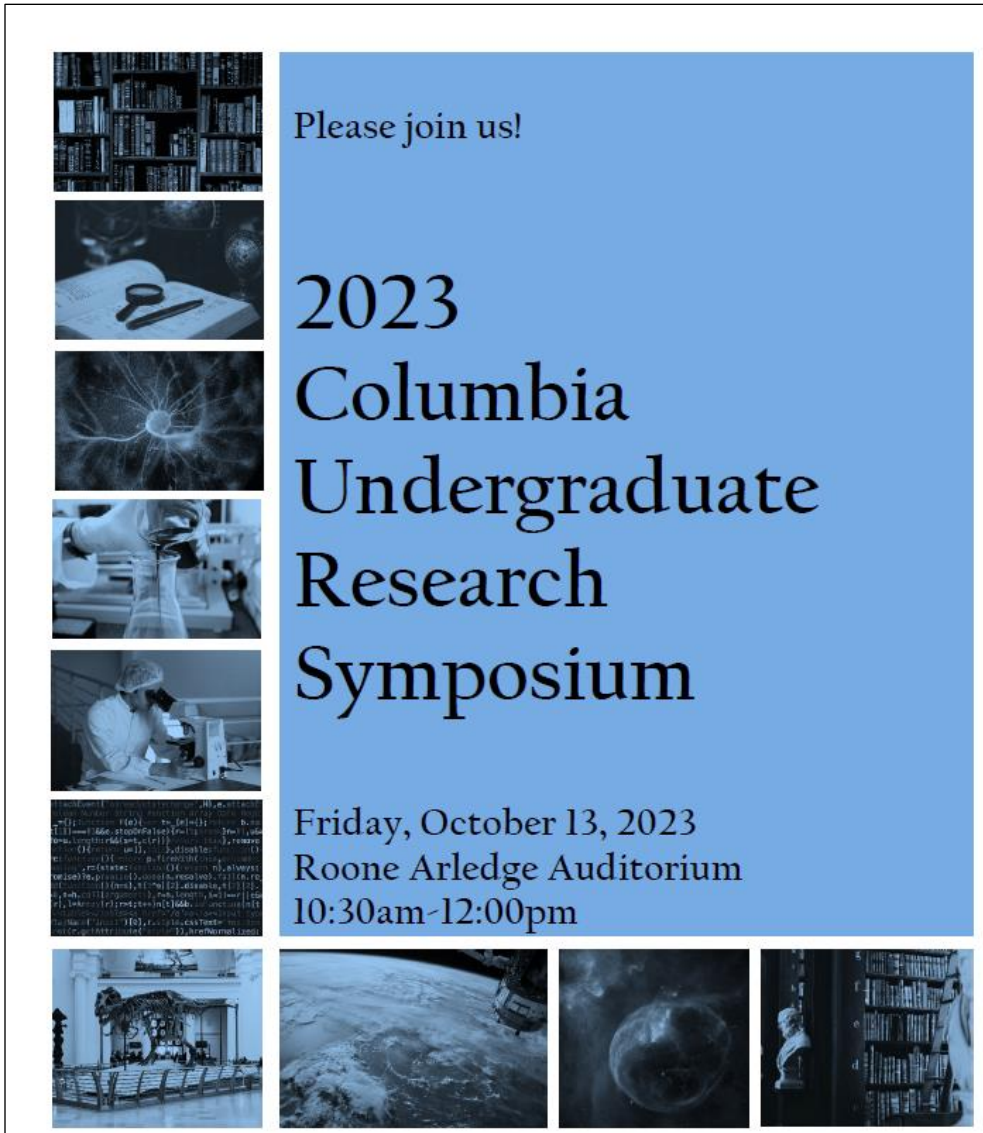

RESEARCH SYMPOSIUM 2023
Research Abstracts:

SECTION ONE: HUMANITIES RESEARCH

Eli Andrade CC'24, English

Faculty Mentor(s) or Supervisor(s): Nicole Gervasio

Title: Females, Cyborgs, & SCUM: Transformative Textuality in the Feminist Manifesto Genre

Abstract: Valerie Solanas' SCUM Manifesto, which calls for the complete eradication of the male sex, has elicited a wide range of reactions, often prompting readers to hastily categorize it as deranged, misandrist, and transphobic. However, when situated as a work of utopian fiction, the manifesto reveals itself as a forceful and trenchant critique of normativity and the intricate gendered dynamics of everyday life. Despite the apparent paradox of using a patriarchal genre like the manifesto to convey an overtly anti-male message, I posit that embracing this very irony facilitates a more nuanced understanding of the manifesto's contents, including Solanas' satirizing of male-female social dynamics, her characterization of females as the vanguard of revolutionary praxis, and her construction of a compelling mythos that rationalizes the exigency for contemporary dissent while envisioning an emancipatory, manless utopian future. By reinventing the present patriarchal order to benefit females, Solanas delivers a mimetic reflection of current gendered norms that can only be read as a critique of male dominance when read figuratively. This analytical and literary approach facilitates a nuanced exploration of the sex and gender binary, positioning it as a pivotal marker of identity that warrants respect while simultaneously highlighting its role as a mechanism of oppression necessitating redress, remediation, or even dismantlement. Contrary to signaling a deficiency in generic appropriation, I contend that the manifesto's irony serves as a potent locus of transformative textuality, imbuing feminist discourse with profound implications for fostering social change and engendering a more equitable society. Ultimately, this approach enables us to rethink the epistemological foundations upon which male-dominant knowledge is normalized and question the expectations and reality of a gendered world and those who live within it.

Izagani Aquino CC ’25, History/English

Faculty Mentor(s) or Supervisor(s): Aaron Ritzenberg and Michael Gioia
Title: Food that Binds: The Food History of the Delano Manongs and the 1965-1970 Delano Grape Strike

Abstract: Most historical accounts of the 1965-1970 Delano Grape Strike in California’s Central Valley focus upon the perspectives of Chicano migrant farmworkers and leaders such as Dolores Huerta and Cesar Chavez. Despite such Chicano-Centric depictions, the strike was started by a group of Filipino American migrant farmworkers known as the “Manongs,” the central hub of protest was Delano’s Filipino Community Center, and residents of Delano at the time have indicated that the movement was perceived as a uniquely Pinoy one. This project reclaims the central role which the Manongs played and ultimately argues that the Grape Strike was a work of Filipino Activism on numerous levels. In making this point, Filipino involvement in the Grape Strike will specifically be approached through a lens of food history and the work they did to “feed the strike.” Firstly, visual archives of the Delano “strike kitchens” are used to show that the food served to both Filipino and Mexican strikers was Filipino cuisine. Next, primary documents from the United Farm Workers will investigate how Filipino Americans created “food caravans” between Delano and the Bay Area to collect donations for the farmworkers. Furthermore, oral history interviews with the children of involved Filipino farmworkers are used to highlight daily “camp life” and how shared Filipino meals were utilized to unite individuals throughout their protest. Ultimately, each of these food related components are synthesized to show that like daily meals, Filipinos were a constant presence in the Delano Grape Strike and were key to its groundbreaking success.

Sarah Bryden CC’26, Linguistics

Faculty Mentor(s) or Supervisor(s): Aaron Fox
Title: Language Mixing in Contemporary Maya and Quechua Hip Hop

Abstract: This research explores the intention and impact of bilingual Indigenous rap music in the Yucatan Peninsula of Mexico and in Peru. In both countries, hip hop has recently been popularized as a grassroots tool for language promotion, intended to counteract long-standing marginalization of Indigenous languages across Hispanic America. While the choice to rap exclusively in Yucatec Maya or Quechua has clear social significance, the choice to create songs which intermix one of these languages with Spanish has a somewhat distinct impact. This research centers on four Maya-Spanish songs and four Quechua-Spanish songs that have been transcribed and translated into Spanish and English. Particular attention is paid to ways subject matter changes as rappers switch from one language to another, as well as ways that similar ideas are expressed differently in either language. Additionally, the project observes how lyrical elements of the genre (such as puns, rhyme, and meter) change with the introduction of a second language. Ultimately, the research suggests that in Mexico and Peru, bilingual rap is a key element of the wider Indigenous hip hop movement. Specifically, incorporating Spanish into some rap songs lends legitimacy to Maya and Quechua, while simultaneously involving a larger audience. Both of these goals are crucial steps towards the larger ideal of language promotion..

Christina Clark GS’25, English and Comparative Literature

Faculty Mentor(s) or Supervisor(s): Eliza Zingesser
Title: A Statistical Analysis of Avian Mentions in Medieval French and Occitan Literature

Abstract: As a research assistant for a faculty member writing a book entitled “Lovebirds: Avian Erotic Entanglements in Medieval French and Occitan Literature,” the primary aim of this project was to create two comprehensive databases of all instances when birds are mentioned in the troubadour and trouvère corpora. These databases were generated to enable statistical analyses of trends, test various hypotheses about this poetic convention, and better understand the composers’ relationship to avian life beyond symbolism. Using information from existing catalogues and relevant contemporary scholarship, we sourced editions of troubadour and trouvère poetry and noted each instance where birds were mentioned. In addition to listing reference numbers that make these databases easily navigable, each entry includes information about the composer’s name, the song’s incipit, the species mentioned, the approximate date of composition, and its placement in the poem. By filtering the dataset based on metrics such as date and species, observations could be made about the popularity and prevalence of different species over time and about the extent of composers' differing levels of ornithological knowledge. This data was helpful in formulating theories about initial research questions regarding the degree to which composers were attuned to actual changes in bird populations or in society’s attitude towards birds. Moreover, by creating separate databases for the troubadours and the trouvères, it is possible to contrast these neighboring yet distinct traditions through the lens of birds.

Gabrielle Epuran CC'24, Classics

Faculty Mentor(s) or Supervisor(s): Kathy Eden, Elizabeth Irwin
Title: Credibility in ancient rhetoric

Abstract:
In both Aristotle's Poetics and Quintilian's Institutio Oratoria, the objective of narrative --- whether it be a tragic drama or the narratio section of a speech --- lies in the effect that it can have on its audience. While the former prioritizes the plot of the tragedy because of its ability to instill fear and pity in its audience, the latter states that the narratio of a speech --- the account of person, place, time, and causes --- was invented primarily to induce the audience to agree with the central argument of a case before it is even heard. While Cicero and Quintilian include clarity, brevity, and credibility as the main virtues of a narrative, Aristotle only includes the first and the last qualities in his Rhetoric, and Theodorus only includes credibility. Yet, one of antiquity's greatest storytellers, Herodotus, who has also been well-regarded by rhetoricians such as Dionysus, is well-known partly due to the supposed lack of credibility in his stories. In her research, Gabrielle investigates the essence of credibility in literary theories of antiquity and attempts to examine Herodotus' credibility --- specifically in Book III --- through these criteria. She concludes that credibility is largely dependent on a harmony between particulars and generalities through a quality of vividness, which is accomplished in Herodotus through narrative repetition and variation, as well as the de casibus motif.

Kathy Fang CC'24 Comparative Literature & Society

Faculty Mentor(s) or Supervisor(s): William B. Worthen
Title: Theatres of Translation: Meng Jinghui and Performing in Difference at the Festival d'Avignon

Abstract:
In 2023, reflecting on its intercultural legacy as a globally renowned theatre festival, the Festival d'Avignon took translation as its theme. Yet the festival's program and rhetoric strayed little from Western colonial ideologies of translation—namely, that translation can "build bridges" insofar as it naturalizes certain marginal languages as assimilable and transparent to a central universalizing language (here, English). However, the recent productions of Meng Jinghui, a Chinese avant-garde director of huaju (spoken dramas), at the Festival d'Avignon pose a striking challenge to such Euro-normative assumptions about theatre translation. In Meng's two mainstage shows Teahouse (2019) and The Seventh Day (2022), his company's work with language, embodiment, and intercultural tradition rehearses translation against the audience's interpretive practices. Set against translated French surtitles, his irreverent mise-en-scène forces the audience to confront their own linguistic and cultural alterity, holding them responsible to/for an event of multiplicity. In this sense, Meng's theatre-in-translation sheds crucial light on the relation of translation to performance: Translation is not merely a dramaturgical concern—that is, the staging of a text's intending meanings through assumptions of semiotic equivalence, unmediated identification, and linguistic transparency—but the political and ethical condition of theatrical performance itself as, fundamentally, an experience of incommensurable differences between the sites of performance. Moving from interior-exterior, margin-to-center, origin-and-deviant paradigms of translation to a topographical mapping of identity and difference, à côté and à l'écart, this project asks for whom, to whom, against whom, and at whose loss translation is performed on intercultural stages.

Aleena Garrison CC'25, Cognitive Science & Computer Science

Faculty Mentor(s) or Supervisor(s): Deborah Paredez
Title: American Diva Project

Abstract: Over the course of six weeks, Aleena assisted her faculty mentor Dr. Deborah Paredez in gathering materials and information related to divas and girlhood to support in research for Dr. Paredez's forthcoming book "American Diva". These divas, celebrated for their talents and commanding presence in many areas like music and sports, have played a significant role in shaping the perceptions and aspirations of girls growing up in divas primes and beyond. The research question Aleena was initially exploring was how divas impacted girlhood in the early 2000s, but it quickly expanded to include even bigger questions like: How have divas impacted girls and individuals post 2010? How has public perception of divas evolved? What does it mean to be a diva? What purpose do divas serve in POC individuals' lives? Aleena was surprised to see how much iconic and modern divas had directly and indirectly shaped her life. Along with this discovery, she also learned more about the stereotypes placed against divas and how that was pushed onto women and queer people in the form of advertisements, television shows, and dolls. She found that the definition of a diva was incredibly altered leading into the 2000s. And finally, Aleena learned more about what it takes to become a diva, and that most if not all of the iconic diva individuals people know and love have faced so much backlash and hardship for being

themselves and leading as an example for others to embrace their individuality.

Rainier Harris CC'25, English

Faculty Mentor(s) or Supervisor(s): Jean Howard
Title: Holy Theater, Mad Men, and the Black Literary Canon

Abstract: Anchoring his research in the seminal text "The Empty Space" by Peter Brooks, Rainier looked at how the type of "theater" that he loves, found in his both his favorite show Mad Men and in the Golden Collection of plays from playwright Jeremy O. Harris, actually comes about. His research focused on Brooks' idea of the "Holy Theater" defined as "the notion that the stage is a place where the invisible can appear and has a deep hold on our thoughts. So what elements do plays like Slave Play, Les Blancs, and Trouble in Mind share with a show like Mad Men. He noted that many of these works shared the aristotelian unities of time, place, and action. Even meta-theatrical plays like Adrienne Kennedy's Funnyhouse of a Negro, the backbone of the plays in Harris' Golden Collection, the still had a "container" of sorts that bound the play together like the protagonist's mind. The second major element he noted bringing these works together across genres was how they alluded with various degrees of uncertainty to the past, trading a collective memory of events by all characters in for individual memories that could be undercut and doubted. It wasn't that the audience couldn't be sure that what actually happened within the play happened but more so that the characters were given their own interpretation of how the events took place. The dialogue fixated on harkening back to the past so the audience could offer their own justification of present events.

Marco Jimenez CC'25, Philosophy

Faculty Mentor(s) or Supervisor(s): Jane Gaines
Title: How the 120 Desitālas of Śārṅgadeva's Saṃgītaratnākara Influenced the Pre-1950s Oeuvre of Olivier Messiaen

Abstract: Marco Jimenez's research examines the influence of the desitālas on Messiaen's pre-1950s oeuvre, identifying many of the instances where Messiaen incorporated the various desitālas into his own music. When Messiaen was asked about the influences most important to his music, he cited the 120 desitālas, or rhythmic patterns, that appear in the treatise Saṃgītaratnākara, written by the 13th-century Indian theorist Śārṅgadeva. While much of the previous research done on music of 20th-century composer Olivier Messiaen has focused on the influence that birdsong, Gregorian chant, Catholicism, and the historical context of the 20th-century had on Messiaen's music, Marco aims to contribute to the far smaller body of research that explores the influence of the desitālas on Messiaen's oeuvre. In addition to identifying where the desitālas occur, Marco discusses and reconstructs Messiaen's motivations for choosing certain desitālas for certain musical moments. This discussion is informed by the penciled-in marginalia and notes found, in Messiaen's hand, on his own sketches and manuscripts. Moreover, Marco examines how Messiaen's choices conflict or harmonize with traditional Indian cultural understandings of the function of desitālas. Marco's research is based on original manuscripts and sketches of Olivier Messiaen in Paris, France, generously made available to him by the Bibliothèque nationale de France.

Sam Klein Roche CC'25, English

Faculty Mentor(s) or Supervisor(s): Elly Moseson
Title: Spoken into Existence: Nahman of Bratslav's Theory of Oral Torah

Abstract: This research explores the theme of Oral Torah in the teachings of Nahman of Bratslav, a radical late 18th-century Jewish spiritual leader of the burgeoning Hasidic movement. In several teachings, Nahman casts the teacher-follower relationship as spiritually sexual, and describes the transmission of oral and written teachings as a sexual, and even procreative, ritual. Nahman participates in an intellectual tradition of understanding the Oral Torah as the metaphorically feminine counterpart to the masculinized Written Torah. Understanding Oral Torah as feminine allows Nahman to acknowledge, and implicitly celebrate, the latent homoeroticism of his spiritual community. The mutual engagement of two men over a feminized subject sanctions a homoerotic relationship between the two.
The second part of the research deals with Nahman's theory of God's withdrawal from the universe in order to create the material world. The Oral Torah in Nahman's construction is analogous to the material world through their mutual association with the Kabbalistic concept of divine garments. The process of divine withdrawal, according to Nahman, is analogous to the process of scholarly dispute. Both the created world and the Oral Torah are also symbols of the particularism of the people of Israel. Nahman articulates a messianic eschatology which involves the subsumption of both the created world and the Oral Torah into the divine. His vision implies an erasure of the Jewish people's singularity in favor of a more universalist messianism.

Elianna Lee CC'25, Ethnicity and Race Studies

Faculty Mentor(s) or Supervisor(s):

Title: Transnational Mexican-American Families: Gender, Labor, and Digital Media

Abstract: The phenomenon of transnational families has deep historical roots, with loved ones often separated by geographic and political boundaries, however, the rapid advancement of digital technology over the past two decades has ushered in a new era of transnational communication. Current digital ethnographic work has come to the consensus that the study of digital spaces alone is insufficient in trying to understand how communities use technology; rather, a non-digital-centric approach that focuses on already existing communities and how digital technologies manifest themselves in the daily lives of its members is necessary. While existing research has touched upon the relationship between gender and transnational communication, a significant gap remains when it comes to understanding the role of social media platforms in shaping these connections, as most studies have primarily focused on direct communication methods like phone calls. This research project aims to bridge this gap by delving into the complex relationship between digital technology, gender roles, labor, and culture within transnational families, with women vendors being subjects of particular interest. Elianna seeks to investigate how women leverage digital technology in their domestic and public lives to foster cultural connection and how this relationship to culture may be influenced by employment status, as well as how informal economies–and subsequent gender disparities in labor roles–transfer to online spaces. By investigating these questions through a comprehensive ethnographic approach, Elianna seeks to unravel the intricate web of connections that bind together gender, technology, labor, and culture in an ever-evolving digital landscape.

Josh Martin CC'24, Italian and Philosophy

Faculty Mentor(s) or Supervisor(s): Naor Ben-Yehoyada
Title: Anti-Mafia Investigative Journalist

Abstract:
Mauro Rostagno was an Italian investigative journalist who spent his career trying to improve the lives of those in need and to reveal the crimes of those who made many lives worse. Born in Turin, he died on September 26, 1988 in Sicily, murdered in a scene that matched the modus operandi of assassinations by the predominant mafia group in the region, Cosa Nostra. Layered within the resulting murder trial, though, are magnifying details that point beyond the violent act. Instead of a routine silencing of a voice in opposition, the case made apparent that Rostagno's attempted exposure of mafia crimes was anything but local: research into international racketeering, corruption in the government, and Masonic lodges where malfeasance took place all stand behind the curtain of his murder. The aim of Josh Martin's research project was to piece the names of these trials together - the defendants and their benefactors, the victim and his motives to reveal what could be revealed.

Mira Mason CC'25, English and Gender Studies

Faculty Mentor(s) or Supervisor(s): Jack Halberstam
Title: Becoming Woman: The Female Impersonation of Julian Eltinge

Abstract: The first person to be called a "transvestite" in the English language also happened to be the highest paid American actor of the 1910's. It was Julian Eltinge, the famous female impersonator who dazzled audiences with his startling convincing transformations and gorgeous gowns in a multi-decade, multi-genre, and multi-national career. More famous than Charlie Chaplin at his peak, Eltinge's career flies in the face of common conceptions surrounding the linear progress of trans acceptance or of the historical marginalization of all those of trans-feminine experience. This research project draws upon the limited archival material documenting Eltinge's life and career and the scant critical attention he's received to try to answer two related questions: why was Eltinge able to become so successful? And how does that success challenge or confirm our understanding of the history of sex, gender, and trans-femininity? This project found that Eltinge's success was made up of three related discourses. First, a discourse of fashion, or a set of clothing choices and the publicization of those choices that positioned Eltinge as one of the tastemakers of female fashion of the 1910's, debuting and popularizing the latest styles from Paris and London, but not before Eltinge altered them to suit his specific aesthetic needs. Second, a discourse surrounding his transformation itself. The most common archival material by far are articles that narrativize Eltinge's backstage transformation, beginning with his perfectly normal and unassuming masculinity before ending with his final female persona. And lastly, a discourse on race, namely the role that his Japanese butler Shima and his brief venture into blackface played in enabling his unprecedented fame.

Anna Patchefsky CC'25, Comparative Literature

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

Abstract: The Critical Studies in Harm Reduction History (led by Prof. Samuel Kelton Roberts and coordinated by Valentina Parisi) concerns itself with the historical analysis of events pertaining to public health activism against structural racism and punitive drug policy. Anna's research contributes to the online Historical Atlas and Directory of BIPOC Harm Reduction Organizations, which aims to provide a historical development of such organizations. Anna's research focused on the Young Women's Empowerment Project (YWEP) in Chicago, an organization formed in 2003 in Chicago, led by and for young women of color who have current experience in the sex trade and street economies. Anna's research is a comprehensive overview of the history of the organization that focuses on YWEP's practice of Liberatory Harm Reduction. Exploring the philosophy that values self-determination and relationship to the entire community, Anna's research explores the successes and limitations of an organization facing the intersection of policy, institutional violence, and harm reduction's status quo. Additionally, Anna conducted archival research on DW Griffith's Broken Blossoms, or The Yellow Man and the Girl (1919) producing a paper to be used in Professor Robert's forthcoming syllabus concerning race, drugs, and media. As was the case with its forebear, Birth of a Nation (1917), Broken Blossoms' popularity further propelled a decades-long tendency in Hollywood to produce, market, and profit from racist fantasy. Broken Blossoms narrates the intersection of Lucy, played by a 23-year-old Lillian Gish, her abusive boxer father, Battling Burrows, and her eventual friend who is a "sensitive Chinese immigrant" named Cheng Huan. The paper explores how Cheng Huan is a visual vessel for American and English eugenic fears.

