RESEARCH SYMPOSIUM 2022
Project Abstracts:

SECTION ONE: HUMANITIES RESEARCH

Fatima Ahmad CC'25, MESAAS and Political Science

Faculty Mentor(s) or Supervisor(s): Professor Isabel Huacuja Alonso
Title: Manto, Partition, and Education: A New Chapter for Pakistan

Abstract: Saadat Hasan Manto was a writer, playwright, and author who was born in Ludhiana, India in 1912 and died in Pakistan in 1955. Most famously known for his 1947 Partition stories like "Toba Tek Singh" and "Thanda Gosht," Manto communicated harrowing descriptions of violence, psychological trauma, separation of families, the objectification of women as a tool of revenge, religious turmoil, and cultural confusion unlike any other historical retelling of the effects of Partition. These themes are inherent to the becoming of Pakistan and Manto's literature revealed this through the lack of blame placed on a single individual, faith, or state, humanizing the experiences of everyone. They also highlight the significance of literature itself. Using analysis on Manto as a case-study, this research argues the importance of using literature as a means of discourse on the larger study of the Partition of 1947, but to also value the analysis of literature as an educational tool that should be implemented throughout schools within the Pakistani educational system, stepping away from traditionally memorizing history or poems. This value is found within Manto's stories that evoke dialogue, discussion, and understanding, encouraging readers to think critically whilst reconsidering their initial beliefs. When taught in conjunction with history, literature becomes a powerful tool in humanizing the experiences that are described, but not fully painted.

Eli Andrade CC'24 English

Faculty Mentor(s) or Supervisor(s): Professor Nicole Gervasio
Title: Read the Rainbow: Culturally Revolutionary Queer Portrayals in Latinx Young Adult Literature

Abstract: The current field of literary studies gives little consideration to contemporary popular literature, particularly the young adult (YA) genre.

Much less has been investigated about the rapid emergence of queer themes and ethnic representation within YA literature. As the YA market grows, so does the demand for queer ethnic characters, reflecting the youth's progressive content preferences and displaying YA's influential social power. Particularly noticeable are the literary trends accompanying such rapid growth. Queer-coded works no longer focus on stereotypes and the "tragedy of queerness," but rather, they celebrate homosexuality and urge its acceptance. Through a close examination of over 30 current YA novels and canonical Latinx texts from social movements, this project centers queer Latinx portrayals and focuses on the use of literary devices, language, and plots to shed light on literature targeting one of the United States' largest ethnic minorities. Despite a historical intolerance for LGBTQ+ individuals and those whose oppression is exacerbated by racial otherness, current YA novels shift the dynamic between the novelist's role and the public's reception of ethnic queerness. Substantive cultural and historical analysis of the Chicano Movement, Latin-American culture, immigration, and intergenerational trauma contextualize these novels for a vital understanding of the time's social climate—crucial for a comparative analysis of today's perception of homosexuality. Ultimately, a rise in the socially accepted consumption of a previously stigmatized concept (homosexuality and race) by a vulnerable population (children and teens) is evidence of an at-large cultural phenomenon delivered through popular YA literature.

Charlotte Atkins CC'23, English

Faculty Mentor(s) or Supervisor(s): Professor Pamela H. Smith
Title: Renaissance Paints and Dyes: Experiments from BnF Ms. Fr. 640

Abstract: This summer Charlotte conducted work at Columbia's Center for Science and Society with the Making and Knowing Project under the supervision of Professor Pamela Smith. Charlotte's work largely consisted of testing and performing instructions for dyeing and painting found in BnF Ms. Fr. 640, a manuscript from Renaissance-era France. She first followed three different sets of instructions for making pigment from Madder Root, a common European plant used to make dye. This experiment had already been performed by the Making and Knowing Project in April, and the objective of this second trial was to determine the replicability of the initial trial's results. Charlotte's second major task with the Project was to follow similar dyeing and paintmaking instructions with Sappanwood, a plant substituted for an endangered redwood that appears in BnF Ms. Fr. 640 directions. Sappanwood pigment extraction and dyeing had not previously been undertaken by the Project. By performing the Sappanwood experiments alongside the Madder Root experiments Charlotte was able to compare and contrast not only the different kinds of Madder Root experiments, but also the two different plants' different paint and dye functionalities. Ultimately both plants yielded quite strong and usable paint and dye, an outcome which many might find surprising. Despite these instructions being hundreds of years old, their products are functional and useful – there is a present-day tendency to dismiss old recipes like these as uninformed or outdated, a tendency that this work rejects. This project instead affirms the quality and ingenuity of Renaissance-era craft practices and the richness found in the intersection of art and science.

Audrey Brown GS'23, English and Denise Taveras CC'25, Psychology

Faculty Mentor(s) or Supervisor(s): Professor Shana Redmond
Title: The Last Time We Danced: Musical Life Before Mourning

Abstract: "The Last Time We Danced" consisted of a research undertaking in support of Professor Shana Redmond's literary nonfiction exploration of human joy—namely, using music as a sort of survival tactic—before state violence. In particular, research was focused on police violence inflicted upon Black bodies and thus the use of music despite a constant, overhanging wariness of state-inflicted brutality. This summer, research was performed which included contacting local and state police departments and communicating with officials to secure sometimes previously unreleased information surrounding the circumstances of an individual's death, as well as inspecting the social medias of the family members and friends of victims of state violence. In many cases, instances both before and after the individuals' deaths were rich with surrounding sound, whether research unearthed the trending songs that Ma'Khia Bryant selected for her TikTok hair tutorials; official recordings of phone calls that were made by concerned neighbors to police officers as they recounted the "suspicious" behavior of Ahmaud Arbery passing on his jog; or the gospel songs that were played at live streamed memorial events posted to grieving families' Facebook feeds. The findings of this project will strive to capture the humanity of Black people during their lives, bringing a voice and a sound to their stories in the face of a media landscape which typically silences the rich lives that people led in favor of static imagery and detailed accounts only of the few moments before and after their death. (A.Brown)

Policing in the United States has a strong relationship with the exploitation and in many cases, murder of Black Americans. Whether it be through practices that endanger people without forewarning (no-knock warrants) or the constant assumption of criminality, many people only understand the lives of Black Americans through their relation to the numerous acts of violence that have been carried out by police against them. The lives they lived, the connections they made, and what they cared about is often overlooked as their arrest and murder are shared through the news. The lives of these people matter. Black lives matter and by learning about their lives and experiences through the music they cared about, the work of decriminalizing individuals who have been forced into the role of the suspect can be spread beyond their community. Through examining the posts made by those killed by police, their families, and their friends as well as memorials and protests that have taken place in their honor, the life that is taken away by the hands of the police and the white supremacy that enabled their murder can be recognized as what it is. Life that is worth keeping and protecting because it matters. (D.Taveras)

Yuxin Chen CC'23, Art History

Faculty Mentor(s) or Supervisor(s): Professor Anupama Rao
Title: W. E. B. Du Bois and His Use of the Term "Caste," 1898–1935: A Word History Project

Abstract: In the 1940s, the Dalit political leader B. R. Ambedkar shared brief correspondence with W. E. B. Du Bois, one of the foremost Black intellectuals. Steadfast in his anti-caste activism, Ambedkar, in his letter, aligned the cause of the Untouchables in India to that of the Black population in the United States. Du Bois, in turn, expressed sympathy for the oppressed Dalits in the Indian subcontinent. This instance of Afro-Indian connection is preceded by Du Bois's repeated usage of the term "caste" in his earliest writings. Yuxin's research focuses on said materials—to be more precise, a selection of Du Bois's books, speeches, and essays between 1898 and 1935—and aims to plot Du Bois's changing use of the word "caste" on a timeline. For her project, Yuxin relied on both publications and archival sources (in particular, UMass-Amherst's W. E. B. Du Bois Papers Collection) and engaged in close reading. The common scholarly narrative holds that Du Bois moves from the sense of a "social caste" to that of a "color caste" when he brings up the term in his writings. However, Yuxin's project suggests that Du Bois's use of "caste" does not develop linearly. On the contrary, Du Bois did not provide a concrete definition of "caste" until his 1935 publication, Black Reconstruction in America. Prior to that, "caste" in the context of his writings exists more as a lexical shorthand for various concepts, some overlapping and some interchangeable with each other. Yuxin hopes that her research can, to some extent, make evident the process in which Du Bois struggles with concepts, an aspect of intellectual history often overshadowed by the fully-formed theoretical legacy of the thinkers.

João Costa CC'23, Linguistics and Philosophy

Faculty Mentor(s) or Supervisor(s): Professor Meredith Landman
Title: Understanding até in Brazilian Portuguese

Abstract: The aim of this project was to expand upon an ongoing debate in the field of formal semantics regarding the nature of the word 'until' in English by making a cross-linguistic comparison between it and the word 'até' in Brazilian Portuguese. Both 'until' and 'até' can be used to delineate a span of time in which an action occurs or fails to occur. However, behavior of these two words when they have this meaning is not the same when they attach to verbs like sleep which indicate an action that has a duration and when they attach to verbs like wake up which describe an action that is punctual in nature. The discussion revolves around determining if there is a single analysis that can account for both of these uses or if there must be two separate explanations for them. Both 'until' and 'até' are accepted with durative verbs both when sentences are negated and when they are not. But in the case of punctual verbs, English speakers only accept 'until' in negated sentences. However, this is not the case in Brazilian Portuguese, where 'até' is sometimes accepted with punctual verbs in sentences that are not negated. The environments in which this happens in Brazilian Portuguese point to this use of 'até' having a different way of working altogether, more similar to the English word 'by'.

Gabrielle Epuran CC'24, Classics

Faculty Mentor(s) or Supervisor(s): Professor Kathy Eden

Title: The Aristotelian Literary and Moral Framework

Abstract: Aristotle's Poetics and Ethics are foundational for both literary theory and moral philosophy. While writers and critics alike have used the former to understand fundamental concepts of literature such as plot, character, mimesis, and theme, Aristotelian notions of happiness, "the good life," moral character, and intellectual virtue have greatly influenced the whole of Western philosophy. Many theorists have noted how The Ethics and The Poetics share common understandings of fundamental terms such as "nature," "technique," and "reason," but little work has been done to investigate how these concepts function similarly within these texts. Through a textual analysis of The Nicomachean Ethics, The Poetics, and secondary work done by Stephen Halliwell, Pierre Hadot, and others, Gabrielle argues that the proper formation of the good life and the proper formation of the Greek tragedy share common structures. This consistency indicates that Aristotle's moral framework and literary theory not only complement each other in the use of common concepts but necessitate each other in Aristotle's creation of a universal system. These conclusions may serve as a greater explanation for why literary conventions imply moral frameworks and how modern literary theories in opposition to Aristotelian poetics have arrived with the shift against Aristotelian virtue ethics.

William Gore CC'24, Linguistics and EALAC

Faculty Mentor(s) or Supervisor(s): Professor Meredith Landman
Title: Definiteness marking and the default determiner in Maninka

Abstract: What does the word "the" mean in English? All languages have ways of distinguishing new information from old information, a distinction known as definiteness that English marks with "the." As languages distinguish varying shades of definiteness, the purpose of this project was to document definiteness marking in Maninka, a Manding language spoken in West Africa. Previous literature on other Manding languages presents conflicting accounts of how definiteness is marked, with the marker appearing variously as -ò or as a floating low tone that influences the tone of the words around it. This project clarified the role of this marker as a "default" form in Maninka in line with Creissels (2010), meaning that it marks that a noun is not specifically definite or indefinite. The presence of this marker only contrasted with its absence in certain situations, indicating that in limited contexts, including negation and questions, it marks a noun as definite. The data for this study was collected in elicitation sessions with a native speaker of Maninka, who supplied translations of English sentences into Maninka and evaluated whether Maninka sentences the researchers supplied were acceptable. The data elucidated where various markers in Maninka lie on the spectrum from indefinite to definite. The results revealed that Maninka does not distinguish shades of definiteness in the same way as English, which demarcates whether something is unique or has been previously mentioned: rather, there is a distinction between nouns that are unique globally and those that are only unique in a particular situation.

Roberta Hannah CC'23, African American and African Diaspora Studies and Psychology

Faculty Mentor(s) or Supervisor(s): Professor Estela Diaz
Title: Hot Girl Summer: The Role of Black Female Youth in Urban Cultural Diffusion

Abstract: In contemporary digital spaces, there is an overwhelming dominance of urban youth in developing the culture of the Internet. As some of the highest users of the web, they are bringing in their lived realities as persons in close proximity to street cultures to these digital playgrounds and street corners. Phenomena such as gang paraphernalia, discussions of illicit activities, and communal grief were historically silenced and bounded by the community of origin. Now, these behaviors are broadcast on the explore pages of almost every social media platform. Previous literature has credited the diffusion of urban street culture into mainstream digital spaces to the desires of men to display their masculinity in all aspects of their lives. However, presently, through the emergence of Black female rap, web reality television, and the new-age "Instagram model," urban female youth are, in fact, the underlying mechanism in this cultural diffusion. Black female youth have more extensive networks and an equal, if not greater, desire to reaffirm their gender identity online. Their removal from traditional femininity forces them to validate their positioning as women. They are found participating in the same illicit street activities as their male counterparts. Now that their lives are marketable, they are teaching their existences to audiences abroad in exchange for emotional relief, identity validation, and financial and social gains.

Elliot Hueske CC'23, Philosophy and Psychology

Faculty Mentor(s) or Supervisor(s): Professor Katja Vogt

Title: Making Stoic Non-Precipitancy Plausible for Current Challenges Relating to Discrimination

Abstract: Research in philosophy and psychology introduces a challenge regarding the achievability and potential approaches to altering the mental processes implicated in biased cognition. This project incorporates ancient Stoic ethics and epistemology, contemporary moral and evolutionary psychology, and cognitive neuroscience to develop a proposal for training in which to delay prejudicial thinking. More specifically, Hueske incorporates the Stoic virtue of non-precipitancy to argue for the importance of avoiding rash assent to certain thoughts including those relating to discrimination, heuristics, and stereotyping. Hueske distinguishes the two fast-thinking processes of cognitive bias and reflex through considering their "closeness" to intentional attitudes and ex post facto reflection which dictates the moral valence of the cognitive processes. Hueske asserts that the near proximity of bias to intentional mental states makes bias within reach of strategies that diminish its influence. When identifying the most effective strategies in which to do so, she draws from the ancient Stoics. Hueske acknowledges that targeting a sphere in which fast thinking can be reduced is demanding and she rejects the idea that we might aim to retain fast thinking in empirical matters while eliminating it in moral questions. She addresses these issues by proposing a domain-specific model of targeted non-precipitancy training that concentrates on behaviors and attitudes related to human action and social behavior. To this end, Hueske incorporates a modified conceptualization of the Stoic theory of expertise and the Stoic notion of excessive impulse to offer a potential direction for training paradigms in which to combat destructive expeditious thinking.

Timothy Kinnamon CC'23, Classics and Political Science

Faculty Mentor(s) or Supervisor(s): Professor Katharina Volk
Title: The Irreconcilable Regimes in De Re Publica

Abstract: Timothy's research examines the constitutional theory in Cicero's De Re Publica, a first-century BC dialogue of Roman political philosophy. He demonstrates how Cicero discusses political regimes in terms of distributed governmental power and a corresponding distributional ideology, which attempts to justify the stability of a regime based on nature. Thus, democratic regimes pursue egalitarian governmental structures because they see discord arising from inequality. Aristocratic regimes seek a hierarchical governmental structure based on a view that a natural hierarchy of virtue exists in every society, which, when implemented as the basis of rule, results in the best government. Monarchy gives power to one on the basis of the necessity of consistency, which allows a polity to weather difficulties. Cicero also shows that these legitimate ideological justifications do not result in stable political regimes and instead cause instability as these regimes seize power from each other. The solution to instability that Cicero identifies is the mixed regime, which seeks to reconcile the ideologies of the 'simple' regimes through constitutional structures that adhere to each. The mixed regime achieves stability as wise political leaders promote harmony in a society divided by irreconcilable political ideologies. This Ciceronian theory of the mixed constitution differs sharply from the system of checks and balances posited by the second-century historian Polybius, which opens the door to a theoretical distinction between these formulations of the mixed regime.

Elianna Lee CC'25, Race and Ethnicity Studies

Faculty Mentor(s) or Supervisor(s): Professor Deborah Paradez
Title: The American Diva

Abstract: This summer, Elianna served as a research assistant for Dr. Deborah Paredez's project titled "The American Diva", which seeks to blend both a personal and academic approach to the presence of the diva in American culture. Elianna investigated the role that market capitalism played in creating an image of girlhood and its relationship to "diva" during the early twenty-first century; more specifically, they focused on pieces of media and products that aimed to capture the interest of girls from toddlers to teenagers. Their work involved scholarship summarization, looking at pop-culture items with a critical lens, and providing examples of diva-like description or behavior found within media. In order to supply Dr. Paredez with relevant and insightful sources, Elianna investigated the images of girlhood and performance that large corporations—such as Disney, Barbie, and Bratz—pushed through their use of cinema, music, promotional deals, and toys. In conducting this research, they found themselves intrigued by the abstraction of "diva" into a status-symbol rather than a term that embodies extraordinary talent and personality, as well as the development of diva into a female archetype within children's media. As Dr. Paredez works with the materials that they provided, Elianna is interested in independently creating works that address the significance of Bratz dolls in contributing to the commercialization of "diva" and the popularization of the "down-to-Earth" female celebrity archetype which contrasts with mainstream definitions of diva.

Amira McKee CC'25, Sociology

Faculty Mentor(s) or Supervisor(s): Professor Jane Gaines
Title: Theatre to Film Migration: Silent Era Actresses of New York

Abstract: As the original "Hollywood" took root in Fort Lee, New Jersey in the 1910's, many theater actresses transitioned from performing live on Broadway to the silent screen. This project uses archival photographs, posters, and video footage to chart the transition from theater to film for these women, America's first film actresses. But the traditionally exaggerated, vaudeville-style performances of the time were not fit for the close-ups of the camera. Through side-by-side comparisons of theater and film performances, the project offers analysis of the social, economic, and artistic shifts demanded by the emergence of the American film industry. Many women of early film history, performers, directors, and writers alike, went unrecognized for their contributions to film canon. This research, with a special focus on the contribution of immigrant women, acknowledges and addresses the positionality of early film stars and the push and pull factors for migration across both continents and mediums.

Sophia Mickelson CC'24, Architecture

Faculty Mentor(s) or Supervisor(s): Professor Eleanor Johnson
Title: Dance Horror Films: Expressions of Female Bodily Autonomy or Lack Thereof

Abstract: In horror films, women's bodies are often sites of terror and pain. From menstruation to social conformity, body horror constantly negotiates female bodily autonomy. Since 2000, a budding subgenre has emerged—dance horror films. Films such as Black Swan, Suspiria and Climax depict a complex relationship between the female body and its agency (or lack thereof). While existing gendered horror studies such as Carol J Clover's Men Women and Chainsaws identifies tropes such as the 'final girl'—a woman who endures degradation to ultimately conquer the antagonist—a glaring gap in research on the gendered role of dance in horror remains. What do dance horror films suggest about female autonomy in the face of violence? Who gains power and who is threatened by the heightened energy women conjure through dance? Grounded in media and feminist theory, my research explores these questions while relating them to existing conversations surrounding the impact of the male gaze. In addition to watching the films themselves, I explored the Columbia University Libraries, director interviews and film reviews. Further, research through the Jacob's Pillow Archive allowed me to define the gendered expectations inherent to the dance styles pictured in these films. Dance horror forces us to examine what is at stake when women harness the vast potential power they contain within their own bodies. While seemingly niche, the budding sub-genre is perhaps a critical reflection of our ongoing societal conversation around consent and bodily autonomy.

Isabella Ramírez CC'25, Sociology

Faculty Mentor(s) or Supervisor(s): Professor Deborah Paredez
Title: Databasing a diverse network of contemporary, U.S.-based Latinx poets pioneering the literary sphere

Abstract: Within scholastic literary circles, the domination of traditional, white-American narratives has stifled the representation of Latinx poets and writers. CantoMundo, one of the largest national organizations dedicated to Latinx poetry, aims to fundamentally change that through the celebration, cultivation, and education of its expansive community. This research project set out to create one of the most robust databases of contemporary, U.S.-based Latinx poets, drawing publication, demographic, geographic, and accolade data from over 100 poetry fellows and faculty within CantoMundo's network into an adaptive, custom spreadsheet. While preliminary data offered a glimpse into the diversity of identities and experiences of Latinx poets captured by CantoMundo, it also left room for interrogation of ways the accessibility of poetry and writing opportunities could be further expanded to certain facets of the Latinx community. Analyzing and visualizing the data, even in its early stages, has provided CantoMundo with an avenue to explore the organization's reach and build upon its network with the purpose of advancing the visibility and development of poetry centering Latinx narratives and histories.

Julien Ken Ange Roa CC'24, Classics

Faculty Mentor(s) or Supervisor(s): Professor Carmela Vircillo Franklin
Title: Bearing the Weight: The Physical Poem and Material Metaphor of Venantius Fortunatus

Abstract: This research project contextualizes the production and poetics of Venantius Honorius Clementianus Fortunatus' acrostic figure poems, Carmina 2.4 and 2.5, in which (usually) rubricated versus intexti, intertextual verses, produce the appearance of two variations of abstract cruciform shapes within a field of text. Fortunatus, an Italian born, Latin poet and

hymnographer of the Merovingian court in 6th century France, and the poems are illuminated by his own literary and epistolary corpus as well as by the pertinent poetic, visual, and theological trends from sources of influence on the author and the cultures in reception of his works. This entails an examination of Fortunatus' prose letter about his only other acrostic, comparisons to gemmed cross reliquaries, textile analogs found in late antique Coptic tunics, art historical studies of Merovingian semiotics, a survey of the Merovingian social landscape, and, most importantly, a close investigation of the acrostics themselves in light of all the preceding aids. If Fortunatus is an 'occasional' poet, that is a poet whose works are often driven by events and occurrences, then the occasion associated with the two acrostics is the arrival of the first relic of the True Cross to Northern Europe, which was brokered by Radegund, a queen-turned-abbess, and her patronage of Fortunatus himself. As such, the True Cross as a relic, a physical object, a narrative subject, and semiotical progenitor as well as Radegund and her abbey will be keys to unlocking the full range of interpretive registers of the iconotexts. The objective in this paper is to recreate the 6th century experience of primarily 2.4 such that the especially potent material register that Fortunatus impregnates the acrostics with may be accessibly related to the modern viewer, of course while arguing that his own authorial habits, the common visual and lexical rhetoric of his contemporaries, and the liturgical-devotional possibilities of the relic may have worked to invite such a peculiar type of poem. From the materiality, both literally and symbolically, the utility and efficacy of the cross-object, particularly in the liminal, parchment-textile form observed in 2.4 and 2.5, will be highlighted and demonstrated as existing on the basis of the enabling power of the Cross-symbol.

Aiden Sagerman CC'24, Comparative Literature and Society and Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Annie Pfeifer
Title: At the Intersection of (Pseudo)science and Mass Politics: American Eugenics and Italian Fascism

Abstract: The American eugenics movement played a central role in the scientific and political landscapes of early-twentieth-century America. In recent decades, historians have begun to examine this movement more carefully, often emphasizing the relationship between American eugenicists and the Nazis in the decades before WWII. The connection between American eugenicists and Italian fascists, on the other hand, has gone comparatively unexamined. At a glance, these two groups were strange bedfellows: the American eugenicists were aristocratic conservatives who despised mass politics and believed Italians to be racially inferior to their "Nordic" cousins; the Italian fascists were a revolutionary populist movement who, unlike the Nazis, had no theory of Nordic supremacy. But despite this, the American eugenicists were infatuated with Italian fascism. Throughout the interwar years, they corresponded with officials in Mussolini's government, praised fascist governance in their published works, and attended conferences hosted by Il Duce himself. In this project, Aiden Sagerman attempts to discover what drew the American eugenicists to the fascist political model, with an eye towards the conflict that arises at the intersection of (pseudo)science and mass politics. Through analyzing published works, personal correspondence, and official documents, he uncovers the relationships between four prominent eugenicists and eugenics donors and key figures in Fascist Italy such as Mussolini's science advisor Corrado Gini. These interpersonal relationships take place against the backdrop of a complex (and also underexplored) history of international collaboration on eugenics in the interwar era, involving thinkers from across Europe and the Americas.

Justin Shaw CC'24, Religion

Faculty Mentor(s) or Supervisor(s): Professor Jacqueline M. Klopp
Title: Religious Conceptions of Nature and the Production of Space in the Manhattan Grid Plan

Abstract: The Commissioners' 1811 Plan that structured Manhattan's streets around a grid is often considered one of the most ambitious and influential projects in urban planning and an archetypal example of the influence of 19th century American liberal ideology on the use of space. Although the grid plan has long been linked to utilitarian economic considerations, recent scholarship has uncovered various religious motivations. The way that religious frameworks imagine "Nature" and the implications for urban planning are largely unexplored. I use a close textual reading and analysis of writings by the Commissioners to examine how they depicted Nature, placing these images in cultural and historical context tracing influences from Christian urban idealism, Cartesian dualism, and Enlightenment Rationalist theology, I find that "Nature" served multiple purposes in the grid plan, being both a transcendent justification for a specific moral order and an idealized space that functions as a tabula rasa for the projects of American liberalism. I connect the latter image to the colonial narrative of the frontier, and contrast the absolute space of the Commissioners with the more dynamic and

multiplicitous spatiality of Manhattan's indigenous inhabitants, offering a critique of how the spiritual and ideological foundations of the grid construct a spatiality that runs counter to ecological understanding of the environment. Adopting Lefebvre's idea of the "production of space," I argue that imposition of abstract visions of space into the physical construction of the city encodes it with a neutrality that promotes the view of land as what Heidegger calls a "standing reserve" of raw material. This research shows how visions of space are deeply ingrained with a legacy of religious thought and suggests the importance of using a "post-secular" lens to re-analyze certain fundamental assumptions of urban planning in an era of ecological crisis.

