much greater economic development in comparison to Tarim Basin, the region of Xinjiang home to a majority Uyghur people. Even with a meteoric Chinese political and economic rise, Uyghur Muslims of Xinjiang are not reaping the benefits. This economic disparity could help explain the civil unrest that has plagued Xinjiang over the past few decades.

YIQI WANG CC'22: GERMANIC LITERATURE; MATHEMATICS-STATISTICS

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Faculty Mentor(s): Dorothea von Muecke, Columbia University
Title: Twilight in Thomas Mann's The Magic Mountain

Abstract:
The research is an exploration of the function and meaning of twilight in Thomas Mann's The Magic Mountain. Yiqi concentrates on a single example entitled "Kahnfahrt im Zwielicht" that has the advantage of brevity and rarity in appearance. She explores the location of the episode with regards to the entire novel and its textual composition through a linguistic approach. The analysis would yield conclusions that shed light on the personality of the protagonist Hans Castorp and his interactions with other characters--most conspicuously Settembrini, the instigator of her example and Hans' primary mentor known for his rhetoric. Starting from the linguistic analysis, she considers the problem of verbal language framed in the immediate context and in relation to other references, and investigates eye contact as an alternative means of expression. Her further task is to examine the applicability of perspectival reading, including psychoanalytic and Dionysian. She would return to the theme of twilight and inquire its relation to wider issues of time, art, and life in general.

DAVID WANG CC'22: BIOLOGY

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Faculty Mentor(s): Chao Lu, Columbia University
Title: Histone H3K36 Methylation Is Associated With 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 approximately 13% of all HNSCC cases—possess defects to histone H3 lysine 36 methylation (H3K36). Of these patients, the majority suffer from mutations in the NSD1 gene, 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 manifests 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 disrupting H3K36me2 will alter chromatin structure by interfering with looping. 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: COMPUTER SCIENCE; NEUROSCIENCE AND BEHAVIOR

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Faculty Mentor(s): Paul Sajda, Columbia University
Title: Investigating arousal signals in mediating attention reorientation tasks using eye-tracking and kernel decomposition

Abstract:
Recent evidence points at a functional link between the locus coeruleus-norepinephrine (LC-NE) system and the ventral frontoparietal network in driving attention reorientation, a cognitive process that redirects attention towards novel and potentially threatening or rewarding environmental cues. The LC-NE system also plays an important role in dictating human arousal levels, which has been shown by previous studies as a performance indicator for cognitively-demanding functions such as completing boundary-avoidance tasks. This project aimed to clarify the role of LC-NE system in attention reorientation and arousal modulation, specifically focusing on extracting arousal signals from pupil data and inspecting their roles in driving attention shifts. To do this, an immersive virtual reality (VR)-based paradigm was used to collect pupil data of human subjects undergoing target/distractor detection tasks. Time-locked eye movements events are decomposed using kernel regression to examine their roles in dictating pupil diameter, a proxy for arousal levels, and model fit was then evaluated using Pearson correlation. Arousal levels across target and distractor trials were found to be significantly different, where higher arousals persist in target trials. Moreover, the following eye movement kernels were found to be most significant in reconstructing pupil diameter: stimulus onset, first saccade, first fixation and second saccade. Further studies are required to elucidate the differences among eye movement kernels and their roles in orchestrating differential arousal responses to target and distractor stimuli. Upon completion, this study has the potential to inspire novel neurotechnology and eye-tracking devices that optimize human attention redirections to maximize cognitive performance.

LAUREN WILKINS CC'22: PSYCHOLOGY

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Faculty Mentor(s): Kevin Ochsner, Columbia University
Title: Emotional Expressivity Across Genders

Abstract:
One of the most consistently replicated gender differences in social psychology research is that of emotional expressivity; women are found to be more facially expressive (Kring & Gordon, 1998), report more intense emotional experiences (Grossman and Wood, 1993), and show greater emotional concordance across behavioral, physiological, and experiential (self-report) systems (Rattle, et al. 2020). Yet, past behavioral research has relied on the use of written responses or video recordings, coded by raters, thus activating social display norms and opening the door to self-regulation of emotions to conform with such norms. This research addressed the question of whether gender differences in subjective emotional expressivity found in past research will hold if participants make more controlled emotional responses. In an online study, participants were asked to report their emotional responses to a series of short video clips. Then, they completed questionnaires measuring trait emotional expressivity. Existing analyses showed that, across gender, higher questionnaire scores predicted lower thresholds to emotional responses on the video task. Additional analyses were conducted to replicate gender differences in the questionnaires and investigate gender differences on the task. The questionnaire scores

replicated previous findings, with women scoring higher on emotional expressivity than men, while the video task found no difference in emotional thresholds across genders. This research sheds light on the contribution of social display rules to observed gender differences in emotional expression and experience, and the video rating task could be used to measure emotional responses without the actual or implied presence of an observer.