Linda Qu CC'24, Comparative Literature

Faculty Mentor(s) or Supervisor(s): Lu Kou
Title: In Search of Current States of Mind

Abstract: My research over the summer attempted to begin answering the question of Who are we? by outlining the answers to Where we were before? and Where do we want to be hereafter? More specifically, I was intrigued by the proposition of the post-postmodern that emerged in the 1990s, since it suggests that our current ideology is attempting to revolt against postmodernism as the postmodern had against modernism just a few decades ago. Ever since the birth – or rebirth, rather, – of the concept of modernity, human intellectual development has always seemed to orient itself around it – whatever came before the Chinese Revolution of 1911 is labeled as the premodern, and whatever came after World War II the postmodern. The concept of the post-postmodern has not yet gained mainstream traction as it continues to compete with other terms such as hypermodernity and posthumanism, but the vast majority of these alternatives does not escape the framework of modernity, and modernity thus continues to be the dominating singularity through which history continues to be narrated. I thus seek for a systematic break from modernity and its satellite concepts by examining less-examined (in the West) societal models that nonetheless thrived in often overlooked corners of history such as that of premodern China and medieval Europe. Modernity helps me grasp the foundations of contemporary society, whereas postmodernity informs me of the primary discontents of modernity; the premodern and other human narratives outside of the modern scope, on the other hand, allows me to characterize contemporary human condition outside of the singularity of modernity

Krishan Rai CC'26, Music

Faculty Mentor(s) or Supervisor(s): Aaron Fox
Title: The Phono-poet: The Voice of Katalin Ladik

Abstract: The art of Katalin Ladik spans multiple mediums: from body art performance to collage, from photography to poetry to singing. Born in 1942 in the former Yugoslavia, and continuing her artistic practice between Hungary and Serbia to this day, Ladik has been described as "a very individual artist," (Ladik, Katalin. Interview by Obrist 2018), a feminist, and "a pop culture icon,"(Kurti 2017). In her own words, "My creative attitude is very personal. But this doesn't mean I'm not affected by social issues…I did occasionally provoke society in relation to my art and self-expression."(Ladik, Katalin. Interview by Obrist 2018). Although Ladik is primarily analyzed from an art history perspective, rethinking Ladik as a musician shows her work's relevance to 20th century histories of avant-garde vocal music. Her nonlinear and experimental path as an artist resulted in the creation of a diverse array of music with different groups and collaborators. Her music is radical: challenging the traditional division between composer and performer and bridging the gap between visual and sonic art forms. She represents a important and often critiqued female voice in a male dominated Yugoslav experimental art scene. Ultimately, through her reinterpretation of traditional balkan folk music Ladik's work also represents an alternative understanding of the meaning of "avant-garde" or "new" art.

Kira Ratan CC'26, History

Faculty Mentor(s) or Supervisor(s): Professors Jane Gaines/Racquel Gates

Title: Minority Experiences and Perceptions in Early Hollywood: An Archival History

Abstract: Kira Ratan spent her first summer as a Laidlaw Research Scholar conducting archival research of minority communities in Hollywood for two faculty-sponsored projects with Columbia's Graduate Film and Media Studies Department. Her first project, supervised by Professor(s) Jane Gaines, included locating, organizing, and analyzing archives for individual case studies of racial passing in the American film industry from the late 1800s to early 1920s. In addition to database searches, Ratan conducted copyright research, including taking inventory of glossy stills and digital images, as well as the archival deposits they came from, gaining insight into the exclusionary motivations behind racial passing in film and television casting. These collections are now in the process of being published as a public site through the Columbia Libraries system. Her second project built onto similar themes and involved assisting Professor(s) Racquel Gates with historical research for her second book on the aesthetics of classic Hollywood and Blackness. Ratan's research consisted of compiling materials like secondary sources and scholarly articles, in addition to sorting through and analyzing archival evidence on shared and shifting perceptions of classic Hollywood stars by historically marginalized groups. With both research projects now off the ground, Ratan has learned so much not only about the historical implications of minority experiences within the American film industry, but also about conducting thorough archival research and analysis for wider audiences. She is grateful to have been able to contribute to ongoing investigations in these relatively under-researched areas of history.

Olivia Ruble CC'24, Ancient Studies

Faculty Mentor(s) or Supervisor(s): Kristina Milnor
Title: Domestic Disruption in Harriet Hosmer's Daphne and Ovid's Metamorphosis

Abstract: This project examines how the figure of Daphne, the Greco-Roman mythological nymph-turned-laurel, is reinterpreted by Harriet Hosmer, a prominent 19th-century American neoclassical sculptor, in her work of the same name. The reception of Hosmer's work by her contemporaries was often obscured by her gender; Male critics relegated Daphne to passive feminine traits: steadfastness, self-sacrifice, and courage in the face of adversity. The goal of this project is to provide a more comprehensive study of the circumstances under which Hosmer brought Daphne to fruition. Furthermore, in grounding Hosmer's work within Book I of Ovid's Metamorphosis, this project aims to give credence to Hosmer's distinct interpretations of the text. In addition to a visual analysis of Hosmer's Daphne, this project entails a gendered analysis of portions of Book I of Ovid's Metamorphosis and an examination of Hosmer's correspondences. Contemporaneous texts regarding Hosmer and her work are also considered. Hosmer presents Daphne's metamorphosis as a confrontation between a woman and her autonomy; Daphne accepts that she must abandon her humanity in order to avoid a worse fate–conubia with Apollo. Studies of Hosmer's correspondence with Wayman Crow and Cornelia Crow revealed that Daphne was likely intended to resemble Cornelia Crow. This, coupled with Hosmer's intense opposition to marriage, for both female artists generally, including herself, and for her best friend, Cornelia Crow, especially, suggests that Daphne is a unique portrait of domestic disruption.

Aiden Sagerman CC'24, Comparative Literature and Society

Faculty Mentor(s) or Supervisor(s): Annie Pfeifer
Title: Eugenics across Borders: Georges Vacher de Lapouge, Corrado Gini, and American Eugenics

Abstract:
"Eugenics" refers to the now-defunct (pseudo)science of attempting to control reproduction to promote traits considered "desirable." The United States' eugenics movement played a central role in the scientific and political landscapes of the early twentieth century, intertwining itself with causes ranging from environmental conservation to racialized immigration restriction to birth control. In recent decades, historians have uncovered a history of collaboration between American eugenicists and Nazi Germany. However, American collaboration with eugenics movements across the rest of Europe has been comparatively underexamined.
In this project, Aiden Sagerman traces the relationships American eugenicists maintained with the French racial anthropologist Georges Vacher de Lapouge (1854-1936) and with the Italian statistician and science-advisor-to-Mussolini Corrado Gini (1884-1965) during the interwar period. While the Americans agreed with their European counterparts on the basic tenets of eugenics, they differed radically in their politics. American eugenics was dominated by a clique of aristocratic conservatives who looked down on mass politics, while Lapouge was a socialist activist and Gini supported Mussolini's populist regime. They similarly differed on racial ideologies: the American eugenicists, for instance, believed Italians to be racially inferior, a claim which the Italian Gini unsurprisingly rejected. Aiden's project seeks to

understand how movements so deeply inflected by national concerns managed to collaborate across national boundaries.

Olivia Wein CC'24, English

Faculty Mentor(s) or Supervisor(s): Edward Mendelson
Title: Passion and Its Friends

Abstract: There is no group of artists and intellectuals as prolific as The Bloomsbury Group. John Maynard Keynes altered economic colonialism between the British and India. Virginia Woolf brought the soul to literature. Roger Fry helped introduce Monet, Picasso, and Cezanne to America, and Leonard Woolf began the Hogarth Press (responsible for the first English translations of Freud) with Virgina- and that's only four of them! But this is not the whole story. The group discovered–and this research uncovers–that friendship, artmaking, and social change have passion in common. This early era of the 1900s, saturated with so much self- documentation and creation, tells us that every bit of our lives are motivated by connection. Passion expounds when other people are involved. The self concentrates in connection. Friendship is work, art is work, change is work, and all of it is only survivable if it is done with and for other people. It was conducted using primary source accounts from group members, critical studies on the relationship between war and artmaking, gender and the art-deco movement, resistance to the Victorian era, and the emergence of a social dialectic of eroticism. It was completed with the help of Lionell Trilling Professor, Virginia Woolf scholar, author, and head of W.H. Auden's Literary estate, Edward Mendelson.

Giselle Williams CC'24, History

Faculty Mentor(s) or Supervisor(s): Shana L. Redmond
Title: Dark Prelude: Black Life Before Mourning

Abstract: Professor Shana Redmond's research project, entitled Dark Prelude: Black Life Before Mourning, is an experimental recovery of Black life in the wake of spectacular state and vigilante violence. The project attends to the joys and practices of refusal in which Black people engage in the face of state-sanctioned terror, particularly those related to their music choices. Throughout the project, researchers conducted internet searches and preliminary archival searches and requests, as well as created secondary source curation and annotated bibliographies for books including Blackpentecostal Breath by Ashon Crawley, Development Arrested by Clyde Woods, and Black Boy by Richard Wright. Additionally, they had music-related duties, which included listening to music referencing the deceased and surrounding the circumstances of those who experienced anti-Black state and vigilante violence. Three subjects, in particular, occupied most of the research this summer: the cases of Aderrien Murry, Ralph Yarl, Brandon Calloway, and Ahmaud Arbery. These were young Black men and boys who faced state violence in high-profile, widely publicized incidents. The former three survived the violence, but as many know, Arbery did not. Concerning these cases, researchers exhumed any evidence of music that may have accompanied these scenes of violence. For example, they spent significant time examining the gospel song No Weapon by Fred Hammond, which Aderrien Murry sang after being shot by a police officer in front of his home in Indianola, Mississippi. Working on Dark Prelude this summer provided the opportunity to engage in research activities related to relevant and captivating topics while allowing researchers to learn firsthand about what such research entails.

Aristotle X CC'26, English

Faculty Mentor(s) or Supervisor(s): Shana L. Redmond
Title: The Dark Prelude: Black Life Before Mourning

Abstract: "The Dark Prelude" is a tracing of Black musical life before, during, and in the wake of, antiblack violence. The soundscapes of Black social life illuminate the absorption of vigilante violence as state violence, revealing a "vigilante state" in sites of the home and the car, both critical sites of antiblack violence. Particularly in the lives of Ralph Yarl, Aderrien Murry, Brandon Calloway, their sonic narratives tell stories of performance traditions that span across time and space. These soundscapes are placed in the context of medical, theological, and geographical literature, which accompanies each person's music as part of an inseparable history told through Black performance across myriad sites, including but not limited to coming-of-age dramas, thrillers, the blues, church congregations, step performances, and orchestral concerts. Each person's musical connection to history reveals a lineage of Black musical life, which paints practices of survival, migration, and community care that state records and dominant archives conceal. Against the grain of state narratives that preserve only the aftermaths of antiblack violence, sound becomes a unique and necessary history of Black life. Listening to Black musical life is not just an unflinching archive of the vigilante state's evasive and ever-changing violences, but also a countermelody of performance as life, resurrection, and love.

SECTION TWO:
SOCIAL SCIENCES RESEARCH

Xavier Amaro CC'25, History

Faculty Mentor(s) or Supervisor(s): Natasha Lightfoot
Title: Mexican-Americans in the Nuevo South: Race, Ideology, and White Supremacy?!

Abstract: Over the last few decades, historians have become increasingly interested in the historical distinctiveness of what some have called the Nuevo South. Some Nuevo South scholarship aims to understand the contemporary transformation of race and place in the American South by Latino immigrants who have made the South their home, starting back in the 1980s. The majority of Nuevo South scholarship, however, aspires to understand how Latinos themselves have been understood and treated by Southerners. These Nuevo South historians continue to investigate the racialization of Latinos, specifically Mexican immigrants, as a product of white supremacy. Xavier's intervention in Nuevo South research introduces a Marxist analysis to the field, problematizing the dominant ethnic studies framework and engaging with the scholarship of southern historian Barbara Fields to better understand the transformation of race and place. He is interested in the children of Mexican immigrants to the South, specifically Mexican-Americans in North Carolina. He explores their relationship to radical ideas like communism and anti-capitalism as well as their understanding of race and racecraft. He also explores the tension in using Chicano history as Southern history, and the tension in Mexican-Americans owning a Southern identity with Fields's history of the (white and black) South in mind. In the future, Xavier hopes that his research will help Nuevo South, Latino, Southern, and American historians alike understand the unique social terrain these southern Mexican-Americans occupy as well as the particular ideology that is produced and subsequently followed.

Asher Baron CC'25 History

Faculty Mentor(s) or Supervisor(s): David Doyle
Title: Unequal Gender-affirming Geographies: A Comparative Analysis of European Transgender Healthcare Systems

Abstract: Gender-affirming healthcare, composed of services such as hormone replacement therapy, psychotherapy, and surgery, carries significant benefits for transgender people. However, there exist geographic variances in both access to and provision of gender-affirming healthcare across Europe, previously largely unstudied. This study aimed to compare trans-specific healthcare systems across 28 European countries (the EU 27 plus the UK), and to examine country-level factors that may affect or be affected by these systems. Countries were classified into four typologies using a hierarchical cluster analysis, based on measures of trans-specific healthcare provision, regulation, and access. Country-level factors, including general healthcare expenditure and social climate, were then compared across clusters using an analysis of variation (ANOVA). All measures were extracted from publicly-available governmental, non-governmental, and academic secondary data sources. The analysis yielded four clusters of trans-specific healthcare systems in Europe: 1) Centralized conservative (highly centralized, many available treatments, few trans-specific government policies); 2) Centralized reformist (highly centralized, many available treatments, multiple trans-specific government policies); 3) Decentralized marketized (highly decentralized, moderate range of treatments, few trans-specific government policies); and 4) Underdeveloped (highly decentralized, few available treatments, few or no trans-specific government policies). Statistically significant differences between clusters were found in rates of: public support for trans people; gender identity concealment; treatment access; general health expenditure; and binary gender inequality. This study builds upon existing, more general healthcare systems typology research and highlights the unique structural variances present across trans-specific healthcare systems; future research should aim to link trans-specific healthcare system structure to outcomes for transgender people.

Rojeh Dayan CC'26, Financial Economics

Faculty Mentor(s) or Supervisor(s): Clémence Boulouque
Title: The Iranian Jewish Diaspora: Navigating Dual Identity, Assimilation, and Affiliations with Israel and Iran

Abstract:
For nearly three millennia, the lives of the Iranian Jews have oscillated between inclusion and marginalization within Iranian society and culture. Iranian Jewry enjoyed a time of exceptional prosperity in the twentieth century; however, the Iranian character was altered by the 1979 Iranian Revolution and its aftermath, prompting the emigration of most of Iran's Jews. Rojeh's research explores the Iranian Jewish community's affiliations

with Israel and Iran in Israel and the US, and how they influence assimilation and the formation of a dual identity. Negative social representations are associated with Iranian identity in Israel and of Israel in Iran, and Rojeh's research examines this tension. His research findings indicate that in Israel, Iranian Jews were excluded from the Israeli mainstream, causing a cultural identity clash between Iranians and Israelis. However, they also suggest that many Iranians in Israel have maintained both individual and collective reflections of Iranian culture in their lives. His research further indicates that in the US, Iranian Jews have formed close-knit communities amid America's individualistic culture and liberal social values, which clash with their traditional way of life. His findings reflect that Iranian Jewish immigrants as a whole have assimilated into their conception of American life while simultaneously maintaining their Iranian and Jewish identities. His research suggests that today, new waves of Iranians are proudly reclaiming their heritage and identity. His findings may contribute to learning about other cultural groups and have important implications in the areas of cultural integration and identity formation.

Sively de los Santos CC'26, History

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

Abstract: Face masks, sex education, and needle exchange programs. Harm reduction explains itself: reducing the harm involved in physical and social behaviors. However, a simple name does not equal a simple task. The Critical Studies in Harm Reduction History Project examines the social and political history of harm reduction initiatives. Often, reflecting on previous harm reduction policies may lead to criticisms of the effects of these policies. Dr. Roberts, who is leading the Harm Reduction History Project, specializes in African-American urban history and public health. In the summer of 2023, Sively joined this project to help build an archive of interpretive essays, oral histories, and a historical directory related to harm reduction. She centered on researching organizations involved in harm reduction and the effects of harm reduction policies. The archive culminating from this research will serve as an educational outlet allowing readers to better inform their discussion around harm reduction and leading to more effective health policies.

Griffin Fadellin, GS'24, Anthropology, Emma Germano BC'24, Medical Anthropology & Cell and Molecular Biology, & Mohammad Zaidi CC'25, Sociology

Faculty Mentor(s) or Supervisor(s): Madisson Whitman
Title Post-Pandemic Data Literacy and Autonomy: A Qualitative Study of Students in Higher Education

Abstract: With the exponential proliferation of data-collection in higher education and the world at-large during the COVID-19 pandemic, students are now expected to manage their data in an age increasingly defined by spuriously clicked terms of use and ever-more technologically advanced methods of data gathering. Our qualitative research aims to uncover the lived experiences of students as they actively grapple with this new wave of opportunistic data collection. What are the limitations of individual 'data literacy' on contemporary college campuses? Are consent processes for data collection understandable and accessible for students? What efforts can and do students take towards maintaining their autonomy and privacy? What are their different levels of awareness of and reactions to the scale and presence of data collection in higher education? We investigate these questions using an online survey and semi-structured interviews with college students, with a particular focus on students who were enrolled during the COVID-19 pandemic. Initial results indicate a stark lack of transparency students face when it comes to investigating the role their personal data has played at their institutions. While our study remains ongoing, our qualitative analytical approach explores the limitations of 'data literacy' in the face of increasingly complex and opaque systems of data.

Harrison Gerson CC'25, Sustainable Development

Faculty Mentor(s) or Supervisor(s): Bryan Brazeau
Title: Venice: the city of overtourism; current challenges and future sustainability steps

Abstract: The natural environment has shaped the development of Venice, a city built on a lagoon. Since its inception, humans have altered the natural structure of the lagoon and the surrounding lands and waters to create an island city and empire of La Serenissima. As the island manages over-tourism and climate change today, understanding the environmental history, present, and future of Venice is key to solving its growing challenges. This map and related research share highlights of environmentally-minded activities and functions of Venice. As tourists, learning about, supporting, and sharing the environmentalist activities around Venice can help ensure a more sustainable city. This summer, Harrison Gerson traveled to Venice with the Columbia Global Collaboratory program in partnership with the University of Warwick entitled A Sustainable Serenissima. The course analyzed the past, present, and

future of Venice and its relationship to tourism and the environment. Tourism significantly affects the global carbon footprint, about 8% worldwide (according to Nature). The social, economic, and environmental effects of the tourism industry display so clearly in Venice, as the city is overwhelmed with tourists and built on a very biodiverse and geographically unique lagoon. This research shares the environmental complexities of Venetian developments in Venice first-hand, as well as future plans to ensure that Venetian tourism occurs more sustainably.

Hannah Halberstam CC'25, History

Faculty Mentor(s) or Supervisor(s): George Chauncey
Title: Dean Virginia Gildersleeve: Limited Use of Limited power

Abstract: Virginia Gildersleeve was dean of Barnard from 1911 to 1947 and a lifelong advocate of women's advancement. Prior work has examined her efforts to promote measures that expanded and enriched opportunities for some women in the academy while simultaneously limiting opportunities for others. This project investigates her complex tenure and legacy through an examination of her letters and speeches alongside letters, essays, and fiction produced by students and faculty who lived and worked at Barnard during Gildersleeve's deanship. This inquiry shows Gildersleeve's interest in the promotion of women's access to education and careers, her paternalistic efforts to uplift people in other countries whom she believed needed her help, and her intent to make Barnard into a more elite, nationally recognized institution. The documents reveal that these efforts yielded improvements in Anglo-Protestant women's access to academic work and, specifically, their ability to pursue careers whether married to men or, like Gildersleeve, unmarried and living with women; admissions policies that offered Anglo-Protestant women from the Midwest, South, and West residential scholarships to attend Barnard; and support of international aid organizations that purported to provide healthcare to residents of China and to advocate for refugees. In each instance, Gildersleeve sought to provide various groups with marginal assistance to problems she identified, without challenging the power structures which created these problems in the first place. Examining the writings of Barnard students and faculty during Gildersleeve's deanship shows their interpretations and responses to Gildersleeve's ideas and politics, and thereby offers further insight into Gildersleeve's legacy.

Roberta Hannah CC'24, African American and African Diaspora Studies

Faculty Mentor(s) or Supervisor(s): Lisa Del Sol
Title: Fossilizing Our Histories: Digital Worldmaking and Urban Black Girlhood

Abstract: Living in what we call the digital age, historically underrepresented populations are left to form their legacies out of anonymous artifacts scattered across the internet. Much like the fossils and tools seen in museums across the globe, the internet is the new viewing ground for history. In formerly Black and Brown communities in New York and Los Angeles, which are facing intense displacement and gentrification, the only standing remains of their former citizens are the internet clips posted. While ubiquitous to the average person, the Internet, and Social Media hold the tools for preserving community and culture. Researchers have many theories about the purpose of Internet participation, but underscoring them all is the idea of connectivity and reputation. This is especially important in urban communities, as one's reputation can differ between being a victim and a victimizer. Building a reputation also creates a legacy for the participant and the place they represent. In contrast to traditional paradigms of gatekeeping, those who hold the key to the new urban archive are the youth, specifically young girls, as they have the most prominent social networks. Their seemingly benign Instagram and Twitter posts are writing the pages of our future history books. With this, this project tackles the question: How do the unassuming digital behaviors of these young Black girls mediate the fossilization of what can be considered dying communities and histories?"

Charlie Hoskins CC'25, History

Faculty Mentor(s) or Supervisor(s): Dayle Jones
Title: First Nations Australians and Over-Representation in the Justice System

Abstract: Despite the efforts of the 1991 Royal Commission on Indigenous Deaths in Custody in Australia, First Nations people are still overrepresented in Australian prisons. Indeed, the Australian justice and policing systems are grounded in the settler colonial legacy of British imperialism. As a result of this, Indigenous Australians continue to face intergenerational trauma and disconnection from country, as well as over-policing, which leads to their increased incarceration compared to white Australians. Over a six-week period, Charlie Hoskins worked for the Victorian Aboriginal Legal Service (VALS), a non-profit law firm that provides necessary legal services to Indigenous Victorians. While working here, Charlie saw firsthand the impacts of judicial racism, over-policing, and imperialist governance on First Nations

Australians. Through his project with VALS and in conjunction with his prior research on American and Australian settler colonialism, Charlie aims to show how British imperialism in the 18th, 19th and 20th centuries has left a devastating aftermath that Australian state and federal governments are still hesitant to solve, or even address. With a referendum in October about the enshrining an Indigenous Voice in Parliament and treaty negotiations taking place in Victoria on a state level, now is the time for Australians to reckon with their history. By amalgamating first-hand accounts from Indigenous Australians alongside academic perspectives on the Australian prison system, Charlie's poster invites others to address Australia's past whilst looking to the future.

Joe Karaganis CC'26, Philosophy and Political Science

Faculty Mentor(s) or Supervisor(s): Chris Wiggins
Title: Automating the Fourth Estate: Journalistic Norms and Ethics Under the LLM Revolution

Abstract: This research project explores the journalism industry's reaction to new developments in generative artificial intelligence technology (ChatGPT, Google Bard, etc.). It focuses on the editorial policies and business strategies that have emerged to regulate newsroom uses of AI content production--what norms and practices have spread throughout the industry, and how have those norms and practices been created? These questions are pursued through interviews with leading tech reporters and academics. The interviews are contextualized by extensive background research on the history of newsroom AI automation and contemporary frameworks for ethical AI integration. These two currents of research help form a conceptual framework that describes the debates, points of consensus, and conflicts surrounding AI in the journalism industry.The study's main conclusion is that its own questions are somewhat unanswerable at present--the rapid speed of innovation and shifting attitudes of business leaders makes it far too early to tell where industry norms will land. The study suggests that most journalists share this profound sense of uncertainty. Publications have been hesitant to pursue aggressive AI adoption, and especially hesitant to use generative AI for content production. The few that have pursued aggressive strategies have experienced public backlash that has served as a warning to others. Future work will be needed to assess the trajectory of policy standards and established norms as AI technology grows more complex and capable.". The few that have pursued aggressive strategies have experienced public backlash that has served as a warning to others. Future work will be needed to assess the trajectory of policy standards and established norms as AI technology grows more complex and capable.