Sylvi Stein CC'25, Art History and Creative Writing

Faculty Mentor(s) or Supervisor(s): Professor Noam Elcott
Title: Monumental Changes: Exploring the Intersection of Public Monuments and Contemporary Art in NYC

Abstract: In recent years in the United States, monuments have become subject to intense scrutiny as objects that exemplify the values of a community. They also have become sites where the contemporary art world, usually confined to galleries and museums, spills over into public life. In 2019, a statue of gynecologist J. Marion Sims statue was removed from Central Park when the problematic history of its subject was brought to light. A panel of contemporary art critics selected a replacement design created by a star in the contemporary art world. Local community members objected, lobbying instead for a local artist whose design was a more traditionally recognizable monument. An investigation of the case study of the J. Marion Sims statue offers an understanding of how monuments have become polarizing objects through the significance with which they are invested. Through an analysis of news sources produced at the time of the replacement decision, scholarly papers written on the event, and a series of interview with members of the community involved with the replacement, this research project seeks to investigate the ways in which the contemporary art world's academic elitism can clash with public sentimentality and traditionalized values when it comes to the definition of a "monument." This research has the potential to uncover the consequences of the divide between the contemporary American art world and the American public, as well as what can be done to bridge the gap between the two communities.

Jonathan Truong CC'25, English and Philosophy

Faculty Mentor(s) or Supervisor(s): Professor Patricia Dailey
Title: Twitterfiction: Digital Media as Narrative Theory

Abstract: Digital media have afforded new possibilities for narrative serial fiction, a growing literary corpus which includes what Thomas (2014) names Twitterfiction. Web-disseminated narratives such as Twitterfiction have influenced the narrativity of serial fiction in novel ways, including narrative tense, sequence, and author/narrator distinctions. Existing scholarship has focused on how the material and distributional aspects of digital media—character limits, the organization of Twitter feeds, publication schedule—contribute to meaning in Twitterfiction. Little attention, however, has been paid to how digital media inform the narrative quality of serial fiction. To discuss this re-configured mode of narration on Twitter, this research analyzes the application of core narrative concepts to Jennifer Egan's "Black Box," a short story released by The New Yorker's Twitter account in 2012. Drawing upon contemporary narratology, it analyzes how central concepts—narrator, character, plot, time—are renegotiated by Egan's Twitter story. By both participating in and challenging existing literary theories intended to deal with literature-in-print, this research aims to define how digital environments like Twitter make visible the tensions and ambiguities in existing narratological models.

April Wang CC'24, Philosophy

Faculty Mentor(s) or Supervisor(s): Professor Christia Mercer
Title: Discursive Injustice: Maintaining Sexism Through Language

Abstract: For humans, speech dominates social interactions. What we say simultaneously informs and is informed by what we know—this interplay of discourse and knowledge reveals an inextricable link between our concepts of the world and what we say about them. In the philosophy of language, speech act theory posits that every utterance—what we say—constitutes an action in the social world. That is, saying something does something. An inherently collaborative project, speech requires a speaker and listener who, in the interaction, constantly define and redefine their relationship and statuses. Through speech, individuals have the agency to negotiate their material social statuses on a micro-level. In a successful speech act, the listener responds based on her recognition of what the speaker says and intends. This relationship underscores a speaker-listener dependency; the speech act produces a material social effect by shifting each agent's status within the

local context. The interplay of speech and knowledge plays out on a larger sociopolitical stage. Discursive practices develop in tandem with larger structures of power—in other words, local uses and patterns of language reflect and reinforce social concepts of gender and systemic-level power relations. Structural disadvantages against women and other identities manifest in the speaker-listener relationship; one's concepts of gender shapes her language in an interaction and can produce discursive injustice. The social construction of women as less credible than men epistemically disadvantages a speaker whose listener who fails to perceive her as a credible knower. As such, she fails to exercise agency over her speech and social status. These forms of silencing in individual interactions are intertwined with larger, often invisible, systems of power. Through a survey of feminist philosophical literature, from the initial rise of academic feminist philosophy in the 1970s to contemporary discussions of linguistic sexism, this project uses conceptual frameworks from the philosophy of language to analyze the relationship between gender oppression and speech.

SECTION TWO: SOCIAL SCIENCES RESEARCH

Nikka Afshar GS'23, Philosophy, Meeral Tashfeen CC'25, History and Political Science, Jason Trinh GS'23, History and Political Science

Faculty Mentor(s) or Supervisor(s): Professor Christian De Vos

Title: Embassies in International Law

Abstract: On August 7, 1998, two truck bombs were simultaneously detonated at the United States' embassies in Nairobi and Dar es Salaam. These coordinated attacks were orchestrated by al-Qaeda, in revenge for the extradition of Egyptian Islamic Jihadi terrorists. Through selecting the embassies as a direct target, Bin Laden was able to attack an agent of American soil, and by extension, possibly forewarn for a domestic attack on the United States. This research project examined the paradox through which embassies embody both symbols of comfort and contention to a nation. Put differently, embassies, have simultaneously been utilized as spaces of sanctuary, but also as sites of secrecy, sabotage, and conflict. With a lack of prior research on this subject, this project aimed to examine the embassy's position as a legally protected space, allowing us to build a deeper understanding of its history and role. Meeral explored this conception through the lens of two revolutionary organizations: the African National Congress and the Palestine Liberation Organization. The early years of both ANC and PLO activism were marked by political advocacy, however this quickly turned into violence and radical terrorism in their desire for national recognition. The control of embassies positioned both entities in a crucial position, which they deployed as useful tools of political and diplomatic control in international negotiations. Nikka's research revealed the difficulties associated with holding embassies accountable for the constant violation of domestic and international law, focusing on the Iranian Hostage Crisis as a case study. Jason's examination of Southeast Asia exposed the stark contrast between the activities and priorities of the American embassy compared to the exiled Burmese embassy. He concluded that influential nations are more likely to advance their interests through backchannel actions, while less powerful nations are more likely to focus on advocacy through the media and official channels. This research was made possible by collaborative archival research carried out at the International Institute of Social History in the Netherlands, the Rare Book and Manuscript Library at Columbia University, and the virtual catalog of the U.S National Archives. It is evident that embassies are the primary agency which advance countries interests abroad, and as a result, hold a prominent role in popular culture. When countries engage in international disputes, and as political events unfold, embassies act not only as orchestrators of diplomacy, but also as influencers of their home countries' foreign policy. Through understanding their key role in executing negotiations, particularly during conflicts, it is thus possible to grasp a more nuanced picture of international law.

Asher Baron CC'25 History

Faculty Mentor(s) or Supervisor(s): Professor Samuel Kelton Roberts

Title: BIPOC Harm Reduction Organizations Historical Atlas and Directory

Abstract: Harm reduction is a growing field that seeks to reduce the negative health, social, and legal consequences of drug use, policies, and laws. As part of a broader movement for social justice, harm reduction also calls to critique and eliminate the structural racism inherent to the carceral state and the War on Drugs. Since its beginnings in Europe in the 1980s, the movement has grown to include grassroots organizations, government agencies, and religious groups, with much work being conducted within the United States. Though the United States has become a key player in harm reduction efforts, there exist few resources for centralized information on the history and development of the movement. In particular, little scholarship centers the

work of Black, Indigenous, and People of Color (BIPOC)-led organizations. The BIPOC Harm Reduction Organizations Historical Atlas and Directory is building an online repository of historical documents, images, recordings, and interpretive essays on the work of such organizations in the United States and Canada. The Atlas and Directory provides users with an understanding of the profusion and development of BIPOC harm reduction organizations. The project draws upon publicly available information such as newspaper articles as well as documents, social media posts, and location information sourced directly from included organizations. The Directory also includes interpretive essays that demonstrate the varied organizational approaches and service delivery methods across organizations. This project begins to establish a body of research that centers BIPOC voices and enriches historical relevance within the harm reduction movement.

Peyton Barsel CC'25, History

Faculty Mentor(s) or Supervisor(s): Professor Justin Phillips
Title: Tracking the Culture War through Political Polarization

Abstract: A Culture War is defined as a conflict between groups with different ideals, beliefs, and philosophies. There is a Culture War progressing within the United States, mainly from increased political polarization over the last few decades but interestingly, political scientists don't know why this has happened. Peyton Barsel's research project aims to track LGBTQ+ and abortion legislation, two polarizing social issues, in an effort to better understand the Culture War and what it represents in the United States. The project took the form of a database that tracked all Congressional legislation related to either topic from the 1960s through today. The purpose of forming that database was twofold: to consolidate relevant cases for researchers that will continue studying politics and to evaluate how polarization affected the voting results of individual bills. While the findings of this project were not quantitative, the results were illuminating. Throughout the project, researchers became increasingly interested in the link between public opinion and legislative results, and their focus shifted to tracking that with the Culture War. For example, Roe v. Wade was decided upon in 1973, the same year that the largest number of anti-abortion legislation on record was drafted. Those results do not directly respond to whether legislation leans towards or away from the will of the majority, however, they do demonstrate the impact of the Culture War in political spaces. This project makes the case that the Culture War is ingrained in the very structure of our democracy as we know it today.

Lilia Brooker CC'23, Human Rights

Faculty Mentor(s) or Supervisor(s): Professor Michael Gerrard
Title: Compilation of Legal Strategies to Combat Climate Change

Abstract: Climate change must be fought from multiple angles, including legal methods and considerations. This presentation discusses three ongoing projects at the Sabin Center for Climate Change Law that all focus on using legal methods that contribute to climate change-fighting strategies. The first project analyzes domestic and international laws relating to the potential implementation of ocean carbon dioxide removal (CDR) technologies. Ocean CDR is a powerful method for removing carbon from the atmosphere, which can help slow down global warming and counteract greenhouse gas emissions. This project discusses both the legal complications and opportunities for ocean CDR off of different countries' shores. The second project involves updating a list of climate impact assessment guidelines from foreign jurisdictions and NGOs. Impact assessments are conducted prior to the execution of a new project or policy, examining how such project will impact the environment and contribute to climate change. The significance of this research is to investigate how the guidelines for impact assessments are improving globally and increasingly taking climate change into account. The third project is a database of local laws in the United States that are targeted at combating climate change. Some examples include laws to reduce greenhouse gas emissions, or plans to become carbon-neutral by a certain year. The significance of these three projects is to utilize legal techniques and frameworks to further the fight against climate change.

Lizzy Carpenter CC'25, Political Science and Public Health

Faculty Mentor(s) or Supervisor(s): Professor Rachel Moresky
Title: Evaluating Equipment and Staffing Barriers to the Provision of EmONC Signal Functions by CHPS Facilities in Ghana

Abstract: The Acute Care and Emergency Referral Systems (ACERS) Project is a four-year, USAID-funded implementation research and a capacity-building project that aims to contribute to the improvement in maternal and newborn outcomes by increasing care-seeking behavior, strengthening emergency referral and dispatch systems, and providing high-quality emergency obstetric and newborn care (EmONC) services in the Northern and Oti Regions of Ghana. Ghana's Northern and Oti regions EmONC can be limited in rural regions due to health resource limitations and the geography of Ghana; it is often difficult to access and arrange transport to higher-level

hospitals in emergencies. Therefore, local Community-based Health Planning and Services (CHPS) facilities are often the first resources for providers of EmONC in Ghana. Health facilities in Ghana are evaluated by their ability to provide the seven basic EmONC signal functions that can be categorized as a Basic EmONC (BEmONC) facility, the health facilities must have sufficient supplies of Oxytocin, Magnesium Sulfate (MgSO4), and parenteral antibiotics, as well as the ability to perform assisted vaginal delivery, manual removal of placenta, removal of retained products, and neonatal resuscitation. During a recent visit to fourteen healthcare facilities, thirteen of which were ACERS intervention sites, the CU Mailman School of Public Health sidHARTe- Strengthening Emergency System's Fulbright Scholar conducted semi-structured interviews with the CHPS staff to assess their medicine stock and staff capacity. Through thematic analysis of the collected data, several barriers to the performance of the BEmONC signal functions became apparent. Regarding medicine stock, CHPS facilities typically do not receive all the medications they need in their commodity distribution, particularly MgSO4, which is needed to treat eclampsia. In terms of staffing and referrals, the data indicate that CHPS staff do not always accompany their emergent patients during a referral due to limited staff and other patients at the center. Additionally, patients cannot always be accompanied by health staff if they choose to take their own transportation, often based on the cost of ambulance transport and fuel. These findings emphasize the need for communication between the CHPS facilities and the Regional Medical Stores (RMS) to ensure that the CHPS are completing their commodity distribution requests and that RMS provides the CHPS with early notification when they will not be distributing a supply so the CHPS may find supplies elsewhere. For CHPS to be appropriately prepared for emergencies and provide EmONC, sub-district supply chain issues, communication barriers, referral accompaniment, and cost concerns should be addressed by both CHPS facilities, local stakeholders, and the national government.

Claire Choi, CC'23, Human Rights

Faculty Mentor(s) or Supervisor(s): Professor Meredith Giovanelli
Title: Family Separations Were Never New: Racial Disproportionality Among Child Welfare Involvement and Removals

Abstract: While national outcry followed the Trump administration's separations of immigrant families at the U.S.-Mexico border, much less awareness exists surrounding the state-sanctioned family separations carried out every day by child welfare agencies. As a result of the Child Abuse Prevention and Treatment Act of 1974 ("CAPTA"), which conditions federal child welfare funding upon state mandated reporting laws, as well as the Adoption and Safe Families Act of 1997 ("ASFA"), which promotes the termination of parental rights and obstructs family reunifications, child welfare agencies separate hundreds of thousands of children from their parents each year. While potentially well-intentioned, these laws and corresponding broad statutory definitions of neglect have, in practice, led to a criminalization of poverty and allowed racial bias to inject itself into every phase of the child welfare process. As a result, the child welfare system disproportionately surveils, polices, and separates Black and Indigenous families, inflicting lifelong trauma upon children and parents of color. Black and Indigenous families are overwhelmingly overrepresented among those investigated by Child Protective Services, are more likely to have their children removed from the home, and are less likely to be reunified than white families. This research explored state-level disproportionality of children of color involved in child welfare in Minnesota through examination of state laws, child welfare involvement data, and recent policy proposals. Mandated reporting laws were also investigated in Connecticut, where new mechanisms strive to minimize child welfare involvement by redirecting reporters and families to other avenues of support.

Alejandra Díaz-Pizarro Perdomo CC'25, History

Faculty Mentor(s) or Supervisor(s): Professor Caterina Pizzigoni
Title: The Benefit of the Commons?: Indigenous Land Management and Collective Resource Use

Abstract: Over the last thirty years, economic scholarship on collective resource management has shifted away from merely accepting the "tragedy of the commons" and proposing privatization or centralization as the only two solutions. Instead, economists have sought to outline the conditions under which communities, working as a collective and not as individuals, can efficiently manage their resources. The seminal work on this subject, Elinor Ostrom's Governing the Commons (1990), outlined eight principles—drawn from empirical research at several common pool resource sites worldwide—that all successful commons follow; since then, many theorists have elaborated upon or altered these principles to better fit emerging contexts. These theories remark on the importance of personal connections among group members and with the land; however, little is said about the groups that (perhaps best) fit these criteria: indigenous communities. As a whole, this project seeks to find connections between Ostrom's principles and those of

indigenous governance, to find where the latter fit within or overlap with the former. The first part, undertaken during summer 2022, consists of a broad-ranging literature review on the history of land management in Latin America, indigenous governance theory, and collective resource management theory, yielding the necessary context and list of principles that will serve as framework for field research in Cuetzalan, Mexico next summer. Altogether, the project stands at the crossroads of three key issues: the urgent need to find sustainable alternatives to current land management practices; the social push to restitute indigenous autonomy beyond purely nominal land acknowledgements; and the lack of specificity and vision in the Mexican government's policy language of "traditional knowledge" and "originary peoples."

Harrison Gerson CC'25, Sustainable Development

Faculty Mentor(s) or Supervisor(s): Professor Shannon Márquez
Title: Ecotourism in NYC

Abstract: When travelers think of ecotourism (environmentally-minded tourism), the rainforests of Costa Rica or the savannas of Kenya often come to mind. Yet, these "eco-friendly" locations often require a large carbon footprint to reach and harm native communities and biodiversity. However, cities present a new way of framing ecotourism in locations that are more environmentally, economically, and socially resilient. New York City's urban environment presents a new angle on ecotourism: one that sets the natural environment in constant conversation and conflict with changing communities and their development. The "Ecotourism in NYC" map, developed through StoryMapJS, educates New Yorkers and ecotourists on how to view NYC as an accessible location where one can learn about how humans harm, maintain, and restore nature with a growing population. NYC exposes visitors to environmental justice, elucidating the inequalities in nature and sustainability and the progress made to improve communities through the environment. The map also acknowledges NYC as the native home of the Lenape, who have been forcefully displaced through settler colonialism, and the project intends to uplift and educate on historically disadvantaged communities and support works that embrace these communities and sustainable development. One can gain a better sense of place through the featured opportunities. The map activities go beyond the traditional views of NYC and nature into more environmentally-minded and regenerative urban activities such as waterway restoration, thrifting, and cycling. The map will inform travel decisions and encourage people to reduce their carbon footprint, contribute to regenerating nature, and elevate local communities.

Charlotte Hoskins CC'25, History

Faculty Mentor(s): Professor Hannah Farber
Title: A Comparative History through Literature: 19th-20th Century Settler Colonialism in the U.S and Australia.

Abstract: Many often consider imperialism as the product of European attempts to control large swarths of territory and establish globalised trade. However, colonised countries, for example the United States and Australia, also practiced imperialism, and settler-colonialism specifically. This project compares and contrasts the ways in which the U.S. and Australia carried out settler-colonialism in their countries, particularly through land expansion and racism against native peoples in the 19th and 20th centuries. To do this, Hoskins uses literary works, such as novels and poetry anthologies, as primary sources for their research. They argue that though both Australia and America used settler-colonialism as a means of forcibly displacing native peoples in order to establish continental, agricultural, Anglo-Saxon empires, each used different justifications. Through reading and studying six pieces of literature, three for each country, Hoskins determines that whilst 'manifest destiny' and the inevitability of white expansionism was fundamental to American settler-colonialism, Australia more heavily relied on 'terra nullius' and the idea that Indigenous Australians held no claim over the land due to their race and white people had sovereignty. This study is important as there is a lack of academic research into the relationship that exists between the U.S. and Australia as countries with a close alliance currently, and also shows that the current racial inequalities seen in both countries is rooted in white colonialism.

Hassan Javed CC'25, Political Science

Faculty Mentor(s) or Supervisor(s): Professor Aftab Ahmed
Title: Advocacy of Refugee Needs in the EU

Abstract: Interning with the Center for the Study of Democracy in Bulgaria, the researcher contributed to the PERCEPTIONS project by writing policy briefs addressed to the European Union. The two areas of focus were the impacts of the EU-Turkey Statement on refugees and the challenges of the European housing market specific to migrants. With the signing of the EU-

Turkey Statement, the agreement instituted a system between the European Union and Turkey to curb the flow of undocumented migration from Turkey by deporting any irregular arrival back to Turkey. Although the Statement reduced the number of in-transit deaths, numerous NGOs, such as the IRC, have criticized the Statement as Europe shirking its responsibility of vulnerable populations. It also exposed refugees to harm in Turkey through xenophobia- and nationalism-fueled riots, the absence of protections guaranteed by the 1951 Refugee Convention, and refoulement back to Syria for trivial infractions. As a solution, the researcher recommended the imposition of a sanctions and monitoring mechanism on Turkey, an increase in the number of refugees resettled in Europe, and the provision of safer, legal ways to reach Europe. Meanwhile, concerning the poor living conditions and ethno-spatially segregated residences that refugees face in the European housing market, the researcher recommended an improved monitoring of public housing living standards, partnership with social development firms like InvestEU, feasibility studies to improve transit connectivity in poorly-connected neighborhoods, and the provision of voucher subsidies by European housing agencies to tackle the geographic segregation that inhibits migrants' inclusion into their host societies.

Animesh Joshi CC'24, History

Faculty Mentor(s) or Supervisor(s): Professor Anupama Rao
Title: Ambedkar's Castes in India: "Surplus" in Translation

Abstract: Working with the Ambedkar Initiative, this project explores B.R. Ambedkar's utilization of "surplus." Ambedkar was a prominent Dalit activist, father of the Indian Constitution, and nationalist hero—one who spent time at Columbia learning under teachers like E.R.A. Seligman and John Dewey. Surplus is a concept used by economists and political scientists alike, but Ambedkar's "Castes in India" (1917) chooses to use "surplus" in the context of undesirable populations. Surplus becomes an excess that must be done away with. This alternative definition requires its own, alternative, history: one that traces the deployment of surplus when it is addressed to precarious populations. To this end, this project creates a "mind map"—a spatial visualization of the different influences on Ambedkar at Columbia. The "mind map" begins by understanding some of the more structural forces at play, starting with the seminar model in which Ambedkar developed his paper and presentation on Indian caste. At the same time, this "mind map" attempts to branch out from direct, institutional connections. It is interested in the surrounding intellectual community of interlocutors that Ambedkar found himself in, and the research places Ambedkar in a rich, vibrant community—W.E.B. DuBois, Mary Ovington, Florence Kelley, and others. Clearly, surplus did not come out of thin air for Ambedkar: it was a reflection and product of an intellectual conversation at and around Columbia.

Yoni Kurtz CC'25, History

Faculty Mentor(s) or Supervisor(s): Professor Frank Guridy
Title: Little League, Big Impact: Historical Intersections in Race and Youth Baseball

Abstract: The experiences of immigrants and people of color in America have been inextricably tied up with athletics. However, while the stories of sports and race in America have been told extensively on the professional level, research into the historical connection between youth sports and race has been limited. This project seeks to partially fill that gap by detailing the historical intersections between race and youth baseball. Separating the research into several historical periods across the 20th and early 21st centuries, this research examines primary source material including newspaper articles, magazines, proposed youth projects, and government documents to identify the historical changes and continuities between the experiences of various racial groups in youth baseball and their experiences in broader American culture. This project primarily focuses on the experiences of people of color, but also includes some research into the youth baseball experiences of Jewish immigrants in early 20th-century New York City. Overall, using the lens of American youth baseball to understand the experiences of historically marginalized groups is valuable because youth baseball itself is such a venerated piece of American culture. In studying the interactions that marginalized people have had with something so close to the pinnacle of American culture, one can understand the role that these groups played in this culture across different eras of baseball, racial, and American history.

Astrid Liden CC'23, Political Science, Latin American & Caribbean Studies

Faculty Mentor(s) or Supervisor(s): Professor Randa Serhan
Title: Family & Migration: Venezuelans in Chile

Abstract: Nearly 450,000 Venezuelan migrants live in Chile, making Venezuelans one of the largest migrant populations in the country and Chile

as one of the top receiving countries of Venezuelan migrants. This project looks at how Venezuelan forced migrants in Santiago have created and sustained family ties across and within borders, interacted with policies of family reunification, and how family ties have motivated or dissuaded migration. Based on semi-structured interviews with Venezuelan forced migrants in Santiago, conducted in July and August 2022, this research centers on the stories and motivations for Venezuelans arriving in Chile and how, despite distance and barriers, Chile becomes an ideal destination for Venezuelan forced migrants– how do they understand it, what narratives does the state perpetuate, what assumptions are made about family migration, and how desires to reunify with family has evolved over times. This will provide an insight about how Venezuelan migrants view and understand policies of family reunification, how the state aids or prevents family reunification, and how organizations have adapted to the case of Venezuelan migrants and families in recent years.

Ashwin Marathe CC'25, Political Science

Faculty Mentor(s) or Supervisor(s): Professor Sudipta Kaviraj
Title: Indian Farmers' Protest Oral History Project

Abstract: In June 2020, the Indian government passed three farm bills to bring commercial businesses into the Indian agricultural sector. In November, thousands of rural farmers marched in protest of the farm bills, which they believed would disrupt their income and livelihood. The protest, which ultimately successfully repealed the farm bills, involved numerous rallies, protests, and bargaining meetings between Indian farmers and the government. Thousands of protestors, including farmers, community organizers, and unions, set up campsites in Delhi and Punjab to pressure the government to repeal the bills. Media coverage of these protests was mixed, as government-controlled media blamed protestors for creating violence. To understand the different tactics that protestors used during sit-ins, including visual and musical art, tractor rallies, and the creation of new newspapers, the Indian Farmers' Protest Oral History Project seeks to document the voices of citizens that worked to repeal the farm bills. Currently, there exists no oral history project centered on archiving the lives of these protestors. This project ensures that the life of each protestor can be understood in the context of the protest, enabling future researchers and historians to understand who these protestors were, why they took part, and in which ways they adapted their protest strategy as time moved forward.

Neely McKee CC'23, History

Faculty Mentor(s) or Supervisor(s): Professor Francesco Baro
Title: Preventing Gentrification and Promoting Community: Exploring Informal Green Spaces and Park Accessibility in Brussels, Belgium

Abstract: As cities across the world attempt to mitigate the impacts of the climate crisis, public parks and urban green spaces provide many key tools to both increase sustainability and promote neighborhood wellbeing. However, significant research has shown that in many cities disparate access in park spaces can further inequities in community health and the provision of ecosystem services. Here, focusing on Brussels, Belgium as an important example and case study, this research explores how "informal" green spaces provide for areas underserved by the city's larger network of park infrastructure. Focusing on demographic data and the spatial distribution of park spaces, this research examines informal green spaces across the city and highlights how they provide crucial services for low-income areas of higher urban density that lack access to the city's traditional park spaces. Using spatial analysis tools, this research centers the importance of untraditional urban green infrastructure in the quest to inspire more sustainable and equitable cities. As cities design sustainable park infrastructure projects to promote urban resilience, "green gentrification" can occur as local residents become priced out. Thus, focusing on informal green spaces and other metrics of sustainability allows for alternate pathways to resilience, focusing on how local communities design a future for themselves. Here, the further study of informal green spaces provides important opportunities to critically examine public park accessibility, city management of green spaces, inequities in the provision of ecosystem services, and crucial measures to promote community wellbeing in the pursuit of environmental justice.