SARAH XI CC'23: CHEMISTRY

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Faculty Mentor(s): Neel Shah, Columbia University
Title: Computation-guided design of activity-based probes for tyrosine phosphatases

Abstract:
Phosphotyrosine signaling plays a crucial role in regulating animal physiology and is controlled by two families of enzymes, protein tyrosine kinases and protein tyrosine phosphatases, which phosphorylate and dephosphorylate proteins in cells to relay information. These enzymes are important drug targets, as the dysregulation of these enzymes is often seen in human diseases, but the regulation of protein tyrosine phosphatases (PTPs) has not been extensively studied. Phenyl vinyl sulfonates are a class of molecules that are useful as they covalently bond with tyrosine phosphatases and can be used as activity-based probes to track phosphatase activity in cells. A successful activity-based probe would inhibit the activity of PTPs and/or label them when they are active, and they can be used to profile and study the activity of PTPs. However, there is currently not a good understanding of how changes to the structure of these molecules impact their reactivity. This project uses computational methods to inform the development of molecules to act as activity-based probes for PTPs. A virtual library of nearly 200 phenyl vinyl sulfonate derivatives with varying substituent groups was designed and used to run covalent docking simulations with 20 different protein crystal structure files using the CovDock module in the Schrodinger molecular modeling software package. These simulations identified many promising molecules and substituents which will be further investigated experimentally in the lab.

MICHELLE XU CC'23: COMPUTER SCIENCE-MATHEMATICS

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Faculty Mentor(s): Yufeng Shen, Columbia University
Title: Predicting pathogenicity of missense variants by deep representation learning

Abstract:
Accurate prediction of the genetic effects of missense variants, a genetic mutation where a single base pair is altered, is critical to the interpretation of genomic data in genomic studies and clinical genetic testing. However, the performance of these methods is limited due to issues related to the complexity of the mechanisms of pathogenic variants and suboptimal usage of large training data sets. We describe a new prediction method called MissenseDL which predicts the pathogenicity of missense variants using a deep representation learning model trained with a large number of curated pathogenic variants. MissenseDL uses an embedding technique to learn a representation of amino acids within the context of the sequence and structure of the protein they encode. MissenseDL uses convolutional neural networks to predict the pathogenicity of amino acid substitutions based on context-specific features of protein sequence conservation, meaning the preservation of a protein sequence across the genomes of primate species, protein structural properties, and regional coding constraint in human population, which is the frequency of genetic variation in a region. Using functional data from saturation

mutagenesis experiments as ground truth, MissenseDL outperforms published methods in identification of damaging variants in well-known disease genes, including TP53, PTEN, BRCA1, and PPARG. We also show that MissenseDL achieves better performance in identifying the pathogenicity of de novo mutations in birth defect cases. MissenseDL can further improve interpretation of missense variants for diagnosis of genetic disease in clinical genetic testing and discovery of new disease-risk genes.

ALEXANDRIA YAO CC'22: COMPARATIVE LITERATURE; BIOLOGY

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Faculty Mentor(s): Alison Taylor, Columbia University
Title: Genetic Associations of Biological Sex and Survival in Head and Neck Squamous Cell Carcinoma

Abstract:
Approximately half of all head and neck squamous cell carcinoma patients die within five years of diagnosis despite treatment. Recent studies revealed that females have a worse overall prognosis; however, the genetic and molecular underpinnings have not yet been identified. In this paper, Alexandria Yao investigates the genetic characteristics of head and neck squamous cell carcinomas stratified by HPV status and biological sex. Within the HPV-negative cohort, female patients have lower aneuploidy and worse survival outcomes compared to male patients. Moreover, there were significant differences of DNA amplification and deletion between males and females. Chromosomes 4, 5, 6, and 20 showed amplification in males, and not in females. mRNA, miRNA, and gene expression also showed significant differences between the biological sexes. Sex-chromosome genes XIST, TISX, and PRKY, were up-regulated in the respective biological sex, and contributing pathways to the immune system were enriched in female patients. This study provides new insight into possible gene expression biomarkers for HNSCC, and future research will gather and analyze data of varied populations to distinguish the confounding factors that affect HNSCC development.