Grace Kaste CC'25, Economics

Faculty Mentor(s) or Supervisor(s): Michael Gerrard
Title: New York Cap and Invest: Linking Cap-and-Trade Programs in the Wake of Overallocation

Abstract: As New York State follows California, Quebec, and Washington in adopting a cap-and-trade initiative, policymakers have planned to link these programs to create a larger shared market of emission credits. The dominant theory is that linkage should be pursued because it enhances the economic and environmental effects of cap-and-trade programs by lowering compliance costs. Because of these benefits, New York Cap and Invest (NYCI) administrators are now considering linkage with California and Quebec, who have already linked to form the Western Climate Initiative (WCI). However, previous research and opinion has failed to take into account the effects of California's chronic oversupply of emission credits. This project quantifies and compares the projected environmental effects of WCI and NYCI's individual cap-and-trade programs, first without linkage and second with linkage, by analyzing past emissions data and results from California's emission credit auctions, as well as WCI and NYCI's future emission-reduction targets. Contrary to what is assumed, immediate linkage of NYCI with WCI would dilute their shared market. 29% of achieved emission reductions would be lost in both NYCI and WCI due to California's oversupply. In conclusion, an analysis of the collected data and the relevant academic literature suggests that New York should pursue linkage with WCI due to its economic benefits to both parties. However, linkage should be contingent upon California eradicating its oversupply so that the environmental effectiveness of both states' cap-and-trade programs may be restored.

Erica Lee, CC'26, Urban Studies

Faculty Mentor(s) or Supervisor(s): Chandler Miranda
Title: Exploring Student-Panelist Relationships in Performance-Based Assessment Tasks (PBATs) for Recently-Arrived Immigrant Students

Abstract: Traditional standardized high school exit exams are known to disadvantage recently arrived immigrant students, yet few studies have demonstrated how this population experiences performance-based assessment tasks (PBATs) as supplements and substitutes to standardized tests. PBATS

are structured such that one student presents to and is questioned by three evaluators on a panel: the mentor of the student being tested, a teacher of the subject of the PBAT, and an external observer—a teacher, social worker, volunteer, or other figure. Using ethnographic methods and qualitative coding, this research explores the effect of student-panelist relationships on the PBAT testing experiences of students at an urban high school for recently arrived immigrant youth. Framed around each of the three types of panelists, the following findings indicate that student-panelist relationships commonly foster constructive environments which actively encourage students to present their full understanding of a subject. However, student-panelist relationships also create confounding variability between different students' PBAT testing environments and outcomes.

William Liu GS'24, Undecided

Faculty Mentor(s) or Supervisor(s): Chandler Patton Miranda
Title: Unveiling the PBAT Scoring Phase: Investigative Insights into Teachers' Strategies for Enhancing Student Improvement

Abstract: The policy of college entrance exams in public schools has always been controversial. In the case of the Regents Exams in New York State, research shows that this standardized test has not effectively improved educational outcomes, but instead has exacerbated inequalities. Therefore, Performance-Based Assessment Tasks (PBAT) aim to replace standardized tests. PBAT is a student-centered, performance-based assessment method. Previous research literature suggests that the difficulty of passing the PBAT is similar to that of standardized tests, and statistics show that it is much harder to get good grades on the PBAT. However, both teachers and students have consistently shown greater enthusiasm for working with the PBAT. The extensive literature review indicates that many studies of the PBAT focus their research on the pre-scoring phase, with less research on the scoring phase (how the committee evaluates and grades student work). For example, studies focus on whether the PBAT is easier than the Regents, or whether the PBAT improves students' skills in certain areas, such as reasoning, compared to standardized tests. Not much literature has examined the scoring process of the PBAT. Compared to standardized tests that only give students a final grade, how does the process in PBAT effectively guide students to reflect on their strengths and weaknesses? Thus, this research project aims to examine teachers' techniques for maximizing the benefits of PBAT's unique assessment process when students perform poorly. The study will be conducted through extensive in-person fieldwork at the school, its subsequent research notes, interviews, and other analytical data in the Dedoose database.

Roli Nyirenda CC'26, Human Rights

Faculty Mentor(s) or Supervisor(s): Widney Brown
Title: The Efficacy of the Boone Rule in Reducing Wrongful Conviction of Black Men in NYC

Abstract: Cross-racial identification is the psychological phenomenon that explains why people often have a difficult time identifying individuals that do not belong to their self racial or ethnic group. It is linked to the exacerbation of intersectional discrimination in criminal court proceedings by affecting how and what evidence is impermissible in court, and the likelihood of a case resulting in a plea bargain with an admission of guilt. For example, the NYC Courts Database indicates that 78% of Manhattan jurors are Caucasian males, whereas 90% of defendants are Black and Hispanic men. Alarmingly, there has been a 14% increase in wrongful conviction among Black men. The Boone Rule was introduced as a legal rule in 2018 after the Boone v. The People case that resulted with a wrongful conviction of Otis Boone, as a measure to reduce such cases of wrongful conviction due to cross racial identification. By analyzing opinion pieces, law review articles and statistics, this project evaluates the efficacy of the Boone Rule. Ultimately, this research concluded that even with thorough implementation of the Boone Rule, it would not make a statistical difference to the NY incarceration demographics due to multiple discrimination. It is currently impossible to eliminate all the biases at play in the legal system. The Boone Rule's efficacy would increase by working in tandem with other systemic changes that deal with the slew of existing prejudice in our criminal justice system. On its own, it would however, change the type and quality of witness-based evidence that is permissible in court with eyewitness evidence being appreciated in the context of cross racial bias. More policies like the Boone Rule are a step towards acknowledging that multiple discrimination, and cross racial identification could significantly affect incarceration rates of certain groups, namely Black men in Manhattan.

Mathew Oey GS'24, History, Luc Hillion GS'24, History & Stephanie Chan BC'24, History

Faculty Mentor(s) or Supervisor(s): Professors Kwa Chong Guan and Peter Borschberg

Title: Reimagining Southeast Asian History: Postcolonial Theory, Singapore Historiography, and the Triumphs and Challenges of Organizing a High-profile Academic Conference as Undergraduates.

Abstract: The history of Singapore has traditionally been taught as beginning in 1819 with the founding of a decrepit backwater by British colonialist Stamford Raffles. However, much archaeological and historical scholarship has disproven this narrative, showing that Singapore (under the name Temasek) was a thriving and cosmopolitan port city in the 13th and 14th centuries. Knowledge of pre-colonial Singapore has existed at least since the 17th century. However, even after Singapore became an independent state in 1965, Singapore's history continued to be taught through the lens of British colonialism, in the process turning Raffles into a "great man" of history. The myth that nothing existed before British colonialism continued to be reproduced in textbooks, monuments, and political speeches. Assessing why certain versions of Singapore's history were cast aside in favor of Eurocentric ones is a problem for historiography. How does neo-colonialism influence the teaching of Singapore's history? Why are narratives of pre-modern Singapore left out in its collective memory? How have myths shaped the hypostatized narratives of Southeast Asian history? These questions formed the thematic crux of "Reimagining Southeast Asian History," a conference organized by Matthew Oey, Luc Hillion, and Stephanie Chan at the Asian Civilisations Museum. The conference featured leading academic and popular historians of Singapore and Southeast Asia from the National University of Singapore. The conference discussed such themes as applying post-colonial theory to history, the historiography of Stamford Raffles, archaeological and non-English sources on pre-modern Singapore, and the relationship of Singapore to macro-historical forces in Southeast Asia.

Sami Omaish GS'25, Urban Studies

Faculty Mentor(s) or Supervisor(s): Lila Abu-Lughod
Title: A Way of Walking: Conversations with Michael Gilsenan

Abstract: Dr. Michael Gilsenan is a renowned British social anthropologist specializing in the Middle East and Muslim world. Upon Dr. Gilsenan's recent retirement from NYU, a group of his colleagues, led by Dr. Lila Abu-Lughod and Dr. Naor Ben-Yehoyada, set out to celebrate his career in a "Festpod," taking from the German term "Festschrift" for the purposes of creating a podcast that will soon be published on an online website. This podcast consisted of a series of conversations between Dr. Gilsenan and his colleagues, discussing both personal life and work while giving insight on topics of both spirit and intellect. Fatima and Sami's contribution came in the form of transcription so that these conversations may serve as digital oral history archives in the future. They worked through multiple iterations to transform these conversations into a scholarly resource on anthropological questions concerning everything from the dhikr rituals of Sufi orders in Cairo to the economic dominance of Yemeni immigrants in Singapore. As such, Fatima and Sami hope to have created a sort of anthropological "encyclopedia" of the topics of Dr. Gilsenan's career that would be useful to anthropologists and anyone curious about the Middle East — one that, rather than serving to reach some elusive teleological end, exemplifies Dr. Gilsenan's own "Way of Walking."

Daniela Palacios CC'26, Political Science

Faculty Mentor(s) or Supervisor(s): Lael E.H. Chester
Title: Education Behind the Wall: Examining the Impact of College Prison Programs on Formerly Incarcerated Students

Abstract: An emerging adult, typically defined as an individual between the ages of 18 to 25, marks a distinct developmental phase from adolescence to young adulthood. This demographic is disproportionately represented within the criminal justice system, raising questions about their support mechanisms for personal development and community reintegration. Under the Emerging Adult Justice Project (EAJP), this research project focuses on emerging adults pursuing higher education while incarcerated. Conducted through four in-depth exploratory interviews with individuals from New York, Pennsylvania, and Massachusetts, who enrolled in college-in-prison programs while incarcerated, the research revealed their distinctive educational journeys. Employing qualitative coding and thematic analysis of the interview transcripts, a more profound understanding of education's potential for young individuals in the justice system was uncovered. Higher education can play a crucial role in the developmental journey of emerging adults, acting as a tool to address recidivism. The findings offer timely insights for criminal justice reform efforts, as interviewees underscored diverse positive impacts of higher education on their personal growth, identity reshaping, and re-entry experiences. According to the emerging adult justice developmental framework, change must span the individual, practice, and policy levels. Justice systems should offer access to quality education, including materials, spaces, and mentorship, fostering pivotal life experiences for a mature, healthy adulthood. Effective partnerships between correction departments and postsecondary educational institutions are pivotal for maintaining engaging and respect-centered educational opportunities. Equally significant, justice

system stakeholders should actively seek and integrate the insights and suggestions of the emerging adults themselves.

Yardena Rubin GS'26, Sustainable Development

Faculty Mentor(s) or Supervisor(s): Gale Lynch
Title: Unveiling the Illusion: Exploring the Impact of Social Media on Travel Disconnect in Venice, Italy

Abstract: In today's digital era, social media has transformed the way people approach and experience travel. Tourists are constantly driven by the quest for capturing the perfect photograph for social media, often prioritizing aesthetics over authentic experiences. With a focus on Venice as a case study, the paper examines how the pursuit of this picturesque social media moment has transformed the environment, altered societal interactions, and impacted local culture. This paper aims to bring awareness to the evolving dynamics of travel in the digital age, emphasizing the need for conscious and sustainable tourism practices, while harnessing the potential of social media as a tool for both education and global connection. Recent research and experimentation have brought to light the issues that overtourism and social media driven tourism pose to the environment and culture in Venice. There have been some advances in the right direction with newly proposed regulations on tourism management and environmental protection. However, it is still a long way from directly targeting the problems that Venice faces. This paper calls attention to these issues currently faced as the threat of social media driven tourism continues to grow. As Venice struggles with the ongoing challenges posed by social media and tourism, it becomes increasingly vital to develop comprehensive and tailored solutions for its preservation and sustainability.

Easton Schindler CC'24, Sociology

Faculty Mentor(s) or Supervisor(s): Adam Reich
Title: The Racial Hate Strike Phenomenon in Wartime Detroit: A Case Study

Abstract: In the first week of June 1943, as part of the largest racial hate strike to roil Detroit in the Second World War, approximately 25,000 white workers walked off the job at the Packard Motor Car Company plant on the city's East Side, spurred by the hiring of a handful of Black workers in a previously segregated department. That race relations were in such a strained state in the early 1940s, and in light of the seemingly-complete lack of studies of the hate strike phenomenon, "The Racial Hate Strike Phenomenon in Wartime Detroit: A Case Study" set out to probe what went on in the months and years around June 1943 at the Packard Plant. Essentially, this meant constructing a chronological account of the events that were to culminate in the biggest hate strike to hit the Motor City, as well as developing an appreciation for the roles assumed by different actors in the situation. Drawing on documents photographed during archive trips to Detroit and Chicago, and also on historical newspaper issues available on the internet, the project revealed the Packard Plant to be the site of a continuous and complex contest over the representation of Black workers in the workplace. Hate strikes appear, from this angle, as dramatic demonstrations in favor of the status quo by whites. Importantly, however, the overall picture cannot be comprehended without acknowledging the self-advocacy of Black workers, the balancing act executed by the liberal UAW local, and the desire of management to sow discord.

Balthazar Sheehan GS'24, History

Faculty Mentor(s) or Supervisor(s): Samuel Roberts
Title: Critical Studies of Harm Reduction Project

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, he investigated the history of the Black Temperance Movement in the United States, examining its nuances and evolution over the course of the nineteenth century. Balthazar examined primary source material from Black Temperance advocates like Frederick Douglass, W.E.B. Du Bois, and Frances Ellen Watkins Harper, while also parsing more recent historiographical debates surrounding the motives and efficacy of the movement. Black intellectuals and activists envisioned temperance as not merely a movement to restrict the consumption of alcohol, but an expansive campaign seeking to cultivate political, economic, and moral security for Black Americans. As such, Black Temperance featured a variety of unique ideologies and organizational strategies, serving as an incredibly important period for the cultivation of subsequent activism. Unfortunately, by the end of the century, the American temperance movement had delivered prohibition of liquor traffic at the expense of Black social and civic elevation. Rhetoric involving the concept of "Black uplift", functioned as the tacit embrace of a spectrum of meritoriousness and set the criteria through which many Black Americans could (and would) be disenfranchised.

Mrinalini Sisodia Wadhwa CC'24, History & Mathematics

Faculty Mentor(s) or Supervisor(s): Susan Pedersen

Title: Of 'Representative Women' and 'Women Representatives': Debating Women's Reservations in India's Last Colonial Constitution, 1930-35

Abstract: Early twentieth-century British India saw a diverse cast of activists lay claim to rights, from nationalists demanding autonomy to minorities seeking representation. In response, Britain convened a series of reform committees, culminating in the Government of India Act of 1935, India's last colonial constitution, which created assemblies for Indians to participate in domestic policy. This project traces how Indian women's organizations engaged in these debates, focusing on the issue of reservations—i.e., reserved assembly seats for female candidates. Reservations split the women's movement. Proponents argued they advanced feminist social reform; opponents claimed they undermined national unity. How did leaders of the three main women's organizations—the All-India Women's Conference, National Council of Women in India, and Women's India Association—understand the role of 'women representatives'? What was the tenor of their relationships with each other, and with the British feminists and Indian nationalists they allied with to advance their positions on reservations? To address these questions, the project draws on these women's correspondence in British and Indian archives, triangulated with committee records. It reveals the need to treat these women not as a nationalistic monolith, but as political agents negotiating representation within the power structures of empire. In doing so, it challenges the mainstream view that Indian women, "infected… with the spirit of national unity," never sought reservations, revealing how feminists were pressured into abandoning their original vision of representation, and how those who refused were sidelined as 'unrepresentative'—generating controversies over women's reservations that continue in the present-day.

Sinziana Stanciu GS'24, History

Faculty Mentor(s) or Supervisor(s): Catherine Evtuhov
Title: Sibling Xenopol: Romanian Nationalism in the 19th and 20th century

Abstract: Dive into the world of Eastern European nation-building during the 19th century, and peer into the inner life of a family of intellectual elite as they strive to reconcile Occidental influences with domestic Romanian history. This project has centered on three siblings: A.D. Xenopol, Adela Xenopol, and Nicolae Xenopol. A.D. Xenopol is the most famous of the three, as a significant historian, philosopher of history, and professor. Adela was a prolific writer and feminist, advocating for women's rights while organizing and editing journals dedicated to works written by female authors. Their brother, Nicolae Xenopol, was an intellectual, domestic politician, and foreign diplomat. The goal of researching this family and their thoughts on Romanian nationalism is twofold. Firstly, it shows the significant overlap between the domestic and political spheres. Intellectual elites from different families were answering these questions of Romanian nationalism amongst themselves and the public. Secondly, this project will bring to the fore the question of foreign versus domestic within the Romanian sphere. Concepts such as citizenship, ethnicity, and international cultural ties were vital in defining what Romania is and what it should be. This family collectively contributed to different parts of the tableau of what is Romania, and this project assesses their conclusion. The research project entailed going to archives in Romania and reading personal correspondence, notes, published and unpublished material, and personal documents.

Andrea So CC'23 Political Science

Faculty Mentor(s) or Supervisor(s): Robert Shapiro
Title: Americans' perceptions of democratic decline and public opinion towards China and Russia

Abstract: In an age where the liberal world order seems to be in decline, this project aims to understand the influence of Americans' perceptions of democracy on public attitudes towards China and Russia, and how this relationship shifted from the years of 2018 to 2022. Specifically, whether public opinion surveys indicate that global democratic decline is perceived as a critical threat, and how these results relate to public support of US military intervention should China and Russia attack Taiwan and NATO countries respectively. The analysis controls for variables that include the survey respondents' political party, self-identified political ideology, gender, age as well as level of education. Within the project, differences are examined between survey participants who have graduated college and those who have not. Although there are issues of endogeneity and the use of instrumental variables was explored, the basic results show a relationship between the public's concern regarding democratic decline and public attitudes toward China and Russia and their leaders. Furthermore, this relationship is stronger in 2022 than in 2018. These findings suggest Americans' heightened perception of threats to democracy due to events that occurred between 2018 and 2022, and these are related to an increased willingness to support US intervention should democratic norms be challenged on the global stage in 2022.

Pablo Torres Tey CC'25, Economics & Math

Faculty Mentor(s) or Supervisor(s): Mauricio Cardenas
Title: Ritual Responsibilities: Khmer Buddhism and the Family During and After Democratic Kampuchea Implications of Climate Change for EMDEs: Exploring the Asymmetries

Abstract: The main purpose of this work was to focus on the asymmetries that differentiate EMDEs from Advanced Economies, not only in terms of the impact of climate change but also in the ability to adapt. Failure to acknowledge these differences can result in insufficient climate action, undermining the efforts of Advanced Economies and causing large costs due to extreme weather events, migration, and conflict. Importantly, if the asymmetries highlighted in this paper remain unaddressed, the decline in global inequality observed during the last 40 years can be reversed and achieving the SDGs can be severely compromised. Climate actions adopted by advanced economies can have negative consequences in EMDEs, especially when they are guided by domestic political considerations. If the goal is to decarbonize the world economy, the priorities should be placed on those interventions with the lowest cost and the highest return per ton of CO2 avoided or abated. Climate efficiency would point in the direction of supporting some interventions in EMDEs, rather than introducing expensive subsidies with significant capacity to distort economic decisions.

Janessa L. Vargas CC'26, Political Science & Comparative Ethnic Studies

Faculty Mentor(s) or Supervisor(s): Andrew McCall
Title: The Kids are not Alright: An Inter-disciplinary Investigation into Nationwide Educational Gag Orders concerning Critical Race Theory and Sex Education

Abstract: As a moral panic over Critical Race Theory and LGBTQ+ rights has taken storm, over 300 bills limiting the instruction of American history and human sexuality have been introduced within state legislatures since January 2021. These bills, alongside media frenzy, have fueled the so-called "culture wars" in the United States in the lead-up to the 2024 Presidential election. As of July 2023, 76 laws restrict the autonomy of public school teachers and university professors, as well as the very students who count on them for a now state-sanctioned education. Though the battle started in Alabama, the "culture wars" are now widespread, with legislation either introduced or signed into law in 45 out of 50 states. Vargas undertook the project of finding commonalities between legislative texts. Using a database compiled by PEN America, Vargas cross-referenced legislative texts to find frequency in phrasing and employed topic modeling program (MALLET) which runs in either Python or JavaScript, to gather quantitative data on the frequency of phrases used within legislation surrounding the subjects of race, ethnicity, and sexuality.

Nicole Vieira-Pires CC'25, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Rajat Agrawal
Title: Drug Development and Pricing – How do pharmaceutical companies decide on the cost of a drug*?*

Abstract: The pharmaceutical industry plays an essential role in improving health conditions worldwide through the development of medications. The investment to produce a new drug is very expensive, and the process is explained throughout the article. However, because it costs much for pharmaceutical companies to produce a drug, the cost of the drugs for patients has become a major public concern in the United States, given that a great percentage of individuals who need them cannot afford them. In this paper, the authors explain the imbroglios of drug pricing, stating the reason why drugs are priced the way they are and how this impacts patients and society as a whole. Additionally, they dive into the detailed steps of negotiating and pricing a drug, considering costs of preclinical research, laboratory tests, and clinical trials in human subjects, and the rebates done by Pharmacy Benefit Managers, Manufacturers, and Insurance Companies. Transparent drug pricing is crucial for fostering trust between pharmaceutical companies, healthcare providers, policymakers, and patients. The authors have reviewed published literature to present the current status of the issues facing the many stakeholders in the process. They have concluded that addressing drug pricing and ethics in the pharmaceutical market is not a singular challenge; instead, it is a collective responsibility that demands transparent practices, thoughtful policymaking, and a commitment to putting patients as the priority of healthcare systems.

Luiza Vilanova CC'24, Political Science

Faculty Mentor(s) or Supervisor(s): Natalia Ortiz
Title: From Finland to Brazil's heart: Comparative Education Reform

Abstract: Believing in the extraordinary power of education is difficult in a country where many schools lack conditions for learning. Education reforms, however, provide a glimpse of hope amid complex realities. Consequently, this research aims to showcase key aspects of two distinct reforms around the world. Focusing on Goiás—a Brazilian state—and Finland, quantitative and

qualitative analyses were conducted to evaluate the impact of public policies implemented. Improvements in infrastructure, teacher training, and curriculum were measured based on national and international datasets. A literature review was conducted to describe further the primary aspects of each education reform examined. Infrastructure was the most striking difference between the countries. More than 6,800 Brazilian educational institutions do not have sewage, while another 3,031 do not have electricity. In clear contrast, 99% of Finnish schools had access to the Internet. Teacher training was a key area of reform: Finland significantly introduced practical learning and in-school experience for its future teachers. Meanwhile, 6 out of 10 Brazilian teachers are trained solely through online courses. Curriculum changes were implemented to ensure equity across schools. After examining extensive evidence on students' performance, three main reform components were found to have the most significant impact. First, establishing clear goals after a holistic examination of pre-existing challenges. Both Goiás and Finland ensured every stakeholder was aware of the reforms' primary purposes. Second, at first compliance mechanisms were introduced to guarantee changes. Finally, emergency infrastructural upgrades were funded to create preconditions for successful learning.