Sebastian Preising CC'23, Political Science

Faculty Mentor(s) or Supervisor(s): Professor Peter Bearman
Title: Crooked Concepts: Investigations into the Semantic and Conceptual Tendencies of Political Propaganda

Abstract: With the advancement of online communication and news distribution, governments and individuals have gained a greater ability to circulate large volumes of misinformation and propaganda that masquerade as veritable information. As such, new means of identifying propaganda are required to combat this spread of misinformation, which this project seeks to

address in novel ways using computational methods. Hand-annotated articles from the Propaganda Technique Corpus (a dataset of 446 news articles that labels specific instances of propagandistic language) were transformed into semantic networks so that structural analyses could be performed on them. One of the investigations this project undertook is whether there exist categorical differences in the concepts (or topics) most frequently utilized by articles with high and low propaganda scores. After calculating the centrality of the concepts in each article and analyzing their frequency and importance, this project discovered that articles scoring highly in propaganda showed significantly greater usage of concepts pertaining to individuals (e.g., "Trump", "Brett Kavanaugh", "President"), nationally related concepts (e.g., "people", "nation", "Muslims"), and abstract ideals (e.g., "justice," "power," "truth"), whereas articles scoring low in propaganda used more concepts relating to professional groups (e.g., "reporters", "investigators", "police"), means of communication or transaction (e.g., "statement", "report", "deal"), and unspecified authoritative groups (e.g., "officials", "members", "sources"). The existing literature in propaganda analysis overwhelmingly focuses on classifying textual propaganda by examining its author. However, by bringing to light a semantic tendency, this project puts forth a new factor that can be considered to improve the accuracy of propaganda identification.

Sierra Romero CC'24, Mathematics-Statistics and African American and African Diaspora Studies

Faculty Mentor(s) or Supervisor(s): Professor Samuel K. Roberts
Title: Critical Studies in Harm Reduction History Project: Historical Analysis of Health Activism against Structural Racism and Punitive Drug Policy

Abstract: From the 1950s through 1990s, strict legislative policies addressing drug addiction and public health became popular due to the declaration of the War on Drugs and the emergence of the HIV/AIDS epidemic. Simultaneously, in the 1980s, numerous grassroots organizations formed in response to the insufficient effort made by the government to provide healthcare services to vulnerable communities of color. Known as harm reduction, these organizations emphasized care, education, inclusion, abolition, and autonomy. Harm reduction organizations played an important role in providing resources to communities who had been historically and systematically denied access to care due to their race, class, sexual orientation, or gender. This summer, Sierra Romero 24' served as a research assistant to Professor Samuel K. Roberts's ongoing project, Critical Studies in Harm Reduction History Project: Historical Analysis of Health Activism against Structural Racism and Punitive Drug Policy. The purpose of the project is to create an online database of prominent harm reduction organizations and significant legislative events that impacted poor communities of color in the United States and Canada. As a research assistant, Sierra conducted digital and archival research to create encyclopedia-style entries documenting the historical background of different harm reduction organizations. Focusing on three different organizations that each targeted different demographics, the project provided insight to how culture, race, class, and queerness inform approaches to care, kinship, and mutual aid.

Hanes Rosenau CC'24, History

Faculty Mentor(s) or Supervisor(s): Professor Kenneth Jackson
Title: The Stagger Plan

Abstract: During the 1940s New York City faced a public transportation crisis. Expansion and improvement plans had been put on hold during the war and Annual subway ridership had grown to over 2 billion by 1946, its highest level to date. This resulted in crowded conditions in the subways, particularly during the morning and evening rush hours. As a solution to the rush hour congestion, the city tried to get businesses to stagger their employees' working hours—a strategy to combat congestion that had been tried multiple times before this crisis, and considered multiple times since—all to no avail. Using letters, internal documents, and public statements from the New York Transit Museums' archive along with newspapers from the period, this project examines this attempt to stagger the city's workday and uses it as a case study for these attempts as a whole. Particularly it focuses on the experiences of everyday straphangers, the internal mechanisms of the Board of Transportation and City Hall, the nature of the plan as a public-private partnership, and the city's seeming constant revisiting of stagger plans. Furthermore while New York City's stagger plans, and others like it, have been studied and written about by urban planners, this project is a novel look at this plan as a historical event and draws connections to New York City's present debate around the congestion charge.

Lourdes Russell CC'25, Medical Humanities

Faculty Mentor(s) or Supervisor(s): Professor Sarah Hansen
Title: Improving Learning in Chemistry

Abstract: How do college chemistry educators determine whether their students are genuinely learning the material presented in lectures? They can

analyze student performance on exams and assignments or the feedback received on professor reviewing websites; however, there are even more profound methods one can utilize when recording levels of understanding in the classroom. Employing techniques that give greater insight into students' thought processes and attention could aid professors in creating lectures that are tailored to the student experience, forming a classroom environment that prioritizes learning. Previous research has demonstrated that empowering students to critique, question, and verify the accuracy of the information they are presented in the classroom–instead of immediately imploring them to immediately accept all material as objective truth–guides students to more fully understand course content. In this project, college students were presented with varying forms of stimuli related to the chemical processes they would generally learn in a college chemistry course; they were shown animations explaining the occurrence of oxidation-reduction (redox) reactions and then prompted to replicate and verbally explain their how they formed their own diagrams of the reaction using magnets to depict the involved reactants and products. Additionally, the student participants' eye movements were tracked to understand which visual aspects of the videos were potentially the most impactful on the students' attention. This paper intends to explore which aspects of chemical reactions capture students' attention and how their achievement is impacted by critiquing their own performance.

Balthazar Sheehan GS'24, History

Faculty Mentor(s) or Supervisor(s): Professor Samuel K. Roberts
Title: Critical Studies in Harm Reduction

Abstract: This past summer, Balthazar worked with the Research Cluster for the Historical Study of Race, Inequality, and Health on a program of research titled "Critical Studies in Harm Reduction History". Under the supervision of Professor Samuel Kelton Roberts, they investigated the work, activism, and history of various harm reduction organizations across North America, focusing in particular on harm reduction groups catering to Canada's Black and Indigenous communities. These organizations, were created by activists seeking not only to introduce harm reduction principles and practices to communities that had long been neglected and ignored by provincial health authorities but to diversify existing harm reduction spaces. Since harm reduction philosophy emphasizes the importance of community-based solutions to unsafe drug usage, these groups adopted a malleable and intersectional approach to community building. Through instructional literature and workshops covering topics like the administration of Naloxone, safer drug usage, and the prevention of sexually transmitted and blood-borne infections, harm reduction groups serve as vastly important educational resources by providing accurate information reported by trustworthy and knowledgable members within affected communities. Indigenous-led Harm Reduction organizations also seek to foster community ties through Indigenous gathering spaces and support groups in order to prevent dangerous or unsafe drug usage prevalent in socially isolated groups (street-involved people, sex-workers, local incarcerated populations, etc.). Black and Indigenous harm reduction uniquely embody the vision of harm reduction and community based health solutions by providing for both short-term material well-being and long-term social and emotional health of historically marginalized groups in need of both.

Mrinalini Sisodia Wadhwa CC'24, History and Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Sneha Krishnan
Title: "Intimate Internationalisms": Tracing Networks of Indian, Anglo-Indian, and Missionary Women Studying at Oxford, 1891-1947

Abstract: Elite British universities such as Oxford were at the crux of early twentieth-century internationalism and imperialism. Educating both a generation of British colonial officers and missionaries, and a powerful class of Indian anticolonial leaders, these sites linked colonies and metropole, their influence extending even beyond independence and Partition in 1947. Yet what international histories have left out, in studying the British sojourns of famous male figures such as Gandhi and Nehru, is that a significant number of women with ties to Empire also attended these universities in the 1920s-30s. They were, moreover, hardly homogenous: lower- and middle- as well as upper-class; Indian, Anglo-Indian, metropolitan British; Hindu, Christian, Muslim, Parsi; future Sanskrit academics, anticolonial activists, missionary educators. "Intimate Internationalisms" draws these women into an international history 'from below,' examining how they participated in and shaped internationalism during and after their time at university. Drawing upon original archival research from student registers, correspondences, and files at Saint Anne's College, University of Oxford—which took many non-elite women who could not otherwise attend—Mrinalini traces the backgrounds of 134 Anglo-Indian, Indian, and missionary women who came from 1891-1940. She does so with an eye towards how international ties were shaped by imperial interests, reflected in the politics of these women's funding sources: the gendered, racial, and class categorizations made by wealthy donors and colonial officials seeking to produce 'useful' subjects.

Seizing upon the rare case of a lower-class Anglo-Indian woman attending Oxford on a Government of India Scholarship, Mrinalini argues that the funding sources often disrupted the very colonial categories they presumed. By granting recipients transnational mobility, scholarships and donations brought Indian, Anglo-Indian, and British women together in close quarters—despite rigid segregation in British India—forging unlikely networks of women that challenge colonial 'order' and open new possibilities for envisioning internationalism.

Wena Teng CC'25, History and Computer Science

Faculty Mentor(s) or Supervisor(s): Professor Dorothy Ko
Title: Mothers of Memory: The Temporality of Literature and Art as Political Intervention in Pre-Modern and Contemporary China

Abstract: Much of current scholarship on China and its history is viewed through a binary: "good/bad," "oppressed/liberated," or "collective/individualistic." The status of pre-modern women, for example, was either oppressed or liberated and the spaces they occupied were bifurcated. However, recent scholars add complexity, suggesting that "literate gentry women…were far from oppressed" by building "intellectual and emotional" networks (Ko, 1994). Curious about how these practices were sustained intergenerationally despite changing political and social systems, Wena's research project examines three time periods of Chinese women networks. How did Ming-Ch'ing women in Jiangnan, late-Qing women in Fujian, and contemporary women activists cultivate a continuous line of influence contingent on memory, tradition, and literary? First, she analyzes these traditional networks through a literature review on Ming-Ch'ing women and Min writing-women culture. Next, through the work of Xue Shao Hui, Wena explores how these literacy traditions influenced late-Qing women's intervention within a state diverging from a Confucian family paradigm. Lastly, Wena argues that the temporality of memory is present in the modes of activism performed by contemporary feminists in China today. The use of their bodies and minds as instruments of intervention towards domestic violence, sexism at school, and in the workplace holds a resemblance to historical interventions. Through the reconstruction of the way pre-modern women lived where literature was not merely for sensibility or the expression of "cloistered" emotions, but also for political intervention, gender/social relations, and moral systems, we find historical resources to allow a redefinition of public dissent — especially through using art, fashion, performance, and bodies as vessels.

Karuna Vikram CC'23 History

Faculty Mentor(s) or Supervisor(s): Professor Debjani Bhattacharryya
Title: Intellectual Property in a Decolonizing Moment: Patents, Power, and Pharma in South Asia

Abstract: As we have shifted from the industrial age to the "informational" age, the production, processing, and ownership of knowledge has become crucial to the global political economy. Today, we see how corporations have been able to claim monopoly rights to information, thus growing immensely powerful. This is the story of the pharmaceutical industry, Monsanto, and Silicon Valley, which wield extraordinary economic power globally. However, their success is a consequence of extracting and exploiting labor from the global South, and inequitable access to industrial knowledge and products. Under the supervision of Professor Debjani Bhattacharyya at the University of Zürich, this project sough to ask, how did information come to be defined as protectable, intellectual property? How does the division of labor and knowledge reproduce historical colonial structures? Is there an emerging empire of information and what are the histories of the making and colonizing of this knowledge? This project examined four archives, looking at patent filings, legal cases, speeches, policy manuals, newspaper clippings, statistical commentary, and more, in the UN, WTO, British Library, and Novartis archives to compile a novel perspective of the power and potential of IP between India and the United States. This project is book-ended by the 1970 Patent Act in India, where the country declared that no medicine was allowed to be patented, and the TRIPS agreement in 1994, where India acceded to the US's terms and instituted a baseline IP standard for medicines. This project is ongoing, and seeks to understand on what and whose terms this transition occurred, and how the UN was the setting which facilitated this change.

Kelly Warner CC'25, Psychology and Human Rights

Faculty Mentor(s) or Supervisor(s): Professor Larisa Heiphetz
Title: Curious & Curioser: Moral Cognition in Children

Abstract: Previous studies have revealed that older children (ages 7-9) typically care more about transgressive behavior as opposed to prosocial behavior. Whereas younger children (ages 4-6) did not demonstrate this increased interest in transgressive behavior. Previous studies have also revealed that older children increasingly make moral judgments based on intent, as opposed to the outcome of an action. These findings coupled with

evidence of a positivity bias existing in younger children, where they selectively process information to maintain a positive perception of themselves and others, implies a shift in the moral development and cognition of children as they grow older. This study explores whether this phenomenon occurs because as they grow older children care more about the intention of people's actions. This research gives us insight into the development of theory of mind (the ability to understand and predict the mental states of others) and other moral reasoning skills in children. This study also explores the implications intent has on judgment for deserved punishment in children. This is explored through instances of accidental harm (bad outcome lacking ill-intent) compared to instances of attempted harm (benign outcome with ill-intent). While this line of study is ongoing, making findings unavailable at the moment, previous findings and research on which this study is based, along with the inner workings of the study procedure are explained in greater depth in the poster presentation.

Bryley Williams CC'25, History

Faculty Mentor(s) or Supervisor(s): Professors Napakadol Kittisenee and Lien-Hang Nguyen
Title: Ritual Responsibilities: Khmer Buddhism and the Family During and After Democratic Kampuchea

Abstract: During Democratic Kampuchea (1975-1979), the brutal regime under which more than 1.7 million Cambodians died as the Khmer Rouge strove to turn the country into a classless agrarian utopia, religion was forbidden. Many scholars have studied processes of post-conflict social reconstruction, which naturally included the re-establishment of Khmer Buddhism, Cambodia's predominant religion. However, few have investigated the ongoing personal practice and preservation of Khmer Buddhist belief and ritual during Democratic Kampuchea. In "Ritual Responsibilities: Khmer Buddhism and the Family During and After Democratic Kampuchea," Bryley Williams, CC '24, explores how the intertwined nature in Cambodian society of Khmer Buddhism and the family (particularly the relationship between parent and child) meant that spiritual and familial upheaval went hand-in-hand under the Khmer Rouge. Bryley's research, which draws on oral histories, interviews, written survivors' testimonies, and secondary source material, argues that the accumulation of unfulfilled ritual responsibilities toward kin during Democratic Kampuchea exacerbated a sense of moral and cosmic disorder within the familial consciousness. However, due to the inextricable ties between Khmer Buddhism and the family in Cambodia, the continued sense of obligation and the performance of rituals, even retroactively, were central to the re-stabilization of moral, cosmic, and familial order. Finally, this research aims to demonstrate how studying personal religious rituals deepens historical understanding.

Kennedy Winslow CC'24, Urban Studies

Faculty Mentor(s) or Supervisor(s): Professor Estela Diaz
Title: Staying Dangerous: Reexamining Nihilism in Rap Music for a Postmodern Revolutionary Ideology

Abstract: The current chronology of academics examining rap music for its revolutionary potentials stops at the 90s. The existing literature connects public policy and practices, social effects, and rap music's ability to reflect the socio-spatial realities that inform its creation, but fails to endeavor to trace those connections to the current generation of rappers, the new sounds they are producing, and the new topics they are covering. These newer rappers do not fit squarely with the intentions, sounds, and topics of the 90s. It seems as if the ivory tower wants nothing to do with the perceived extreme nihilism of current rap music and sees it as laying down to die as opposed to a reinvigorated but unfamiliar uprising. Kennedy Winslow (CC'24) is addressing this nihilism head-on as a continuation of the practice of reflecting socio-spatial realities in rap, those realities being the long-steeped continuations of those same public policies and social effects evolved from the 90s. This project begins to approach the idea of this nihilism as a form of resistance to the conditions of oppression pushing the producers and consumers to the margins of citizenship, if they haven't already imparted social death and statelessness upon them. In her work, Kennedy looks to examine "gangsta rappers" and how they embrace conditions of mass incarceration and (over)policing and urban spatial issues like gentrification and displacement as a means of "discarding the master's tools". In the name of revolution, amen brotha.

Rosie Zhou CC'25, Film Studies and History

Faculty Mentor(s) or Supervisor(s): Professor Michael Gerrard
Title: Environmental Justice: Movement Building, Challenges, Policy Implementation

Abstract: Following community protests against hazardous pollution that occurred in 1982 in Warren County, North Carolina, discussions arose nationwide about the disproportionate impacts of polluting facilities and hazardous waste sites on low-income communities and predominantly communities of color. Since then, the environmental justice movement has gained momentum and the term "environmental justice" has become more commonly recognized among environmental organizations and political spheres than before. A holistic approach to working towards environmental justice requires a comprehensive analysis of interconnected issues, including residential housing segregation, discriminatory zoning practices, and unequal distribution of political power across different communities. Rosie's research on environmental justice focused on this analysis and aims toward understanding how environmental justice can be incorporated into every step of the policymaking process. She first researched the background of the environmental justice movement, seeking to understand the term's historical, social, and political context. She then looked into the legal framework surrounding environmental justice to determine what legal avenues exist to bring relief towards affected communities. Shifting towards a more applicable pathway, she researched past and existing programs aiming to advance environmental justice, specifically Biden's "justice40" initiative. From there, she applied her research to the local level, trying to determine how the program can provide benefits to local communities in Spokane, WA. Analysis of environmental justice policies and their implementation is critical, allowing for a better understanding of the importance of community involvement in policymaking.

SECTION THREE: STEM RESEARCH

Avi Adler CC'24, Biology

Faculty Mentor(s) or Supervisor(s): Professor Erin Barnhart
Title: Investigating Factors that Control Neuronal Mitochondrial Distribution

Abstract: Mitochondria are crucial for cellular function especially in energetically demanding neurons. Since neurons exhibit extensive dendritic arborizations, an evenly distributed population of mitochondria is essential to meet its energetic demands. To accomplish this mitochondria are known to employ an array of dynamic processes including fission, fusion, biogenesis, degradation, and motility. Mitochondria must balance these dynamics throughout a neuron's life to maintain neuronal health. However, it remains unclear the extent to which each process contributes to the maintenance of both an even distribution and a stable, healthy, population of mitochondria. Furthermore, it is also unclear how energetic demands of a neuron modulate these processes. To investigate this, neuronal activity (and thus hypothesized energetic demand) was perturbed in the Drosophila visual system by rearing flies in control and complete dark conditions. Mitochondrial distribution patterns were then assessed in horizontal system (HS) neurons by calculating mitochondrial densities in primary and distal regions of neurons. We expect rearing flies in the dark will lower their visual experience and therefore lower the energetic demand in HS neurons. Here, we show that density and distribution of mitochondria are unaffected by changes in neuronal activity. This adds evidence to a growing hypothesis that mitochondrial distribution is controlled rather than energetic demands by other factors, such as dendritic architecture (unpublished data from the Barnhart Lab). Preliminary results also indicate that mitochondrial distribution is minimally affected by perturbations in PINK1 and Parkin proteins, two essential proteins in mitochondrial autophagy and whose role in overall mitochondrial turnover remains unclear. Further quantification is needed to confirm this result. Together, these studies will help elucidate the dynamics that maintain a stable and healthy population of mitochondria.

Arooba Ahmed CC'23, Biochemistry

Faculty Mentor(s) or Supervisor(s): Professor Jean Gautier
Title: Role of Translesion Synthesis Polymerases in DNA Interstrand Crosslink Reoair

Abstract: 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, cells have developed mechanisms to repair ICL lesions and prevent cell death. SJG-136, a synthetic drug which forms ICLs with high efficiency, has been used to study the role of Translesion Synthesis (TLS) polymerases in ICL repair. Preliminary data has shown that concomitant loss of Polymerase Eta (Pol κ) and Kappa (Pol η) contribute to a significant inability of cells to promote repair by a mechanism that is not fully characterized. In these experiments, SJG-136 induced RPA foci were used as an intermediate to observe Replication Coupled ICL repair. Quantification of foci in U2OS Pol η/κ double knockout cells and Pol η/κ knockout treated with Pol ι siRNA showed a persistence in repair foci, and cells depleted of all three polymerases demonstrated the most severe defects. This provides the insight that defects in ICL repair are likely due to an impairment in the gap filling

step by the TLS polymerases. To determine the role of these polymerases in Replication Independent ICL repair, a plasmid containing a single SJG-136 crosslink was transfected into double knockout cells. GFP expression in transfected cells indicated ICL repair completion. Normalized GFP intensity ratios demonstrated a decrease in intensity of the brightest GFP population, indicating a decrease in the ability to complete repair to the fullest extent. Altogether, these studies provided critical insight into the role of these polymerases in ICL repair.

Christa Akerele CC'25, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Professor Alexander Nectow
Title: Exploring the Role of the Dorsal Raphe Nucleus in Glucose Metabolism

Abstract: The dorsal raphe nucleus (DRN) is a brainstem structure that has been implicated in energy homeostasis. Our lab has recently shown that GABAergic cells (cells expressing Vgat, the GABA transporter) in the DR modulate both food intake and thermogenesis (Nectow et al., 2017, Schneeberger et al., 2019). Specifically, optogenetic and chemogenetic activation of Vgat cells has been shown to upregulate food intake in sated mice and downregulate thermogenesis, respectively. Based on recent evidence of the role of DRN-VGAT neurons in modulating energy homeostasis, experimenters investigated the role of DRN-VGAT neurons in glucose metabolism. Because Vgat neurons control food intake and are likely embedded in circuits that control peripheral physiology and metabolic syndromes, they are likely to play a role in glucose metabolism. Researchers utilized optogenetics to stimulate the Vgat neurons and glucose tolerance tests (GTT) and insulin tolerance tests (ITT) to investigate further the mechanism by which Vgat activation impacts blood glucose levels. An unpaired, one-tailed t-test of the average area under the curve for GTT, showed that overall there is a statistically significant difference between the experimental versus the control mice's blood glucose levels. This implies that the activation of DRN Vgat neurons impacts glucose reuptake from the blood into the periphery, resulting in higher blood glucose levels for the experimental group. There was no statistically significant difference in glucose blood level after administering insulin, indicating that the Vgat-expressing neurons are not changing insulin's affectivity in order to prolong glucose amounts in the blood.

Naira Altunkeser CC'25, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Professor Kevin Bath
Title: Early life adversity in mice intensifies threat reactivity and results in sex biases in the activity of corticotrophin releasing hormone in neurons in the central amygdala

Abstract: An increased risk for anxiety-related disorders, which is seen twice as much in females in comparison to males, has been linked to exposure to early life adversity (ELA). Anxiety-related disorders harbor enhanced reactivity to real and perceived threats as a central characteristic. Corticotropin-releasing hormone (Crh) is a sexually-dimorphic neuropeptide released under stress and is significant for hyperarousal related to threat reactivity. Changes in Crh levels in the brain region amygdala have been linked to ELA for males, yet the effect of ELA on females and its impact on threat reactivity still haven't been explored in depth. The activity of Crh within brain regions may influence the sex biases that have been observed in the risk and appearance of symptoms of anxiety-related disorders. To test ELA's effects on fear-potentiated startle, which is a behavioral phenotype used to assess threat reactivity, this study used limited bedding/nesting (LBN) as a model of ELA in mice. The activities of Crh-positive neurons in bed nucleus of the stria terminals (BNST) and central amygdala (CeA) were measured via two methods. The first method included cFos as a neuronal activity marker to quantify the number of active Crh-positive neurons post-testing in central amygdala. The method of fiber photometry was also utilized to measure the level of Ca2+ in Crh-positive neurons in CeA during fear-potentiated startle experiments. The study discovered that LBN amplifies acoustic startle in only females in both cases of predictable and unpredictable threats. An increase of co-labeling of cFos- and Crh-positive in CeA and maintained Ca2+ activity of Crh-positive neurons during tone associated with foot shock threat emerged in female mice who were raised with LBN. As a result, this study indicated a sex-specific mechanism for enhanced threat responding in the presence of ELA.

Arnold Caleb Asiimwe CC'25, Computer Science and Biochemistry

Faculty Mentor(s) or Supervisor(s): Professors Carl Vondrick and Mary Salvatore
Title: On explainable attention-based deep neural networks trained on radiographic data augmented with diffusion models.

Abstract: The application of artificial intelligence in radiology is revolutionary, and developing explainable artificial intelligence is significant for medical professionals to work with and trust intelligent systems. Previous research on the application of A.I. in radiology has demonstrated that commonly occurring thoracic diseases can be detected on chest radiographs and even be spatially-located via a unified weakly-supervised multi-label image classification and disease localization framework. Although the initial quantitative results have been promising, deep convolutional neural network-based classification (recognizing and locating the common disease patterns trained with only image-level labels) remains a strenuous task for fully-automated high-precision computer-aided diagnosis systems. This research presents a neural network architecture that can regularly provide reliable attributions for more than 15 classes of cardio-thoracic conditions on chest radiographs—atelectasis, cardiomegaly, consolidations, edema, effusion, emphysema, fibrosis, Morgagni hernias, infiltrations, masses, nodules, pleural thickenings, pneumonia, and pneumothorax—augmented with diffusion models. Rather than training a multi-label image classifier, a single network architecture with an "ensemble of binary classifiers" is trained with normal chest radiographs as the baseline. The neural network is made explainable with integrated gradients. This novel attention-based architecture generates better attributions for several chest radiographs as opposed to multi-label classification; and looks for the exact radiological features as radiologists on some radiographs. We use over 112,000 publicly available frontal-view chest radiographs from the National Institutes of Health database to train denoising diffusion probabilistic models from which new datasets for each class are generated as the training data for the "ensemble of binary classifiers."