MICHELLE YAO CC'22: BIOLOGY; HISPANIC STUDIES

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Faculty Mentor(s): Vincent Ferrera, Columbia University
Title: A Pipeline for Processing Macaque MRI Images

Abstract:
Electrophysiology studies in non-human primates (NHP) largely depend on precise anatomical localization of electrode recording sites. Current methods use structural neuroimaging to accurately delineate the anatomical divisions of recording locations in the brain. The lack of a standard consistency in imaging techniques, coupled with a greater availability of neuroimaging data from multi-laboratory collaborations, creates the need for a normalized pipeline for data collection and NHP image processing. In this study, we explored the image processing functions of the NIMH Macaque Template (NMT), an anatomical template developed from a macaque brain population average, and related analytical tools (Analysis of Functional NeuroImages - AFNI; SUMA) that aided in surface mapping of brain regions. We started with a modeled example macaque magnetic resonance image (MRI) and unprocessed MRIs of two macaque monkeys (F and H). Using the pipeline, we were able to overlay the NMT template onto the example macaque data, producing clear and defined regions of the brain, though alignment of template to MRI was not exact. We expect to be able to do the same with the MRIs of F and H by the same alignment pipeline. Mapping out a standard procedure for processing MRIs using NMT resources

will help to drastically improve the accuracy of recording location identification in electrophysiological experiments, resulting in clearer mapping of physiological function to specific brain structures.

EMILY ZHANG CC'21: ASTROPHYSICS

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Faculty Mentor(s): Pat Slane; Peter Edmonds; Megan Watzke, Harvard-Smithsonian Center for Astrophysics
Title: IXPE Research & Chandra Scicomm

Abstract:
Emily split her time between two projects this past summer - one centered on astrophysics research and one centered on astrophysics science communication. Her research focused on an upcoming telescope dedicated to measuring the polarization of X-rays from powerful cosmic sources like supernova remnants and black holes, titled the Imaging X-ray Polarimetry Explorer (IXPE). She worked on generating simulated IXPE observations in order to test and update IXPE software analysis tools before they would be needed for real observations. She created two Python programs towards this goal – one to automatically draw polarization vectors onto IXPE observations, and one to automatically extract spectra from grids overlaid on IXPE observations. Her science communication focused on writing blog posts for the Chandra X-ray Observatory and its related research projects, editing educational sections of the Chandra website, and writing tweets for the Chandra Twitter account to post in honor of its 21st First Light Anniversary.

JOCELYN ZHANG CC'22: BIOCHEMISTRY

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Faculty Mentor(s): Luis Campos, Columbia University
Title: Singlet Fission in Dendrimers

Abstract:
Singlet fission (SF), a process that converts a higher-energy singlet exciton into two lower-energy triplet excitons, offers the potential to reduce thermalization losses and enhance efficiencies in solar cells. SF is a multichromophoric process that can occur through-bond or through-space. Studies of SF have largely been focused on crystalline films and isolated small molecules. Here, we explore the intermediate context of macromolecular dendrimers, which offer precise synthetic control to manipulate SF dynamics. We can tune the branch and core multiplicity of dendrimers to alter the spatial interactions between chromophores. We plan to functionalize our dendrimers with pentacene, a prototypical SF chromophore, and use transient absorption spectroscopy to monitor the photophysical dynamics. We have identified two suitable dendrimeric architectures for our study—a thiol-based dendrimer and a bis-MPA dendrimer. Both dendrimers have terminal hydroxyl groups, enabling us to functionalize with a carboxylic-acid pentacene derivative. We will use a fluoride-promoted esterification reaction to ensure high yield functionalization. Overall, we believe these pentacene-functionalized dendrimers will provide controlled environments to study the SF mechanism, allowing for fast SF and long-lived triplet excitons. These dendrimer systems will pave the way for a new class of organic SF materials.