Jack Walker CC'24, Political Science

Faculty Mentor(s) or Supervisor(s): Justin Phillips
Title: Party Reform and the Origins of Abortion Politics

Abstract: The movement for abortion rights has become a defining feature of the American political landscape and concomitant partisan polarization. The issue of abortion, in this way, is a meaningful case study for the emergence of social issues in the political discourse along with the growing divide between the Democratic and Republican parties. While the vast majority of existing scholarship suggests that position-taking on abortion initially occurred in 1978-80 at the hands of social conservatives joining the national GOP, newly created data sets challenge this understanding. Through a novel collection of state party platforms and archival news coverage, this project finds that the partisan divide on abortion actually began in 1970-72, before the landmark Roe v. Wade Supreme Court decision. This project also finds that position-taking was driven at the state level rather than the national level. Additional findings include that Democratic leaders, even at the state level, nearly always resisted the work of issue activists, and that such liberal activists, empowered by reforms to party structure and delegate selection, laid the groundwork for the divide in question. (This paper is a rough draft and still being developed. Citation or quotation without written permission of the authors is not permitted).

Katherine Wang CC'24, Economics-Political Science

Title: COTPA and Cocaine: How A Trade Agreement Affected Organized Crime-Related Violence in U.S. and Colombian Port Cities

Abstract: The transportation of illegal goods across international borders often involves legal trade routes; as such, the passing of legislation might have an impact on their trafficking. This paper seeks to understand how the United States-Colombia Trade Promotion Agreement of 2012 (COTPA) affects the volume of cocaine trafficked between the two countries. The production and distribution of cocaine are controlled by organized criminal groups, and this paper applies Lessing's theories of the benefits and costs of violence to the bilateral agreement. I use a differences-in-differences model to estimate the effect of the treaty on measures of violence associated with organized crime in port- and non-port cities; while I find that the COTPA is associated with more market activity, there is little causal effect on violence. However, my findings highlight the discrepancies and uncertainties that shroud the market for cocaine, even amongst official government sources. Given, also, the difficulties in measuring and attributing some of these metrics to organized crime, I find my results are curious enough to merit further research.

Sarah Yu Wang CC'24, Economics-Mathematics

Faculty Mentor(s) or Supervisor(s): Lauren Bauer
Title: Prime-age women are going above and beyond in the labor market recovery

Abstract: Since February 2023, the labor force participation rate for prime-age women—those between the ages of 25 and 54—has exceeded its all-time high. As of the most recent August jobs report, prime-age women had a labor force participation rate of 77.8 percent. This is remarkable, given evidence that the 2020 recession initially widened the labor force participation gap by gender and by parental status. These peaks are also surprisingly happening in the summer, even after seasonal adjustment, as this is typically the season when participation for caregivers is at its lowest. Using the American Community Survey (ACS) and Census Household Pulse Survey, the Brookings Institution's Lauren Bauer and Sarah Yu Wang seek to explore contemporary trends in prime-age female labor force participation and analyze underlying factors to the trends. After controlling for demographic

changes, they find that those who have contributed most to the rebound in overall labor force participation in April and May of 2023, three years after the nadir of pandemic-era participation, are in fact prime-age women. Moreover, among prime-age women and indeed among all groups, women whose youngest child is under the age of five power the pack's upward trajectory. Tight labor markets, the changing nature of and compensation for work, evolving norms around working, and the need to work when one's children are young are all factors that support the empirical fact that mothers with young children's labor force participation has accelerated in the post-2020 to exceed pre-pandemic levels.

Kelly Yoshimura CC'26, Sociology

Faculty Mentor(s) or Supervisor(s): Marissa Thompson
Title: The Individual and the Institution: An examination of first-year participation in student clubs based on race, ethnicity, and culture at Columbia University

Abstract: As the United States transforms into an increasingly diverse society, colleges and universities are similarly following suit. The general acceptance and celebration of shifting racial/ethnic demographics through race/ethnicity/cultural (REC)-based clubs on college campuses have been evident, but various barriers, whether individual or institutional arise. In Kelly Yoshimura's independent research, she explores how Columbia University's student organizations have impacted their targeted audience and if their goals of inclusivity and diversity have been achieved. Through qualitative research, ten rising sophomores at Columbia University have been interviewed regarding their experiences within these spaces, and what influenced them to join–or not join– REC-based clubs on campus. A combination of factors, including the diversity of their hometown as well as cultural practices within the household present the general basis of student's accounts. In addition, affiliation with intersecting identities including, gender identity, sexuality, economic class, and domestic/international student status, have been common factors in students' decisions to participate in these clubs. Finding a community is evidently important as students transition into university-life, and understanding the reasons for who joins and who doesn't remains an important issue in improving student-life involvement, as well as striving towards a goal of acceptance and celebration of diversity.

Ariel Yu CC'26 Philosophy & Cognitive Science

Faculty Mentor(s) or Supervisor(s): Bruce Western
Title: We The People: The History of SCI Graterford and A Landscape Analysis of Criminal Legal Reform Organizations

Abstract: The research project includes two parts. The first part is a memo of the history of Graterford prison in Pennsylvania. From mainly archival research of journal articles, newspapers, and case laws, the memo explains the prison's history based on themes of construction, the inhumane environment, prison uprisings, and treatments of people in solitary confinement. The second part is based on the Square One Project in the Justice Lab. It researches on currently active organizations that focus on narrative change and reckoning, explores the common themes across organizations and communities, and suggests the types of contribution the Square One Project could make to the sphere of criminal legal reform. Together, the research project calls for the societal attention to mass incarceration in the U.S. and how it dehumanizes a significant population. To advance for social justice and equality, the society as a caring community should treat people as people — as how the Constitution starts.

Janus Yuen CC'25, History

Faculty Mentor(s) or Supervisor(s): Elizabeth Blackmar
Title: Preliminary Research Toward a History of Religious Institutions in the American Commercial Revolution, 1890-1930

Abstract: At the turn of the 20th century, the population of NYC exploded, driven by immigrants from Central and Eastern Europe and by Afro-Americans from the South. Janus' project seeks to understand how these communities and the religious institutions they imported interacted with the city at the heart of the American commercial revolution—specifically whether, how, and to what extent these theologically diverse congregations and their leaders reacted to the emergent consumer culture and its radically individualist and voluntarist ethic. At stake was religious communities' ability to provide their members moral guidance in the midst of this new, disorienting, consumer-capitalist world.To limit the scope of the project, Janus focused on Harlem, where each of the three religious groups resided in large numbers between 1890 and 1930. Even so, due to time constraints, this project was necessarily preliminary. The primary question at hand was whether the kind and quantity of sources needed to track such institutional reactions—let alone conduct an inter-religious study—even existed in the first place. Using secondary readings both as indications of what source bases were available and as examples of how similar studies are conducted, Janus sought out archival repositories across NYC containing materials relevant to

the questions. Janus found that while such a history of religious institutions and consumerism is possible with the sources available, it could not be a history of a "reaction" as commonly understood—that is, a conscious response to a consciously identified problem. Those who lived through the commercial "revolution" perceived continuity as much as rupture, so researching attitudes toward the emergent culture is akin to researching the air people breathe, which, turns out, people don't write much about. The model for further research, then, is not one of action and reaction but rather a hunt for the changing unspoken assumptions of religious leaders in their writings and organizational activities—a history of religious institutions' ends and the means by which they sought them.

Karen Zhang CC'26, History and Economics

Faculty Mentor(s) or Supervisor(s): Chandler Miranda
Title: The Impact of History PBATs on Immigrant Students' Understanding of US History

Abstract: Studies show that high school exit exams disadvantage immigrant students and English learners linguistically, raising inequities in urban education. In response to standardized testing, Performance-Based Assessment Tests, or PBATs, were created in the 1990s as an alternative testing method to measure learning outcomes. A PBAT consists of a student's prepared research paper or project, an oral presentation, and a question-answer session with a panel of three. With little scholarship on PBATs—especially its impact on immigrant students—this study aims to address this gap in the literature by examining one NYC international high school that exclusively serves newly arrived immigrant students. Here, students use PBATs instead of Regents as their high school exit exams. Specifically, this study analyzes impact of History PBATs on immigrant students' understanding of United States history. Ethnographic research methods, such as participant observation of PBAT presentations or conversations with students, teachers, and staff, were used to explore the way students learn about history through PBATs. Given the recent introduction of PBATs and the study's six-week timeframe, more time is required to fully understand the effect of History PBATs. Still, this study suggests that History PBATs are an effective assessment for students to learn and understand history. The multiple components of a History PBAT push students to reflect on history's role in their own lives and draw connections between historical contexts, historical legacies to the present, and future implications. Ultimately, PBATs are an example of how project-based learning can integrate culturally relevant pedagogy into the classroom to better serve immigrant students.

SECTION THREE: STEM RESEARCH

Mahdi Abdul-Jabbar CC'24, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Minoree Kohwi
Title: Gene Mobility Elements Offer a Novel Function for Polycomb Repressive Complexes

Abstract: A striking element of chromatin is its ability to package itself in a highly organized manner within a micrometric nucleus through the help of specific proteins. The three-dimensional organization of the genome is thought to underlie gene expression and is likely unique to specific cell types, cell cycles, developmental stages, and can be altered in disease. Here we study Polycomb (PcG) proteins in Drosophila neuroblast genome organization. PcG factors are known to be responsible for regulating the transcription of their target genes by acting on polycomb response elements (PREs) and modifying the chromatin. Work from the lab has previously shown that PcG factors function in relocating the Hunchback (Hb) gene locus to the nuclear lamina for heritable silencing. PcG acts on this gene through a cis regulatory element in the hb gene intron, termed Gene Mobility Elements (GMEs). These GMEs seem to relocate the gene's position in the nucleus without affecting its transcriptional dynamics, unlike PREs which relocate and silence genes simultaneously. Using hb's GME, we have found several other putative GMEs using several parameters, including chromatin accessibility and PRC1/2 affinity. One GME we have found is associated with the Ladybird Early gene (lbe) which is a spatiotemporally regulated homeobox gene. We find that this gene is regulated within neuroblasts similarly to the hb gene while being relocated to the nuclear periphery in late stage embryos. This provides evidence for a connection between GMEs and a temporally regulated reorganization of the neuroblast genome's GMEs within late stage embryos.

Sophia Abrahamson CC'23, Biochemistry

Faculty Mentor(s) or Supervisor(s): Ofer Shoshani
Title: Evaluating the Cellular Model for Chromosomal Catastropher

Abstract: Cells within a tumor are not always homogeneous. Tumor heterogeneity, as it is called, is a powerful driver of tumor survival and treatment resistance—a factor caused by or made worse when these cells experience breaks in their DNA. Cellular attempts to then repair the broken pieces can lead to various dramatic outcomes, from abnormal chromosomal rearrangements to asymmetrical genetic inheritance, in an event known as chromosomal catastrophe. Its consequences ultimately fuels tumor progression. A more robust understanding of the short- and long-term implications following DNA breaks is required in order to construct more effective treatments. At Ofer Shoshani's lab at the Weizmann Institute of Science in Israel, Sophia Abrahamson investigated how best to employ a CRISPR/Cas9 cellular model that instigates chromosomal catastrophes. Using immunofluorescence, she determined the optimal concentration of doxycycline (dox), a chemical compound that initiates the production of Cas9 enzymes, which, in turn, can be directed by guide RNA (gRNA) to make purposeful, precise cuts in DNA strands. She then evaluated the timeline for first initiating and finally terminating Cas9 expression following dox exposure. Curious to observe that Cas9 was not always concentrated in the nucleus but also found diffused throughout the cytoplasm and, at times, completely absent from the nucleus, she assessed the effect of gRNA on the location of Cas9 within the cell. The results demonstrated that the presence of gRNA did not impact the distribution of Cas9 in the cell.

Sreyas Adiraju CC'25, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Elias Issa
Title: Biologically Plausible Self-Supervised Learning with Augmented Prediction

Abstract: The primate brain has an incredible capacity to represent the visual world in a robust, generalizable manner. During the first few years of development, a young animal explores visual scenes and interacts with objects, learning to independently and coherently represent their identities, poses, textures, and other attributes. This powerful visual code stands in stark contrast to the relatively brittle representations produced by their silicon-based counterparts. Current state-of-the-art computer vision models are trained on millions of static images; although they match human performance on object classification and image recognition, they fail to encode even basic non-identity attributes of objects, e.g., their orientation in a scene. This work produces a novel approach to designing and training computer vision models that match the representational capabilities of the primate brain. To do so, it introduces a new dataset for training computer vision models that consists of static images connected by meaningful, learnable transforms, enabling models to understand the effect changes in object pose, camera position, and lighting have on the pixels of an incoming image. It then presents a new kind of self-supervised computer vision model, the augmented prediction network, designed to learn the structure in input transformed image pairs. Finally, it demonstrates that augmented prediction networks yield robust representations similar to the primate visual system.

Avi Adler CC'24, Biology

Faculty Mentor(s) or Supervisor(s): Erin Barnhart
Title: Parkin Regulates Mitochondrial Morphology in aged Drosophila Neurons

Abstract: Two proteins associated with Parkinson's disease, PINK1 and Parkin have shown to regulate mitochondrial degradation in cell culture. The role they play in mitochondrial degradation in vivo is controversial. To investigate how Parkin and PINK1 contribute to mitochondrial homeostasis in neurons in vivo, the expression of PINK1 and Parkin was up- and down regulated in neurons of the drosophila visual system. The impact on mitochondrial morphology and density was then measured. It was shown that Parkin overexpression decreases mitochondrial density in distal dendrites and that Parkin is not necessary to maintain wild type levels of mitochondria. In addition, up- and down-regulating either Parkin expression perturbs mitochondrial morphology. Parkin overexpression leads to fragmented mitochondria, while knock down leads to overly fused networks. Preliminary experiments suggest that PINK1 expression levels also affect mitochondrial morphology. This provides evidence that PINK1 and Parkin contribute to maintaining a fission/fusion balance in addition to their role in canonical autophagy.

Andre Adonnino CC'26, Biochemistry

Faculty Mentor(s) or Supervisor(s): Yueqing Peng
Title: Investigating the Basolateral Amygdala (BLA) Inhibition on Sleep Architecture.

Abstract: Although it is known that the sleep following learning helps to consolidate memory, the underlying cellular and molecular mechanisms have yet to be properly understood. One such approach to tackling this uncertainty is the usage of optogenetics, which is using light to manipulate neuronal activity in the brain, specifically focusing on regions that involve memory consolidation during sleep. The basolateral amygdala (BLA) complex serves

as one of these regions, as it is known for storing fear memory. In this research, the lab used optogenetic methods to inhibit the neuronal activity within the BLA complex during post-learning sleep to investigate its role in memory consolidation. However, the lab needed to conclude whether or not this BLA inhibition impacts the natural sleep architecture of the experimental mice, since it has been previously researched that the BLA region may play a role in regulating sleep. Thus, the lab hypothesized that BLA inhibition could impact sleep patterns. In this study, the lab combines rodent sleep recordings and optogenetics to evaluate the durations of sleep states within mice before and during BLA inhibition. After analyzing the obtained sleep state data, the lab deduced that there were no significant changes in sleep architectures as a result of the current practices involving BLA inhibition.

Erin Ahern CC'24, Biophysics

Faculty Mentor(s) or Supervisor(s): Clara Schoeder
Title: De novo Immunoglobulin G3 binder design with ProteinGenerator

Abstract: Staphylococcal Protein A (Protein A) is a virulence factor that does not bind to the constant domain (Fc) of Immunoglobulin G3 (IgG3), yet tightly binds to the Fc region of IgG1, IgG2, and IgG4. The lack of binding to IgG3 leads to limitations regarding the use of Protein A in antibody purification for therapeutic developments, since no Protein A scaffold can currently be used for IgG3 purification. The aim of this project is to design a novel protein with high binding affinity to the IgG3 Fc domain using the new protein design tool, ProteinGenerator. ProteinGenerator is a diffusion-based machine learning model that outputs protein sequence and structure simultaneously. Approximately 18,000 designs with varying topologies and folds were made with ProteinGenerator. Computational tools such as FastRelax and Protein Docking generated Rosetta calculations, including RMSD, total score, and interface score, which were utilized as filtering metrics. Those metrics as well as PyMOL visualization were used to determine the most successful designs. The selected top 15 designs will be tested for expression and binding affinity to IgG3, which will further inform and benchmark the functionality of ProteinGenerator for protein binder design. The Rosetta Protein Docking results indicate that strong binding may occur between IgG3 and approximately half of the top designs. Combining ProteinGenerator with Rosetta Docking creates a promising workflow for de novo binder design.

Naira Altunkeser CC'25, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Liam Paninski
Title: Volumetric Dendritic Imaging and Computational Techniques for Voltage Data Analysis

Abstract: Deeper insight into neural information processing is enabled by electrical signaling within dendrites. The fact that dendritic trees are not electronically compact, that is the voltage of the membrane can vary substantially across the tree, enables this information processing. The computations pertaining to these dendritic voltages differs depending on the brain state and regions, cell types, and across species (Gidon, 2020). Still, there is no viable techniques to analyze the spatio-temporal dynamics of membrane voltage in dendrites in vivo. High-speed mapping of bioelectrical dynamics in intact tissues became possible with recent advances in voltage imaging, though only in one focal plane at once. Hence, this project aims to propose a computational approach, combined with molecular and instrumentation techniques provided by the Cohen Lab and the Abdelfattah Lab, to establish volumetric voltage imaging at up to a 1 kHz frame rate. This project, which is the computational leg of a larger collaboration, aims to create broadly applicable software tools for high-speed volumetric imaging data. This project addresses questions about the nature of dendritic computations and will demonstrate this technology by mapping dendritic voltages in acute brain slices and in vivo. Consequently, three-dimensional mapping of membrane voltage in intact tissues would enable broader and deeper understanding of bioelectrical dynamics.

Haroon Arain CC'24, Neuroscience And Behavior

Faculty Mentor(s) or Supervisor(s): Stephanie Herrlinger
Title: Characterizing interneuron subtypes in the CA1 region of the hippocampus of mice with the 22q11.2 deletion synome

Abstract: Schizophrenia is a mental disorder marked by positive symptoms (i.e. hallucinations), negative symptoms (i.e. apathy), and cognitive deficits including episodic memory deficits. Although present in 1% of the population, the specific neurological effects of the disorder remain poorly understood. Amongst the breadth of symptoms, schizophrenia induced episodic memory deficits are common, but their precise neural correlates are unknown. Given the hippocampus' role in episodic memory, we investigate the hippocampal microcircuitry to explore the reasons for episodic memory deficits in patients with schizophrenia. Prior work in our lab revealed hippocampal place cell deficits in mice with the 22q11.2 deletion syndrome (the largest known genetic risk factor for schizophrenia). The microcircuitry of the hippocampus contains both the excitatory neurons and diverse

populations of inhibitory interneurons that suppress and modulate their activity. To better understand how changes in the hippocampal microcircuitry may contribute to place cell instability and possibly manifest as episodic memory deficits, our experiment investigated hippocampal interneuron subtypes to ask if the heterogeneous landscape of interneuron populations are altered. To achieve this, hippocampal sections from wild-type mice (n=6) and Df(16)A+/- mice (n=5) with the 22q11.2 deletion were stained for five interneuron markers and imaged with a confocal microscope. Acquired images were analyzed to determine concentrations of markers within sections through the novel Cell Analysis/Typing Tool (CATT) with the intention of simultaneously troubleshooting development of CATT for future applications. Analysis of single-marker concentrations between groups and categorized by layer between groups was performed, revealing one statistically significant result - a greater concentration of NPY in the Stratum Radiatum of mice with the deletion - with all other differences being insignificant. These results suggest that the place cell instability apparent in Df(16)A+/- mice may not be attributed to differences in proportions of interneuron subtypes, warranting further investigation into the question.

Arnold Caleb Asiimwe CC'25, Computer Science

Faculty Mentor(s) or Supervisor(s): Carl Vondrick
Title: Leveraging Multi-Modal Deep Learning Architectures for Enhanced Error Detection and Autocorrection in Medical Documentation

Abstract:
In healthcare, the accuracy of medical documentation is non-negotiable due to its immediate impact on clinical decision-making and, consequently, patient outcomes. Nonetheless, the human element in medicine inevitably leads to errors. This research addresses this underexplored area by introducing a two-pronged system aimed at, firstly, error detection and, secondly, correction in medical text—termed here as "medical autocorrect." Our methodology employs a multimodal deep learning architecture, utilizing both image and textual data from the MIMIC-CXR dataset—a repository of medical images and corresponding textual descriptions. To initiate error detection, we artificially inject errors into the dataset. A multimodal model is then trained on these altered medical images and reports, enabling it to proficiently identify inaccuracies in medical text. Subsequently, an autocorrection component is activated that fine-tunes pre-existing large language models, such as GPT-2 and Llama 2, using a conditioning mechanism based on image embeddings. This component learns to generate corrected versions of medical reports, guided by the synergistic analysis of both image and textual embeddings. The corrected text is presented to medical professionals for validation. By introducing a two-component system that leverages both textual and visual data, this research pioneers new avenues in the realm of automated medical documentation. Our multimodal architecture not only rectifies textual inaccuracies but also holds the potential to significantly improve data quality in healthcare systems. This stands to have profound implications for clinical decision-making and patient outcomes. Preliminary results indicate that our multimodal approach is markedly superior to text-only methodologies for identifying and rectifying errors. By offering an initial proof-of-concept, this study lays the groundwork for future empirical research, signaling a paradigm shift in error management within healthcare documentation.

Miriam Aziz CC'25, Chemistry

Faculty Mentor(s) or Supervisor(s): Theodor Agapie
Title: Developing Molecular Systems for Single-Atom Catalysis and Quantum Information Science

Abstract: Two-level quantum systems (qubits) have emerged on the frontier of quantum information science (QIS) research. Relative to classical components, these qubits offer a substantial increase in information storage capacity and processing speed. Rare-earth metals hold promise as light-matter interfaces, facilitating coherence transfer to nearby nuclei. We aim to adjust the described ligand scaffold of optically addressed lanthanides by known synthetic methods to investigate the impact of nuclear spin, distance, and chemical environment on coherence transfer. Additionally, single-atom catalysis (SACs) is a rapidly growing field, offering advantages toward enhanced selectivity, reactivity, and stability relative to traditional catalysis. However, the synthesis of SACs is ill-defined, and the degree to which metal sites communicate within the carbon framework is poorly understood. Here, we work toward conducting a synthesis of multimetallic macrocycles of graphene-fixed aromatic hydrocarbons doped with nitrogen. We develop methods to generate a high-solubility mesityl-based ligand by tuning existing phenyl-based syntheses and perform the modular synthesis of alternating oligomers, an essential step in generating a multi-nucleating ligand. Ongoing research to grow these systems involves deliberately and systematically harnessing control over the terminating ends of the compounds. This work sheds light on both the interactions within these quantum systems and SACs.

Ara Bakhteyar GS'24, Biophysics

Faculty Mentor(s) or Supervisor(s): Kristin Myers

Title: Investigating Myometrial Muscle Fiber Alignment and Extracellular Matrix Composition Across Pregnant and Non-Pregnant Uterine Layers.

Abstract: Each year, billions of women endeavor to conceive, yet infertility remains a challenging issue for millions. A successful pregnancy often hinges on the embryo's implantation; however, failures in this crucial step are not uncommon, emphasizing the intricate nature of the female reproductive system. Dysfunctions in any segment of this system can substantially influence pregnancy outcomes. Despite the confirmation of pregnancy, numerous complications can arise, notably abnormal implantation, leading to conditions like preterm birth, preeclampsia, and placenta accreta. To comprehensively address these challenges, this research investigates the anatomical layers of the uterus: Perimetrium, myometrium, and endometrium. Uterine samples were procured from pregnant and non-pregnant women, incorporating all three layers. This research is divided into two separate sub-projects. In step one, The alignment of smooth muscle fibers in the inner versus outer myometrium was assessed. Preliminary data suggests an absence of distinct alignment at the endometrium-myometrium interface. In step two, the structure and composition of the Extracellular Matrix (ECM) components in uterine layers were analyzed for both pregnant and non-pregnant samples. Microscopic imagery revealed morphological differences using selective staining. Notably, the endometrium/decidua from pregnant samples appeared less organized, with a marked decrease in uterine glands. In light of these findings, future research endeavors will encompass nanoindentation of the inner and outer uterine regions for interface assessment, extended staining for diverse ECM components, and quantitative analysis of ECM components using advanced biochemical assays.