Scarlet Au CC'23, Environmental Biology

Faculty Mentor(s) or Supervisor(s): Professor Deren Eaton
Title: Generation time differences amplify concatenation bias in phylogenetic inference

Abstract: Multispecies coalescent (MSC) models are parameterized with branch lengths in coalescent time units (Tc), which correspond to the probability that genealogical discordance will occur over the length of a branch. These units are in fact a compound unit (Tc = Tg / 2Ne), and can be decomposed into two factors that can be measured separately: effective population sizes (Ne) and generation times (Tg). A common assumption is that decreasing Tg or increasing Ne will have similar effects on genealogical variation, and thus most attention has focused solely on Ne. We investigate an additional and often overlooked source of biological variation, in the form of generation times (Tg), which affect the rate of recombination, and thus also the rate of concatalescence. Through the use of coalescent simulations and an empirical example, we develop new software tools for measuring variation among gene trees and demonstrate how variation in generation times may amplify the effects of concatalescence, leading to systematic biases in species tree inference.

Miriam Aziz CC'24, Chemistry

Faculty Mentor(s) or Supervisor(s): Professors Latha Venkataraman and Colin Nuckolls
Title: Accelerating an S_N2 Reaction Using Electric Fields in a Scanning Tunneling Microscope Break-Junction (STM-BJ)

Abstract: Electric fields have been utilized to control and tune chemical reactions in bioenzymatic catalysis, where enzymes exert electric fields in their active-site environments to achieve rapid reaction rates. An ongoing challenge is to develop synthetic conditions that match enzymatic rates. The Venkataraman group has shown that electric fields can induce organic reactions inside the scanning tunneling microscope break-junction (STM-BJ)[1].This project is the first to use this technique to examine electric-field catalytic effects on an S_N2 reaction. Previous computational studies[2] have predicted that electric fields may catalyze this reaction in solution, yet herein we offer the first experimental rate study of the Menshutkin reaction at ambient temperatures with STM-BJ measurements. High-performance liquid chromatography (HPLC) and UV-vis analysis is utilized for *ex-situ* rate characterization, and density-functional theory (DFT) calculations provide support for product stabilization in a field. We aim to show that S_N2 Menshutkin reaction may be driven as the result of an applied electric field and solvent dielectric constants.
Keywords: Scanning tunneling microscopy, single-molecule conductance, electric-field catalysis, S_N2 reaction, Menshutkin reaction, green chemistry

Ara Bakhteyar GS'23, Biophysics

Faculty Mentor(s) or Supervisor(s): Professor Arnold Han
Title: Pathological Analysis of Mouse Brain Infected With Fusobacterium nucleatum During Gestation

Abstract: Fusobacterium nucleatum, a gram-negative anaerobic bacteria, has long been found to cause opportunistic infections such as endocarditis, brain abscesses, and infections of the pregnant uterus. F. nucleatum, however, has been mainly studied for its etiological factor in periodontal diseases affecting most of the world's population. Furthermore, due to its elongated shape, F. nucleatum can interact with many other microbial cells and acts as a bridge for the early colonization of the surfaces such as teeth for other pathogens such as Streptococcus. This research focuses on establishing a link between F. nucleatum and the development of neurodegenerative diseases such as Alzheimer's disease and Autism Spectrum Disorder. To diagnose Alzheimer's disease, observing amyloid plaques on a brain scan is required. Based on the amyloid cascade hypothesis, a novel model was developed at Dr. Han's laboratory to analyze the brain pathologies of mice off-spring infected with F. nucleatum during gestation. Here we show that F. nucleatum acts as a pathogen and secretes FadA adhesions with amyloid properties, directly linked to neurocognitive disorders. These results are obtained by behavioral analysis, Immunohistochemistry, and Thioflavin T staining. These results confirm the previous observation in human case studies regarding the preclinical stage of Alzheimer's disease and the DSM-5 criteria for the autism spectrum disorder.

Dave Banerjee CC'25, Physics

Faculty Mentor(s) or Supervisor(s): Professor Jose Perez
Title: A Novel Approach to Slowing the Degradation of Monolayer Molybdenum Disulfide
Abstract: Advancements in nanotechnology have sparked a demand for nanoscopic materials. Molybdenum disulfide (MoS_2) is a novel 2-dimensional semiconductor whose mechanical flexibility and thinness present many applications in nanoelectronic and microelectronic fabrication of devices like sensors, transistors, optoelectronics and solar cells. Despite ultrathin MoS_2's potential, its use is limited due to its propensity for degradation under ambient conditions. While studying the degradation of MoS_2, it was found that humidity hastens the degradation of MoS_2. Based on this discovery, it was hypothesized that if MoS_2 crystals are grown onto a hydrophobic substrate, the degradation rate would decrease. This hypothesis was tested by comparing the degradation of MoS_2 on Silicon nitride (Si3N4), a hydrophobic substance, to the degradation of MoS_2 on Silicon dioxide (SiO_2), a hydrophilic substance, using optical microscopy, atomic force microscopy, photoluminescence spectroscopy, and Raman spectroscopy. To quantitatively determine the hydrophobicity of each substrate, an apparatus was built to calculate the water contact angle. The results showed that the degradation of the MoS_2 on the hydrophobic substrate was significantly less than the degradation of the MoS_2 on the hydrophilic substrate. This indicated a negative correlation between the hydrophobicity of the substrate and the degradation rate of MoS_2. Understanding the implications of using different substrates to grow 2-D materials will enable improved protocols for device manufacturing, resulting in an improved manufacturing process. Optimized environments will help increase the lifespan of devices and MoS_2-based sensors, thereby saving companies the time and money spent on replacing degraded nanodevices.

Noah Bergam CC'25, Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Kathleen McKeown
Title: Legal and political stance detection of SCOTUS language

Abstract: Despite its insulation from the electorate, the Supreme Court of the United States (SCOTUS) is generally quite reactive to the politics of American public opinion. In this project, we seek to understand this behavior from a computational linguistics standpoint. Namely, we use automated stance detection models to measure the extent to which the Court's public-facing language, as expressed in oral arguments and written opinions, is political. We compare our linguistic indicators of ideology to existing metrics of SCOTUS behavior, such as the Martin-Quinn score and the Clark case salience metric. Notably, we find that justices who are more responsive to public opinion tend to use language which correlates ideologically with their voting behavior. We also find, somewhat counterintuitively, that cases which are more salient in the public eye tend to contain less political language in their written opinions. As a natural extension of our investigative use of political stance detection, we propose the more specialized task of legal stance detection with our new dataset SC-stance, which matches legal questions to SCOTUS written opinions. We approach this dataset in a zero-shot setting with large, BERT-based language models, and we find that the use of language adapters (Pfeiffer 2020) pre-trained on legal language has competitive performance with existing legal language models like Legal-BERT (Chalkidis 2020) and CaseLaw-BERT (Zheng 2020). Our method has wider implications in legal AI as it allows for a flexible and effective way to tackle domain-specific tasks which have large analogous datasets in the general domain.

Shelton Brister GS'23, Psychology

Faculty Mentor(s) or Supervisor(s): Professor Serra Favila
Title: How does memory competition influence attention?

Abstract: Attention can be guided by cues stored in long-term memory, a process called memory-guided attention. However, many of our memories are similar, creating competition between them. The present study investigated the consequences of memory competition for memory-guided attention. In the first session of the experiment, participants learned that very similar scenes were linked to circular regions in different spatial locations. This task required participants to differentiate the similar scenes to effectively learn the scene-location associations. The second session tasked participants with using the scene-location associations to guide their attention in a timed visual search task. Their job was to find a small target in each scene. If participants could remember the associations from the first session, they could predict the location of the search target in the next trial. Participants effectively learned to differentiate the similar scenes in the first session and were able to draw on their memories to improve search performance in the second session. Specifically, participants did best on the search task when targets were in locations predicted by their memory and worst when targets were in locations predicted by the similar competing memory. To test whether there is suppression of attention toward locations associated with competing memories, a follow-up study compares attention to targets in locations associated with competing memories to targets in neutral locations. These findings contribute to our understanding of the mechanisms driving memory-guided attention.

Pablo Buitrago SEAS'25, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): Professors Lauren E Marbella and Andrew Ells
Title: Optimization and Characterization of Flame-retardant TEP Electrolyte Additive in KIBs

Abstract: In an increasingly electrifying world full of next-generation battery chemistries, safety is a primary concern. Specifically, ensuring flame-retardant properties in energy storage devices without compromising high-capacity and high-power properties is of paramount importance. Triethyl phosphate (TEP) has been shown to be a powerful flame retardant electrolyte additive which we optimized for both ionic conductivity and flame-retardance around twenty percent by volume in ethylene carbonate/propylene carbonate (EC:PC) electrolyte. Our results focus on characterizing the mechanisms of TEP interactions inside the battery and analyzing possible degradation mechanisms. Our results indicate minimal solid-electrolyte interface (SEI) impedance and minimal liquid electrolyte decomposition at the volume fraction of twenty percent, thus explaining why this volume fraction is the optimum in capacity performance.
Keywords: Potassium-ion batteries, battery characterization, NMR, electrolyte chemistry, flame-retardant solvents

Sergio Zafra Butron Jr. SEAS'23, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): Professors Pamela Bjorkman and Alex Cohen
Title: Mosaic Nanoparticle Vaccine Designed to Elicit Cross-Reactive Immune Responses to Merbecoviruses

Abstract: The global 2012 MERS-CoV outbreak demonstrated the imminent risk merbecoviruses pose to public health, suggesting that such coronaviruses could follow a similar fate as SARS-CoV-2 in becoming a pandemic-level threat. Therefore, we sought to develop a mosaic nanoparticle vaccine presenting merbecovirus spike receptor binding domains (RBDs) capable of triggering broad immune responses as a countermeasure to future merbecovirus-spillover events. We constructed mosaic-8 nanoparticles co-displaying eight varying merbecovirus receptor binding domains (RBDs) alongside eight homotypic nanoparticles displaying one of each type of the eight RBDs. Immune response data from mice immunization of the mosaic-8 MERS-RBD vaccine (Mosaic 8M) against the eight homotypic nanoparticles and an admixture of those eight will demonstrate whether or not Mosaic-8M is effective at eliciting cross-reactive antibody response against the entire merbecovirus lineage. We will conduct enzyme-linked immunosorbent assays (ELISAs) and neutralization assays to characterize and detect antibody specificity and presence in the mice study. Supporting results would suggest that immunization with the mosaic-8 MERS-RBD vaccine could protect against future infection and spillover events involving a broad range of merbecoviruses.
Keywords: Vaccine Development, Imunology, Nanoparticle Engineering, Biomedical Engineering

Elizabeth Caso SEAS'24 Biomedical Engineering and Margaret Jakus SEAS'22 Biomedical Engingeering

Faculty Mentor(s) or Supervisor(s): Professor Samuel Sia
Title: Immunohistochemistry Staining of Mouse Wound Tissue to Determine Efficacy of Wound Healing Treatment

Abstract: Open wounds may lead to complications, whether from something as small as a scrape to something as large as a surgical wound. Certain wounds, such as skin wounds from diabetes, burns, and blast injuries, are considered chronic wounds due to their tendency to heal slowly or recur. Chronic wounds are more likely to get infected and have a larger impact on patient quality of life. The focus of this project is to develop a method for increasing the rate of wound repair by focused ultrasound (FUS)-mediated release of growth factors from microbeads on loaded hydrogels. This may be tested on live mouse models and analyzed using wound tissue from the first and last days of testing. By staining these tissues for various indicators of wound healing, such as for new blood vessel growth (CD31, VEGFA) and immune cells, including leukocytes (CD45), macrophages (F4/80 + iNOS or CD206), and neutrophils (NIMP R-14), the effect of the treatment on wound healing can be observed. This paper will focus on the preliminary results of these stains, as well as future steps for this project.
Keywords: Wound healing, blast wounds, chronic wounds, FUS, immunohistochemistry, GFs

Adina Cazacu-De Luca CC'24, Biochemistry and Anthropology

Faculty Mentor(s) or Supervisor(s): Professor Kimberlee Gauvreau
Title: The Effect of Neighborhood Socioeconomic Status on the Surgical Outcomes in Infants Born with Single Ventricle Heart Disease

Abstract: Infants born with hearts unable to efficiently pump blood to the body must undergo corrective surgery in the first days of life. Single ventricle heart defects affect ~1 in 10,000 newborns, have relatively high surgical mortality compared to other congenital heart defects, and require costly hospital stays and extensive follow-up care. We used data from Boston Children's Hospital between 1997 and 2017 to determine, after accounting for known risk factors such as low birth weight and prematurity, whether socioeconomic status has an effect on surgical outcomes. We used a socioeconomic status neighborhood score previously derived from US census data that incorporates income, educational attainment, and employment data. In-hospital mortality or transplant was analyzed using logistic regression. Post-discharge mortality or transplant was analyzed using Cox proportional hazards regression. Postoperative ICU length of stay was analyzed using a generalized linear model with a gamma distribution. The results highlight that low SES patients were at higher risk for mortality or transplant and longer ICU stays, even after adjusting for known risk factors.

Fiorella Chacon CC'23, Chemistry

Faculty Mentor(s) or Supervisor(s): Professor Virginia Cornish
Title: Expression of Rotavirus antigen (RTV), Norovirus (NoV), and SARS-CoV2 (RBD) in Saccharomyces cerevisiae through yeast engineering

Abstract: In humans, various microorganisms are found in the gut; Candida Albicans and Saccharomyces Cerevisiae are two different yeast strains that reside in the intestine. By taking advantage of this, an oral vaccine using S.cerevisiae can be developed by engineering strains of yeast to contain the target antigen; using this strain will render the proteins resistant to extraction and allow for safer delivery through the mucosal surface of the intestine. S.cerevisiae has GRAS status and is safe for oral use, contained across various types of products. In addition, its genetic system allows for the expression of several genes and constructs using modular cloning. During my time in Dr. Virginia Cornish's lab, Rotavirus (RTV) and Norovirus (NoV), two types of gastrointestinal disease, and SARS-CoV2 (RBD) were all cloned and expressed in S.cerevisiae. Western blotting was used to quantify the amount of protein expressed and each protein was purified through Ni-NTA columns then characterized by circular dichroism spectroscopy and mass spectroscopy. All three antigens were successfully expressed in S.cerevisiae but encountered some folding issues. The development of an oral vaccine will allow for the easier and more targeted delivery of the vaccine as the disease itself is gastrointestinal. Additionally, an oral yeast vaccine will be more accessible to third-world countries as it is more easily transportable and does not require licensed nurses or practitioners to administer it.

Haozhe Chen, Run Chen, Aruj Jain, Anushka Kulkarni, Tejasri Kurapati, Andrea Lopez, Linda Pang, Divya Tadimeti, SEAS, Computer Science

Faculty Mentor(s) or Supervisor(s): Professor Julia Hirschberg

Title: Conveying Empathy in Spoken Language

Abstract: Empathy is the ability to feel another's pain and help solve problems. In this study, we aim to understand and synthesize empathetic speech, focusing on compassionate empathy – the ability to understand another's pain as if we were having it ourselves and taking action to mitigate the problems producing it. We collected and labeled empathetic, neutral, and anti-empathetic speech on both video and segment levels. In order to understand empathetic speech from cross-cultural perspectives, we also collected and annotated Mandarin videos. With the collected data, we conducted preliminary analysis on comparing acoustic-prosodic speech features and lexical features of empathetic speech and neutral speech.
Keywords: Empathy, Speech, Spoken Language Processing, Cross-Cultural, Acoustic-Prosodic Features, Lexical Features

SooYeon Choi GS'23, Psychology

Faculty Mentor(s) or Supervisor(s): Professors Lila Davachi, Camille Gasser, John Nathaniel Thorp, Wangjing Yu
Title: Endpoint

Abstract: Previous research has investigated the impact of emotional valence on memory and cognition. For instance, positive emotion is associated with a wider scope of attention and enhanced associative memory which links multiple pieces of information. Negative emotion, on the other hand, is associated with a narrower scope of attention and memory for the details of an experience. Furthermore, memories for neutral information can be preserved by a future emotional event, implying that emotion can retroactively modulate memory for neutral information. Following up on these findings, Soo's research intends to explore how the emotional valence of the end of an experience impacts the way people subsequently remember the entire event. In this experiment, participants read four short stories with valenced endings, two with positive and two with negative. Participants then return after six hours and conduct two memory tests. They are first asked to verbally recall each story and then answer questions about specific details from each story. Soo builds two hypotheses: (1) participants will recall more details from stories with negative endings than from stories with positive endings; (2) participants will recall stories with positive endings more in order than stories with negative endings. This study is currently in the data collection stage, but preliminary results show that participants recalled significantly more details from stories with positive endings than from stories with negative endings. However, order memory did not differ across stories. These results might suggest that emotional valence affects different forms of memory in different ways.

Farihah Chowdhury CC'23, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Professor Francesca Bartolini
Title: Pathogenic Role of Tubulin Post Translational Modifications in Chemotherapy Induced Peripheral Neuropathy: Preliminary Data on changes with Oxaliplatin Induced Peripheral Neuropathy

Abstract: Chemotherapy-induced peripheral neuropathy (CIPN) is a debilitating disease that targets the peripheral nervous system and causes nerve damage and sensory and motor dysfunction in cancer patients undergoing chemotherapy. Each CIPN inducing drug has a different target but most of them affect the peripheral nervous system, suggesting that they may have similar underlying mechanisms of pathogenesis. Drugs that do not target microtubules have been shown to still effect perturbation of microtubule behavior and/or tubulin post translational modifications (PTMs). Here we asked whether oxaliplatin affects PTMs in rat models. Immunofluorescence stainings were performed on dorsal root ganglion neurons from rats treated with the chemotherapy drugs oxaliplatin and 5-Fluororacil (5-FU) in acute (24h) and chronic treatments (3wks and 6wks for oxaliplatin, 2wks and 4wks for 5-FU). The results show changes in the levels of the tubulin post translational modification (PTMs) polyglutamylation (polyE). As treatment time increased, the levels of polyE increased. These results suggest that increased polyE could induce neurodegeneration.

Carson Convery CC'25, Physics

Faculty Mentor(s) or Supervisor(s): Professor Eric Cunningham
Title: Optimized Fourier Filter for Improved Laser Amplification Simulation

Abstract: At SLAC National Laboratory's Matter in Extreme Conditions Lab (MEC), the long pulse laser system emits high-power temporally-shaped pulses, which are used to create exotic states of matter. In order to determine the temporal shape of these emitted pulses, a measurement system converts the optical intensity of the beam into an electrical signal that the researchers then record for future analysis. However, this measurement system is not perfect. Due to the pulses' extremely short duration (~10 nanoseconds) and the measurement system's frequency response dropping off at around 2 GHz,

the measured signal is distorted. Using signal processing theory, however, this distortion can be reversed with a fourier filter—the focus of this project. This is most effectively done through a "best guess" approach, where a set of optimized parameters are used to artificially create a complex frequency response that attempts to match the actual frequency response of each measurement system. The unique fourier filter divides by this complex frequency response in the frequency domain of the signal and applies a low pass filter to correct for the distortion. To test if this filter is successful, laser amplification simulations based on the Frantz-Nodvik equation were run with both filtered and unfiltered signals. Using the filtered signals as inputs, the laser amplification simulations match the data significantly more accurately than the unfiltered signals. These results suggest that the filter is successful in reconstructing temporal pulse shapes that are more physically accurate than the unfiltered signals, and thus is successful in reversing the distortion.

Devon Davey CC'24, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): PI: Professor Kevin Ochsner Grad student mentor: Zhouzhou He
Title: How do Beliefs about Social Regulation Predict the Quality and Quantity of our Social Network?

Abstract: This social psychology summer research project examines how one forms beliefs about the people they interact with in daily life. When a family member, friend, or even a co-worker in one's social network expresses they are upset, one forms beliefs about social regulation relating to proper responses to what they want and how to help them. These social regulation beliefs inform how one responds to them and, consequently, the quality and quantity of our social network. The essential social regulation beliefs that this project analyzes are an individual tendency to approach others when others are upset and an individual's beliefs about others' needs for problem-solving when they are upset. The social network measurements used a standard scale called the Social Network Index (SNI) to measure the total social network size (quantity) and high-contact social roles in a diverse social network (quality). The first hypothesis for this study was that individuals who believe they have a higher tendency to approach others when others are upset tend to have more high-contact social roles. The second hypothesis was that individuals with stronger beliefs about others' needs for problem-solving when others are upset tend to have a larger social network size. Two separate regression models tested the two hypotheses. These models found robustly significant evidence that stronger beliefs for a greater tendency to approach others when they are upset and found no evidence that stronger beliefs about others' need for problem-solving when others are upset predict social network size.

Adriana Delagarza SEAS'25, Mechanical Engineering

Faculty Mentor(s) or Supervisor(s): Professor Kristin Myers
Title: Investigating Ultrasonic Cervical Shape in Patients at Low Risk for Preterm Birth

Abstract: One of every ten babies born in the United States is born preterm. A premature baby (born before the 37th week of pregnancy) is at a higher risk of developing physical and mental disabilities like cerebral palsy and blindness. Many people who deliver preterm babies have also developed postpartum depression and anxiety. The mechanics behind premature birth—and pregnancy as a whole, for that matter—are still understudied. In preterm birth computational modeling, the structural function of the cervix is of significant concern. To study how the cervix is loaded during gestation, the Myers Soft Tissue Lab has developed a patient-specific computational solid model of the uterus and cervix. Currently, the cervix is modeled more or less cylindrically, but after analyzing transvaginal ultrasounds of 27 patients at low-risk for preterm birth, it has been hypothesized that an expansion of that model is needed. After measuring cervical diameters (anterior and posterior, relative to the central 'cervical length') and angular diversions from the cervical length, graphical representations of patient trends to identify cervical phenotypes were created. Some cervices taper from the uterine wall to the vaginal canal; some tapers turn more cylindrical; some taper then widen; some just widen, etc. It has been concluded that the cervix is not necessarily cylindrical, so in future research, incorporating different cervical phenotypes to better understand how cervical shape affects the mechanics of pregnancy is necessary in future computational simulations.

Tuan Dolmen CC'24, Physics and Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Elena Giorgi
Title: The Angular Teukolsky Equation & Spheroidal Harmonics

Abstract: A useful way of studying the differences between the predictions of Newtonian physics and general relativity is examining a set of equations called the Einstein-vacuum field equations, which describe the spacetime structure of our universe when there is no matter-field in it (i.e. when it is

Ricci-flat). The Lorentzian manifolds which satisfy these equations are called the vacuum solutions. The most popular two known solutions for these equations are the Schwarzschild and the Kerr solutions, which describe non-rotating and rotating uncharged black holes, respectively. A black hole is said to be "stable" if it's resilient to perturbations, and to determine if a black hole is stable, one needs to understand the behavior of these perturbations. The evolution of the Kerr black hole in time through perturbations of the Kerr metric is given by the "Teukolsky Master Equation." Separation of variables can be applied to the master equation, which yields two different equations: the radial equation and the angular equation, where the latter is also called the "spin-weighted spheroidal wave equation." In this project, we investigated whether we can treat this equation as an operator acting on a function such that the operator can be expressed in terms of Laplace-Beltrami operators, which would render the solutions eigenfunctions of a Laplacian. More specifically, we examined whether or not there could be a Riemannian metric for which the associated Laplace-Beltrami operator is the spheroidal wave operator given in the angular Teukolsky equation.

Nick Dutra GS'24, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Professor Kai Ruggeri
Title: Poor but not by choice(s): The persistence of cognitive biases across economic groups

Abstract: While economic inequality continues to rise within countries, efforts to address it have been largely ineffective, particularly those involving behavioral approaches. It is often implied but not tested that patterns among low-income individuals may be a factor impeding behavioral interventions aimed at improving upward economic mobility. To test this, we assessed rates of ten cognitive biases across nearly 5,000 participants from 27 countries, comparing between low-income adults and individuals that had overcome financial disadvantages as children, known as positive deviants. Using discrete and complex models, we find robust evidence of no differences within or between groups or countries. We therefore conclude without reservation that choices impeded by cognitive biases alone cannot explain why some individuals do not experience upward economic mobility. Policies must combine both behavioral and structural interventions to improve financial well-being across populations.

Krystell Susana Santiago Estrella, SEAS'25, Biomedical Engineering and Applied Physics

Faculty Mentor(s) or Supervisor(s): Professor Virginia Cornish
Title: Effectivity of fusion and recombinant proteins for yeast-platform vaccine candidates

Abstract: Vaccination has become a central topic of discussion in both the scientific community and the general public ever since the surge of the epidemics and pandemics such as the COVID-19 pandemic. There are a variety of vaccination methods and platforms readily available for usage, but the main problem that is currently being faced is the inequity of vaccine distribution around the world due to the costs of their development, transportation, and maintenance. The creation of low-cost, low-maintenance, and highly effective vaccines is imminent and should be prioritized. This goal can be achieved through the usage of yeast as a vaccine platform. Protein expression through yeast has been proven in several investigations to have the potential to be the mainstream vaccination method of the future. Immunogens and protein secretory pathways through the usage of yeast are more cost-effective than the long preparation and incubation periods needed for currently licensed vaccines which involve inactivated or attenuated versions of the diseases they fend off. Certain components of the yeasts' cells act as natural adjuvants, so this is the ideal candidate for the foundation of an adjuvant-based vaccine platform. Five protein targets/systems were investigated for the initial phase of this project. These targets were evaluated with the goal of finding the most effective protein fusions to create working yeast-expression systems along with the identification of potential candidates of a model antigen.