ALAN ZHAO CC'23: MATHEMATICS; COMPUTER SCIENCE

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Faculty Mentor(s): Chao Li, Columbia University
Title: Familial Lower Bounds on Canonical Height of Elliptic Curves

Abstract:
A 2016 work by Pierre Le Boudec established lower bounds on the so-called "canonical height" of rational points (which may be thought of as a measure on the "complexity" of the point) on a given set of elliptic curves (a special type of curve on the standard XY-plane) parameterized by one integer variable. This lower bound is given in terms of this variable. We generalize this work of Le Boudec as follows: we take two different sets of elliptic curves, both parameterized by one integer variable. With this setup, we seek to solve the exact same problem as Le Boudec. We solve one case with a generalization of Le Boudec's method ("descent on an elliptic curve"), and the other by exploiting a lattice structure unique to the set of generalized integers within a system of numbers containing the traditional rational numbers. While this research question specifically pertains to elliptic curves, the aforementioned "descent" allows us to pass solutions from the elliptic curve to other polynomials. It is this passage that provides a rich intersection ("Diophantine equations") within the greater context of modern algebraic geometry and analytic number theory. Indeed, textbooks on this matter have only been produced from 2010 on, and there are many unanswered conjectures. The rapidly expanding theory of elliptic curves coupled with the rapidly expanding theory of Diophantine equations displays the rapidity of the evolution of this theory of which my research has become a part.

SUSAN ZHOU CC'21: COMPUTER SCIENCE; ECONOMICS

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Faculty Mentor(s): Filippo Taddei, Johns Hopkins SAIS, Bologna
Title: Understanding GDP and Employment with Regards to Covid-19 Economic Recovery Policy

Abstract:
The impacts of the Covid-19 crisis have been felt globally, as countries and regions around the world went under lockdown. The Covid-19 crisis is, first and foremost, a global health and public health crisis, and an additional impact was that many countries also took on heavy debt burdens in order to sustain their economies. In order to gain a better understanding of these dynamics, she collected and organized data from the Federal Reserve Bank of St. Louis, as well as the European Statistical Commission. The countries included in the scope of this study were the US, UK, France, Germany, Spain, Italy, Portugal, and Greece. Using the software package STATA, she ran statistical analyses in order to better understand patterns in the data. She used the trends extracted from past data to predict how employment and GDP would have looked like, in the absence of Covid-19. In doing so, she hoped to develop a framework to gain a better understanding of the countries' economies, particularly in the ongoing crisis. Another important component of the project was collecting data on the debt taken on by different countries in the E.U. This data will be synthesized to build a better understanding of and hopefully guide post-lockdown recovery policies.

KETSIA ZINGA SEAS'21: BIOMEDICAL ENGINEERING

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Faculty Mentor(s): Oleg Gang, Columbia University

Title: Mitigating DNA Damage from XRay Radiation

Abstract:
DNA, the genetic material for life, is sensitive to environmental factors. One source of damage to DNA is ionizing radiation, including UV, X-ray, and gamma. The major cause of damage are interactions of free radicals with DNA. This study examines how DNA-based materials are damaged and methods of mitigating this damage under X-ray irradiation. This is important for medical imaging, therapeutic applications, and for other conditions where humans might be exposed to ionizing radiation.
The model system is a well-ordered superlattice composed of dsDNA assembled into nanoscale octahedra, attached at vertices via hybridization of ssDNA “sticky ends”. The use of “sticky ends” is extended to enclose DNA-grafted nanoparticles in the lattices. Superlattice structure is interrogated using small-angle X-ray scattering (SAXS) while simultaneously exposing samples to synchrotron radiation. Structure is therefore tracked as a function of exposure time, allowing for direct observation of DNA damage via structural analysis. An autocorrelation function was applied to the scattering data as a measure of degradation.
Loading DNA superlattices with metallic nanoparticles was shown to lead to higher degrees of structural damage. Potential mitigants were added to samples prior to X-Ray exposure to observe their efficacy at maintaining structural integrity of the lattices. Additives were primarily evaluated on how well later time points were correlated to the initial state, in comparison with a control sample. The results suggest that the presence of antioxidants, most notably vitamin C, effectively mitigates damage to DNA during radiation exposure. However, this may cost initial structural integrity of the sample.