Thilina Balasooriya CC'26, Computer Science

Faculty Mentor(s) or Supervisor(s): Xiaofan (Fred) Jiang
Title: Effect of Skin Color on Thermal Camera-Based Measurements of Skin Temperature for Mass Fever Screening in Public Spaces

Abstract: Use of Non-contact Infrared Thermometers (NCITs) has recently grown as a result of COVID-19 and social distance requirements. However, these have not been widely used due to both high cost and limited feasibility in areas with large public traffic. To address these issues, this research uses SIFTER, a low-cost system that utilizes both RGB and Thermal cameras for continuous fever screening. SIFTER uses both image types to create a thermal model mapping of the individual's head, which can be used to interpret body temperature and screen for fevers. However, several studies have outlined a possible bias in measurement using infrared (IR) sensing based on skin color. For example, recently the bias in IR wavelength measurement in pulse oximeters has been found to systematically cause underdiagnosis of hypoxemia (low blood oxygen). This poster presents a skin tone bias study of SIFTER body temperature measurements compared to ground truth temperature data obtained from 226 people at the ColumbiaDoctors - Midtown facility using the Withings Thermo handheld thermometer. The RGB images of individuals obtained from the study were first processed to mitigate the effects of lighting and labeled into three categories (Dark, Medium, Light), based on the standardized Monk Skin Tone scale, and then processed by SIFTER to estimate body temperature. Compared with the ground truth data, SIFTER (inferring from only a single subject image) showed an average error of -0.611, -0.626, and -0.630°F, for Dark, Medium and Light skin tones, respectively. Using a combination of statistical T-tests, it is concluded that there is no significant difference in the errors of each skin tone category when compared to the ground truth. The p-values of each T-test are 0.903, 0.878, and 0.965 (for comparing Dark/Medium, Dark/Light, Medium/Light respectively), all much greater than the 0.05 threshold.

Noah Bergam CC'25, Mathematics

Faculty Mentor(s) or Supervisor(s): Nakul Verma
Title: On Optimal Stochastic Neighbor Embeddings

Abstract: :The t-distributed stochastic neighbor embedding (t-SNE) is a powerful method for visualizing cluster structure in high-dimensional data. Although recent theoretical analysis has yielded strong performance guarantees for t-SNE optimized with gradient descent, little insight has been been shed on \textit{globally optimal} t-SNE embeddings. In this work, we present a number of interesting results in this vein, including: (1) there exist extremely simple scenarios in which t-SNE optimal embeddings are trivial or unattainable, (2) optimal embeddings occur in uncountable localized families, as a byproduct of the normalization of the \(Q\) output affinity matrix, and (3) optimal embeddings of \(n\) points must occur within a ball of finite radius \(R = O(n^{nC})\), where \(\min_{i,j} P_{ij} \geq 1/Cn^2\). Combined with a Lipschitz bound on t-SNE cost function, this third result lends itself to an exhaustive search algorithm for finding globally optimal t-SNE embeddings. We also find how to express the connection between t-SNE and spectral clustering through simple Taylor expansions of the cost function.

Giuliana Bilbao SEAS'24, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Alexander Harris
Title: Modeling social buffering of stress effects on reward processing in mice

Abstract: Stress increases the risk of developing anhedonia, which can be defined as a reduced ability to seek and/or experience pleasure. Anhedonia is a core symptom of psychiatric disorders associated with stress, such as depression and schizophrenia. Social support has previously been shown to alleviate many negative consequences of stress in both humans and rodents. However, whether and how social interactions can reduce stress-induced anhedonia is not fully understood. Therefore, this proposal aims to establish a new behavioral model to measure the extent to which social interaction buffers stress-induced reward-seeking deficits in mice. We successfully replicated the effects of acute stress on reward seeking. However, we did not see any effects of social buffering on stress-induced reward seeking changes. Further analysis of behavior during the social interaction period revealed that our behavioral model does not allow us to study the effect of social buffering.

Maya Bodick CC'25, Biophysics

Faculty Mentor(s) or Supervisor(s): Ruben Gonzalez
Title: Analysis of the Free-Energy Landscape of Pre-Translocation Ribosomal Complexes

Abstract: During protein synthesis, large-scale rearrangements of the ribosomal complex (RC) are necessary to facilitate translocation of amino-acylated transfer RNAs (tRNAs) and messenger RNA (mRNA) within the ribosome. Previous research has shown that these rearrangements may be represented as transitions between two global states of the RC, global state 1 and 2 (GS1 and GS2). Individual ligands have been shown to entropically perturb the free-energy landscape underlying the dynamics of the GS1⇌GS2 transitions in model RCs. This study aims to characterize the free-energy landscape of more complex RCs bound by multiple ligands that are analogous to the intermediates observed during protein synthesis. Specifically, the RC investigated in this study contains a ribosome-bound tRNA and a protein translation factor that aids in translocation. Using single molecule fluorescence resonance energy transfer (smFRET), the GS1⇌GS2 transitions of this complex were observed at varying temperatures. These smFRET datasets were subsequently pre-processed to identify and classify heterogeneities among the observed single-molecule trajectories. A preliminary analysis was used to characterize the rates of these transitions at varying temperatures using hidden Markov model-based analyses, a commonly used technique for studying smFRET kinetics. However, with increasing temperature, the rates of transition became comparable to the acquisition rate of the experiments, leading to inaccuracies in such HMM-based analysis. Currently, further analysis of these datasets is ongoing, using more sophisticated, but computationally expensive techniques, that can analyze such fast kinetics in single-molecule trajectories.

Pablo Buitrago SEAS'25, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): Lauren E Marbella and Anew Ells
Title: Why Batteries Fail: Investigating Hydrolysis in Electrolytes using in situ NMR

Abstract: Li-ion batteries (LIBs) are critical to enabling grid storage for renewable energy sources and a successful global energetic transition. All LIBs have an electrolyte composed of a lithium salt and an organic solvent. The lifetime and performance of LIBs is heavily influenced by the accumulation of unwanted byproducts from decomposition of the liquid electrolyte. LiPF6 is the prevailing commercial salt for LIB electrolytes, and it is known to be highly susceptible to hydrolysis from H2O produced during oxidation of the organic solvent in normal cell operation. The principal product in PF6- hydrolysis is hydrofluoric acid (HF), a highly corrosive compound known to devastate battery performance and lifetime. However, the progression of LiPF6 hydrolysis over time and the array of resulting byproducts is not fully understood and is studied in this work via in-situ nuclear magnetic resonance (NMR) techniques such as homonuclear correlation spectroscopy (COSY) and heteronuclear multiple-quantum correlation spectroscopy (HMQC). Our results indicate that the main secondary decomposition products in hydrolytic degradation of PF6- are fluorophosphoric acid (H2PO3F) and alkylated derivatives of both fluorophosphoric and phosphoric acids. Furthermore, the same hydrolytic reaction is studied in the similar sodium salt NaPF6 to analyze the mechanism behind decreased hydrolysis in sodium salts. The role of NaF in modifying the amount of intact PF6- is also explored, as NaF has been historically used to remove HF impurities.

Pablo Buitrago SEAS'25, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): Lauren Marbella
Title: Why Batteries Fail: Investigating Hydrolysis in Electrolytes using in situ NMR

Abstract: Li-ion batteries (LIBs) are critical to enabling grid storage for renewable energy sources and a successful global energetic transition. All LIBs have an electrolyte composed of a lithium salt and an organic solvent. The lifetime and performance of LIBs is heavily influenced by the accumulation of unwanted byproducts from decomposition of the liquid electrolyte. LiPF6 is the prevailing commercial salt for LIB electrolytes, and it is known to be highly susceptible to hydrolysis from H2O produced during oxidation of the organic solvent in normal cell operation. The principal product in PF6- hydrolysis is hydrofluoric acid (HF), a highly corrosive compound known to devastate battery performance and lifetime. However, the progression of LiPF6 hydrolysis over time and the array of resulting byproducts is not fully understood and is studied in this work via in-situ nuclear magnetic resonance (NMR) techniques such as homonuclear correlation spectroscopy (COSY) and heteronuclear multiple-quantum correlation spectroscopy (HMQC). Our results indicate that the main secondary decomposition products in hydrolytic degradation of PF6- are fluorophosphoric acid (H2PO3F) and alkylated derivatives of both fluorophosphoric and phosphoric acids. Furthermore, the same hydrolytic reaction is studied in the similar sodium salt NaPF6 to analyze the mechanism behind decreased hydrolysis in sodium salts. The role of NaF in modifying the amount of intact PF6- is also explored, as NaF has been historically used to remove HF impurities.

Kassey Chang, GS'24, Linguistics

Faculty Mentor(s) or Supervisor(s): Alfredo Spagna
Title: Using Neighborhood-based Clustering to Categorize Visual Mental Imagery and Perceptual Domains

Abstract: Visual mental imagery (VMI) and perception, while distinct, may share overlapping cognitive mechanisms. Using the English adaptation of the French Enhanced Imagery and Perception Battery (eBIP), this study delves into domain-specific abilities in VMI across five domains: color, face, map, letter, and shape. Do both VMI and visual perception exhibit domain-specific clustering? We would like to investigate whether behavioral performance, indexed by accuracy and response time, clusters along fewer dimensions than the battery's predefined five. Our study seeks to characterize these imagery domains and comprehend their interconnections, aiming to elucidate individual differences and inform models investigating the neural architectures underpinning these domains. We hypothesize that a correlation between imagery and perception scores for each domain would indicate shared mental resources employed, aligning with models suggesting common high-level visual regions. Through ANOVA analyses, we observed notable differences in accuracy and response time between imagery and perception tasks. Using t-SNE, k-means and neighborhood-based clustering analyses, we further explored this clustering phenomenon, aiming to offer a refined perspective on the domains of VMI. Preliminary findings from online participants (n = 36) provide evidence that visual mental imagery and perception abilities may cluster into fewer broader domains rather than strictly separated by the five domains defined a priori, although the clusters for imagery and perception may differ. This suggests the existence of shared and distinct processes underlying domain-specific imagery and perception performance. Our findings validate the potential of using dimension reduction and clustering techniques to offer new perspectives on the domain-specificity of VMI abilities.

Ethan Chang CC'26, Computer Science

Faculty Mentor(s) or Supervisor(s): Brian A. Smith
Title: Automatically Generating Audio Descriptions for Blind and Low Vision People Using Crowdsourcing and AI

Abstract: Videos have become a predominant way of sharing information and content (education, news, social media). However, the visual nature of videos cause them to be inaccessible for blind and low vision (BLV) people. Currently, videos are made accessible to BLV people via audio descriptions (AD). Audio descriptions are narrations of the visuals that are overlaid onto the video, providing information about the scene, characters, and actions. However, adding AD is both time consuming and requires expertise that make it challenging for most video creators to make their videos accessible. In this work, we present a system that automatically generates AD by crowdsourcing descriptions and effectively combining them via AI. Our system processes an input video by first segmenting the video into inaccessible video segments that do not contain any speech. For each inaccessible video segment, we generated two types of AD — one via crowdsourcing on Amazon Mechanical Turk and the other via a dense video captioning algorithm. We then combined these two ADs via large language models (such as GPT) to generate a cohesive and more accurate set of ADs for the video. In the future, we will evaluate the quality of these AD with BLV people by having them watch videos that have ADs generated by our system.

Cady Chen CC'26, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Peter Canoll

Title: How do Beliefs about Social Regulation Predict the Quality and Quantity of our Social Network? Characterizing Pathological Neuronal Activity-Induced Changes in the Tumor Microenvironment

Abstract: Gliomas, the most commonly diagnosed brain tumor, develop in complex microenvironments in which tumor cells intermingle with non-neoplastic cells like neurons and microglia. Recent studies have shown that these interactions cause molecular and functional alterations in the tumor microenvironment, like neuronal hyperexcitability, that drive tumor invasion and progression. For example, research in our lab has found that sensory stimulus-evoked neuronal activity, as measured by intracellular calcium, increases as the tumor progresses and is most elevated in neurons closest to tumor cells. While previous studies have shown that increasing neuronal activity encourages glioma cell proliferation, the underlying mechanistic pathway remains unknown. Microglial activation further accompanies this progressive neuronal hyperexcitability at the glioma margins, suggesting that pathological neuronal activity induces alterations in microglia as well. Here, we use immunohistochemistry to characterize the consequences of whisker stimulation-induced neuronal activity on microglia and glioma cells within the same tumor microenvironment. Our analysis reveals that repeated whisker stimulation over the course of seven hours causes a significant increase in glioma cell proliferation, measured by EdU labeling index, at the infiltrative tumor margin. Although previous research has demonstrated that direct optogenetic stimulation of tumor-associated neurons increases tumor proliferation, this study suggests that noninvasive, physiologic-level sensory stimulation promotes glioma cell proliferation and therefore carries critical clinical implications. We further show that P2RX7, a purinergic receptor that mediates communication between neurons and microglia, is overexpressed in tumor-associated microglia and that whisker stimulation induces the activation of Iba1+ microglia. Together, these findings suggest that sensory-evoked neuronal activity affects both tumor cells and tumor-associated microglia. Ongoing experiments are aimed at investigating whether this neuronal activity-induced increase in glioma cell proliferation can be blocked by administering therapeutics targeting microglial inflammation and neuron-microglia communication. Ultimately, this research hopes to leverage microglia as an underutilized, yet effective therapeutic target in glioma patients.

Emma Chen CC'25, Computer Science

Faculty Mentor(s) or Supervisor(s): Mohammed AlQuraishi

Title: Constructing a General Attention-Based Model to Predict Transcription Factor Binding

Abstract: Transcription factors (TFs) are proteins that bind specifically to DNA regions to regulate gene expression. Determining their binding specificities is crucial for understanding their role in fundamental biological processes like cell differentiation and in diseases like cancer. However, experimental methods for determining binding specificities are time-consuming, expensive, and subject to random artifacts. Here, we present an attention-based model that predicts whether binding occurs solely based on a TF's amino acid sequence and the nucleotide sequence of the DNA region. By incorporating pre-trained large language models for proteins and DNA into our model architecture, we are able to leverage representation learning accomplished during pretraining on extensive datasets. Our model's later layers then use attention mechanisms to find relevant features in each sequence's representation, recognize interdependencies between these features, and generate the final prediction. While there are models that predict the binding of one fixed TF to different DNA sequences, to the best of our knowledge, this is the first model that sets out to predict binding for any TF-DNA sequence pair. When deployed on a balanced exploratory dataset derived from TF-DNA binding experiments in Arabidopsis thaliana, our model attained a Precision-Recall Area Under the Curve (PR-AUC) score of 0.970 for seen TF-unseen DNA pairs (i.e., the TF sequence was included in training, but not with the same DNA sequence) and a PR-AUC score of 0.787 for unseen TF-unseen DNA pairs (i.e., neither TF nor DNA sequence were included in training).

Yuxi Chen CC'25, Computer Science, Dragon Yuan CC'25, Applied Mathematics and Computer Science

Faculty Mentor(s) or Supervisor(s): Eric Balkanski

Title: A (1– ε)/2 Approximation to Submodular Maximization in O(log n) Adaptive Rounds and 2 MapReduce Rounds

Abstract: Submodular maximization, the study of choosing elements from a ground set that maximizes the a given submodular function (a set function with the property that the marginal contribution of an element decreases as the size of the input set increases), has received significant attention in both practice and theory. Submodular maximization is regularly applied on a wide array of problems involving large datasets, such as data summarization, recommender systems, feature selection, and maximizing influence in social networks.

In recent years, a new framework for submodular maximization—known as the adaptive complexity model—has received widespread attention. This framework, proposed and popularized by Eric Balkanski (Columbia IEOR), aims to "quantify the information theoretic complexity of black-box optimization in a parallel computation model." Another popular framework for submodular optimization is the MapReduce model, where "complexity is measured as the number of synchronous communication rounds between the machines involved." However, existing submodular maximization algorithms, when analyzed under these frameworks, exhibit limitations in either one or the other. Our proposed algorithm combines the strength of both frameworks while achieving the same approximation guarantees. Empirically, we show that our algorithm obtains a faster running time than state-of-the-art algorithms on large example datasets. We also support our results by proving theoretical guarantees.

Clara Cheng GS'24, Chemistry

Faculty Mentor(s) or Supervisor(s): Helen Ngo
Title: Synthesis and Analysis of Advanced Bio-Based Polymers from Waste Brown Grease

Abstract: Fatty acids are fundamental components of lipids and play crucial roles in various biological processes. Their significance extends beyond their role as an energy source and their structural contribution to cell membranes. This study focuses on the synthesis of fatty acid bio-based polymers with antimicrobial properties, which allows them the capability to repeatedly kill pathogenic bacteria. Conventional biocidal agents like disinfectants have a short efficacy lifetime, can spread, and may pose risks to both humans and the environment. The designed process involves the reuse of brown grease, a waste byproduct of food preparation accumulated in sewers that pollutes the environment. Transforming this waste product into antimicrobial bio-based polymers involves the separation of brown grease from the waste matrix, esterification and amination synthesis into an amine carrying monomer followed by polymerization. The products of each step were analyzed using various analytical techniques such as titration, TLC, GC-FID, FTIR, NIR, HPLC, and MS. Data indicates a successful esterification with no residual starting material and a successful amination with no methyl ester contamination of the amine. The resulting amine monomer was polymerized with an epoxy resin called diglycidyl ether of bisphenol A and was solution-cast into molds. The bio-based polymer films were then extracted from the molds. These films have numerous functional applications and may exhibit antimicrobial activity which can potentially be used for creating a variety of sanitation coatings that are environmentally friendly and sustainable alternatives to typical disinfectants.

Daniel Choi CC'26, Neuroscience

Faculty Mentor(s) or Supervisor(s): Lynn Yap
Title: Representations of Odor Value in Medial Prefrontal Cortex

Abstract: The myriad of sensory stimuli humans encounter in the environment typically lack immediate significance; their value emerges through experience. This study investigates the neural circuit mechanisms by which animals learn and consolidate the value of sensory stimuli, focusing on mouse olfaction. Mice were trained on an olfactory-based classical appetitive conditioning task, in which they learned to associate certain odors with reward (CS+ odors) and others with no reward (CS- odors). Previous work found that the medial prefrontal cortex (mPFC), a brain region critical for memory and cognition, is necessary for learning the task. Neural recordings in the mPFC revealed two populations of neurons representing CS+ and CS- odors, respectively, that emerged over learning and remained stable post-learning. However, it is unclear why the mPFC retains a memory of both information of value (CS+) and no value (CS-). A hypothesis is that the CS- population acts as a failsafe, allowing animals to respond flexibly to CS+ cues depending on the context. To test this, an activity-based genetic labeling strategy ('FosTRAP2') was used to access the CS- population. Task-proficient mice were exposed to CS- odors only. Neurons activated by CS- odors express the protein Fos fused to CreER. When 4-hydroxytamoxifen is present, CreER enters nuclei, causing recombination and permanent neuron labeling with a reporter (mCherry). This strategy was validated by comparing endogenous Fos expression with mCherry labeling. This prompts future optogenetic studies using light to manipulate the CS- neurons. Observing the animal's resulting behavior could elucidate the function of the CS- population.

Erica Choi CC'24 Mathematics

Faculty Mentor(s) or Supervisor(s): Jonathan Simone
Title: Cubiquitous Lattices and Chi-sliceness

Abstract: It is a classical result that any knot or link in R^3 bounds a surface embedded in R^3. It turns out that knots and links also bound surfaces embedded in R^4. An active area of research explores knots and links that bound surfaces in R^4 with simple topology, or in other words, are slice and chi-slice, respectively. Greene and Ownes have proved that if an alternating

nonsplit link L is chi-slice, then there exists an associated cubiquitous sublattice. A lattice is cubiquitous if it admits an embedding into Z^n in such a way that its image lambda contains a point in each unit cube with integer vertices. We show various properties that a basis B = {v_1,...,v_n} that generates a cubiquitous lattice has, and prove that B^TB has 1's, 2's, and 4's on the diagonal. This finding proves that Greene and Owens' conjecture that cubiquity implies chi-sliceness for torus links.

Farihah Chowdhury CC'24, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Sundari Chetty
Title: Investigating the Role of Microglia in Autism Spectrum Disorder

Abstract: Autism Spectrum Disorder (ASD) is one of the most common genetic and neurodevelopmental disorders. A subset of males with ASD consistently show evidence of disproportionately enlarged brains, known as megalencephaly, during their first year. This increase in brain size usually precedes the first clinical signs of ASD, so if the mechanisms that lead to this brain overgrowth are understood, there could be opportunity for ASD intervention to prevent the full effect of the disorder. This project has investigated and evaluated the neuro-immune mechanisms that makeup ASD, using 2D models of microglia. These models were created from human induced pluripotent cells of typically developing patients (TD-N), typically developing patients with enlarged brains (TD-DM), patients with ASD (ASD-N), and patients with ASD and enlarged brains (ASD-DM) that were then differentiated into microglia.These microglia were validated for its homeostatic markers and evaluated for its functional activity through phagocytosis assay and inflammatory cytokine profiling. The overarching goal of this research project is to investigate whether neuroimmunological changes regulate neurodevelopment and brain size in autism and other brain growth related neuropsychiatric disorders, and identify targets for therapeutic intervention. Preliminary results show greater amounts of pro-inflammatory cytokines secreted and higher levels of phagocytosis for microglia from ASD-DM patients, as well as higher rates of microglial cell proliferation from ASD-DM patients. These results could indicate that the highly activated microglia phenotype from ASD-DM patients develop early on in its developmental process independent of the brain environment.

Peyton Chui CC'26, Mathematics

Faculty Mentor(s) or Supervisor(s): Tudor Padurariu
Title: On the Use of Gauss and Jacobi Sums to Count Solutions to Equations Over Finite Fields

Abstract: Originally, Gauss developed his theory of quadratic Gauss sums to attack the problem of determining when an integer is a square modulo a prime p, a result now known as the law of quadratic reciprocity. Jacobi and Eisenstein built on Gauss's ideas to find the laws of cubic and biquadratic reciprocity, developing Jacobi sums along the way. However, Gauss and Jacobi sums also have another lesser-known application, namely that of determining the number of solutions to certain equations modulo a prime p. More generally, we can determine the number of solutions to these equations over any finite field F_q with little extra effort. The method goes as follows: we first relate the number of solutions to the equation $x^n=a$ in F_p to a sum over certain characters on F_p. We then write the number of solutions to an equation $a_1x_1^{l_1}+\cdots+a_rx_r^{l_r}=b$ in terms of these character sums which can then be turned into an expression involving Jacobi sums. Finally, we use properties of Jacobi sums to simplify this expression into something more manageable. The importance of this question is highlighted in the famous Weil conjectures (now theorems), which have had a far-reaching impact on the development of modern algebraic geometry and number theory. Indeed, special cases of the Weil conjectures can be proven using this relatively elementary approach.