Aatir Fayyaz SEAS'22 Mechanical Engineering and Emily Shipley SEAS'22 Mechanical Engineering

Faculty Mentor(s) or Supervisor(s): Professor Sunil K Agrawal
Title: Dynamic Modeling of the Kipping Motion

Abstract: Kipping is a technique used in CrossFit that allows an athlete to build momentum while hanging perpendicular from a horizontal bar. The motion of kipping involves moving from an arch position to a hollow body position. This movement is driven from the athlete's shoulders and hips. Kipping helps an athlete to perform multiple pull ups and other movements without fatigue. This project uses a dynamic three-link pendulum model to

simulate the motion of an athlete kipping. Focusing on the initial arch position; we are able to achieve a desired arch trajectory using set joint positions and set link masses and lengths. From this model, we can predict the trajectory of the joint torques that are ideal for kipping.
Keywords: dynamic model; 3-link pendulum; kipping; torque projection

Ethan Feng CC'23, Chemistry and Philosophy

Faculty Mentor(s) or Supervisor(s): Professor Ruben Gonzalez
Title: The role of initiation factor 1 in the mechanism of translation initiation

Abstract: Translation is the step of gene expression in which ribosomes synthesize proteins by decoding mRNA. The initiation phase of translation, during which the two ribosomal subunits assemble at the start of the mRNA's coding region, is arguably the most important step in protein synthesis. This is because initiation is the rate-limiting step of translation and is the focal point of major regulatory mechanisms in the cell. In bacteria, three initiation factors, known as IF1, IF2, and IF3, bind to the ribosome and facilitate initiation. Of the three, the role and mechanism of IF1 remains the most poorly understood. Here, we have hypothesized that a region of IF1 comprised of a positively charged arginine (R) residue sandwiched between two large, hydrophobic isoleucine (I) residues (I44, R45, and I46) plays a crucial role in the function of IF1 through an electrostatic interaction with the negatively charged 16S ribosomal RNA (rRNA). To test this hypothesis, we have generated a series of IF1 mutants in Escherichia coli in which we replaced the positively charged R45 with a neutral or negatively charged residue, or in which the large I44 and I46 are replaced with smaller, less sterically constrained residues. We show that E. coli strains expressing these mutant IF1s instead of wild-type IF1 grow significantly slower than the control wild-type strain. Moreover, we show that the amount of fully initiated ribosomes in the strains expressing the mutant IF1s is drastically decreased relative to the wild-type. The fact that perturbing this region of IF1 disrupts initiation so severely indicates that the region plays an important role in the function of IF1 in initiation. This conclusion is supported by structural studies in the literature showing that R45 forms a direct interaction with the universally conserved adenine base A1493 in the 16S rRNA; this base is known to undergo important conformational changes during initiation, which we propose may be modulated by R45. Collectively, our results provide a basis for further investigation of the mechanistic role of this interaction using in vivo and in vitro single-molecule biophysical techniques.

Samuel Freiberger CC'23, Physics

Faculty Mentor(s) or Supervisor(s): Professors A.O. Nelson and Carlos Paz-Soldan
Title: Shape Optimization for Negative Triangularity Plasmas

Abstract: Modeling of trapped particle bounce points in negative triangularity equilibria is performed in order to optimize plasma shaping parameters such that trapped particles bounce in the good curvature region. The study uses equilibria generated by the ECOM code to gauge which shaping parameters have the greatest influence on particle trapping. The fraction of the trapped particles that bounce in the good curvature region of negative triangularity (NT) equilibria are then compared with those in positive triangularity (PT) equilibria via a model that approximates particle orbits as being constrained to flux surfaces and then compares the energies of particles in a Maxwellian velocity distribution to the toroidal field strength along the flux surfaces to determine the effect of triangularity on good-curvature particle trapping. Initial results indicate NT equilibria having a larger portion of their trapped particles in the good-curvature region. Further, we have simulated these equilibria using the MAST-U coil configuration to begin determining the feasibility of future experimental runs for these shapes. This project is ongoing, and next steps include performing profiling of the pressure, density, transport, and other metrics as well as further simulation of particle orbits and iteration with the General Atomics gsdesign code.
Keywords: Plasma physics, fusion, negative triangularity

Pranav Garimidi CC'24, Computer Science

Faculty Mentor(s) or Supervisor(s): Professor Tim Roughgarden
Title: Delegated Auctions

Abstract: There is a rich literature on studying auctions where different parties are competing to acquire a single item or a set of items. Traditionally each party has a single valuation function over the items being auctioned off and submits bids for themselves to the auctioneer. We study a variation on this setting where instead of individuals participating themselves, individuals join together into groups and have a representative bid on the groups behalf. In this setting only one of the groups can win the item, but if a group wins the item they can distribute the item to as many individuals in their group as they want. In line with the traditional literature, we study auction mechanisms that maximize social welfare and admit dominant-strategies for individuals within each group to report their true valuation to their group's delegate. For the

single item case where each individual in a group has a binary valuation over whether or not their group wins, we construct such a mechanism that admits a log n approximation (where n is the number of groups) of the optimal social welfare and show that this is the best any such mechanism could hope for. We complement this result with negative results showing that in the multi-item setting where individuals within a group have more complicated valuation functions than additive, no truthful mechanisms can hope to achieve any reasonable approximation of the optimal social welfare.

Scott Geng CC'23, Computer Science and Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Carl Vondrick
Title: Zero-Shot Adversarial Robustness for AI Vision
New Abstract

Abstract: Pretrained large-scale vision-language models like CLIP have exhibited strong zero-shot generalization over unseen tasks. Yet imperceptible adversarial perturbations can significantly reduce CLIP's performance on new tasks. In this work, we identify and explore the problem of adapting large-scale models for zero-shot adversarial robustness. We first identify two key factors during model adaption—training losses and adaptation methods—that affect the model's zero-shot adversarial robustness. We then propose a text-guided contrastive adversarial training loss, which aligns the text embeddings and the adversarial visual features with contrastive learning on a small set of training data. We apply this training loss to two adaptation methods, model finetuning and visual prompt tuning. Overall, our approach significantly improves the zero-shot adversarial robustness over CLIP, seeing an average improvement of 31 points over ImageNet and 15 zero-shot datasets. We hope this work can shed light on understanding the zero-shot adversarial robustness of large-scale models.

Aryan Ghotra CC'25, Biology

Faculty Mentor(s) or Supervisor(s): Professor Liza Pon
Title: Crosstalk Between the Unfolded Protein Response in ER Stress Induced Lipid Droplet Microautophagy

Abstract: 30% of the proteins that are present in eukaryotic cells are translocated into the endoplasmic reticulum (ER) where they undergo folding to their final 3D conformation. Defects in protein folding can lead to ER stress, characterized by the accumulation of toxic, misfolded proteins in the organelle. The unfolded protein response (UPR) is the process by which the cell responds to ER stress by upregulating pathways to promote correct protein folding or degradation of proteins that are damaged beyond repair. A newly identified pathway, microlipophagy (microautophagy of lipid droplets), also responds to ER stress but in a different manner: ubiquitinated misfolded proteins are carried by lipid droplets (LDs) to lysosomes for degradation. However, regulators for microlipophagy and its connections to other ER protein quality control mechanisms such as the UPR still remain unknown. Ire1p, a required transmembrane protein for functional UPR, was deleted in Saccharomyces cerevisiae cells (Ire1Δ). Cells were tagged with Pho88-GFP, a transmembrane ER protein marker, and Erg6-mCherry, a lipid droplet membrane protein marker. Cells were treated with 1mM Dithiothreitol (DTT), a reducing agent that prevents disulfide bridge formation, and incubated for 3hr at 37℃ in mid-log phase. Ire1Δ+DTT cells showed large lipid droplets with a >2 fold increase in lipid droplet volume compared to WT+DTT cells ($p<0.0001$) implying that microlipophagy is upregulated. Future studies can be aimed at finding the transcription factor responsible for upregulation of microlipophagy. This could lead to the treatment of diseases caused by misfolded protein aggregations.

Devin Golla, SEAS'23, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): Professor Cory Abate-Shen
Title: Investigating the function of NKX3.1 in prostate tissue differentiation by analyzing transcriptomic profiles

Abstract: Nkx3.1 is a transcription factor involved in tissue patterning and cellular differentiation, and is one of the earliest markers of prostate development. The NKX3.1 gene is of interest because it is downregulated in roughly 80% of prostate cancer cases, and is considered an early indicator of prostate cancer. The goal of this project was to validate previous observations of genetic alterations mediated by NKX3.1 loss in the prostatic epithelium that impair cellular differentiation and contribute to the promotion of prostate cancer. Transcriptomic data collected by previous RNA-Seq experiments in human cells and mouse tissue recombination assays were analyzed using the DESeq2 analysis pipeline, in order to observe differences in patterns of gene expression related to NKX3.1 loss. Using two separately collected datasets of gene counts from human RWPE1 cells, either infected with NKX3.1 lentivirus (Nkx3.1+/+) or a control vector (Nkx3.1-/-), heat maps were generated that corroborated the previously observed upregulation of a number of genes related to prostate differentiation in cells expressing NKX3.1. The

DESeq2 tool was used to analyze expression profiles of prostate differentiation-related genes in a number of mouse tissue recombinants, and additional heat maps were generated suggesting a similar correspondence between the expression of NKX3.1 and the differentiation of tissue into prostate tissue. Furthermore, the GSEA pathway analysis tool was used to observe the enrichment profiles of the RWPE1 transcriptomes, in order to begin to explore correlations between NKX3.1 expression and the expression of genes related to a range of different metabolic functions.

Julia Goralsky CC'25, Biochemistry and Comparative Literature

Faculty Mentor(s) or Supervisor(s): Professor Jaewon Min
Title: Examining the Impact of WEE1 and PKMYT1 Inhibitors on ALT Cancers

Abstract: To ensure their unlimited replicative capacity, 15% of cancers employ a telomere maintenance mechanism called the alternative lengthening of telomeres (ALT). Due to the limited molecular understanding of this mechanism, the efficacy of WEE1 and PKMYT1 inhibitors, therapeutics that target cell cycle checkpoints, on ALT cancers has yet to be determined. Given that WEE1 and PKMYT1 inhibitors promote DNA damage accumulation that leads to apoptosis or cell death, it is uncertain if the inhibition of DNA damage repair pathways within these ALT-positive cancer cells could, as hypothesized, increase the success of these therapeutics. This study employed cell viability assays, microscopy, and C-circle assays to compare the effectiveness of WEE1 and PKMYT1 inhibitors and elucidate their interaction with the DNA damage repair pathways associated with the SMARCAL1 gene and polymerase kappa. As a result, the ALT-positive U2OS cell line demonstrated increased sensitivity to the WEE1 inhibitor, MK-1775, in comparison to the PKMYT1 inhibitor, RP-6306, for treatment concentrations under 0.8 micromolar. In comparison to the wild-type U2OS cells, the polymerase kappa knockout clone predictably demonstrated increased susceptibility to therapeutic treatment, particularly with RP-6306, even as the SMARCAL1 knockout clone unexpectedly demonstrated decreased susceptibility to therapeutic treatment in concentrations above 0.16 micromolar. Although further trials are essential to justify these observations in a statistically significant manner, these findings support the inclusion of select inhibitory agents of DNA damage repair pathways, including those associated with polymerase kappa, in combination with WEE1 and PKMYT1 inhibitors in ALT cancer treatments.

Lauren Goralsky CC'25, Biochemistry and Comparative Literature

Faculty Mentor(s) or Supervisor(s): Professor Ameeta Kelekar
Title: A Novel Role for FBP1 During Early T cell Proliferation

Abstract: Most cells increase glucose uptake and accelerate glycolysis during growth, and T lymphocytes are no exception, undergoing a proliferative burst upon antigen stimulation. Preliminary evidence suggests fructose 1,6-bisphosphatase 1 (FBP1), a gluconeogenic enzyme, may also be active in T cells following receptor co-stimulation. This is surprising given that gluconeogenesis, occurring primarily in liver and kidney cells, is the reverse of glycolysis, producing rather than consuming glucose. Additional evidence demonstrates that a shorter isoform of FBP1 may be a functional enzyme. It is hypothesized that FBP1 activity is required early in stimulated T cells to enhance glucose entry into the pentose phosphate pathway (PPP) to generate NADPH responsible for mitigating oxidative stress. Build-up of reactive oxygen species (ROS) can disrupt homeostasis, leading to DNA damage or cell death. Western blot data from CD8T cells demonstrate that the shorter isoform is upregulated within 24 hours of stimulation but undetectable after 6 days, suggesting FBP1 activity is not required at later times. Cell proliferation rates and ROS levels, measured at these time points, support the hypothesis. Preliminary studies demonstrate high FBPase activity, represented by colorimetric detection of conversion of F1,6P to F6P, in 24h-stimulated CD8T cells, further supporting the hypothesis. The research suggests a novel role for FBP1 in cell proliferation, potentially explaining the elimination or mutation of the FBP1 gene in many cancers.

Sophia Guizzo SEAS'24, Applied Physics

Faculty Mentor(s) or Supervisor(s): Professor Paz-Soldan
Title: Electron Beams for Cryogenic Pellet Ablation

Abstract: One major area of focus in fusion research is effective disruption mitigation strategies that can halt disruptions in fusion reactors like tokamaks. One method for stopping disruptions is injecting a cryogenic pellet deep into the core of the reactor to cool the runaway electrons. Therefore, a quantitative

description of how pellets ablate (burn up) while passing through a plasma is strongly desired by fusion scientists. The Columbia Plasma Physics Lab is working on developing a laboratory setup to measure pellet ablation at Columbia using a high-energy electron beam to ablate frozen pellets. The electron beams will mimic a plasma but have much more controllable properties. The focus of this project was to perform computational analysis using theoretical pellet ablation models to determine the correct parameters for the electron beam and the viability of different pellet materials and setups. The project primary focused on hydrogen and noble gas pellets, and investigated the effect of the electron beam energy, current, and spot size on the expected percentage of the pellet that would be ablated.
Keywords: Plasma, Disruption mitigation, Ablation, Cryogenic pellet, Electron beam

Brianna Han SEAS'25, Computer Science

Faculty Mentor(s) or Supervisor(s): Professor George Dragomir
Title: Using Stochastic Models to Characterize the Metastatic Progression of Breast Cancer

Abstract: Due to the biochemical, physiological, and genetic complexity of cancer metastasis, a deterministic model which accurately predicts metastatic progression of breast cancer is not currently feasible. Therefore, we utilized a probabilistic approach, modeling the presence of cancer at sites within the body as states in a Markov chain. We used a transition matrix to represent the probabilities of metastasis from one site to another. The algorithm used to obtain such a transition matrix is inspired by an iterative adjustment method used in the analysis of lung cancer metastasis. Additionally, we sought to improve current models by further developing Monte Carlo simulations to more adequately account for a patient's metastatic history. After running 1000 simulations, we recorded the average time that each site was first reached. We were able to deduce other clinically relevant information from our simulations, such as the most likely metastatic pathways given metastases at specific sites.

Elise Han, SEAS'25, Computer Science

Faculty Mentor(s) or Supervisor(s): Professor Chi-Min Ho
Title: Image Processing and Data Analysis for Cryo-electron Tomography of P. Falciparum Parasites

Abstract: Using *in situ* cryo-electron tomography (cryoET) to directly visualize ultrastructures and protein complexes in the native cellular context will yield exciting new insights into the molecular machinery underpinning malaria parasite biology and pathogenesis. From the raw images taken by the electron microscope, we are able to use computational methods to reconstruct 3D tomograms of the sample(P. falciparum), from which we can further obtain segmented cell structures like membranes and ribosomes. We are experimenting ways to process these images to tackle noise and other inherent limitations of cryoET. One of my main projects is ribosome profiling. We carried out ribosome density calculation to find the relationship between ribosome density and distance to membranes like ppm and pvm. We also tried to explore the translational activities by locating and visualizing polysomes.
Keywords: Cryo-electron tomography(cryoET), malaria parasite, image processing, data analysis

Yilun (Bobby) Hua CC'23, Computer Science and Mathematics-Statistics

Faculty Mentor(s) or Supervisor(s): Professor Kathleen McKeown
Title: AMRTVSumm: AMR-augmented Hierarchical Network for TV Transcript Summarization

Abstract: Despite the success of automatic summarization systems for various types of documents, dialogue summarization is still an open field of research due to dialogues' complex structures and rich interactions between involved entities. Among the common dialogue settings, TV series have arguably posed some of the greatest challenges, including longer transcripts, parallel subplots, and numerous speakers. On the other hand, fluent episode summaries for TV shows will substantially help potential viewers make their choices and current viewers follow the plot. So far, websites that provide such summaries only use human volunteers, significantly limiting the number of shows they can cover. Therefore, this project develops an effective system to automatically generate TV show summaries. Specifically, to better capture and summarize the complex dialogues in TV transcripts, this project introduces a novel graph representation for the dialogue input. This representation is based on the Abstract Meaning Representation (AMR) proposed by Banarescu et al. and is designed to model the diverse scenes in TV series. This project also proposes an innovative neural network architecture and a new mechanism named "cross-level cross-attention." The new system can effectively incorporate the information from individual scenes' graph representations into a hierarchical encoder-decoder neural

network, which then generates fluent summaries. Experiments on a large TV transcript dataset, SummScreen, have demonstrated the effectiveness of this proposed system.

Billy Hughes CC'25, German Literature and Cultural Studies and Linguistics

Faculty Mentor(s) or Supervisor(s): Professor Lila Davachi
Title: Time Warp

Abstract: Although we experience life as continuously unfolding, we often remember our experiences as discrete events. One theory suggests that our brain uses the context of events to create the boundaries between separate event memories. The existing literature has therefore shown participants instantaneous shifts in an underlying context to understand the event boundaries elicited by these shifts. Theoretically, however, mental context can gradually drift, rather than instantly shift, between discrete states (DuBrow et al, 2018). Several studies from the Davachi Lab have shown participants a series of objects with either an orange or purple background, with the color background acting as a proxy for the context of an event. Switches in this color then elicit an event boundary. In previous studies, these switches elicit greater source memory for the color an item was seen with, indicating stronger contextual binding at event boundaries. This is what our experiment sought to investigate. Rather than show participants objects two distinct colors, we showed objects with a range of different colors. Different blocks of trials had different levels of contextual stability. Some trials jumped all over the color wheel (i.e., red to green to purple), while others made a gradual transition between different colors (i.e., red to salmon to orange to orange-yellow).We are curious as to where the brain draws boundaries in different levels of contextual stabilities, which we determine by response time when participants are prompted to recall the order in which objects appeared. As we increase contextual stability, we expect an increase in source memory accuracy. While preliminary results demonstrate that participants are performing as expected, further data and analyses will further determine the relationship between context and memory formation.

Tanisha Jhaveri CC'23, Physics

Faculty Mentor(s) or Supervisor(s): Professor Adam Lidz
Title: An Alternative Interpretation of Extended Lyα Emission (100 - 1000 comoving kpc) Around Star Forming Galaxies

Abstract: Lyman Alpha Emitters (LAEs) are star-forming galaxies that emit Lyman Alpha (Lyα) radiation, a powerful emission line found in the spectra of galaxies. It is used extensively in astronomy, especially to probe the large-scale structure of the universe. This work presents an alternative interpretation of the extended Lyα emission around LAEs found by Kakuma et al. based on cross-correlation of Lyα radiation with Subaru/Hyper Suprime-Cam (HSC) images of LAEs at z = 5.7 (when the Universe was ~ 1 billion years old). The authors stacked the images around individually detected bright sources, allowing them to see extended, low intensity emission from both the central source and surrounding galaxies that are too faint to detect individually. They conclude that the Lyα emission surrounding a random sample of ~1000 LAEs comes from "a combination of Lyα photons emitted from the central LAE and other unknown sources, such as cold-gas streams and galactic outflow." However, this work details the results of a numerical model of the average clustered Lyα surface brightness as a function of radius, which suggests contribution from neighboring galaxies. In particular, the diffuse emission can be explained by a combination of faint, unresolved satellite galaxies (the one halo term) and neighboring galaxies in separate dark matter halos (the two-halo term). This bounds the total Lyman-alpha luminosity density from sources clustered around the central LAE, and yields limits on the total star-formation rate density from individually unresolved galaxies at a time when the Universe was only ~1 billion years old.

Brian Jiang CC'23, Physics

Faculty Mentor(s) or Supervisor(s): Professor Norman Christ
Title: Topological Diffusion in Monte Carlo Gauge Theories

Abstract: Lattice Quantum Chromodynamics (QCD) is a numerical approach for finding solutions to analytically unsolvable QCD - ex. quark - phenomena via simulations over a 4-dimensional lattice. Such simulations typically involve Monte Carlo algorithms that draw samples obeying probability distributions dictated by QCD; samples close in Monte Carlo time are strongly correlated. Here, correlations are measured with respect to the topological charge, a value representative of topological features of gluon (strong force)/quark fields, of lattice samples over the duration of the simulation. Decreasing lattice spacing, or increasing simulation accuracy,

dramatically increases correlations between neighboring lattice samples, which in turn prohibitively increases required computation time, a problem known as Critical Slowing Down. Resolving this problem requires the development of a robust mathematical model describing how topological charge correlations evolve that can be used to evaluate different lattice configurations. Here, a model is proposed asserting that correlations of topological charge obey a diffusion equation. Not only does this model consistently describe data over simulation time via analysis with two separate numerical methods, it also illustrates how topological charge moves throughout physical time, illustrating real-world QCD phenomena. A justification for this diffusion model is presented from a statistical mechanics perspective. Finally, it is demonstrated that open (rather than periodic) boundaries reduce autocorrelation times by allowing new topological charge to flow in from the boundaries, resulting in faster diffusion and ultimately more time-efficient simulations.

Jingjing Jin SEAS'21, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): Professor Daniel Esposito
Title: Analyzing Transport Properties on Oxide Overlayers with Variable Ionic and Electronic Conductivity

Abstract: The goal of my study is to model polarization curves for oxide encapsulated electrocatalysts (OECs) with multiple active sites and different transport properties. Metal oxide overlayers can act as mixed ionic electronic conductors. Understanding the mechanisms for which these oxide overlayers take an active role in electrocatalysis is very important to the development of OECs. As the figure shown below, Reactions can potentially occur at two sites: the buried interface and the outer surface, and this depends on the ion permeability and electronic conductivity of the oxide overlayer. A sandwich structure with one nanometer platinum coated on the oxide overlayer is fabricated to investigate the resistivity of oxide overlayer. This structured is fabricated in a way that only allows electron to diffuse through the plane, and all reactions would, ideally, happen at the outer surface of the structure. Sandwich structure processes additional overpotential predominantly due to overlayer ohmic resistance compared to the control sample. Thus, by analyzing the experimental polarization curves, electronic conductivity could be extracted. The results can be utilized in modeling work along with the permeability that extracted previously by our group members. Polarization curve modeled based on Butler-Volmer Equation is compared to experimental results. Using experimentally extracted transport properties, polarization curves from OEC 1D modeling and experiments shows significant similarity.
Keywords: Polarization Curve, Oxide Encapsulated Electrocatalyst

Daniela Juarez GS'23, Psychology

Faculty Mentor(s) or Supervisor(s): Professors Anna Vannucci and Nim Tottenham
Title: Feasibility and Acceptability of the Experience Sampling Method in Families Exposed to Early-Life Adversity

Abstract: The experience sampling method (ESM) involves intensive longitudinal data collection from participants in their daily lives. ESM is demanding which may compromise compliance, as was found in children and clinical samples. However, the feasibility of ESM has not been evaluated in families with children exposed to early-life adversities (ELAs), a high-risk population. This study examined the feasibility and acceptability of ESM in parent and ELA-exposed child dyads. 45 dyads (ages 11-14) completed an ESM study of affective processes. Dyads underwent a ~5-7-minute in-person training and then completed 4-5 surveys/day for 7 days via text messages. Surveys assessed context, emotions, and emotion regulation. The last survey contained questions about the feasibility and acceptability of ESM. Dyads completed the protocol with high compliance (94%). Although ELA-exposed adolescents had qualitatively lower compliance (M=88%, range=0-100%) than non-exposed comparisons (M=97%, range=88-100%), there was no statistical difference between groups, t(43)=1.81, p=.07, d=.56. There were no compliance differences between parents with ELA-exposed (M=95%, range=40-100%) and non-exposed (M=99%, range=92-100%) children. The vast majority of parents and adolescents reported that: a) the training was sufficient (parent: 97%, child: 91%); b) they felt supported by the research team (parent: 100%, child: 93%); and c) the surveys were easy to complete (parent: 97%, child: 91%). These findings suggest that ESM is feasible and acceptable in ELA-exposed youth and their parents, with potential to provide novel information about how and when parents and children can support each other.

Richard Kam SEAS'24, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Professor Nandan Nerurkar
Title: Molecular and Mechanical Cues of Gut Looping: Exploring the Role of Elastin in the Development and Regulation of Small Intestine Shape

Abstract: The unique shape of an organ arises from a combination of genes and mechanical properties that work together to shape the tissue during embryonic development. The study of organ development and shape, or morphogenesis, is useful in understanding development disorders and providing a roadmap for how replacement organs can someday be engineered in the lab. We look at the looping of the small intestine, a process where the initially straight intestinal tube is bent into its compact form within the body, which when occurring abnormally, can lead to severe birth defects in the clinical setting. The dorsal mesentery is a thin tissue that anchors the small intestine to the body cavity, and it is the mechanical interaction between these tissues that shapes the loops of the intestine. During development, the intestinal tube elongates faster than the mesentery, so the small intestine exerts tension on the mesentery, which in turn exerts a compressive force on the small intestine. This interaction gives rise to the buckling and looping of the small intestine. In order to exert the right compression on the small intestine, so as to create the exact, or stereotyped, organ shape seen across all healthy individuals, the mesentery needs to have the right amount of stiffness: if it is not stiff enough, it will not compress the small intestine, and if it is too stiff, the small intestine will not buckle and loop normally. Using the chick embryo model, we are looking at how the regulation of the gene for elastin, an elastic fiber protein, drives the development of mesentery stiffness for the correct lopping of the gut. Using immunohistological and mechanical tests, we demonstrate that the stiffening of the mesentery during gut looping correlates with the upregulation of the elastin gene. Work building on these findings will test the causality of this relationship, to understand the role of elastin in regulation of tissue stiffness during morphogenesis.
Keywords: morphogenesis, developmental biology, small intestine, elastin, biomechanics, biomedical engineering.