Maria Cuevas CC'26, Undecided

Faculty Mentor(s) or Supervisor(s): Jonathan Fortney
Title: Exploring the Bolometric Correction of Exoplanets and Brown Dwarfs Using State of the Art Models

Abstract: Exploring the Bolometric luminosity is a fundamental physical property of directly imaged exoplanets and brown dwarfs, providing key information about these objects' evolution. However, direct measurements of bolometric luminosities have been hampered by the lack of spectrophotometry spanning a sufficiently wide wavelength coverage, particularly for directly imaged planets that are at small angular separations (<1 arcsec) from their much brighter host stars (>10^4 times).Empirical measurements of the planets' and brown dwarfs' luminosities rely on the bolometric correction, that establishes a conversion (e.g., polynomial relation) from a photometry in a certain instrument filter, which are commonly observed, into the bolometric luminosity. Such bolometric correction has been established for a few filters but is lacking for most of the filters typically used in the direct imaging community. The goal of our project is to establish the bolometric correction for all filters (approximately 80) that are relevant to directly imaged exoplanets (e.g.,

JWST/NIRCAM, JWST/MIRI, JWST/NIRISS, VLT/SPHERE, Gemini/GPI, and LSST). We have established the bolometric correction for each filter and then derived the coefficients of the polynomial that can convert an object's directly measured magnitude in a given filter into its bolometric luminosity. Our bolometric correction provides useful tools for future observations of directly imaged exoplanets to reliably determine the object's fundamental physical propertiesBolometric Correction of Exoplanets and Brown Dwarfs Using State of the Art Models.

Vinicius da Silveira Lanza, Avelar CC'26, Chemical Physics

Faculty Mentor(s) or Supervisor(s): Xiaoyang Zhu
Title: Optically accessible exciton-coupled coherent spin waves in $NiPS_3$ and $FePS_3$

Abstract: Exploring coupled systems is of fundamental importance in the field of condensed matter, as they can induce emergent physical properties, such as the case of electron-phonon coupling that was discovered to be the origin of conventional superconductivity in some materials. Magnons and their coupling with excitons are exciting phenomena that have been explored in the area of two-dimensional magnetically ordered semiconductors. Recent works have successfully studied and quantified coherent magnons in the antiferromagnetic semiconductor CrSBr through pump-probe transient reflectance spectroscopy, probing the change in excitonic energy due to the coupled interlayer interaction. Here we explore the phenomena of exciton-magnon coupling in two layered materials with tightly bound excitons with large oscillator strength, anisotropic magnetic ordering, and expected strong intralayer coupling: $NiPS_3$ and $FePS_3$, from the family of MPS_3 semiconductors. The crystals were synthesized using Chemical Vapour Transport (CVT) methods, then structurally characterized using Powder X-ray Diffraction and Raman Spectroscopy. Photoluminescence Spectroscopy was conducted on $NiPS_3$ with a 632.8nm excitation laser and yielded the expected narrow PL peak, confirming the quality of the crystals. Preliminary Static and Pump-Probe Transient Reflectance measurements were conducted and evidenced the expected excitonic transition. Further characterization will be performed on $FePS_3$ crystals with a 532nm laser, and Pump-Probe Transient Reflectance Spectroscopy with a higher canting field will be performed on both crystals to detailedly study the anisotropic optical response of the exciton-magnon coupling in these systems.

Aruna Das CC'26, Biology

Faculty Mentor(s) or Supervisor(s): :Martin Chalfie
Title: Investigating a C. elegans Mutant with an Imbalanced Nervous System

Abstract: In any nervous system, different cells and components must be coordinated so that one particular stimulus results in one particular outcome. We can learn more about this balance and the mechanisms that govern it by observing organisms where it is faulty. Caenorhabditis elegans, a compact nematode that exhibits diverse touch behaviors and has a known cell lineage, neural connectivity, and complete genome sequence, is an ideal model for studying the reflex system underlying mechanosensation. Recently, Terese Lawry in the Chalfie Lab identified a C. elegans strain (VC40578) that exhibited an abnormal response to touch. Unlike wild-type worms, these animals did not consistently respond to tail touch after being touched on the head, suggesting a potential defect in the nervous system's balance and coordination. To begin the analysis of this strain and its underlying defect, I explored the conditions that promote the strongest unique response in VC40578 compared to the wild type. Next, I plan to identify the causative mutation by sequencing the DNA of outcrossed and then reisolated homozygous mutants. The mutated gene likely plays a crucial role in balancing and evaluating responses when C. elegans encounter conflicting stimuli rapidly. In wild-type worms, the most recent response dominates, but in mutants with the mutated gene, signals from the anterior sensory system overpower those from the posterior system, preventing it from initiating movement. Further investigations into the implicated gene's molecular mechanisms could contribute to a deeper understanding of maintaining proper sensory response coordination in both C. elegans and other organisms.

Sonali Dasari CC'23, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Natasha Kyprianou
Title: Circadian Rhythm Disruption as a Contributor to Racial Disparities in Prostate Cancer

Abstract: In the United States, African American (AA) men have a 2.4 times higher mortality rate due to prostate cancer than White men. The multifactorial causes of the racial disparities in prostate cancer involve various social determinants of health, including socioeconomic status and access to healthcare. However, emerging evidence also suggests that circadian rhythm disruption (CRD) contributes to prostate cancer, and AA men may be more susceptible to developing CRDs. Circadian rhythms play a significant role in metabolism, hormone secretion, and sleep/wake cycles. Disruption in these circadian rhythms can be caused by airplane travel/jet lag, night shift work, exposure to light, and neighborhood noise levels, which can

contribute to sleep disorders and chronic conditions such as obesity, diabetes, cardiovascular disease, and depression. The drivers of the racial disparities in CRD include night shift work, racial discrimination, elevated stress, and residing in poor neighborhoods characterized by high noise pollution. Given the increased vulnerability of AA men to CRDs, and the role that CRDs play in prostate cancer, elucidating the clock-related prostate cancer pathways and their behavior and environmental covariates may be critical to better understanding and reducing the racial disparities in prostate cancer.

Ekwueme Eleogu, SEAS'25, Computer Science

Faculty Mentor(s) or Supervisor(s): Joanna Smeeton
Title: Development of an intubation rig for long-term imaging of adult zebrafish

Abstract: Synovial joints are complex organs consisting of lubricated articular cartilage, specialized synovial cavities, and ligaments stabilizing the articulating bones. Mature joint tissues have a limited ability to regenerate to their native forms. Despite the sizeable clinical burden of joint disease, we currently have a poor understanding of the cellular mechanisms through which joint progenitor cells regenerate and integrate into functional tissues after injury. Here, we have developed a new craniofacial whole-joint regeneration model to test the capacity of adult zebrafish to perform coordinated regeneration of all synovial joint tissues. After complete resection injury, endogenous neural-crest-derived progenitor cells resident within the adult zebrafish skeleton respond to loss of the jaw joint by mesenchymal bridging driven from 3 blastema. Followed by lineage differentiation and reintegration of all mature synovial joint cell types into a new 3D structure. Long-term live imaging methods have been developed through the reconfiguration of an intubation rig, with this rig images are taken on the confocal of live adult zebrafish which can be revived after imaging to create long-term time-lapse videos of the dynamics of regeneration. Our whole-joint resection injury and long-term live imaging platform will be useful to define cellular dynamics and tissue crosstalk mechanisms deployed in rebuilding a complex 3D organ.

Lucia Enriquez CC'26, Computer Science

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

Abstract: With the collaboration of her fellow researchers and Professor Frits Paerels of Columbia University's Astrophysics Department, Lucia Enriquez conducted a search for halos that had formed from the merging of two black holes by using archival X-ray images. Lucia compiled locations and times for 100 detected gamma ray bursts using photons' coordinates taken from the sky. Then, she calculated the estimated radius for each halo surrounding the merging black holes by encoding all of the information into a Python script. Files with all of the encoded data were then transferred into an X-ray visualizer software. Lucia was able to analyze 15 mosaiced X-ray images of the gravitational wave 170814. Through all of this data collection and analysis of different photon patterns in the sky, Lucia was able to understand visualizer software used with computers, and their benefits for research. Lucia and her colleagues have not detected any possible halos in their images so far. However, after an entire summer of research work and cross-checking, she is ready to undertake another facet of the gravitational wave research with Professor Paerels and other interested researchers. They will use mathematical calculations to more accurately predict where the halo's photons should be placed after a merger event. As of now, Lucia is working with the research team to hopefully write a research paper on their findings.

Victoria Esquibies CC'24, Neuroscience And Behavior

Faculty Mentor(s) or Supervisor(s): Andrés Bendesky
Title: Effects of 20α-OHP on parental care and pair bonding behavior in genetically similar Peromyscus maniculatus versus P. polionotus

Abstract: Monogamy and biparental care have evolved under different ecological conditions. To understand the evolution of parental care and its onset, it is important to compare genetically similar species that differ in their mating system— monogamy versus promiscuity. This research focuses on two sister species: promiscuous deer mice, or P. maniculatus, that show low parental care, and monogamous oldfield mice, or P. polionotus, that show high parental care. Oldfield mice have evolved a new cell type titled the zona inaudita, not present in deer mice, that converts the steroid hormone progesterone into 20α-OHP. The greater presence of 20α-OHP from the zona inaudita in monogamous, high parental care oldfield mice suggests it may have an effect on parental care behaviors in these species. If exposure to 20α-OHP results in increased parental behaviors such as pup-retrieval, as well as increased selective huddling with partners in oldfield and deer mice, then this research supports the hypothesis that OHP influences monogamy in Peromyscus mice. A pup-retrieval test post-OHP injection was conducted with unmated and mated oldfield mice, revealing possible effects on parental care as shown by increased huddling, licking, and retrieval behaviors. A huddling pair bond experiment post-OHP injection was also conducted,

demonstrating a possible increase in selective huddling, where mice preferred to huddle with their partners rather than with novel mice. Parental care research on genetically similar species that vary in mating system reveals information about the evolutionary background behind these behaviors; further research may have implications for understanding similar social behaviors between humans.

Luke Filor SEAS'25, Applied Physics

Faculty Mentor(s) or Supervisor(s): Kaya Mori
Title: Analyzing X-ray Emissions from Magnetic Cataclysmic Variable Stars

Abstract: Cataclysmic Variables are unique star systems characterized by rapid brightness fluctuations over a period of only months. They consist of a white dwarf, a compact remnant of a lower-mass star, and a main sequence star like our Sun. Main sequence stars sustain fusion reactions, opposing gravitational collapse. When low-mass stars exhaust hydrogen and helium fusion, their outer layers expand and are expelled, leaving behind dense white dwarfs. These tiny but massive remnants possess immense surface gravity. In binary systems, white dwarfs gravitationally attract matter from the companion star. As accumulated matter on the white dwarf's surface reaches a critical density, fusion reignites, causing a significant increase in luminosity. When fusion material depletes, the white dwarf once again goes silent, resulting in the characteristic variability of cataclysmic variables. If the white dwarf accumulates enough mass from its companion star, it has the potential to trigger a type 1a supernovae, one of the universe's most powerful explosions. The idea behind this research project is to examine the accretion characteristics of more than 40 different cataclysmic variable systems of various magnetic field strengths. Catching these systems in their 'bright' phases is critical, so various ground-based observatories have been used to monitor every system continuously. Once a system is confirmed to be in a bright phase, we can use the revolutionary NuSTAR space telescope to record its behavior in the X-ray band. Analysis of this data will help us understand the bizarre behavior exhibited by these exotic systems.

Robert Fox CC'24, Biology

Faculty Mentor(s) or Supervisor(s): Jellert Gaublomme
Title: Fluorescent Tagging of Endogenous WRN in SW620 Cells using the SpyTag/SpyCatcher System and mGreenLantern

Abstract: The Werner (WRN) enzyme is a bifunctional DNA repair enzyme with both helicase and exonuclease activity. WRN is canonically associated with Werner Syndrome, a congenital developmental disease produced by mutations in the WRN gene. A recent study expands WRN's role in the cell, characterizing it as an ideal synthetic lethal target in microsatellite instable (MSI) cancer cells, a trait common in many colorectal cancer cells. That same study identified that inactive WRN is housed in the nucleolus, and will translocate to the nucleus and localize to sites of DNA stress. Because this translocation phenotype during DNA damage allows WRN to be imaged microscopically, this study aims to use the optical pooled CRISPR screening method developed in Dr. Gaublomme's lab to identify genes that aid the activation or movement of WRN. Unfortunately, extant antibody clones do not provide a precise, sub-organelle, indicator of WRN location, suffering from significant background staining throughout the nucleus. To alleviate this, we have tried tagging WRN with both SpyTag, and mGreenLantern. SpyTag is a 7kDa epitope that covalently binds to its partner, SpyCatcher, and mGreenLantern is a fluorescent green protein with significantly higher quantum yield than standard GFP. Given that WRN knock out is lethal in MSI cells and has little phenotypic effect in healthy cells, identifying proteins that aid in WRN translocation is key for therapeutic development. Tagging WRN will enable us to use the optical pooled CRISPR screening method to identify those genes involved in WRN activity, opening up many potential therapeutic targets.

Aziza Ganihanova GS'24, Neuroscience And Behavior

Faculty Mentor(s) or Supervisor(s): Emmanouil Tsamis
Title: Evaluation of a Novel Method for Generating Normative Databases in OCTty

Abstract: Ophthalmological diagnostic devices such as Optical Coherence Tomography (OCT) are crucial in assessing glaucomatous damage. This study introduces an innovative methodology to expedite the identification of healthy eye scans by evaluating the retinal nerve fiber layer and the 'doughnut'-shaped retinal ganglion cell layer in the macular region of the eye. This is crucial for establishing a reliable normative database. To assess the effectiveness of this approach, we collaborated with two OCT experts, who evaluated 2000 OCT scans obtained from optometry practices. The scans were split between the two graders. Scans were deemed unacceptable if there were any signs of abnormality or poor image quality, as described recently.1 In cases of differing assessments, a consensus was reached through additional discussions between the graders. Our analysis revealed that 1448 out of the 2000 scans met the predefined inclusion criteria for healthy controls while 552 scans were categorized as unacceptable. To address discrepancies about

the acceptability of the scan, 345 scans were reviewed by both OCT experts and were ultimately categorized as unacceptable. All scans were evaluated in a month's time and ensured dataset integrity, preserving only high-quality, healthy scans. Our methodology presents an efficient approach to identifying suitable scans for our normative database. This advancement is vital for enhancing the quality and reliability of normative data, offering valuable insights for clinical diagnosis in ophthalmology. This approach could transform glaucoma detection by facilitating the timely identification of ocular abnormalities and providing better patient care.

1. Hood et al., OVS, 2023

Oshmita Golam CC'25, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Juan-Manuel Schvartzman
Title: Investigating the Effects of Hypoxia on Chromatin Dynamics in Colorectal Cancer

Abstract: Colorectal cancer (CRC) is the third most common cancer diagnosed in both men and women in the United States. CRC is a cancer type that is frequently found in low oxygen conditions, or hypoxia. Preliminary research in the lab indicates that the inhibition of oxygen-dependent enzymes can result in replicative stress (RS) through a stalled DNA replication process. DNA and histone proteins are tightly coiled into a highly compact structure called chromatin. In normal oxygen conditions, or normoxia, oxygen-dependent enzymes are activated to interact with chromatin. This interaction is crucial for gene expression because these enzymes create an open chromatin structure that allows the DNA to be transcribed. In hypoxia, these enzymes are inhibited; hence, chromatin is closed and the DNA is rendered inaccessible. Hypoxia-inducible factor (HIF) is a transcription factor that is stabilized in hypoxia. HIF stabilization leads to the activation of gene programs that allow cells to adapt and survive in hypoxic conditions. Because these oxygen-dependent enzymes cannot work in hypoxia to create open chromatin, the upregulation of HIF target genes should be difficult, or rather, unable to occur. However, because tumors, such as CRC, undergo unregulated cell division in hypoxia, this study seeks to understand how hypoxia affects HIF's ability to access its gene targets within a repressive chromatin landscape. How does HIF access sites that are in closed chromatin, and does HIF interact with specific enzymes to do so? This project has attempted to uncover the pathway(s) that HIF uses to access chromatin.

Benjamin Goldman CC'26, Astrophysics

Faculty Mentor(s) or Supervisor(s): Valentin Skoutnev
Title: Simulating magnetic field amplification by the Kelvin-Helmholtz dynamo in neutron star mergers

Abstract: Neutron stars are a dense remnant of collapsed stars. Observational studies have concluded that collisions between neutron stars should produce extremely strong magnetic fields, leading to the emission of gamma-ray bursts. By performing computer simulations of neutron star mergers, past studies have found possible routes for the growth of a strong magnetic field, the most plausible of which being the dynamo effect, whereby small-scale rotational motion of the matter making up neutron stars causes the exponential growth of a magnetic field that permeates the colliding bodies. While these studies have provided clear evidence that a dynamo is capable of amplifying the magnetic field during a collision, they have had to use simplified models of magnetic fluid physics to make up for the large complexity and scale of the turbulent fluid flows involved, and thus, they provide little insight into the qualitative properties of this dynamo. In this project, I use spectral simulation codes to model the shear zone of a neutron star collision. I calculated energy spectra of the kinetic and magnetic fields and found the spectra of the magnetic energy growth rate. I found that the kinetic energy spectrum quickly forms a distribution characteristic of turbulence, which leads to exponential growth of the magnetic dynamo. Future work on this project will determine how this dynamo growth rate responds to changes in viscosity, towards producing a coherent picture of the origin and development of magnetic energy in neutron star collisions.

Sebastian Gomez SEAS'24, Applied Physics

Faculty Mentor(s) or Supervisor(s): Carlos Paz-Soldan
Title: Pellet Ablation Experiment

Abstract: A novel cryogenic pellet injection test stand is under development at Columbia University in collaboration with Oak Ridge National Laboratory in support of the ITER Disruption Mitigation System (DMS) using shattered pellet injection. The experiment will fabricate cryogenic pellets of various compositions and measure ablation rates from well-defined particle sources. A custom gas manifold system allows for precise control of pellet composition; including varying homogenous mixtures of hydrogen isotopes and noble gasses, and different spatial compositions with radial variation (shells) and axial variation (end caps). Pellet formation and injection are carried out by the 'pipe gun' method, where gas is fed to a cold zone held below the triple-point temperature for controlled desublimation, then propelled by a low temperature copper mechanical punch. The primary

research purpose is to validate several models of ablation rates, to further the understanding of DMS pellet behavior. This setup facilitates additional investigation of the pellet freezing process, long-lifetime pellet degradation, and 'dusty' pellets with solid powders, knowledge necessary for improving DMS physics and technology in fusion pilot plants.

Sanya Gupta CC'25, Mathematics

Faculty Mentor(s) or Supervisor(s): Shina Adegoke, Javier Garcia, Fiona Harrison
Title: Modelling the Reflection Spectra of the Black Hole X-ray Binary GX 339-4 from its 2021 Outburst

Abstract: We report on the overarching properties of the black hole binary GX 339-4 to, for the first time, model the broadband X-ray reflection spectrum based on its 2021 outburst observed by the NuSTAR and NICER telescopes. During this outburst, the source successfully went through all state transitions over the course of thirteen different observations. The source exhibited strong relativistic reflection features including the broad iron K_a line at 6.4 keV and the Compton hump that peaks around 20 keV. Using basic phenominological/physical models, we probe the evolution of important accretion flow parameters over the entire outburst. These include the powerlaw photon index, the disk blackbody temperature, and its normalization. We further computed the inner disk radius corresponding to each of the observations. This is important to study the evolution of the inner accretion disk as the source transitions from one state to another. We also quantified the strength of the reflection spectrum (importantly, the broad iron K_{α} line) for any correlations with the illuminating X-ray flux.

Gonzalo Gutierrez CC'24, Biochemistry

Faculty Mentor(s) or Supervisor(s): Virginia Cornish
Title: Improving Ovalbumin (OVA) Protein Secretion Yield in Yeast using a Plasmid Library Screening Approach

Abstract: Saccharomyces cerevisiae and other related yeast strains have served as influential model organisms for decades, and they have been of interest to synthetic biologists because of their well-studied genetics. High yield secretion of recombinant protein in yeast is challenging due to the various bottlenecks in the yeast secretory pathway, including the unfolded protein response (UPR) and endoplasmic reticulum-associated degradation (ERAD), that combat cell stress due to protein overexpression. These pathways decrease secretion yield, and thus a middle ground between protein overproduction and cell stress must be achieved for optimal secretion. This study constructed a library of plasmids that secrete the ovalbumin (OVA) protein, a well-characterized model antigen in immunology. The plasmid library was made using the MoClo-YTK kit for efficient plasmid production, and it consisted of 32 combinations of promoters and signal peptides. The choice of promoter directly impacts the level of transcription, while the choice of signal peptide determines ER translocation efficiency. In addition, two yeast origins of replication (CEN6 and 2u) were used that dictate the plasmid copy number per cell. Taken together, this approach determines which combination of plasmid parts result in the highest secretion yield. While we did not find any yield improvement in this library screening, we are currently testing if the choice of selection marker makes a difference. Moreover, we are using this screening method on other recombinant proteins, with the overall goal of proving the feasibility of yeast antigen secretion as a method for vaccine development.

Milena Harned CC'26, Mathematics

Faculty Mentor(s) or Supervisor(s): George Dragomir
Title: A Noise Level Aware Poisson Denoising Algorithm for Fluorescence Microscopy Data Using Swin Conv U-Net

Abstract: Fluorescence microscopy is a powerful imaging technique widely used in biological research to visualize cellular structures and processes. However, the acquisition process is prone to introducing Poisson noise, which can degrade image quality and hinder accurate analysis. Poisson noise, also called shot noise, tends to affect images captured in low light settings and affects the image quality in a signal dependent manner. Many algorithms currently exist to denoise images corrupted by additive Gaussian noise, but fewer address this less common yet equally damaging noise type. To address this challenge, this project proposes a novel noise level aware Poisson denoising algorithm that leverages the Swin Conv U-Net architecture. The transformer was first applied to computer vision tasks in 2021, and has shown competitive results in a wide range of applications through its multi-headed attention mechanism, allowing it to pick up on long range dependencies. The U-Net's encoder-decoder structure with skip connections allow the model to effectively combine low-level features with high-level context, allowing for effective denoising while preserving important image details. This project's algorithm integrates an estimation of the noise parameter with the strengths of Swin Transformers and U-Net to effectively denoise fluorescence microscopy data.

Youssf Hegazy CC'25, Computer Science

Faculty Mentor(s) or Supervisor(s): Lincoln Harris and William Stafford Noble
Title: A joint match-between-runs procedure for imputing missing values in quantitative proteomics data

Abstract: In proteomics research, the goal of a project is often limited by our ability to detect and quantify as many proteins as possible from a given sample or set of samples. Mass spectrometry is widely used to identify unknown compounds and to quantify known compounds. In bottom-up mass spectrometry, peptides may be detected inconsistently from one run to the next. Researchers analyzing a set of samples will summarize the data in a peptide-by-sample matrix of peptide quantifications in which each entry is a peptide quantification. The inconsistency of detections from run to run leads to missing values in the peptide-by-sample matrix, leading to the use of a match-between-runs (MBR) procedure. Such a procedure involves matching a feature associated with a missing peptide with a feature associated with an identified peptide in a different run. Calibration of retention times and the inclusion of additional features between similar features are often key to this process. Alternatively, we propose the use of a machine learning model to impute missing data by carrying out transfers jointly. In this approach the machine learning model searches for a corresponding feature in the adjoining data for every run and uses that feature to fill in the missing value in the corresponding matrix of peptide quantifications. While a pairwise MBR approach has proved useful to proteomics researchers in determining the intensities of these undetected peptides, this work our proposed method may offer several advantages such as removing calibration steps, considering more data at once, and additional flexibility for the researcher. The model will take into account existing methods for imputation and later take on additional features of the data with a successful model being able to better (with more accuracy) determine the value (in this case - scan numbers) of missing peptides. In a broader context, with more accurate and complete data sets for mass spectrum proteomics data, researchers will be better equipped to make conclusions regarding their samples (a clear scope or impact of this project).

Keondre Herbert† SEAS'24, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Barclay Morrison, PhD
Title: Characterizing Glial Cell Expression in Organotypic Hippocampal Slices After Blast Injury

Abstract: Traumatic brain injury (TBI) affects millions yearly, with mild TBI (mTBI) or concussion being the most common form. Glial cells, especially astrocytes, microglia, and oligodendrocytes, undergo changes post-TBI, promoting recovery or exacerbating injury. Our lab found that inflammation can rise post-mTBI without significant cell death. Addressing this inflammation, particularly by modulating glial activity, offers a potential treatment approach. This research aims to understand glial cell distribution and expression after blast-induced mTBI, mimicking military shockwave injuries. We used organotypic hippocampal slice cultures (OHSCs) from Sprague-Dawley rats, ensuring less than 5% cell death pre-experiment. Data post-injury indicated no significant cell death change (0.57 ± 0.15% vs 0.54 ± 0.18%, n=13). Using immunohistochemistry, we studied glial spatial distribution in the CA1 hippocampal region, quantified using a custom MATLAB code. Preliminary results revealed that CNPase expression was most prominent in the stratum oriens, with a 94 ± 10.42% higher intensity than the stratum radiatum, n=3. Conversely, Iba1, GFAP, and Hoechst peaked in the stratum pyrimidale, showing intensities of 157 ± 6.95%, 120 ± 8.15%, and 98 ± 11.96% higher, respectively, compared to other regions, n=3. We anticipate these expressions will alter post-mTBI. These findings provide insights into healthy glial morphology and potential post-blast changes. Recognizing these glial shifts can help identify mTBI markers and create targeted treatments. Future research will delve into post-mTBI cellular morphological changes and potential anti-inflammatory interventions.

Allison Hess CC'25, Biological Sciences

Faculty Mentor(s) or Supervisor(s): Dawn Davis
Title: Beta-Cell Proliferation in Response to Two Different Metabolic Stress Conditions

Abstract: Type 2 diabetes mellitus (T2DM) is expected to affect 1 in 3 Americans by 2050. T2DM is characterized by insulin resistance and decreased beta-cell mass (beta-cells produce and secrete insulin). In non-diabetic obesity, an expansion of beta-cell mass allows for increased insulin secretion. Understanding the mechanism behind this adaptive expansion could lead to promising therapies for reducing the incidence and/or severity of T2DM by preserving or expanding beta-cell mass. Glucagon-like-peptide-1 (GLP-1) analogues have emerged as promising candidates for this purpose. The role of beta-cell GLP-1 receptor (GLP-1r) signaling in regulating beta-cell mass under metabolic stress has not been studied in vivo. This project utilizes a murine model with a beta-cell-specific GLP-1r knockout to investigate the role of beta-cell GLP-1r signaling in adaptive beta-cell

proliferation under metabolic stress. Two models of metabolic stress were used, a 1-week high fat diet (HFD) or a 1-week insulin receptor antagonist (s961) treatment via an osmotic pump. Immunofluorescence staining and mRNA expression of Ki67 (a marker of proliferation) showed a significant difference in beta-cell proliferation in the HFD model but not the s961 model between wild-type and GLP-1r-knockout mice. This suggests that although GLP-1r signaling is important for adaptive beta-cell proliferation (HFD), it is not the primary factor responsible for beta-cell proliferation in response to severe hyperglycemia induced by insulin receptor antagonism. This supports the use of GLP-1r analogues for the preservation of beta-cell mass, further investigation is needed to elucidate other signaling pathways responsible for proliferation in the setting of severe hyperglycemia.

Moira Hilton CC'25, Biochemistry

Faculty Mentor(s) or Supervisor(s): Darcy Kelley
Title: Exploring the Genetic Architecture of Vocal Communication and Phonotactic Responses in L Clade Xenopus

Abstract: In each Xenopus species, adult males produce an advertisement call that attracts gravid females. The combination of temporal (sound pulse rate and pattern) and spectral (sound frequencies or pitches) features in each pulse provides a unique species call. A specific neuronal cell type - the FTN or fast trill neuron - in the hindbrain parabrachial nucleus controls sound rhythms, which are created by the larynx. To explore laryngeal sound pulse features and phonotactic responses, the Kelley Lab generated approximately 700 F2 hybrids between X. laevis and X. petersii, which are now adults. With the anticipation of performing QTL analysis on the newly-released X. petersii genome, male advertisement calls have been recorded (with replication) at sexual maturity and female acoustic preferences have been quantified. To carry out the phonotaxis experiment, insulated chambers were created with hyophones to capture vocalizations. The female frogs were injected with hCG and then isolated in the tanks overnight. Hourly playback combinations of male advertisement calls were broadcasted through transducers to elicit a sexual response from the gravid females, and movements were tracked using TREX. Analysis of the data revealed that X. laevis females did show a preference for conspecific male advertisement calls, whereas X. petersii showed no species-specific call preference. Further analysis of the X. laevis call preferences also revealed that the male biphasic call (natural call) was preferred over isolated fast and slow trills.

Julia Holder CC'25, Biology and Mathematics-Statistics

Faculty Mentor(s) or Supervisor(s): Peter Andolfatto
Title: Investigating Signs of Past Selection: A Study of Polygenic Pigmentation in Drosophila

Abstract: In evolutionary biology, many interesting traits are polygenic, rather than being controlled by one gene. The evolutionary trajectory of a trait like this can have profound effects on the evolution of a species, such as incompatibility with other sites in the genome that leads to the divergence of one species into two. When comparing Drosophila yakuba and Drosophila santomea, two closely related fly species, D. yakuba has a dark pigmented pattern on the abdomen, whereas D. santomea has light yellow pigmentation. Five genes, yellow, tan, pdm3, ebony, and Abdominal-B, are suspected to control this difference in pigmentation. This project, a continuation of ongoing work in the Andolfatto lab, worked to introgress the genes tan and ebony from the D. yakuba genome onto the background of D. santomea with a series of crosses. These lines reached backcross three this summer. The previously established lines of flies with the yellow, pdm3, and Abdominal-B genes were also backcrossed to narrow in further on the desired genes. This project remains ongoing in the lab, and once lines with each of these genes are established, will open up more possible experiments to investigate if combinations of these genes are incompatible with other parts of the D. santomea genome, a factor which could have driven the two species apart.

Colin Holm-Hansen CC'24, Physics

Faculty Mentor(s) or Supervisor(s): Mary Putman
Title: Detection of Filaments in a High Velocity Cloud

Abstract: High Velocity Clouds (HVCs) are large masses of gas whose velocities are in excess of those allowed by Galactic rotation, with most appearing to be falling in towards the Galactic disk. They are believed to play an important role in providing material to the disk which allows the galaxy to maintain its star formation rate. Despite this, the origin and formation of HVCs are still poorly understood. In this work the authors present the first findings of 3D filaments in an HVC and compare them to local filaments along the same line of sight.

Chih Huang CC'26 Computer Science

Faculty Mentor(s) or Supervisor(s): Meng-Tsung Tsai
Title: Approximating the Influence Maximization Problem using Sub-Linear Space

Abstract: The influence maximization problem is a graph and networks problem. Initially, we are given a directed acyclic graph G, nodes N, edges E, and a constant k. If edge e connects node n1 to n2, and if n1 is under the influence of some form of advertisement, then we said n1 may influence n2. The problem aims to find the best k nodes which will achieve maximum influence if the users initially advertise to these nodes. This research presents a 1-1/e approximation algorithm for the problem under the semi-streaming model, and the algorithm uses a sub-linear amount of space (i. e. less than N) and a constant number of k passes. Using the idea of submodularity, namely always picking the node which influences the most uninfluenced nodes in each pass, the algorithm achieves an approximation factor of 1-1/e. With previous works on finding the most frequented element in the data stream using count sketch, combined with a F0 sketch counter for recording the already influenced nodes, the algorithm w. h. p. identifies the best greedy choice in each pass while using a sub-linear amount of space. Furthermore, our results suggest, through a multi-player multi-round set disjointness problem in communication complexity, that a linear amount of space must be required should any algorithm achieve an approximation factor better than 1-1/e. The above research proposes an 1-1/e approximation algorithm and sets a spatial lower bound for solving the influence maximization problem for the purpose of mass data processing.

Coco Huang CC'25, Biochemistry

Faculty Mentor(s) or Supervisor(s): Harris Wang
Title: Characterizing Interactions between Dietary Polyphenols and Individual Bacteria Strains of the Human Gut Microbiome

Abstract: Diet significantly influences the composition and metabolic functions of the gut microbiome. Polyphenols, natural compounds derived from plants and crucial to the human diet, interact extensively with the gut microbiota as polyphenols often reach the colon unabsorbed. While prior research demonstrated the prebiotic as well as antimicrobial effects of certain polyphenols towards certain gut bacteria strains, the studies typically adopt a broad community-level approach, leaving the extent and underlying mechanisms of these interactions less understood. Our research project aims to bridge this knowledge gap by investigating the individual interactions between different dietary polyphenols and distinct bacterial strains within the gut microbiome. We conduct time point incubation followed by 16S V4 sequencing for a comprehensive analysis. Remarkably, our findings reveal that polyphenols from the same class present unique effects on gut bacteria. For example, not all flavonoids promote prebiotic strains. More specifically, naringin (a flavonoid) consistently demonstrates favorable effects by promoting the growth of beneficial species while inhibiting pathogenic strains. Conversely, naringenin (a flavonoid), at a concentration of 1mM, hinders the growth of all gut bacteria strains. Moreover, we noted a high sensitivity towards polyphenols exhibited by bacterial strains associated with pathogenic diseases, while prebiotic strains are prone to be promoted by all polyphenols. These findings contribute to providing a more complete understanding of how dietary polyphenols affect gut microbiome, offering insights into the potential use of dietary interventions as precision medicine as we can better predict the outcomes of polyphenol consumption.

Lina Huang CC'26, Biology and Medical Humanities

Faculty Mentor(s) or Supervisor(s): Donna Farber
Title: Spatial Determination of T Cell Dynamics in the Lung

Abstract: T cells activate upon encountering antigens found in pathogens and differentiate into effector cells that coordinate an adaptive immune response. T cells can persist after pathogen clearance as memory cells which sustain immune protection. Compared to circulating effector cells or cells in secondary lymphoid organs, most memory T cells reside long-term in tissues. Known as tissue-resident memory T cells (TRM), these cells mediate enhanced, in situ protection against re-infection. However, the effects of tissue-site and the local conditions within specific tissues on TRM formation and organization remain unclear. We examined the localization and dynamics of two sequentially introduced T cell populations specific for different infections in the lung using confocal imaging. We found that development of TRM is impaired by the presence of a past pathogenic encounter, in an infection-dependent manner. T cells that migrate to the lung after secondary infection exhibit altered relationships with neighboring cells and structures, where they possess reduced expression of tissue residency markers and locate further from the airways. CD4 T cells, which have long been recognized as promoters of B cell class switching, somatic hypermutation, and memory formation, interact more with B cells with the presence of a previous infection, indicating a potential switch in function for these cells. This spatial perspective on T cell dynamics underscores the role of local tissue organization in immune cell development and has implications for optimal timing and sequence of strategies to induce T cell responses, such as vaccines.

Phillip Ionkov CC'26, Physics

Faculty Mentor(s) or Supervisor(s): Abraham Tishelman-Charny

Title: ZH Jet Pairing Methods for Higgs Self-coupling Sensitivity Optimization at a Future Higgs Factory

Abstract: In 2012, the ATLAS and CMS collaborations, based at the Large Haon Collider (LHC)at CERN, experimentally confirmed the existence of a particle consistent with the Standard Model (SM) Higgs boson, the final missing piece of the SM. The Higgs boson arises from excitations in the Higgs field, which gives mass to other SM particles. The next step in verifying the SM is to perform precise measurements of the Higgs boson's parameters, including the Higgs self-coupling, which has a direct impact on the shape of the Higgs potential. Verifying that the Higgs potential is SM-like or not would provide insight into the stability of the vacuum, but measuring the Higgs self-coupling is difficult because the physical processes showing observable changes due to its value are very rare. A proposed post-LHC particle collider, the Future Circular Collider (FCC), offers improved sensitivity to the Higgs self-coupling. This depends on many measurements of the Higgs boson's properties, but this project focuses on an unexplored decay channel of the associated production of a Z boson and a Higgs boson (ZH): the case in which both the Higgs and the Z bosons decay into quarks, which is in fact the most common final state for the ZH signal. This project investigates multiple methods toward identifying Z boson candidates by analyzing simulated FCC data using Z decay product masses and jet identification scores as metrics. Then, the recoil mass is calculated and used as a metric for evaluating sensitivity toward the Higgs self-coupling.

Shloka Janapaty SEAS'24, Applied Mathematics

Faculty Mentor(s) or Supervisor(s): Mingzhen Lu, Chris Kempes
Title: Biocrust Growth, Death, and Competitive Controls on Local Biogeochemistry

Abstract: Biocrust, terrestrial communities of cyanobacteria, lichen, and bryophytes, extensively cover global surfaces and play a crucial regulatory role in atmospheric nitrogen fixation. Despite their importance, global variation in biocrust biogeochemical flux is not well understood. In particular, current spatiotemporal models of nitrogen flux lack a metabolic picture of biocrust community dynamics in stochastic environments. Recent advances in population-level scaling and new, updated biocrust flux datasets can fill this gap. In this work, we propose a model of biocrust growth and death with competitive constraints, incorporating competition on a background of fluctuating resources and stochastic disturbance. We suggest that biomass and functional group diversity constrain variation in nitrogen flux across productive zones. First, I develop a reaction-diffusion PDE of biocrust growth and mortality with three resources, N, Fe, and H2O, and four functional groups, non-nitrogen fixing cyanobacteria, nitrogen-fixing cyanobacteria, lichen, and bryophytes. Functional groups were aggregated into distinct maturity classes. New biocrusts enter the community through spore dispersal. Non-nitrogen fixing cyanobacteria deposit iron, facilitating the emergence of nitrogen-fixing cyanobacteria, and lichen and bryophytes appear in response to water availability. I also derive first-principle rules for the relationship between functional groups and competition, disturbance, allometry, and resource consumption, which exert probabilistic dependencies on class mortality rates. Our analysis successfully predicts both biocrust spatial aggregation and ecological succession patterns and suggests constraints on nitrogen flux. This extends ecological insight into biogeochemical feedback loops in terrestrial ecosystems.

Dominique Jenssen GS'24, Environmental Science

Faculty Mentor(s) or Supervisor(s): Maria Tzortziou
Title: A space-based retrieval approach for red-brown tides in Long Island Sound

Abstract: Often referred to as the Urban Sea, Long Island Sound is an Estuary of National Significance located near one of the largest coastal megacities in the world. Home to a variety of marine life, the Sound holds large ecological, cultural, and economic significance. Yet, LIS has been suffering from major water quality issues, including seasonal hypoxia, and recurring harmful algal blooms (HABs) such as red and brown tides. Detection and monitoring of red-brown tides is challenging due to the large spatial extent but also patchiness of the blooms, the transient natures of these events, and the time intensive nature of in-situ sampling. Space-based monitoring can provide high-frequency, synoptic observations of the entire ecosystem, over different seasons and across a range of conditions, uniquely complementing in situ monitoring. Here, we applied the Normalized Red Tide Index (NRTI) approach, to detect red-brown tide blooms across Long Island Sound from space. To validate the NRTI retrievals, we used flow microscopy, high performance liquid chromatography, hyperspectral phytoplankton absorption, and hyperspectral remote sensing reflectance measurements. HPLC analysis showed strong correlation between NRTI and red-brown pigments with an R2 value of 0.79. Seasonal transitions in phytoplankton diversity were captured, showing a 57% increase in phytoplankton diversity in the summer. Combining patterns in microscopy and relative pigment contribution, differences in NRTI values and overall red-brown tide biomass can be

explained. These results highlight the value of the NRTI as an approach that can be applied to capture the magnitude and spatiotemporal extent of red-brown tide events in complex urban estuarine waters.

Ezekiel Johnson SEAS'24, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Kartik Chandran
Title: Nitrogenous Greenhouse Gases from Wastewater Treatment Technologies: Clean Air or Clean Water?

Abstract: Full-scale implementation of the partial denitrification-anammox (PdNA) treatment process is a promising, recent advancement in wastewater treatment. Compared to traditional nitrification/denitrification nitrogen removal, PdNA could reduce oxygen and organic carbon demand by up to 35% and 61-65% respectively (McCullough et al., 2022). These advantages would translate to significant energy savings and sustainability benefits in the wastewater treatment process. Despite these savings, little is known of the nitrous oxide (N2O) emissions from PdNA. N2O is a potent greenhouse gas accounting for 6.2% of the U.S. carbon footprint across all sectors (EPA, 2023). Wastewater treatment accounts for 5% of U.S. N2O emissions and thus increases in wastewater treatment plant (WWTP) N2O emissions would have substantial environmental consequences (EPA, 2023). Using an EPA-endorsed protocol developed by us (Chanan, 2009), we quantified full-scale N2O emissions from a Mid Atlantic WWTP under summer conditions. Additionally, we designed a lab-scale twin of the full-scale wastewater treatment process to further obtain mechanistic information pertaining to the production and emission of N2O from PdNA processes under different conditions and to develop mitigative strategies. These results, along with N2O emission data from other WWTPs, allow for a more comprehensive understanding of the environmental costs and benefits of the PdNA process for both the hyosphere and the atmosphere.

David Ju SEAS'27, Mechanical Engineering

Faculty Mentor(s) or Supervisor(s): Guy Genin
Title: Investigating how mechanical loading influences the maturation of artificial heart tissue using micro-fabricated soft magnetic devices

Abstract: The study of how mechanical forces shape and influence biological processes, a field known as mechanobiology, is essential for understanding how the human body functions. However, the simultaneous combination of simulating, manipulating, and imaging these interactions in vitro has always been challenging, making it hard to thoroughly understand how mechanical cues impact our biology. To address this, this research project presents a novel device to better investigate these interactions—specifically how applied strains impact the stiffening of artificial heart tissues (induced pluripotent stem cells; iPSCs). In this experiment, soft, flexible microarrays with magnetic properties were designed and crafted using 3D prototyping and double-molding processes. After submerging the device into a cell media solution, tiny bands of iPSC tissues collapse around the magnetic pillars within each well. By utilizing an external magnet to deflect the posts and incorporating barriers to control pillar deflection, varying percentages of tissue strain can be tested. Lastly, a microscope can be used to track the deflection of the pillars, and the contractile force exerted by the tissues over time can then be calculated using beam theory. The resulting stress-strain relaxation graphs from this new device show how varying degrees of mechanical stimulation drive the maturation of iPSC tissue, allowing us to gain insight into understanding the development of diseases like cardiac fibrosis. Furthermore, this new device provides a platform for future experiments to study the behavior of tissues under stress.

Jaehoon Jung CC'26, Physics and Mathematics

Faculty Mentor(s) or Supervisor(s): Dmitri N. Basov, Suheng Xu
Title: Optimization of Plasmon-Magnon Polariton Coupling in a Graphene-Antiferromagnet Heterostructure

Abstract: Polaritons are quasiparticles formed from electromagnetic (EM) waves coupling to matter excitations. This hybrid mode exhibits properties of its constituent light and matter modes. Surface Plasmon Polaritons (SPP) are formed from light coupling to oscillations in charge carrier density on metal surfaces. Magnon Polaritons (MP), observed in materials with magnetic resonances, are hybrid modes of light and spin waves. Interaction between these modes can form a new polariton with spin and charge excitations, a Surface Plasmon-Magnon Polariton (SPMP). An EM wave-excited hybrid material constructed from a conductor and a magnetic material provides a potential platform to observe this interaction. Graphene and a 2D Antiferromagnet (NiPS3) serve as viable constituents as they host SPPs and MPs within the same THz energy range. Scattering/transfer matrix methods were employed to extract the heterostructure's SPMP dispersion relating photon energy and momentum. Avoided crossing between constituent modes is a characteristic of hybrid modes, where the coupling strength corresponds to the splitting energy between avoided crossing points. The SPMP coupling was optimized by varying parameters including the Graphene fermi energy,

Graphene electronic scattering rate, NiPS3 thickness, and thickness of a h-BN spacer to achieve mode splitting above 100GHz. The optimized heterostructure's dispersion was used to simulate the sample's near-field signal in a THz measurement. A nano-THz spacetime mapping method allowed visualization of the SPMP's worldline showing its propagation across space and time. With the SPMP's nanophotonic, imaging, and data transmission applications, a future experimental measurement can assess the heterostructure's ability to coherently host this nontrivial mode

Mayra Kalaora CC'24, Neuroscience & Behavior and English

Faculty Mentor(s) or Supervisor(s): Jo He
Title: Investigating the Relationship Between Intolerance of Uncertainty and Interpersonal Emotional Regulation in Romantic Relationships

Abstract: Intolerance of uncertainty (IU) is the tendency of an individual to consider the possibility of a negative event occurring unacceptable, irrespective of the probability of occurrence (Carleton, Norton, & Asmundson 2007). IU is associated with worry, anxiety, and general emotional dysregulation (Shu, Ochsner & Phelps 2022). While there exists considerable literature on IU and its relationship to individual emotion regulation strategies, research on its relationship to interpersonal emotion regulation strategies remains insufficient. This study tested the hypothesis that higher levels of IU would be positively associated with one's tendency to resort to co-suppression, co-brooding, and co-distraction, and negatively associated with co-reappraisal. 120 couples above the age of 21 residing in the United States were given a baseline survey, followed by 21 days of daily diaries, and then a post-survey. For the daily diaries, participants recorded one negative event that happened to them and one that happened to their partner. The surveys included various scales assessing the participants' behavioral and emotional tendencies. By using post-survey data, the hypothesis was tested through comparing participants' scores on the Intolerance of Uncertainty Scale (IUS) and Interpersonal Emotion Regulation in Close Relationships Scale (IER-CR). Understanding how one's IU may affect their preferences for certain interpersonal emotion regulation strategies—and whether one's preference aligns with the effectiveness of the strategy in ensuring the well-being of the individual and their relationship—can inform therapeutic interventions wherein couples are encouraged to understand each other's IU, and, based on such understanding, find the most appropriate strategy to help each other regulate their emotions.

Emily Kalfas GS'24, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): C. Daniel Salzman
Title: The Neural Dynamics and Behavior of Valence and Intensity Encoding in the Amygdala and Prefrontal Cortex

Abstract: During classical conditioning experiments, how much the monkey values a given unconditioned stimulus is measured using behavioral responses to associated conditioned stimuli. For example, after associating a conditioned stimulus with an aversive unconditioned stimulus like a facial airpuff, the animal's anticipatory blink response prior to receiving the airpuff is commonly used as a metric of how aversive the airpuff is. However, historically, the duration of anticipatory blink for airpuffs of varying intensities in classical conditioning tasks has been inconsistent between monkeys (Hayashi et al., 2015). Here we demonstrate that choice behaviors and reaction times on two-alternative forced-choice trials provide more reliable behavioral insights into how much monkeys value varied intensities of airpuff stimuli. This provides an alternative behavioral measure of aversive stimulus value beyond reinforcement trial performance and blink duration. This behavioral analysis serves as a basis for further study, where behavioral data will be analyzed in conjunction with electrophysiological recordings from the amygdala and prefrontal cortex in order to decode how the primate brain represents stimuli of varying valence and intensities.