Tony Kim CC'23, Neuroscience and Behavior, Philosophy

Faculty Mentor(s) or Supervisor(s): Professor Maura Boldrini
Title: Spatial and single-cell sequencing integration provides preliminary spatial transcriptomic map of adult human hippocampus

Abstract: Adult hippocampal neurogenesis (AHN) is necessary for preserving cognitive and emotional functions in mammals. Previous studies have shown that the human hippocampus of aging subjects without cognitive impairments present no age associated decline in the production of neural progenitor cells and immature neurons into the eighth decade of life, despite a smaller multipotent progenitor pool (Boldrini, 2018). The occurrence of AHN in humans remains controversial, however, as other studies have failed to identify immature neuron markers. As it is possible that AHN may be implicated in neuropsychiatric disease, it is important to apply new methods to investigate the molecular features of the human neurogenic niche. Single-cell and spatial sequencing are two such examples of novel technologies to analyze cellular lineages. We implemented single cell RNA sequencing and spatial sequencing to postmortem human dentate gyrus (DG) tissue from 20 non-psychiatric and psychiatric subjects, using the Visium and Chromium pipelines from the 10X Genomics platform. The two methods in conjunction present both transcriptomic resolution of cell types, and spatial localization of such cell types. Preliminary findings from our study demonstrate the value of single cell and spatial integration in mapping gene expression in the human DG. Transcriptomic profiles from single cell sequencing indicate various cell types such as immature neurons, oligodendrocyte progenitor cells, granule neurons, etc. Integration with spatial sequencing successfully localized clusters to provide anatomical resolution. These results show promise for both identifying and localizing immature and neural progenitor pools in the human DG.

Aparna Krishnan CC'24, Biology and Statistics

Faculty Mentor(s) or Supervisor(s): Professor Andrea Califano
Title: Single cell network-based analyses defines the effect of radiation on the tumor immune microenvironment, including the response by and molecular determinants of suppressive myeloid cells

Abstract: Background: More than half of all cancer patients undergo radiation therapy (RT), which can be curative or palliative to improve cancer-specific outcomes and quality of life. Radioresistance challenges our ability to achieve a cure for all patients. To date, researchers have focused on lymphocytes to understand the immunologic response to RT. Less is known about the myeloid compartment. This diverse group of cells helps mount immunological responses, but can also be immunosuppressive. We hypothesized that our network-based analyses of single cell proteogenomic data generated from tumor-infiltrating immune cells can identify druggable proteins in pathways driving unwanted immunosuppressive changes, particularly among myeloid cells. Methods: Proteogenomic (CITE-Seq) analysis was conducted on CD45+ immune cells from unirradiated and irradiated orthotopic 4T1 murine mammary tumors three- and ten-days after

tumor irradiation. Based on select proteins' surface expression, CITE-Seq generated eight distinct clusters, including three myeloid cell clusters — monocytes, macrophages, and granulocytes. We used VIPER (virtual inference of protein activity by enriched regulon analysis), a machine learning-based algorithm that infers protein activities by taking regulatory gene expression networks and calculating the weighted expression on each protein's targets, to create functional subclusters of the eight immune-cell populations. For subclusters enriched by RT, we used OncoTreat to identify active, druggable proteins. Results: As expected, lymphocytes were depleted with radiation, especially ten days post-irradiation, validating our computational approach. Three subclusters became enriched following tumor irradiation: TAM2, PMN1, and PMN4. Antibody marker analysis have enabled us to define the immunophenotype of the three cell clusters for isolation and functional analyses. Conclusion: Suppressive myeloid subpopulations induced by radiation were identified among the immune cells. We aim to experimentally test whether drugging the aforementioned subpopulations of macrophages and granulocytes improves the overall efficacy of RT by augmenting an anti-tumor immune response.

Ope Lekan CC'23, Biology and Psychology

Faculty Mentor(s) or Supervisor(s): Professor Harris Wang
Title: Restructuring the Mammalian Microbiome Using Fecal Microbiota Transplant (FMT)

Abstract:
The human gut microbiome contains hundreds to thousands of species that interact with each other to create an equilibrium that plays a vital role in human health. Many research groups seek to better understand the nature of this equilibrium and ways in which it could be manipulated to improve human health. Fecal Microbiota Transplantation (FMT) is a therapeutic strategy in which healthy gut microbiomes are transferred to individuals whose microbiomes have entered a state of disequilibrium. In this research we investigate the factors related to Fecal Microbiota Transplant using mice model to better understand ways in which we can alter the gut microbiome. We perform Fecal Microbiota Transplants between mice containing different gut microbiomes to identify factors determining the success of these therapies.. We found a microbiome enriched with Porphyromonadaceae species could robustly engraft in recipient mice. Growth assays revealed that this microbiome carried a vast repertoire of polysaccharide degradation capabilities and this characteristic was conferred to recipient microbiomes via FMT. This study investigates the success rate of fecal microbiota transplant between different mouse microbiomes. This study not only explores factors determining FMT transplant success but also presents questions for further research like the advantage of specialization vs generalization in regards to polysaccharide breakdown across gut microbiome communities.

Zachary Lihn CC'25, Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Lev Borisov
Title: Realizing a Fake Projective Plane as a Degree 25 Surface in Projective 5-Space

Abstract: The Enriques–Kodaira classification splits smooth complex surfaces into several classes that may be studied. While other classes are understood, the class consisting of surfaces of general type still lacks a detailed classification. Fake projective planes (FPPs) are smooth complex surfaces of general type with Betti numbers equal to that of the usual fake projective plane. By the classification of Cartwright-Steger there are exactly 50 conjugate pairs of FPPs, given as quotients of the 2-dimensional complex ball by an explicit group. Explicit constructions of these surfaces as the vanishing locus of polynomial equations (an algebraic variety) have been elusive until recently, when some FPPs were embedded in 9-dimensional projective space via their bicanonical embedding. A natural question is if they may be embedded in lower dimensions. This research studies Keum's fake projective plane and uses the equations of Borisov to construct an embedding of a fake projective plane in 5-dimensional projective space as a system of 56 sextic equations in 6 variables. It also simplifies the 84 cubic equations defining the fake projective plane in 9-dimensional projective space.

Eleanor Lin CC'24, Computer Science and Linguistics

Faculty Mentor(s) or Supervisor(s): Professor Vicente Ordóñez Román
*Title:*Text-Based Prediction of Visual Complexity

Abstract: Visual complexity is of interest across cognitive science, computer science, advertising, web design, and other areas, due to the increased difficulty both computers and humans encounter in processing complex visuals. Intuitively, one might expect biases in how complex visuals are described: e.g., using adjectives like "busy" or "cluttered." This work explores the relationship between linguistic and visual complexity by asking if it is possible to predict an image's visual complexity based on its textual

description alone. This text-based approach contrasts with the majority of past work, which focuses on the images themselves, rather than their descriptions. A new automated complexity metric is introduced, number of distinct regions per image, which serves as an effective predictor of human judgments of visual complexity. Using this metric to identify complex and non-complex images from the Microsoft COCO Dataset, the authors fine-tune BERT base (a machine learning model pretrained to understand English-language text) to predict visual complexity from image captions. They find that the model is able to predict visual complexity with a high degree of accuracy, and appears to rely on vocabulary and sentence structure clues in making its predictions. This study suggests a relationship between visual complexity of images and linguistic complexity of image descriptions, which may be leveraged by machine learning models to better identify complex images. Additionally, tasks that involve both vision and language, such as automatic caption generation, may benefit from continued investigation of the relationship between visual and linguistic complexity.

Jonathan Liu CC'25, Computer Science

Faculty Mentor(s) or Supervisor(s): Professor Henning Schulzrinne
Title: Researching the benefits of a Django Web Framework over no-code alternatives for Web Applications.

Abstract: The principle goal of my research with Dr. Henning Schulzrinne was to explore optimal web application architecture for an application requiring advanced form checking and internationalization functionalities. To carry out this project, our research group developed a Django web application capable of handling the pre-approval applications for three Habitat for Humanity affiliates, with target users in low-income demographics from around the country. There were three phases to the research progression: 1) building a full-stack app with a Django frontend and API connected to a PostgreSQL database, 2) implementing sanity checking, error messages, and django form-cleaning to prevent database corruption or incorrect application processing, and 3) gauging optimal implementation of multilingual functionality using Django's gettext and translation models. In seeking to answer the question of whether to use PostgreSQL or MySQL with the Django application, we found PostgreSQL's more intensive constraints and migrations setup to better serve our relational schema, and ultimately opted for PostgreSQL. We also discovered Django's GNU gettext functionality to be a crucial component to the success of our project with a wider target audience, an advantage over many alternatives offered by "no code" movement alternatives such as Webflow. These research findings collectively impacted the non-profit organization Habitat for Humanity by providing them with functional mortgage pre-approval software, catered to the diverse demographics of its applicants. They also provide support for the use of frameworks like Django for creating websites requiring internationalization, localization, and an accommodative UI and form experience over no code/low code development alternatives.

Luke Llaurado CC'22, Biochemistry

Faculty Mentor(s) or Supervisor(s): Professor Jellert Gaublomme
Title: CRISPR-Facilitated Genetic Screening of SARS-CoV-2 Host and Viral Factors

Abstract: This summer, Luke performed host-genome wide perturbation screenings for genes necessary for SARS-COV-2 viral entry and replication to contribute to existing knowledge of the COVID-19 virus life cycle and reveal potential therapeutic drug targets for COVID-19 patients. Employing a spatial transcriptomics approach, he utilized CRISPR knockout screenings in A549 human lung carcinoma. Preliminary experiments have revealed host cell mRNA production is halted in infected cells at 48 hours post infection, making these molecules elusive to detection. Immunofluorescent staining sheds light on this phenomenon, indicating this production halt begins during early stages of viral replication as noted by formation of double stranded RNA viral replication complexes, then continues through later stages of the viral life cycle such as exocytosis of mature, replicated virus.

Andrew Lu CC'24, Computer Science

Faculty Mentor(s) or Supervisor(s): Professor Shih-Fu Change
Title: In Defense of Structural Symbolic Representation for Video Event-Relation Prediction

Abstract: Understanding the relationship between events in videos requires a model to have both factual knowledge and reasoning ability. Compared to structural symbolic representation (SSR) based methods that only use event types and argument roles of the events as inputs, existing approaches with continuous video features achieve much better performance. However, it remains an open question why even oracle event type and argument roles cannot help predict the event relation. In this project, they answer this question by bootstrapping state-of-the-art video event-relation prediction

systems. They first point out the possible reasons that SSR-based models fail to reason effectively: dataset imbalance and sub-optimal training setting. Surprisingly, a simple SSR-based model can actually yield a 20% absolute improvement of macro-accuracy over the state-of-the-art model. They further utilize the rich contextual information in the event chain and all the argument roles as extra context. To improve commonsense understanding ability, they also propose a simple yet effective way of reformulating external visual commonsense knowledge bases into an event-relation prediction format to pretrain the model. The resultant new state-of-the-art model eventually establishes a 25% macro-accuracy performance boost. They observe a significant drop in performance when incorporating video feature vectors into our model, which supports the effectiveness of structural symbolic representations. They believe these findings build a solid foundation for future research on understanding relations between events.

Xinyi Lu† SEAS

Faculty Mentor(s) or Supervisor(s): Professors Lei Shi† and Vijay Vedula*
†equal contribution; *corresponding author
Title: Generating Fibers for Patient-Specific Modeling of Left Atrium Electromechanics

*Abstract:*Atrial Fibrillation (AFib) describes a rapid, irregular beating of the left atrium (LA), and is one of the highest causes of death in the world. Besides, AFib increases patients' risk of stroke by 4-6 times on average. To study the mechanisms underlying AFib and its implications on stroke, constructing a multi-physical model for LA is essential but challenging. Earlier studies of stroke due to AFib focused on simulating blood flow using imposed LA motion extracted from medical imaging data. On the other hand, robust models of LA electromechanics are developed to study fibrillation mechanisms and rotor dynamics from a pacemaker standpoint. In this project, we aim to develop a multiphysics of LA, coupling electromechanics and blood flow interactions, and use it to simulate AFib conditions that will drive the blood flow in a fully coupled manner. As a precursor, this summer project focuses on generating fibers for the LA model using patient-specific CT data employing a Laplace-Dirichlet Rule-Based method. The LA model was created using SimVascular open-source software and a python script was developed to generate fibers on the LA model. The fibers will then be used to simulate electrophysiology and LA tissue mechanics under both sinus rhythm and fibrillating conditions to understand the hemodynamics in the left atrial appendage and its implications on stroke.

Keywords: Atrial Fibrillation, computational modelling, electromechanics

Akshay Manglik CC'25, Computer Science

Faculty Mentor(s) or Supervisor(s): Professor Chris Baldassano
Title: Idiosyncratic Encoding of Words Using the Memory Palace Technique

Abstract: The Memory Palace/Method of Loci (MoL) technique is a specialized memory technique used for memorizing long lists of items or numbers. The technique entails imagining a set of locations, such as areas of one's bedroom or living room, and tying the items that one wishes to memorize to each location by forming an association between them. MoL provides unique insights into how imagination interacts with memory. I investigated the neural response of 11 subjects using MoL to remember a set of the same 20 words and locations. I analyzed subjects' neural patterns while encoding those words using MoL and recalling that same memory, and evaluated the similarity of those patterns within and across subjects. These analyses were conducted for both the posterior medial cortex (PMC) as well as the entire brain, using searchlight analyses. I found that the pattern similarity of a subject's own encoding and retrieval patterns is higher than the pattern similarity of different subjects' encoding and retrieval patterns. This implies that MoL creates idiosyncratic memories unique to each subject, despite the items and locations being the same. Using natural language processing, I also investigated the similarity of the subjects' verbal recollection and compared it to the similarity of their neural patterns during recall. I found a weak positive correlation between semantic similarity and neural similarity, suggesting that the idiosyncratic neural pattern might be related to how people came up with their unique story.

Neha Mani CC'25, Biochemistry and Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Professor Filippo Mancia
Title: Expression and Purification of WLS and PORCN-Wnt for Structural Studies

Abstract: Wnt proteins are short-range signaling molecules that are important for cell differentiation, shape, and fate. Wnt proteins are expressed in the endoplasmic reticulum and are post-translationally modified by the addition

of a palmitoleate chain, by the O-acyltransferase porcupine (PORCN), making Wnts highly hydrophobic. They are then transported to the cell membrane by the membrane protein Wntless (WLS) before getting released and bound to receptors on neighboring cells. Both PORCN and WLS are potential drug targets for Wnt-addicted cancers. In this study, the optimization of expression and purification methodologies are reported for the PORCN-Wnt complex and apo WLS to enable structural characterization. Transient transfection was used to overexpress PORCN and Wnt in mammalian cells; the complex was subsequently purified and reconstituted into amphipols (stabilizing surfactants for membrane proteins in aqueous solutions) or nanodiscs (mimics of the phospholipid bilayer in which membrane proteins reside) for cryo-EM studies. Baculovirus was employed to overexpress WLS in mammalian cells and the protein was purified, reconstituted into nanodiscs, and bound to FAB28, an antigen-binding fragment used to help visualize small proteins, for cryo-EM studies. Through fine-tuning the protocols for expression and purification of these proteins and complexes, we hope to elucidate the structures of these integral proteins to further understand their role in Wnt signaling.

Razvan Matei CC'24, Biochemistry

Faculty Mentor(s) or Supervisor(s): Professor Eric Greene
Title: Analysis of Rad51 DNA Repair Protein Interactions with Rad52-Epistasis Group

Abstract: DNA damage happens at an extremely fast rate in our cells due to a wide array of internal and external factors, yet the human body has many mechanisms of damage repair. One of these mechanisms, homologous recombination, utilizes multiple proteins in order to repair some of the most harmful types of DNA damage. For this repair pathway to function correctly, DNA repair protein Rad51 must interact with many other proteins in the Rad52 epistasis group to carry out its role. While the kinetics of this process have been studied, the specific amino acids which interact between Rad51 and its supporting proteins are not closely studied. Recent research has identified an acidic patch on the protein in S. pombe which is of interest in other species as this patch is highly conserved amongst Rad51 homologs. In this research, we have created various Rad51 mutants to analyze this interaction, and have shown that S. cerevisiae requires this patch to be functional in order to adequately repair DNA.

Peter McMaster CC'25, Physics

Faculty Mentor(s) or Supervisor(s): Professor Frits Paerels
Title: Searching for Counterparts to Gravitational Wave Sources

Abstract: Gravitational wave observatories are now routinely detecting gravitational waves at increasing levels of precision. The result of the acceleration of massive bodies, these waves propagate through space at the speed of light, eventually reaching Earth. However, due to the nature of these observatories, they are limited in their ability to identify the location of a gravitational wave source, as they are unable to identify even in what galaxy these gravitational waves originate. To gain a deeper understanding of binary black hole merger events and interactions between massive bodies more generally, as well as to forward research into the expansion of the universe, it is necessary for these detectors to be optimized to identify the location of gravitational wave sources. Therefore, a technique has been devised that uses x-ray emissions at the source of the gravitational wave that have been scattered through small-angles by the galactic plane, with these x-rays creating a signature halo centered on the wave source. The scattering caused by the dust of the galactic plane causes a slight time delay between the arrival of the gravitational wave and the subsequent arrival of the expanding x-ray halo, which enables telescopes to examine regions of the sky for evidence of these halos. Such halos would point directly to the source of an observed gravitational wave. Using data collected by the Neil Gehrels Swift Observatory and analyzed using the CIAO software package, regions of the sky are being examined to detect the first signature halo accompanying a gravitational wave source.

Jaeda Mackayla Mendoza SEAS'23, Electrical Engineering

Faculty Mentor(s) or Supervisor(s): Professors Ioannis Kymissis and Aaron Moment
Title: Modular Continuous Ultrasonic System for Rapid and Energy Efficient Drying Technology of Ultra-fine Particles

Abstract: 2% of total energy consumption in the United States can be attributed to industrial drying processes, employing approximately 1.5T BTU of energy per year. Moreover, 30% of this energy is wasted due to the inefficiency of such processes. This project aims to develop novel modular ultrasonic technology as an energy-efficient method to drying in industrial settings. This approach involves the reduction of energy necessary for evaporation through using ultrasonic energy to weaken particle

agglomeration. Drying curves of materials through direct and indirect contact with an ultrasonic transducer were collected using a 110khz ultrasonic transducer and a 25khz ultrasonic transducer for direct and indirect drying respectively. Samples of superabsorbent polymer, a wick, apple, grape, and melon were used in experimentation. With a transducer that runs on 2.5 W, the direct drying experiments generate a 12.64x enhanced efficiency. The indirect drying experiments, on the other hand, result in a drying efficiency of 3.8% using a 0.5 W transducer. With direct drying being approximately 333 times more efficient than indirect drying, the next steps of the project will center on direct drying methods. In addition to that, future experimentation will utilize a near infrared spectrometer to precise the loss of moisture in a sample, and drying simulations created using the COMSOL Multiphysics® software will be improved to include ultrasonic energy.

Destiny Meyers SEAS'23, Civil Engineering

Faculty Mentor(s) or Supervisor(s): Professor Arindam Gan Chowdhury
Title: Investigation of Peak Wind Loads on Roof-Mounted Solar Panels

Abstract: Past hurricane events have shown that roof-mounted solar arrays are highly vulnerable to extreme wind events. As solar energy becomes a more reliable and cheaper energy source, it is crucial to understand how wind loads will affect solar arrays. Wind tunnel testing is used to simulate in-situ wind loadings using scale models of solar arrays. However, testing solar arrays using scaled models in wind tunnels can lead to an underestimation of the actual wind effects because of the inadequacy of simulating the right amount of turbulence. This research aimed to improve upon the current methodology used to study peak wind loads on roof-mounted solar arrays. This was accomplished by conducting aerodynamic tests at the Wall of Wind (WOW) experimental facility at Florida International University (FIU). A 1:60 scale model of the Hogue Technology Center (HTC) located at Central Washington University (CWU) was constructed along with a 3D printed solar array and surrounding structures located on the University's campus. At an average wind speed of 9.5 m/s, pressure data was recorded as the model rotated from 180 to 360 degrees at 5-degree increments on a turntable. Results showed that the greatest wind pressure forces occurred at oblique angles due to the generation of corner vortices. Further research involves a comparison between the results found at WOW and in-situ testing done on the HTC building.

Rosalía Minyety SEAS'24 Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Professor Tal Danino
Title: Engineering Pattern Formation To Develop Cell-Based Biosensors Readouts

Abstract: Synthetic biologists genetically engineer biological systems for practical purposes, such as cell-based biosensors to detect specific analytes and produce measurable output, leveraging cells' innate abilities to respond to external stimuli. The outputs of many cell-based biosensors are fluorescent and/or microscopic, thus requiring highly specialized and expensive detection technology. Developing biosensors by making use of the ability of certain bacterial species to form macroscopic colony patterns over space and time could result in macroscopic, easy-to-quantify readouts. *Proteus mirabilis* is a bacterium naturally capable of forming a visible bullseye pattern on a solid surface via alternating events of swarming (in which cells rapidly move together) and consolidation (when cells become immotile and divide). Previously, researchers in our lab engineered *P. mirabilis* to overexpress various swarming-related genes that visibly change the patterns in response to a common laboratory reagent, IPTG; for example, the *pLaccheW* and *pLacflgM* strains form smaller rings with higher concentrations of IPTG. Here, we characterize the engineered strains' ability to sense the analyte of interest under conditions that are common outside of lab settings, working toward proof-of-concept applications. The first application experiment focused on determining if the strains are robust enough to respond solely to a chemical of interest (IPTG) in the presence of other confounding environmental factors (such as salts, sands, etc). Thus, we exposed the strains to minimally-filtered ocean and lake water with and without added IPTG and characterized the resulting patterns. We found that the minimally-filtered water alone does not affect the patterns formed. On the other hand, when IPTG is added, the *placcheW* strain consistently responds by forming rings closer together as expected. The second application-based experiments examined whether the strains could be used in settings with temperatures different from our usual 37°C environment, by testing how the pattern formation of engineered strains is affected by the temperature in which they are grown. From this set of experiments we found that even at different temperatures, the strains *placcheW* and plac*flgM* created different patterns at 0 and 10mM IPTG, showing that they could still sense the IPTG. The strains found to be robust enough to detect IPTG under different environmental conditions will next be engineered to sense other analytes such as lactose rather than IPTG, which will help us towards our goal of using the strains' readout patterns in field settings for biosensing applications.

Keywords: Synthetic biology, biosensors, P. mirabilis, spatiotemporal pattern formation

Aviral Misra SEAS'24, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): Professors Mijo Simunovic and Jessica Zhou
Title: Stem Cell Derived Gut Models Synthesized using Biomimetic Devices

Abstract: There is a growing need for accurate *in vitro* models for a deeper understanding of complex biomedical processes and structure-function relationships. This project is focused on creating a synthetically generated intestinal model by combining developmental biology and bioengineering techniques. In this work, the engineered biomimetic devices were designed using soft lithography techniques to recreate the crypt structure of the colon. A polymeric stamp fabricated using PDMS was used to imprint the replica colonic microarchitecture into a collagen hydrogel upon a base made of a permeable diffusion membrane. Over this membrane, an impermeable polycarbonate backing with an opening in the center was attached to control the diffusion of the differentiation media into the part of the device where the cells are to be seeded. At this stage, over 30 devices have been fabricated to obtain enough *in vitro* colon models for subsequent gut experiments. Once a sufficiently large number of reliable colonic devices are fabricated, they will be analyzed using immunofluorescent (IF) and single cell profiling techniques to qualitatively and quantitatively characterize the resultant tissue. Subsequently, an anaerobic chamber will be used to co-culture the colon and the bacteria of choices to gain an understanding of the interactions and effect the bacteria has upon the colon. The achieved understanding will clarify the complexities within the gut microbiome and will open the avenues for further investigation into gut health and functions.
Key Words: embryonic stem cells; biomimetics; gut health; tissue engineering; organoids; in vitro colon model

Carlyle Morgan CC'23, Mathematics-Statistics, Economics

Faculty Mentor(s) or Supervisor(s): Professor Tian Zheng
Title: Graph Perturbation Theory for Directed Networks

Abstract: Perturbation algorithms for directed network data can add random noise to data while simultaneously preserving some desired aspects of the data. This project studied four techniques for perturbing directed network data. These techniques centered around randomly selecting two or three nodes from a natural or simulated and randomly removing or adding edges between them. One possible application of these perturbation algorithms is to test classification algorithms. Spectral clustering is one of the most popular techniques for detecting communities in network data. Spectral clustering was initially developed for use on undirected network data, but recent developments have suggested a possible framework for spectral clustering in the directed setting. This project attempted to study the stability of directed spectral clustering algorithms when the network being analyzed was subject to increasing amounts of randomization via these perturbation algorithms, as the ability of spectral clustering to detect community structure is weakened when edges are removed between nodes in the same community or when edges are added between nodes in different communities. All four perturbation algorithms exhibited differing abilities to weaken community structure in simulated graph data as measured by the similarity between the ground truth community identities of the nodes and the communities as classified by spectral clustering.

Rahul Mullick CC'24, Biology

Faculty Mentor(s) or Supervisor(s): Professor Steven Reiken
Title: Investigating the Pathophysiological Mechanisms Underlying Cardiac Complications of SARS-CoV-2

Abstract: SARS-CoV-2 is a virus that attacks the human ACE2 receptor which is primarily found in the epithelial cells of the heart and lungs. In the heart, infection of SARS-CoV-2 can lead to hypoxia, inflammation, thrombosis, arrhythmias and direct viral myocardial damage. In fact, cardiac symptoms such as chest pain and tachycardia commonly persist long-term. The aim of this study is to identify the pathological mechanisms involved in SARS-CoV-2 complications of the heart and to determine methods to prevent and treat these cardiac complications. Specifically, a major focus of this study is calcium dyshomeostasis, especially leaky type 2 ryanodine receptor (RyR2) in cardiac tissues involved in excitation-contraction coupling dysfunction. Two models are used in this study: mice with the hACE2 receptor infected with SARS-CoV-2 and human heart samples of autopsied patients who died from COVID-19 complications. Proteomic techniques are utilized to help identify changes to the cardiac proteome and isolate relevant cardiac molecular signaling pathways impacted by SARS-CoV-2 infection. Western Blot Analysis techniques are used to analyze protein expression in the cardiac proteome, including RyR2, DHPR, and calstabin (calcium channel stabilizing

subunit protein). Lastly, immunostaining is utilized to visualize areas of cellular damage or death. The results of this study provide evidence that SARS-CoV-2 infection downregulates key calcium handling proteins, causing leaky RyR2 channels. This study is ongoing and looks to further investigate these changes and possible therapeutics like Rycals (ARM210) to improve cardiac function and outcomes.

Cecilia Nemeth GS'24, Psychology

Faculty Mentor(s) or Supervisor(s): Professor Mariam Aly
Title: Cooperation and Competition in Attention, Perception and Memory

Abstract: Prior research from psychology shows that attention influences memory: you are more likely to remember things you pay attention to. Many of us experience times when we are focused on the task at hand, and other times when we are zoned out or distracted. How do these fluctuations in attention influence our memory? Are there ways to measure these kinds of fluctuations behaviorally? To answer these questions, Cecilia Nemeth designed a study this summer with her mentor, Manasi Jayakumar in Dr. Mariam Aly's lab. The study uses pupil-size measurements from an eye-tracking device to characterize attentional fluctuations. These attentional fluctuations are then related to memory performance. The study consists of three phases. In the first phase participants are shown a series of images while their pupil size is measured continuously. In the second phase participants complete a simple math task as a distractor. In the third phase participants are asked to verbally recall as many images as they can from the first phase. Attentional fluctuations identified in the first phase using pupil-size changes are then related to memory in the third phase. Over the summer, Cecilia helped with the curation of images, running participants on the study, and transcribing verbal recall. Through this experience, she developed an understanding of attention and memory research, learned about eye-tracking and pupillometry methods, and the importance of controlling for external factors while running behavioral experiments in psychology.

Justine Nicholson GS'24, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Professor Daphna Shohamy
Title: Cognitive Reframing in Learning and Decision-Making

Abstract: Our ability to successfully approach stimuli that are rewarding and avoid those that are harmful is crucial for navigating our environment. However, many psychiatric disorders involve an apparent shift in adaptive approach and/or avoidance behavior. Such is the case with Anorexia Nervosa (AN) in which food, an innately rewarding stimulus, is paradoxically avoided. Although it may seem that harm avoidance is at play here, surmounting evidence has implicated reward-seeking processes may be at play in AN symptomology. This inconsistency between reward-seeking and harm avoidance not only applies to AN patients – it has been a prominent topic of research with other disorders and in healthy individuals as well. There has been much progress around reward learning and its neural mechanisms. However, at question still is whether the mechanisms underlying reward-seeking vs. harm-avoidance rely on distinct versus overlapping circuitry in the brain and their association to the development and maintenance of maladaptive functioning in psychiatric disorders. Indeed, there is continued controversy over this relationship. This project addresses this incongruence. It aims to address past inconsistencies in the literature by formally defining how harm avoidance, in some cases, can be subjectively reframed as a reward. The study hypothesizes that using computational methods for quantifying and isolating this subjective reframing will allow one to better disentangle and clarify their neural underpinnings and examine individual differences. Furthermore, this investigation aims to further our understanding of various psychiatric conditions and illuminate how an objectively worse outcome (e.g., the avoidance of food, a stimulus necessary for survival) can be subjectively reframed as rewarding, such as in AN. This past summer, under the mentorship of Dr. Daphna Shohamy and Dr. Jenifer Siegel, Justine Nicholson (jsn2143@columbia.edu) assisted in this project, employing an integration of computational modeling, neuroimaging (fMRI), and behavioral analysis to test this hypothesis. This investigation involved the recruitment of human participants and fitting trial-by-trial learning models to subjects' choice behavior and associated neural systems in a reinforcement learning task. This study offers an integrative computational framework to better understand reward-seeking vs. loss avoidance behavior, which more broadly contributes to a better understanding of psychological disorders and how the brain works.

Ana Carolina Oliveira CC'23, Physics

Faculty Mentor(s) or Supervisor(s): Professor Elisabetta Bissaldi
Title: Time-resolved Spectral Analysis of Fermi GBM Bursts Using GBM Data Tools

Abstract: Gamma-ray bursts (GRBs) are the strongest and most luminous explosions observed in distant galaxies, consisting of the most energetic form

of electromagnetic radiation. GRB events behave very differently from each other and have very strong spectral evolution. Because of that, it is interesting to divide each event into multiple optimal time ranges and perform the spectral analysis individually in each section. This time-resolved spectral analysis helps capture important features of the burst and allows for a better understanding of the physical properties and emission mechanisms of GRBs. In this project, a Python-based pipeline was developed to automatically perform such time-resolved spectral analysis using the Bayesian block binning technique within the GBM Data Tools framework, an API used for analysis of data observed by the Fermi Gamma-ray Burst Monitor (GBM) instrument. The algorithm provides a significant speedup to the process, allowing the user to quickly perform the analysis on multiple events at a time. The pipeline is tested on 20 out of the 25 brightest bursts from the 14 years of observation of the Fermi GBM instrument, resulting in a total of 892 time bins analyzed. Distributions of parameters, statistics of the parameter populations, parameter-parameter and parameter-uncertainty correlations from this analysis are obtained and presented as the result of the project.

Nicolas Ouporov CC'23, Computer Science and Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Shuran Song
Title: Conditioning Robot-Human Handover on Human Object Pose and Delivery Preferences

Abstract: Despite recent advancements in robot automation, the field still lacks a comprehensive solution that can integrate fluidly and safely with humans, especially in tasks with direct interaction. In practice, most robots are relegated to configuration spaces that are separated physically from humans. The field of human-robot interaction (HRI) attempts to bridge this gap by designing robotic systems that successfully model human activity and are able to share workspaces and collaborate on tasks. A common focus of these systems is handover, the process by which an object is transferred from between human and robot agents. Previous studies have shown that, for robots, human-like behavior is crucial to handover success and work has emerged that successfully optimizes robot trajectories to accommodate these ergonomic preferences. However, current HRI research ignores the object pose during handover by the robot, an aspect that psychological studies have shown is critical to the human comfort level and overall success of robot-to-human handover. In this work, we make critical advances in this problem, developing a motion planner that uses multimodal deep learning approaches to predict possible human grasps on an object and filters the robot gripper positioning to accommodate human preferences. In addition, the planner uses human joint prediction and a joint motion model to further optimize for ergonomics and human-like behavior during handover. Initial simulated results show that this method provides robot grasp positions that successfully accommodate many possible human grasps, suggesting a promising new direction for human-robot handover systems that incorporate a knowledge of human-object dynamics.

Stella H Park SEAS'24, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Professors Megan Schertzer and David A. Knowles
Title: Long Read Analysis Pipeline Predicts RBPs with Isoform-specific Functions

Abstract: Alternative splicing (AS) plays a critical role in gene regulation and protein expression by generating different messenger RNA (mRNA) isoforms from the same pre-mRNA. AS is tightly associated with RNA binding proteins (RBPs), as RBPs bind to genetic sequences and regulate RNA processing. Importantly, RBPs often regulate AS of their own transcript and the pre-mRNA of other RBPs, so that the majority of RBPs are expressed as more than one isoform. Because AS typically results in different protein products, it is very likely to affect the downstream function of RBPs, but studies of isoform-specific RBP functions are limited. Here, we aim to identify annotated and novel RBP isoforms across different tissues, predict downstream functional effects based on amino acid sequence, and test them in human cells. To identify high-confidence isoforms, we analyzed 96 PacBio long-read RNA-seq datasets from the ENCODE consortium using a customized FLAIR pipeline. First, similar to the standard FLAIR pipeline, we aligned and corrected reads, then grouped them by their splice junctions to return credible isoforms. However, our analysis differs in that we filtered reads more stringently and ignored the 5' and 3' untranslated regions (UTRs). Next, we used NCBI's ORFfinder to identify the amino acid sequence of each isoform. We identified a total of 22,723 annotated and novel RBP isoforms, with an average of 14 isoforms per RBP. For example, we identified 5 annotated and 40 novel isoforms of RBFOX2, which is a well-studied splicing factor. Approximately two-thirds of the RBFOX2 isoforms lacked both the N and C terminal nuclear localization signals, which we predict will affect protein localization, and thus have downstream consequences for genes with RBFOX2-dependent splicing. Additionally, two RBFOX2 isoforms

differed in the highly conserved RNA binding domain, which we expect to affect RNA recognition and affinity. To test downstream functions of these isoforms, we will express six FLAG-tagged RBFOX2 isoforms in human stem cells. We will use a FLAG antibody to perform isoform-specific RNA-immunoprecipitation, IP-mass spectrometry, and western blot to investigate differences in RNA binding, co-factor binding, and protein localization, respectively. Overall, our method provides a reliable strategy to identify and mechanistically investigate isoform-specific functions of RBPs.
Keywords: Long-Read RNA-seq, RNA binding proteins, isoform-specific study

Kayla Pham CC'26, Chemistry

Faculty Mentor(s) or Supervisor(s): Professor Shreya Goel
Title: Development of Fluorescent Ultrasmall Porous Silica Nanoparticles for Targeting Peritoneal Metastatic Tumors

Abstract: Peritoneal metastasis (PM) is advanced malignancy commonly observed in ovarian, gastric, and colorectal cancer. The current standard of care involves cytoreduction surgery and hyperthermic intraperitoneal chemotherapy with success rates dependent on the completeness of tumor removal. However, difficulty in precise detection and complete resection of microscopic tumors is challenging. Thus, it is vital to develop imaging probes to improve cytoreduction surgery treatment outcomes. Silica nanoparticles have gained widespread interest as diagnostic imaging tools due to low toxicity, biodegradable nature, and tunable pharmacokinetics . Our lab has reported the synthesis of ultrasmall porous silica nanoparticles (UPSNs) that were designed to increase tumor site accumulation while preventing sequestration by the reticuloendothelial system. In this study, we report a novel UPSN – based probe for fluorescence-guided surgery (FGS) of PM. UPSNs were conjugated to a fluorescent dye (Cy5) and the conjugates (USPN-Cy5) were injected in a murine PM model of CT-26 colon cancer to test their efficacy for FGS. Our characterization data show uniform synthesis of UPSN; hydrodynamic size ≈ 15.31 ± 0.35nm (PDI ≈ 0.045 ± 0.0056), zeta potential (16.56 ± 0.25mV), and good stability over 25 days. In vivo studies in CT-26 tumor bearing mice indicated that UPSN-Cy5 (HD ≈ 14.52 ± 0.63nm, PDI ≈ 0.067 ± 0.0072) accumulated selectively at the site of metastatic nodules with reduced accumulation in off-target sites. Overall, we performed a systematic study to synthesize, characterize, and biologically validate a new imaging agent. UPSNs hold promise as a novel intra-operative differentiation tool for FGS in cancer treatment.

Aida Razavilar CC'23, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Professor Peter Canoll
Title: Investigating Neurons at the Margin of Glioma: Structurally and Functionally

Abstract: Gliomas are the most common malignant central nervous system tumor, and neurons are emerging as a critical component of the tumor microenvironment. Recent studies have revealed that crosstalk between glioma cells and the brain microenvironment is a crucial regulator of cancer initiation and progression, yet exactly how neurons change as a consequence of glioma, both structurally and functionally, is not well understood. AZD8055, a competitive dual mTORC1/2 inhibitor, has been shown to not only be a key regulator of neuronal excitability but also to have anti-tumor effects in mouse models of glioblastoma. We have previously shown that AZD8055 suppresses neuronal hyperactivity in acute slices of this tumor model, yet little is known of its direct in-vivo effect on neurons at the infiltrative glioma border. One method of driving neuronal activity in mice is via sensory whisker stimulation. Specifically, we sought to quantify differences in dendritic spine density following chronic (t=6hr) whisker stimulation in three treatment groups (n=3) including non tumor bearing mice and tumor bearing mice who either administered or not administered AZD, an mTOR inhibitor. In-vivo two photon imaging of the brain allows for investigation of spatiotemporal patterns of specific cell types, and of great interest is the ability to perturb this cellular activity with various modes of sensory stimulation as well as local drug delivery. The ability to chronically follow a particular group of cells and their responses to these perturbations, such as prior to and after drug delivery, over time is critical for understanding progressive cognitive and neurological changes during disease and/or learning. In different disease contexts, stimuli evoked sensory responses are often disrupted. Separately, learning and reward responses/behaviors are also altered in various disease contexts. Here we present details of the mechanics, electronics, surgical approach, and behavioral programs for a novel methodology of chronic in-vivo 2 photon imaging in mice with multisensory stimulation, reward, and local drug delivery which synthesizes and combines numerous previously reported imaging methodologies into one singular platform. The current build allows for auditory stimulation in the range of 5-20 kHz, tactile stimulation via whiskers, gustatory stimulation via lickport, and drug delivery via cannulation. All electronics are routed through a custom circuit board also connected to the image acquisition computer to synchronize in time. Our first application of this system is to observe functional alterations in brain activity and sensory based learning in glioma associated neurons.

Understanding these changes as a result of this neural-cancer crosstalk can help to devise more effective therapies for tumor associated cognitive decline and otherwise treatment resistant malignancies.

Lillian Rountree CC'23 Statistics (in collaboration with Sadie Klaus and Wynna Huang)

Faculty Mentor(s) or Supervisor(s): Professor George Dragomir
Title: Tuberculosis transmission in United States correctional facilities pre- and post-2020

Abstract: The main objective of this study is to model the transmission of tuberculosis among incarcerated populations in the United States to explore potential impacts of SARS-CoV-2 pandemic regulations on TB's disease burden. This was done using the Wells-Riley model, originally developed for tuberculosis transmission and used in previous studies for prison settings. Our model follows a previous study about the spread of tuberculosis within Brazilian prisons, but expands the existing Wells-Riley model for application on a state-wide, rather than facility-wide, scale. Using data on the number of confirmed TB cases per year alongside regulations on the dimensions of cells and prison common areas, we created functions pertaining to the number of infectors as well as the ventilation rate within various facilities to estimate key parameters for the overall model. Our analysis showed that the onset of the SARS-CoV-2 pandemic did not lead to a significant change in TB transmission rates, and that the probability of transmission does not appear correlated to how overcrowded a facility is.

Ava Sanjabi CC'25, Chemistry

Faculty Mentor(s) or Supervisor(s): Professor Brent Stockwell
Title: Orange for a Red Planet

Abstract: This project focuses on in situ measurements of samples from lava fields in Vulcano, Italy, highlighting the methodology and resulting data captured by in-field laboratory instruments. The goal is to investigate the site as a Martian analogue with respect to the secondary mineralogy and biological components of the area. The focus of these astrobiology experiments is to identify minerals and compounds that are indicative of life, past or present, specifically carotenoids, which are often yellow-orange pigments and relevant for life in extreme environments. The field measurements were gathered during an expedition that is linked to a summer school in Vulcano. The instrument suite included a portable Raman spectrometer and a Mini-PAM (Pulse-Amplitude-Modulation). The portable Raman has a laser of 532 nanometers (the same wavelength used on Mars 2020 Perseverance Rover), which is used to identify minerals and organic molecules in the field. The Mini-PAM is used to determine photosynthetic activity by detecting the presence of chlorophyll in organic material. The landscape of this region is useful as it could be analogous to early Mars and Venus due to its volcanic activity. The findings from the field measurements are useful in refining spectroscopy techniques and analyzing microbial colonization. Preliminary results show the presence of carotenoids and photosynthetic pigments, which are believed to have originated from bacterial life. Field instruments, like the ones used in this work, are essential for developing future extraterrestrial missions and understanding data from current missions.

Eva Savin CC'25, Physics and Earth and Environmental Sciences

Faculty Mentor(s) or Supervisor(s): Professor Georgia Karagiorgi
Title: Searching for sterile neutrinos at MicroBooNE and SBN through muon to tau neutrino oscillations

Abstract: Neutrino oscillations have been understood through positing the existence of three distinct mass states, each being a mix of electron, muon and tau neutrino, in different proportions. However, a number of experimental anomalies suggest the existence of a fourth, relatively light and mostly "sterile" neutrino mass mass state that cannot interact with matter in standard ways—a sterile neutrino. This hypothesis is being tested by the Short Baseline Neutrino (SBN) and MicroBooNE experiments at U.S. Fermi National Lab. Searches of oscillations caused by light sterile neutrinos in these experiments have been limited to searches for muon neutrino and electron neutrino appearance or disappearance. The goal of this project is to develop the first search for muon neutrino to tau neutrino oscillations (tau neutrino appearance) due to light sterile neutrinos in SBN. This poster will present a preliminary muon neutrino to tau neutrino oscillation sensitivity assuming statistical only uncertainties and optimistic background rejection, and discuss the strategy for differentiating tau neutrino signal from potential mis-identified background. Work is in progress to investigate the strategy and develop a reconstruction-based selection and analysis that can be applied to SBN.

Isabelle Seckler, CC'23, Environmental Biology

Faculty Mentor(s) or Supervisor(s): Professor Laura Duvall
Title: Regulatory effects of insulin and NPY-like signaling on mosquito attraction to humans

Abstract: Aedes aegypti mosquitoes are deadly disease vectors, infecting millions annually with pathogens that cause diseases including Zika, dengue, and chikungunya. Female Ae. aegypti require vertebrate blood to develop eggs and complete a reproductive cycle. The evolutionary pressure to find and bite a host drives robust attraction to humans. After a complete blood meal, female host-seeking is dramatically suppressed, a temporary behavioral phenomenon that could be exploited for vector control. Several signaling pathways activated by a blood-meal are implicated in regulating biting behavior, but the biological mechanisms underlying suppression remain unclear. Recent work showed that activation of a conserved neuropeptide Y-like (NPY-like) receptor, known to regulate satiety, can suppress mosquito attraction to human hosts. Genetic and pharmacological manipulations of NPY-like signaling disrupt blood digestion, host-seeking, and nutrient-sensing. In mosquitoes insulin-like peptides coordinate blood digestion and physiological preparations for egg development, but a role for insulin in host-seeking behavior has yet to be established. My project will investigate how insulin and NPY-like signaling pathways interact to alter mosquito behavior after a blood-meal. To understand if insulin acts in a parallel or downstream pathway to NPY-like signaling, we are pharmacologically manipulating insulin and NPY-like pathways together and independently to determine behavioral effects on host attraction. Resolving the interaction between insulin and NPY-like pathways will help us understand how these pathways coordinate to produce behavioral suppression.

Ratna Sharma SEAS'25, Biomedical Engineering and Neeraj Sakhrani SEAS, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Professor Clark T. Hung
Title: High Glucose-Induced Oxidative Stress Impairs Proliferation and Migration of Healthy Human Synovial Fibroblasts in the Development of Diabetic Osteoarthritis

Abstract: Osteoarthritis (OA) is a degenerative joint disease characterized by synovial inflammation. The prevalence of type 2 diabetes mellitus (DM) has been associated with the progression of OA. DM is characterized by chronic hyperglycemia due to insulin. The impact of sustained high glucose environments due to DM has been shown to inhibit wound healing, increase cytotoxicity and apoptosis, and cause secretion of oxidative stress markers such as reactive oxygen species (ROMO1) and advanced glycation end products (AGEs) in the diarthrodial joint, contributing to OA pathogenesis. However, the effect of hyperglycemia on the metabolic and structural properties of synovium has not been thoroughly investigated. The purpose of this study was to characterize the migration, proliferation, and inflammatory response via diabetic induced oxidative stress of fibroblast-like synoviocytes (FLS), the predominant cell type in synovium, under hyperglycemic culture conditions. Healthy FLS was preconditioned in either euglycemic (EG) or hyperglycemic (HG) glucose concentrations for 48 hours to induce the biological response of the diseased phenotype. Proliferation and migration of FLS were assessed via wound closure assay following initial cruciform injury under HG culture conditions. This study showed that DM has a pathogenic effect on OA through hyperglycemia-induced oxidative stress. FLS exposed to HG culture conditions had overall lower viability and increased cytotoxicity (LDH), suggesting oxidative stress characteristic of the OA and DM disease states. The overproduction of ROMO1 and AGEs in DM have also been implicated in the etiological development of OA, contributing to changes in intracellular signaling processes, chondrocyte senescence, ECM matrix remodeling, and joint inflammation. This model supports basic science and translational studies designed towards understanding OA in DM patients, allowing for future tests that investigate therapies to reverse or at least mitigate insulin resistance and OA development. *Keywords: diabetes, osteoarthritis, synovium, proliferation, migration, cytotoxicity, inflammation, oxidative stress*

Tyler Shern CC'25, Biochemistry

Faculty Mentor(s) or Supervisor(s): Professor Hanrui Zhang
Title: PDCD6IP as a Novel Negative Regulator of Macrophage Efferocytosis

Abstract: Efferocytosis, the phagocytic clearance of apoptotic cells by macrophages, is crucial for maintaining tissue homeostasis. Defective efferocytosis often catalyzes the onset of deadly inflammatory diseases including chronic atherosclerosis, cancer, heart failure, and neurodegenerative disorders. Though recent studies have expanded the understanding of the genes known to be associated with macrophage function, there still remain significant gaps in knowledge regarding how efferocytosis is regulated in normal physiology and how the mechanism becomes defective. We previously used an unbiased CRISPR screen to search for novel regulators of

macrophage efferocytosis, discovering that PDCD6IP was a top hit negative regulatory gene in controlling macrophage efferocytosis and that its knockout resulted in enhanced efferocytosis. Here, we show that the overexpression of PDCD6IP in primary macrophages leads to impaired efferocytosis. By developing a lentiviral vector system to transduce PDCD6IP-GFP into primary macrophages in vitro, we found that the overexpression of the gene leads to decreased uptake of apoptotic cells, diminished lysosomal acidification upon engulfment, and reduced LC3-lipidation. Fluorescence-activated cell sorting revealed an 8% decrease in apoptotic cell uptake in macrophages transduced with PDCD6IP-GFP. Furthermore, we used live cell imaging analysis to visualize the internal function of the gene within macrophages, discovering that PDCD6IP-GFP positive cells do not uptake apoptotic cells and that the cytosolic location of PDCD6IP suggests its role in managing centrosome disorders and vesicle transportation. Our work expands upon society's understanding of how the gene negatively regulates macrophage efferocytosis and demonstrates the therapeutic potential of PDCD6IP inhibition to improve inflammation resolution.

Marija Simjanoska CC'24, Biochemistry

Faculty Mentor(s) or Supervisor(s): Professor Anthony Fitzpatrick
Title: Cryo-Electron Tomography: Segmentation

Abstract: Cryo-electron tomography is an imaging technique that allows 3D visualization of organelles and protein complexes at a nanometer resolution. Cryogenic conditions preserve the sample in a hydrated native cellular environment, allowing for macromolecular structure determination in situ. A direct 3D rendering of a tomogram is often difficult to analyze, as tomograms generally have a low signal-to-noise ratio (SNR) due to the inherent low contrast the samples exhibit. Segmentation involves identifying and isolating multiple cellular substructures from reconstructed tomograms, such as organelles, membranes, and protein complexes, to aid in the interpretation of data. However, segmentation is a time-intensive and manual process involving highly technical software. This project aimed to explore protocols for semi-automated segmentation using Amira (Thermo Fisher Scientific) software to expedite the segmentation process. Low tomogram contrast prevents full automation and as such, tomograms processed manually using EMAN2 software – so as to roughly separate membrane structure from background and generate a tomogram with black-and-white discrimination – were imported in Amira. Different automated methods of segmentation were tried and tested, including segmentation through classification, multiphase segmentation with watershed, and texture separation to evaluate which method yields the most accurate segmentation. Factors such as sharpness, preservation of detail, and smoothness are vital; thus, different filters were tested to evaluate whether they improve the segmentation quality. This project made progress in identifying a more efficient semi-automated segmentation protocol. Streamlining segmentation helps us reveal spatial and organizational relationships between cellular features of interest, thus potentially aiding in our understanding of organelle crosstalk and the roots of cellular dysfunction.

Madeline Skeel SEAS'25, Mechanical Engineering

Faculty Mentor(s) or Supervisor(s): Professors Alicia Dagle and Kristin Myers
Title: Feature Extraction from Segmented Ultrasound Images

Abstract: Despite the fact that preterm birth affects 1 in every 10 babies born and puts children at risk for lasting childhood disabilities, there is a lack of research regarding the cause of preterm birth. This also limits the ability to predict if a patient is at risk for preterm birth. This project explores a cervical feature extraction tool to assist in automating the process of measuring cervical features that may play a role in the prediction of preterm birth. The feature extraction tool uses standard-of-care transvaginal ultrasounds that have been segmented into four classes (cervical canal, anterior cervix, posterior cervix, and bladder) by three experts. Then, using image processing techniques, measurements were found for cervical length, lower uterine segment thickness, anterior uterocervical angle, and anterior and posterior cervical diameter at multiple locations. Results were only validated for cervical length measurements due to the lack of clinical measurements to use for comparisons for the other features. In the future, this tool will be used in combination with an automatic deep learning-based image segmentation method to automate the end-to-end process of finding these measurements from transvaginal ultrasounds. This tool has the potential to enable more in-depth studies of how cervical geometry can be used to understand and assess the risk of preterm birth.

Marc Sorrentino SEAS Electrical Engineering and Cody Slater SEAS Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Professors Qi Wang and Diana M. Martinez
Title: Automated Pipeline to Optimize Patient Specific Electrotherapy Configurations through Finite Element Simulation
Abstract: Previous research has shown various regions of the prefrontal cortex to be viable targets for therapeutic stimulation in depression, addiction, and chronic pain. As non- and minimally-invasive methods to achieve gross increases in neural activation have gained attraction, methods to model off-target effects for brain stimulation protocols remain limited. This is particularly important when targeting superficial structures in the frontal cortex, as accidental activation of the hippocampus can impair spatial and temporal memory. The task of accurately testing and optimizing intracranial stimulation for treatment of cognitive ailments remains challenging due to a scarcity of readily available tools to quickly study the electrical response of the human brain to a wide range of testing parameters. Many existing implementations of computer-aided brain simulation (e.g. SimNIBS, ROAST) limit the user's control over simulation parameters and geometrical configurations; such tools restrict regional selectivity of the brain model to major tissues, blurring stimulatory dynamics at the functional level. The method proposed offers a robust system aiming toward optimizing stimulation conditions in custom-designed experimental systems. We simulated neural response to epidural stimulation, where electrodes were placed on the prefrontal cortex. The results indicated a capacity to target particular regions of the brain (e.g. the anterior cingulate cortex), while monitoring activity in non-target regions (e.g. the hippocampus). The percent of activated volume increased differently with stimulation current among various subregions. These preliminary results validated the anatomical selectivity of the stimulation and thus allows for future iterative optimization of electrode placement and stimulation patterns. This model demonstrates the feasibility of using FEM-based simulation to efficiently determine optimal brain stimulation parameters. By measuring the induced electric field in particular anatomical sub-regions, we can pinpoint the level of activation in designated areas of the brain while minimizing the activation of undesired brain regions. Such results allow a projection of the activation patterns we expect to observe in a real human brain tested under identical intracranial stimulation conditions. Future research might concern the implementation of anisotropic conductivity via diffusion tensor imaging to further render the effects of conductive pathways along neuronal projections on the electric field distribution. Time-efficient optimization algorithms will further help determine optimal configuration parameters during surgery planning.
Keywords: Finite Element Analysis, Intracranial Stimulation, Neuroimaging, MRI, Brain Segmentation, Tetrahedral Mesh

James Stephens CC'25, Physics and Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Dmitri Basov
Title: Critically Phase-Matched Second Harmonic Generation in Molybdenum Disulfide

Abstract: Transition metal dichalcogenides (TMDs, compounds comprised of a transition metal and an element in the oxygen family) are substances of broad interest both for improving understanding of fundamental physical laws and for potential applications in photonics and nanotechnology. Molybdenum disulfide (MoS2) is the most robust of these materials and is therefore one of the most thoroughly studied. Recent reports indicate that MoS2 is unusually capable of doubling the frequency of light which passes through it; that is, it exhibits a useful phenomenon called second harmonic generation (SHG). This project extends the exploration of SHG in MoS2 and promises progress towards both technological applications and fundamental study. The project's novel optical setup allows for light to propagate through MoS2 at the so-called critical angle, the angle at which the incident and second harmonic light are exactly in-phase, enhancing the output power of the crystal. This technique leads to an SHG conversion efficiency orders of magnitude greater than any previously measured in the material. The setup also allows for highly precise near-field measurements of the SHG process, which will allow researchers to compare SHG to absorption in the exciton bandgap, a key inquiry in the study of TMDs. For more general applications, there exists an analogous apparatus which can excite surface polaritons (a technologically relevant quasiparticle consisting of a bound photon and electron) in materials in which such excitations are currently challenging to observe and measure.

Ana Stratan CC'24, Biology

Faculty Mentor(s) or Supervisor(s): Professor Chao Lu
Title: Functionally Investigating Histone H3 lysine 36 dimethylation through Epigenome Editing

Abstract: In recent years, important discoveries have been made regarding epigenetic marks. However, some marks are better understood than others.

DNA methylation is known to be connected to gene silencing, while the acetylation of histone proteins, proteins that help package the human genome, is known to be connected to gene activation and expression. Histone methylation, however, is relatively poorly understood. This project focused on the dimethylation of lysine 36 on histone H3 (H3K36me2), whose altered expression has been connected to developmental disorders and cancers. In order to understand the connection between the modification being deposited and the resulting changes in transcription, we developed a programmable H3K36me2-writer by fusing the catalytically inactive dCas9 to the catalytic SET domain of the human H3K36 methyltransferase NSD2. This construct writes the histone mark in a site-specific manner, as directed by a small RNA called a single guide RNA (sgRNA). Throughout our experiments, the construct led to modest transcriptional activation of the targeted HLA-B gene, which codifies a membrane protein involved in immune recognition. These results suggest that there is a causal role for H3K36me2 in activating transcription, motivating further inquiry into its function in different locations throughout the human genome. Understanding local effects of well-regulated H3K36me2 expression could inform methods of mediating its aberrant expression, opening therapeutic avenues for treating the disorders it can cause.

Aswath Suryanarayanan CC'23, Physics and Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Susanne Yelin
Title: Analyzing superradiant emission by partially inverted atomic ensembles

Abstract: Superradiance occurs in atomic ensembles due to an exchange of photonic excitations leading to constructive interference of emitted photons. The interacting, many-body nature of the problem causes the Hilbert space's dimensionality to scale exponentially, thereby increasing the problem's analytical complexity. Previous models have attempted to simplify the system by working with size-constrained Dicke states or by considering only singly-excited states, or by using quantum jumps. However, these approaches are unable to reveal much about the superradiant burst or the late time dynamics of the ensemble. This research builds on the work of Ma et al. 2022, who use an integrated method with two probe atoms to obtain a non-linear two-atom master equation which captures the dynamics of the whole system. However, this model yields unphysical results for initially partially inverted ensembles. In particular, this research attempts to modify the aforementioned model to avoid apparent unphysical changes to the average upper state population and the cooperative decay rate. This is done by using both brute force and analytic approaches. Finally, this research asks questions about the behavior of subradiant states for half-inverted ensembles.

Pranay Talla CC'24, Biochemistry and Computer Science-Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Peter A. Sims
Title: Development and Optimization of a Whole-Genome and Transcriptome Sequencing Platform for Copy Number Variation (CNV) Identification

Abstract: Tumors are generally composed of a collection of cancer cells with many different phenotypic characteristics, meaning that the cells grow and interact with their environment differently from each other, and have varying degrees of resistance to different cancer therapies. Single-cell sequencing is a useful tool in studying such intratumor heterogeneity because it enables the high-resolution characterization and study of each of the cell types within a tumor. There are two main approaches to single-cell genomics; the first is performing high coverage sequencing of each cell with the aim of identifying specific single nucleotide polymorphisms (SNPs), and the second is a lower coverage sequencing of each cell in order to identify copy number variations (CNVs). In this project, we focus on the second approach, and aim to (1) further optimize nuclei isolation and nucleosome depletion methods, (2) integrate single-cell transcriptomic sequencing through adoption of pre-existing multiome sequencing tools, and (3) build and use computational techniques to perform noise reduction and enhance the CNV signal our sequenced data. Specifically, we used scATAC-seq tools (a pre-existing single-cell genomic and gene expression sequencing technology) to sequence common mouse and human fibroblast cell lines after isolating nuclei with either SDS-based crosslinking (xSDS) or lithium-assisted nucleosome depletion (LAND). GC-bias correction, transcription start site (TSS) coverage normalization, and other statistical methods were used for noise reduction. We find that LAND is the most effective nucleosome depletion method and enables the successful generation of gDNA and cDNA libraries with sufficient coverage for CNV analysis.

Gabriel Guerra Trigo SEAS'25, Computer Science

Faculty Mentor(s) or Supervisor(s): Professor Itsik Pe'er, Alicia Dagle (current PhD student).
Title: Geometric Feature Extraction from Segmented Transvaginal Ultrasound Images

Abstract: Transvaginal ultrasounds are standard exams for pregnant women to investigate possible complications like preterm birth. Yet, these images are severely underutilized in terms of extracting measurements that may be predictive features of preterm birth. Furthermore, even for measurements that are extracted such as cervical length, differences in how different clinicians perform the measurements can hurt the interpretability of the data. Here, we describe a suite of methods to extract features of interest from segmented transvaginal ultrasound images. The proposed methods enable for the scalable and homogenous extraction of a robust set of features. We compare the measurements obtained by the model to the ones performed by clinicians, and discuss sources of divergence.
Keywords: Transvaginal ultrasound, feature extraction, preterm birth, cervical length

Fotios N. Tsitsos SEAS, Biomedical Engineering, Robin Ji SEAS, Biomedical Engineering, Sergio Jiménez Gambín SEAS, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Professor Elisa E. Konofagou
Title: In Vivo MR Imaging of Human Skull for Attenuation Estimation in Transcranial Focused Ultrasound

Abstract: Focused Ultrasound (FUS) can be used in conjunction with systemically administered microbubbles to temporarily open the Blood-Brain Barrier and induce a therapeutic effect. Being a minimally invasive technique, the FUS beam is focused on a region of the brain through intact skull. However, the skull is responsible for a large pressure attenuation and a shift of the focal spot of the FUS beam. Acoustic simulations can be used to calculate the attenuation and focal shift, thus allowing for pre-treatment corrections to ensure sufficient effective pressure at the desired spot. CT scans are considered the ground truth for characterizing the skull architecture and are therefore used to create masks for the acoustic simulations. However, CT exposes patients to ionizing radiation, making it a problematic modality for research studies. MRI sequences with ultrashort echo times provide an alternative to CT, capturing the bone signal quickly before full relaxation, and thus creating a detailed skull image. In this study, three ultrashort echo sequences are investigated to assess bone imaging quality and suitability for acoustic simulations: Zero Echo Time (ZTE), Single Echo Ultrashort Echo Time (UTE) and Dual Echo UTE (DE-UTE).
Keywords: Focused Ultrasound, MRI, CT, UTE, Attenuation

Camila Vicioso CC'23, Psychology and Biology

Faculty Mentor(s) or Supervisor(s): Professor Nim Tottenham
Title: Later caregiving predictability and irritability in children following early-life caregiving instability

Abstract: Early caregiving adversity and irritability pose transdiagnostic risks for psychopathology. While early sensitive periods for caregiver influences on emotion processing are supported, children continue relying on caregivers for extrinsic emotion regulation through late childhood. Therefore, the predictability of later caregiving environments may influence risks for irritability following early caregiving instability. This longitudinal study will test alternative hypotheses regarding how later caregiving predictability modulates risks for irritability in children exposed to early caregiving instability. The sample consists of youth (N=186; ages 8-14 yrs) exposed to early caregiving instability (operationalized as children who had at least one caregiver switch before Visit 1; median=2; range=1-19) and other caregiving-related early adversities (i.e. abuse, neglect). The number of early caregiving switches was determined through a parent interview at Visit 1. Two years later, parents reported their child's current caregiver predictability using the Questionnaire on Unpredictability in Childhood and child irritability using the Affective Reactivity Index. If higher levels of later caregiving predictability are associated with lower irritability in youth with early caregiving instability histories, the hypothesis that later predictable caregiving environments can buffer risks for irritability symptoms would be supported. Alternatively, the developmental mismatch hypothesis would be supported if irritability levels are higher for children in predictable caregiving environments following early caregiving instability. Therefore, for children with early caregiving instability histories, later childhood predictable caregiving environments could create either (a) a sense of reliable emotional support that ameliorates irritability risks; or (b) a developmental mismatch for early neural adaptations tailored to unpredictable environments, thereby exacerbating irritability risks.

Kevin Wang CC'24, Mathematics-Statistics

Faculty Mentor(s) or Supervisor(s): Professor David Knowles
Title: Deep Autoregressive Models of RNA Binding Protein Preferences

Abstract: RNA-binding-proteins, or RBPs, are integral in gene expression and play a role in processes from alternative splicing to genetic diseases. A relatively new RNA assay tool, RNA-Bind-n-Seq (RNBS), is a popular approach for determining which RNA sequences are bound with given RBPs by enriching sequences in different concentrations of the protein. However, there are limited machine learning techniques that can interpret RNBS data, and models that attempt to classify sequences by binding concentration are inaccurate. This project proposes using autoregressive models in order to 1) predict binding affinities of RNA sequences and 2) detect binding motifs. Instead of a traditional classification method, it uses a Bayesian approach, training models to generate RNA sequences under specific RBP concentrations. It can then calculate the probability that sequences will be bound under different RBP concentrations in order to deduce their binding affinities. The models improved upon prior accuracies, and are additionally able to produce position weight matrices (PWMs) for individual sequences. In addition, the researcher studies a convolutional form of Principal Components Analysis as a dimensionality reduction tool in translationally invariant data. This can be used to detect binding motifs in large PWM datasets. Autoregressive models are able to produce novel insights about sequence binding and binding motifs from RNBS data.

Luna Wang CC'23, Astronomy and History

Faculty Mentor(s) or Supervisor(s): Professor Marcel Agüeros
Title: Measuring the UV Emission of M and K Stars in the Hyades

Abstract: Luna's research centers on stellar astrophysics, specifically the refinement of age-rotation-magnetic activity relations in low-mass stars in open clusters. Her summer research focuses on the measurement of ultraviolet activity in M and K dwarfs in the Hyades cluster. In the universe, around 70% of the stars are low-mass M dwarfs, the main candidates for exoplanet hosts. Due to their high possibility to shape planetary environments, understanding the activity of the "dwarfs" has big impacts for the exciting search for habitable planets, the potential hosts for extraterrestrial life and even future home for humanity. She investigated the UV activity of M dwarfs in the open cluster, 700-Myr-old Hyades, a natural laboratory for the study of stellar properties due to its controlled age and relative proximity to earth. Specifically, she measured the flux of Mg II line from 63 spectra collected from the Hubble Space Telescope, then plotted luminosity ratio of the stars over rossby number, an indication of stellar rotation period. Fast rotators exhibit strong magnetic activity, yet the relation no longer holds true for stars with faster rotation, requiring further research. Shaping planetary ozone and atmosphere formation, the high-energy emission from a star on its orbiting planets is crucial for the evaluation of planet habitability, and therefore worthy of in-depth investigation. The research is meaningful on both a professional and a personal level, as she feels humbled by contributing to the understanding of earth-like planets and their environments, exploring both extraterrestrial life and our presence in the universe.

Sarah Xi CC'23, Chemistry

Faculty Mentor(s) or Supervisor(s): Professor Neel Shah
Title: Exploring the covalent ligandability of tyrosine phosphatase active sites

Abstract: Tyrosine phosphorylation is an important post-translational modification that can modulate protein-protein interactions, protein localization, stability, and enzyme activity. Many diseases including cancer arise from the dysregulation of tyrosine phosphorylation. Protein tyrosine phosphatases (PTPs) are an essential family of signaling enzymes that dephosphorylate tyrosine residues on proteins. PTPs serve a variety of functions and have been implicated both in tumor suppressant and oncogenic pathways depending on the specific enzyme and disease context. Despite their importance, relatively little is known about the regulatory roles of PTPs. Thus, there is a need for the development and identification of new active-site ligands for PTPs, which could serve as inhibitors or chemoproteomic sensors for these enzymes. We are developing covalent ligands to site-specifically target PTPs across the proteome at their conserved catalytic cysteine. To design these ligands, we surveyed a broad array of scaffolds and thiol-reactive electrophilic warheads. We synthesized and purchased candidate compounds and characterized them using reactivity and enzyme inhibition assays. From these assays, we identified numerous PTP inhibitors and inferred structure-activity relationships that govern their selectivity and potency towards PTPs. A few candidates that displayed the desired characteristics were converted to chemical probes by installing a bio-orthogonal alkyne tag to facilitate downstream click chemistry reactions. Ultimately, we have identified an array of PTP inhibitors, which we anticipate will guide future inhibitor development, probe development, and be used to discover new regulatory mechanisms of PTPs.

Tony Xiao CC'25, Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Quentin Guignard
Title: Aymptotic Stability in Algebra and Geometry

Abstract: This project is concerned with investigating asymptotic stabilities in the context of algebra and geometry. We first consider the series of symmetric group Sn, where n goes to infinity, and observe that the induced homomorphism on the q-th homology groups Hq(Sn)->Hq(Sn+1) is an isomorphism for large enough n. This is an example of homological stability, which has been generalized by various authors to sequences of classical groups such as On and GLn. In another direction, one might try to quantify in terms of q what is meant by "n large enough" in the stability statement; for example, Nakaoka obtained that $n \geq 2q + 1$ is enough for symmetric groups. Certain groups, such as the pure braid group, do not satisfy homological stability, but it is possible to modify them slightly to establish stability (in an appropriated sense) as a sequence of representations of Sn. This is known as representational stability, and extends to many naturally occurring sequences of representations of Sn. Furthermore, the theory of FI-modules allows us to convert representational stability into a finite generation property. In future researches, we may attempt to generalize the theory of representational stability to a setting designed to obtain representational stability over GLn.

Jeffrey Xiong CC'25, Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Robert Guangyu Yang
Title: Self-Modeling Plays a Crucial Role in Optimal Survival

Abstract: Self-modeling is an important component of human behavior that is notoriously difficult to study. The ability to model the self, the body, and feelings associated with it is one of the most important features of human cognition and integral to the ways in which we act on the world around us. Unfortunately, this process remains under-explored neurally and computationally. This project aims to experiment with reinforcement learning agents in a prey-predator environment to demonstrate that self-modeling is key to maintaining policy-level performance when innate behavior is introduced.

Elise Yang SEAS'25, Mechanical Engineering, Yurui Chen SEAS, Mechanical Engineering,

Faculty Mentor(s) or Supervisor(s): Professors Hiroo Takayama, Vijay Vedula
Title: Patient-Specific Analysis of Aortic Growth in Aortic Root Aneurysms

Abstract: An aortic root aneurysm (rAoA) is a type of aortic aneurysm located in the heart that necessitates surgical intervention in a patient if it dilates quickly and large enough to prevent rupturing. Currently, the surgical criteria for aortic root aneurysms are not distinguished from that of ascending aortic aneurysms (aAoA): when the aorta dilates to 5.5 cm in diameter, surgery should be performed to remove the aneurysm to be replaced with a prosthetic. rAoAs have been traditionally analyzed together with aAoAs, but clinical evidence suggests that the surgical criteria for root aneurysms, however, should not be the same. These specific types of aortic aneurysms require further examination into their local biomechanical environment due to their close proximity to the heart and the complex blood flow dynamics induced by the aortic valve leaflets and coronary sinuses. In this study, we analyze five patients diagnosed with rAoA (data provided by Dr. Hiroo Takayama at the Columbia University Irving Medical Center). Taking each patient's CT scans across certain time intervals, 3-D models of the aortic root were created with the open-source software SimVascular to assess their stability across 12-50 months. Using the data points from the models created, this study investigates each patient's aortic diameter using a semi-automatic Python-based workflow. The current models provide a foundation for further analysis with comprehensive patient-specific fluid-solid-interaction (FSI) simulations. Further steps will allow the establishment of a more accurate, improved surgical threshold by aortic diameter and growth rate for aortic root aneurysm patients.

Joshua Yu CC'24, Biochemistry

Faculty Mentor(s): Professor Brent Stockwell
Title: Dietary metabolites sensitize a hepatocellular carcinoma cell line to ferroptosis induction

Abstract: Hepatocellular carcinoma (HCC) is the most common form of liver cancer and is the fourth leading cause of cancer deaths worldwide. Current treatments, while somewhat effective, can be risky and harsh on a patient's quality of life. Hepatectomies (liver resection) are considered major surgeries

and are often paired with chemotherapy and radiation treatment. There are limited small molecule treatments for HCC. Dietary modifications may be associated with positive HCC outcomes. In this study, it is determined that dietary metabolites, ferric citrate and arachidonic acid, sensitize Huh-7 HCC cells to coordinated cell death via ferroptosis. Ferric citrate is a source of free, ferrous iron, which is necessary for lipid peroxidation. Arachidonic acid is a polyunsaturated fatty acid (PUFA) that can be oxidized to promote ferroptosis. Ferroptosis is an iron-dependent, non-apoptotic form of cell death that can be induced by Imidazole Erastin Ketone (IKE). IKE indirectly inhibits GPX4, a complex that normally hinders ferroptosis induction. Ferroptosis inducers, such as IKE, are associated with antitumor therapies in a variety of cancers. This study reveals that ferric citrate and arachidonic acid treatments prime Huh-7 cells to IKE-induced ferroptosis. Cell viability and lipid peroxidation assays reveal that these metabolites increase the efficacy of IKE as an antitumor treatment. A clearer understanding of how metabolites can promote or inhibit ferroptosis could lead to insights into ferroptosis pathways and diets more broadly. As such, this study investigates the intersection of diet, HCC and ferroptosis to better characterize how dietary intervention can affect future ferroptosis-based treatments for HCC.

Doris Yue, SEAS'22, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): Professor Allie Obermeyer
Title: Self-Assembly of Protein Polyelectrolytes Coacervates for Drug Delivery

Abstract: The use of protein and peptides in the pharmaceutical area has gained significant attention due to the potential for advances in the treatment of cancer, cardiovascular, metabolic, infectious diseases and etc. However, the instability of proteins during formulation and storage and low permeation through cell membranes create limitations for these therapeutics. To address these limitations, scientists have worked to develop site-specific delivery carriers that minimize therapeutic protein and peptides degradation and delivers them across biological membranes. Scientists have explored a variety of delivery systems, and one way is to encapsulate therapeutic proteins or peptides into a particle called protein polyelectrolyte complex micelles. Protein Polyelectrolyte Complex (PEC) micelles are formed by the self-assembly of oppositely charged proteins via electrostatic interactions. PEC micelles can be designed to have a variety of functions by incorporating block polyelectrolytes with different chemical characteristics. In this study, we explored the drug delivery potential of polypeptide block polyelectrolytes (ELP[V30]-Histone H5 [K to QGS]) constructed by a neutral protein (ELP[V30]) and a positively charged protein (Histone H5 [K to QGS]). The positive end of the block copolymer interacts with and stabilizes the negatively charged therapeutic proteins, leaving the neutral end on the outside to assist in the permeation of PEC micelles through biological barriers. The positively charged polypeptide and the fused proteins were both tested for PEC micelle formation and characterized using turbidity assay, salt titration, and observed under the microscope.
Keywords: *Protein polyelectrolyte complexes, liquid-liquid phase separation, drug delivery*

Dennis Zhang, CC'24, Biology

Faculty Mentor(s) or Supervisor(s): Professor Sam Sternberg
Title: IN-TAG-RATE: Harnessing CRISPR-Associated Transposons for Facile Protein Tagging

Abstract: Genome engineering tools in bacteria are limited by editing efficiency, cargo size, and targeting capabilities. These constraints were bypassed by the discovery of CRISPR-associated transposons (CASTs), which allow highly programmable RNA-guided insertions. CASTs accomplish these insertions by directing transposition machinery to DNA targets specified by a CRISPR-Cas ribonucleoprotein complex. Of note, the promising Type I-F CAST system has been harnessed as a tool called INTEGRATE for precise, efficient, and multiplexable integration of large DNA payloads without double-stranded breaks, which are inefficient to repair correctly and can cause unintended genetic abnormalities. In spite of its clear advantages, one limitation of integration with CASTs is that such insertions cannot be scarless. This is because donor DNA must be flanked by transposon end sequences in order to be recognized by transposition machinery. However, the authors hypothesized that they could repurpose these scars as powerful tools for protein tagging by rationally mutating them into functional linker sequences that retain integration capabilities. Indeed, the authors have designed, screened, and identified several such promising linker variants. As a final proof of concept, the authors utilized one linker variant to successfully tag an endogenous E. coli protein and generate a fluorescence microscopy-based readout.

Alan Zhao CC'23, Math and Computer Science

Faculty Mentor(s) or Supervisor(s): Professor Chao Li
Title: Heights of Rational Points on Mordell Curves

Abstract: We conjecture a lower bound for the minimal canonical height of non-torsion rational points on a natural density 1 subset of the sextic twist family of Mordell curves. We then establish a lower bound that yields a partial result towards this conjecture.

Jinpai (Max) Zhao SEAS'23, Applied Mathematics

Faculty Mentor(s) or Supervisor(s): Professor Kyle T. Mandli
Title: Storm Surge Modeling and Validation
Abstract: Coastal communities are home to approximately 40% of the world population. Consequently, loss of property and life has become a major concern when coastal hazards take place. One of the most common, wide-spread hazards is the storm surge, which is the significant and abnormal rise of sea water level caused by storm systems like hurricanes and typhoons. Being able to model and reconstruct these events is considered consequential. The software used was Clawpack (Conservation Law Package), which is a collection of finite volume methods for conservation law problems in linear or non-linear PDE systems. GeoClaw, a variant of the Clawpack, uses the two-dimensional depth-averaged shallow water equation in cooperation with the adaptive mesh refinement (AMR) algorithm to model many kinds of flows and waves over topography data with adjustable resolutions. My work used GeoClaw to simulate four major hurricanes in the 2021 Atlantic Hurricane Season. A rigorous verification and validation process between simulation and observation was performed on all storm systems studied. To reduce data collection time and make data more visualizable, an automated analysis program was developed to assist users in advance of storm surge modeling and validation process. The program was also made compatible with GeoClaw, so that majority of storm specific run-time parameters were selected and filled in automatically.
Keywords: Modeling & Simulation; Verification & Validation; Finite Volume Method for Hyperbolic PDE; Geophysical Flow; Natural Hazards; Coastal Community

Elen Zhu CC'23, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Professor Chang Hun Lee
Title: Delayed Onset of Mechanical Stimulation Promotes Matured-Healing of Avascular Meniscus Tears

Abstract: Injury to the knee meniscus frequently results in cartilage degeneration and the progressive destruction of the knee joint. Meniscal injuries are incredibly common; more than a million patients receive surgical repair treatments annually in the U.S. alone. Upon injury, tears formed at the outer-vascularized region can be surgically repaired with good functional prognosis. Despite the high clinical demand, no successful regenerative therapy has been developed for avascular meniscus defects due to this region's poor intrinsic healing capacity. We have developed a bioactive glue that promotes the healing of inner-zone meniscus tears via synovial mesenchymal stem cell recruitment and differentiation. However, the healed menisci's functional properties were suboptimal compared to native tissue, likely due to immature tissue matrix. Recent studies have demonstrated the significant role of mechanical force in tissue maturation during meniscus regeneration. To closely simulate complex in vivo mechanical loadings, we have developed a meniscus-specific bioreactor that combines compressive, tensile, and shear forces on wedge-shaped meniscus explants. We investigated the effects of delayed onset of physiological loading on tissue maturation during bioactive glue-guided avascular meniscus healing. Here, we show evidence via histological and mechanical analysis that the application of delayed onset of physiological loadings resulted in improved meniscus tissue maturation compared to the no stimulation control and earlier onset stimulation groups. Additionally, we observed more highly reorganized collagen fibers in delayed onset stimulation groups using a tissue clearing procedure and confocal microscopy. These results provide critical information for the future of regenerative healing of avascular meniscus injuries.