Morell Kenmoe CC'25, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Christopher Baldassano
Title: Studying the effect of prior knowledge(schema) on prediction and memory using a board game

Abstract: As people amass different experiences in their lives, their brains develop schemas of what typically happens in specific situations, such as for ordering fast-food in a drive thru. Notably, schemas can also influence memory by aiding in memory retrieval as well as by enabling prediction when encoding a memory. This was demonstrated in a previous study where participants' eyes were tracked while they played an online board game, and the data from this experiment showed that as people developed a schema for how to play the game, they began predicting where they thought upcoming moves were likely to be made. Previous research has suggested that prediction errors, moments when one's predictions turn out to be incorrect, may result in better memory. Thus, this follow-up study aimed to determine how prediction error influences memory. For this experiment the participants first had to spend time playing the game to build their schema; participants

were then shown a board from an in-progress game followed by the same board with a new move placed on it. Their task was to remember the move that was placed, and the prediction error was based on whether the move that was placed matched their predictions recorded by the eye-tracking technology. Results of this experiment showed that participants actually had better memory of the move when the move confirmed their predictions, or there was a low prediction error.

Rinn Kersh CC'27, Biochemistry

Faculty Mentor(s) or Supervisor(s): Amy Warner
Title: Memory Transfer Through Ingestion Shown in Planarians

*Abstract:*This research project seeks to investigate the transferability of acquired abilities between distinct organisms. Specifically, it aims to assess whether naive planarians, after consuming a trained planarian, exhibit a faster acquisition of the learned ability compared to their counterparts who ingested tissue from untrained planarians. This project develops the ideas originally alluded to in the Manual of Psychological Experimentation on Planarians by McConnell and utilizes the more recent knowledge in science to draw more accurate conclusions (McConnell, 1965). This project hypothesized that as a result of the ingestion of a trained planarian, the naive planarian will learn the ability more rapidly than a planarian that ingested an untrained planarian. To answer this question, the learning ability of planarians who ingested trained planaria was compared to the learning capability of those who ingested untrained planaria. The results were analyzed using a two-sample t-test. The data collected showed support for the hypothesis. These findings could contribute to a deeper comprehension of memory storage mechanisms and shed light on how survival instincts may be transmitted as the training process pulled on the planaria's survival instincts. Furthermore, this experiment lays the groundwork for potential future investigations in the fields of epigenetics, evolutionary studies, and animal behavior, offering promising avenues for further research.

Lena Khosrof CC'24, Biology

Faculty Mentor(s) or Supervisor(s): Alexander I. Sobolevsky
Title: Molecular Pathway and Structural Mechanism of Human Oncochannel TRPV6 Inhibition by the Phytocannabinoid Tetrahyocannabivarin

Abstract: Transient receptor potential (TRP) proteins are calcium-ion permeable membrane channels comprised of six distinct receptor families: vanilloids (TRPV), canonicals (TRPC), melastatins (TRPM), polycystins (TRPP), and mucolipins (TRPML). TRPV6, the sixth member of the vanilloid family, is a calcium-selective oncochannel and an important iver of cell proliferation in human cancers. Therefore, it is necessary to investigate inhibiting modulators of TRPV6 activity in order to design templates for drug discovery and development. Despite increasing interest in pharmacological research to develop synthetic inhibitors of TRPV6, natural compounds acting at this channel have been largely neglected. On the other hand, pharmacokinetics of natural small-molecule antagonists optimized by nature throughout evolution endows these compounds with a medicinal potential to serve as potent and safe next-generation anti-cancer drugs. This report encompasses the structure of human TRPV6 in complex with tetrahyocannabivarin (THCV), a natural cannabinoid inhibitor extracted from Cannabis sativa. These experiments include cryo-electron microscopy combined with electrophysiology, calcium imaging, mutagenesis, and molecular dynamics simulations to identify THCV binding sites in the portals that connect the membrane environment surrounding the protein to the central cavity of the channel pore and to characterize the allosteric mechanism of TRPV6 inhibition. Furthermore, these experiments propose the molecular pathway taken by THCV to reach its binding site, thereby providing a foundation for the development of new TRPV6-targeting drugs.

Emily Kilroy CC'25, Biochemistry

Faculty Mentor(s) or Supervisor(s): Anum Glasgow
Title: PARROTS: Protein Antivirals by Rapid Redesign of Tertiary Structures

Abstract: Protein Antivirals by Rapid Redesign of Tertiary Structures or PARROTS is a project that aims to use computational methods to build a library of binders that have tight binding affinities to selected antigens. The basis of the project is inspired by the COVID-19 pandemic and the pressing need for quickly developed therapeutics to treat the evolving virus. In this context, traditional methods of developing therapeutics rely on antibodies. However, with the rapidly mutating strains of the virus, the ability of the antibodies to bind to the antigen often declines and becomes ineffective. This project seeks to create a pipeline that has the potential to quickly develop non-antibody therapeutics. PARROTS consists of two phases, the first being the actual computational pipeline, and the second being experimental validation. The pipeline includes a series of various design and filtering steps to create new binder proteins with a high likelihood of binding to a select viral antigen. The second phase involves experimental validation of the designed models. This includes using hands-on laboratory techniques to

determine if the designed binder shows evidence of attaching to the virus. Thus far, both phases of the project have been completed once. The results from the first trial have allowed significant insight into the development and potential for PARROTS. Future directions for the project include running the pipeline for relevant therapeutic targets and finalizing the pipeline.

Ashley Kim SEAS'23, Computer Science

Faculty Mentor(s) or Supervisor(s): Sanja Vickovic
Title: A Computational Pipeline for Micro Spatial Transcriptomics

Abstract: Precise and accurate measurement of gene expression is pivotal to the life sciences. Single-cell RNA sequencing profiles expression with cellular level resolution, and microfluidic research has resulted in a class of single-cell transcriptomic techniques that not only inventory gene expression but simultaneously preserve and detect each cell's spatial location in tissue. As a result, spatial transcriptomics (ST) offers drastically improved resolution and significant advantages compared to other single-cell techniques, particularly in the detection and analysis of architectures that are position-dependent. Current ST equipment is costly and only available via select manufacturers with limited customizability and resolution; this project is a computational pipeline for the NYGC Technology Innovation Lab's micro Spatial Transcriptomics (µST), which provides a method for custom ST array manufacturing and processing at a fraction of the cost, with significantly improved resolution. Existing pipelining and data processing tools provide a useful template for uST software, which involves filtering and mapping the gene expression data extracted from orthogonally oriented microchannels to respective coordinates of a tissue sample. The result is a highly-precise and customizable method for deriving tissue expression profiles at a resolution level 30x more fine-grained than existing spatial transcriptomic methods. The uST pipeline involves a custom, high-capacity FASTQ demultiplexer with significantly better performance than previous versions, tissue image coordinate mapping software compatible with both hexagonal and square grids, and data processing and visualization tools for output analysis. Each of these components are Python-compatible and together form a cohesive and robust computational infrastructure for improved tissue expression profiling.

Min Jae Kim CC'26, Chemical Physics

Faculty Mentor(s) or Supervisor(s): Angelo Cacciuto
Title: Entropy Production of Active Matter Systems

Abstract: The random (or thermal) movement of particles suspended in a fluid is known as Brownian motion. Active Brownian particles (ABPs) deviate from such behavior by converting surrounding energy into translational or rotational motion. That is, active systems exhibit directed (non-Brownian) motion by exploiting energy from their environment. In this project, we made strides to capture how much active systems deviate from their non-active counterparts by measuring a quantity called entropy production (EP). EP measures the amount of time-reversal symmetry breaking non-equilibrium systems exhibit i.e. how far from equilibrium these systems are. We wrote an algorithm to calculate the local EP of active systems, which illustrates what parts of a system are producing more or less entropy. In other words, measuring the local EP of active systems conveys the inhomogeneity of equilibrium-breaking behavior.We measured the local EP of three systems: a system consisting of a single ABP, one with several ABPs colliding with a symmetric wall, and one with a dynamic cluster of ABPs coexisting with its fluid. The results obtained from the first system were used to quantitatively verify our EP calculating algorithm with theoretical values for the EP of a single active particle. We calculated the EP of single particles while varying their active velocities, and the results scaled as predicted by theory. The results obtained from the second system indicated large EP near the vicinity of the wall, while for the last system, we saw low EP within the cluster and large EP at its boundaries.

Lucy King CC'26, Computer Science and Math

Faculty Mentor(s) or Supervisor(s): Alex Dranovsky
Title: Investigating the Impact of Early Life Stress on Spontaneous Alternation Tasks in Mice: A Quantitative Approach

Abstract: Experiencing early life stress (ELS) has been previously shown to reduce working memory capacity in some rodent models. For instance, when performing a spontaneous alternation task with a four-armed maze, ELS mice reflect a reduced ability to recall previous arm entries, impacting their future entry choices. This difference may inform the neurological mechanisms behind similar trauma responses in humans; however, the exact behavioral and neurological mechanisms causing this impairment in mice remain unknown, and visual analysis of behavior exploring these mechanisms is historically subjective and resource-intensive. This project implements machine learning models to tackle the issue of behavioral subjectivity by applying an unsupervised clustering algorithm to computationally identify behaviors such as rearing, turning, and sniffing, which may be indicative of exploratory or stress behaviors that contribute to animal performance. After

an animal's body parts are labeled with DeepLabCut, these behaviors are identified using the open-source B-SOiD model, which relies on a Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN) algorithm. This analysis reveals that three to five out of sixteen behaviors appear to differ significantly between ELS and control animals or to correlate with high task performance within one or both groups. These findings are now being integrated with additional data from new recordings, which will then be further corroborated through a comparison with neural signal data, ultimately providing insight into why these specific behaviors appear to be related to early life stress while also modeling a quantitative approach for future behavioral analyses.

Anshul Kinley Khazanchi Sinha SEAS'25, Electrical Engineering

Faculty Mentor(s) or Supervisor(s): Henry Huang, PhD
Title: Collision Probability Model for Satcom Constellations

Abstract: In the course of the research study, various innovative analytical models have been designed to cumulatively evaluate collision probability risks associated with the existence of the large satellite constellations and increasing number of debris projectiles (i.e. the Kessler Synome).
The research study primarily revolves around analyzing traffic patterns of functional satellites as well as debris to then determine potential outcomes of catastrophic collisions within LEO over time. The results highlight the significance of certain parameters beyond satellite orbital synchronization, including the rate of change of the semi-major axis and the relative orientation of orbital planes, described by the collision angle. The research emphasizes the adaptability of Δa through the selection of suitable thrusters and underscores the importance of designing optimal crossing orbits, particularly those with a zero-inclination angle. Delving specifically into constellation replacements, a comprehensive risk assessment was conducted for the Starlink constellation first, enabling comparison of hypothetical outcomes to the actual outcomes of Starlink (and subsequent application to other satcom constellations).The study emphasizes the effectiveness of low eccentricity crossing orbits in minimizing collision probabilities through not just well-designed phasing, but rather evasive mechanisms (classical jet propulsion or even novel methods such as solar sailing). The study has also identified the true anomaly phase between constellations and crossing satellites as a pivotal parameter for designing successful shell-crossing events. However, it is acknowledged that the model's reliability remains untested in the presence of J2 perturbations.

Pranav Konda CC'26, Mathematics

Faculty Mentor(s) or Supervisor(s): Anum Glasgow
Title: Triforce: Water Aware Deep Learning Allosteric Protein Engineering

Abstract: Proteins have many essential biological functions and often have their activity regulated by small binding molecules called ligands. The pockets, or zones, which these ligands bind are of particular structural interest in protein engineering. Furthermore, water molecules have a functional impact on stabilizing these pocket structures. We seek to develop an engineering pipeline to facilitate binding arbitrary ligands to proteins through engineering new pockets, leveraging artificial intelligence techniques that have revolutionized the field in the last decade. Data was automatically collected from the Protein Data Bank and filtered by resolution and presence of binding molecules, along with other related datasets. A diffusion-based artificial intelligence architecture, which leverages noising data and training a model to reconstruct original data items through a stochastic process, was chosen and adapted for this generative task on 3D molecular data. Binding pockets were chosen from structural data with a predefined global radius. Work was done toward the initial sequence recovery of test proteins. Such engineering capabilities allow new proteins to be designed to combat various medical diseases and emerging medical challenges.

Lela Kornfeld CC'26, Earth Science

Faculty Mentor(s) or Supervisor(s): Frank Nitsche and Tim Kenna
Title: Grain Size Distribution in the Western Long Island Sound

Abstract: The Long Island Sound (LIS) is located in a highly urbanized area and the annual value of its resources have been estimated to be anywhere between 5.5 (Altobello, 1992) to 17-37 billion dollars (Kocian et al, 2015), making it important to the local economy. There are plans to build offshore wind farms that would provide green energy to 2.4 million homes in New York City (NY gov). These would require laying a cable across the Sound. The Long Island Sound Mapping project was created in order to better manage the resources provided by the Sound. A large part of resource management relies on maps of the sedimentary environments present. The maps created as a result of the LIS mapping project would be utilized to help determine where to best lay cables in order to protect sensitive environments and to monitor the effect of cables on the LIS. Here different lithologies in the phase three area of the study were mapped using 60 grab samples collected in the summer of 2023. The relationship between backscatter and other features

such as water content, shells, and grain size were investigated in order to create more accurate maps in future stages. The results indicate that the overall area is predominantly fine grained and generally align with previous data save a few exceptions. In addition, while there were some trends between backscatter and physical features there are many possible variables that could have affected the data. As a result it may be hard to determine whether backscatter reflects the lithology or is affected by other environmental attributes that were not measured, such as vegetation.

Nina Kornfeld CC'26, Environmental Biology

Faculty Mentor(s) or Supervisor(s): Deren Eaton
Title: Photogrammetry for Botanical Collections

Abstract: Studying the 3D structures of flowers is an important part of understanding their evolution, however, it is difficult to collect this kind of data because flowers wilt quickly, losing their shape. Because of the technical difficulties with preserving 3-dimensional data, it is important to be able to create models of flowers quickly and in the field. Recent approaches to creating such models include techniques such as photogrammetry, a process which involves taking many photographs of flowers with DSLR cameras, and using the resulting pictures to create a model. Photogrammetry is an important and relatively new method of data collection that allows scientists to analyze thousands of traits in a much more meaningful way than before, when flowers were mostly preserved dried and pressed flat. However, photogrammetry is a labor intensive, slow and expensive process. This research aims at finding a faster, automated, cheaper and more portable method for creating 3D models of flowers. In order to confront this issue, Nina helped develop a new system for collecting photogrammetry data, using a Raspberry Pi Computer based setup and making use of the latest camera and camera HAT technology. While research on this method is still ongoing, so far, this new version of photogrammetry can produce accurate flower models in a fraction of the time and cost than traditional photogrammetry methods.

Aparna Krishnan CC'24, Biology / Applied Statistics

Faculty Mentor(s) or Supervisor(s): 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 cell populations

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 immunophenotypes of the three cell clusters for isolation and functional analyses. The PMN1 population of cells was selected as a viable population of cells to sort from mice and undergo a drug panel. Conclusion: Suppressive myeloid subpopulations induced by radiation were identified among the immune cells. We will experimentally test whether drugging the PMN1 population of granulocytes improves the overall efficacy of RT by augmenting an anti-tumor immune response.

Kashish Kumar CC'26, Biochemistry/Evolutionary Biology of the Human Species

Faculty Mentor(s) or Supervisor(s): Yufeng Shen
Title: Exploring Molecular Interactions between SARS-CoV-2 Infection and Diabetes: Transcriptomic Analysis of PBMCs Reveals Converging Pathways

Abstract: Patients with diabetes and COVID-19 are at a heightened risk of developing severe complications, such as acute respiratory distress syndrome, multi-organ failure, and death. This increased susceptibility may be attributed to the underlying inflammation associated with obesity, insulin resistance,

and other comorbidities typically seen in patients. The pre-existing chronic inflammation, augmented inflammatory response, and increased viral load in diabetic patients contribute to a systemic immune response known as the "cytokine storm," which is strongly associated with the severity of COVID-19. Moreover, SARS-CoV-2 infection may also induce dysregulation of metabolic factors and trigger the onset of diabetes. However, the molecular mechanisms underlying the bidirectional relationship between SARS-CoV-2 infection and diabetes are not fully understood. In this study, comparative transcriptomic analysis of peripheral blood mononuclear cell (PBMC) samples using publicly available scRNA-seq and bulk RNA-seq datasets from COVID-19 patients and type 1 and type 2 diabetes patients is used to elucidate the common molecular pathways that are involved in these conditions. An ensemble learning-based classification model informed by cell composition, differential expression, and predicted miRNA interactions distinguished significant features in altered metabolic signaling and immune profiles across measures of SARS-CoV-2 infection severity and stage. Further, functional assessment with gene ontology (GO) and pathway analyses revealed common mechanistic links between SARS-CoV-2 infected and type I and type II diabetes datasets paired with overlapping miRNA–mRNA–TFs regulatory networks through co-modulated genes involved in cytokine signaling. Such insights may contribute to the development of targeted therapeutic strategies and improved clinical management for patients with diabetes and COVID-19 at heightened risk of severe complications.

Jolie L'Heureux CC'24, Astrophysics

Faculty Mentor(s) or Supervisor(s): Frits Paerels
Title: Searching for Counterparts of Gravitational Waves

Abstract: Identifying the electromagnetic counterparts of gravitational waves events is an exciting aspect of multi messenger astronomy. The search for the counterpart of the black hole merger GW170814 started with looking through x-ray sources in the probable locations of GW170814 that had previously been observed but not yet identified. X-rays emitted from these gravitational wave events will be scattered by galactic dust particles and form a halo around the event, incurring travel-time delays of several hours up to about a day. The location of the gravitational wave source will be at the geometric center of the halo, which can be determined with precision sufficient to allow the host galaxy to be identified. Locating these counterparts of historical gravitational wave events will allow astronomers to pinpoint the exact location of these events and gravitational waves can be used as standard sirens to measure the distance to the event. With the distance astronomers can learn more about the early universe and Hubble's constant.

Samay Lakhani SEAS'27, Computer Science

Faculty Mentor(s) or Supervisor(s): Hod Lipson
Title: Fusing ConvNeXT and Histogram of Oriented Gradients (CNHOG) for Modular and Efficient iver Distraction Detection

Abstract: In 2021, the National Highway Traffic and Safety Administration recorded 43,000 fatalities from automotive crashes, an 11% increase from 2020. Automotive accidents (94%) are caused by human driver error, therefore preventable. To reduce fatalities, a race to design a highly accurate and efficient distraction detection system is underway. Distraction detection models rely on combined handcrafted and deep-learning models that use outdated feature extractors such as AlexNet and utilize compute-heavy deep-learning ensembles. Herein, I created a modern hybrid architecture named CNHOG (ConvNeXt Histogram of Oriented Gradients). Fusing target localization from handcrafted features with adaptive generalizability from modern deep-learning architectures enable accuracy and scalability to differentiate types of distracted driving like texting, calling, adjusting the radio or makeup, drinking, and reaching into the backseat. Using the discovered hyperparameters from a hyperparameter search, two variants (CNHOG-Tiny and CNHOG-Large) of the model were trained and compared with accuracy, efficiency, and performance metrics of previous literature with a goal of deployment in motor vehicles. CNHOG-Tiny achieved 98.8% accuracy and CNHOG-Large performed at 99.14% accuracy, which outperform a Video Swin Transformer model (97.5%) the previous state-of-the-art video model. CNHOG-Large model is 69.3% less erroneous than the previous state-of-the-art image model, Canas et al., 2021, and 65.6% less erroneous than Video Swin Transformer. This indicates a new state-of-the-art accuracy for the Driver Monitoring Dataset. CNHOG-Tiny and Large are efficient and scalable to mobile devices and are 12x more efficient than Video Swin Transformer at 4.5 GFLOPs. Future regulations will mandate driver monitoring systems in 2026 in new cars. With modularity, state-of-the-art accuracy, privacy, and high efficiency CNHOG could revolutionize driver monitoring systems.

Alexandria Lam SEAS'26, Chemical engineering

Faculty Mentor(s) or Supervisor(s): Jingguang Chen
Title: Determination of Electrochemically Active Surface Area for Tandem CO2 Reduction

Abstract: In recent years, anthropogenic carbon dioxide emissions have reached new highs, leading to such effects as climate change, ocean acidification, and other environmental imbalances. To incentivize minimizing CO¬2 emissions, methods have been developed to efficiently convert CO2 to value-added aromatics compounds – such as benzene, toluene, ethylene, and xylene – using a tandem electrocatalytic-thermocatalytic setup with a copper cathode. To effectively compare the results of these setups and to monitor electrode degradation, it is necessary to develop an accurate and consistent method of measuring the electrochemically active surface area (ECSA) of the electrocatalyst, in this case, copper. Two ECSA measurement procedures were tested: the double layer capacitance (DLC) method and the lead underpotential deposition (PbUPD) method. DLC involved taking cyclic voltammograms of the desired sample at different scan rates and deducing double layer capacitance from the average resulting current, whereas PbUPD involved loading Pb onto the sample and measuring the amount of charge required to strip off the Pb. These values were used to calculate a specific capacitance (Cs) value for copper, from which ECSA is calculated. Each method was carried out on three different copper foil types – bare, acid treated, and electropolished foil. The most consistent Cs value was yielded by the PbUPD method on acid treated foil. In the future, PbUPD and the Cs determined by it will be used to calculate the ECSA of copper gas diffusion electrodes (GDE's) used in CO¬2 reduction experiments.

Irene Lee CC'25, Biology

Faculty Mentor(s) or Supervisor(s): Meghan Bucher
Title: Effect of altered production and storage of dopamine on development and behavior in C. elegans

Abstract: The nematode, Caenorhabditis elegans, is an advantageous model to studying developmental toxicology due to its similar homology to humans. Prior studies have shown that dopamine regulates C. elegans body size and movement, making dopamine a vital neurotransmitter in the nematode's development. Here, a novel C. elegans strain, MBIA, was generated by crossing two existing strains UA57 (overproduces dopamine) and OK411 (lacks vesicular dopamine storage). This study characterizes MBIA to determine the effect of genetic disruptions in the dopamine system on body size and early adulthood behavior. Body size was quantified using three independent methods, and behavior was characterized through analysis of three dopamine-mediated behaviors. Because dysregulated dopamine can be neurotoxic, neuron size was measured to quantify potential defects in neuronal development. Compared to wild type, C. elegans that lacked the ability to sequester dopamine had shorter body lengths. C. elegans that overproduced dopamine and were unable to package dopamine had body lengths similar to that of wild type, rescuing the body length abnormality apparent in C. elegans with one genetic disruption. C. elegans that lacked the ability to sequester dopamine showed behavioral defects in early life stages. C. elegans showed no significant differences in neuron size across all strains and ages, suggesting that the behavior of the strain was not a consequence of neurodegeneration, but a consequence of dysregulated dopamine transmission. This model serves as an accurate, novel method to investigate the impact of toxicants on development.

Minuk Lee GS'24, Mathematics

Faculty Mentor(s) or Supervisor(s): Tony Dear
Title: Detection and Exploitation of Symmetries in Deep Reinforcement Learning via State Mapping in Euclidean Space

Abstract: Reinforcement learning (RL) is a technique by which an agent aims to solve complex, dynamic problems by repeatedly taking actions, receiving feedback, and adapting its decision-making process accordingly. RL has proven its capability as an underlying algorithm in domains like game-playing, e.g. the world championship games of Chess and Go, and robot automation in tasks like warehouse automation. However, RL often requires a significant amount of time to discover optimal solutions, involving millions or billions of trial-and-error repetitions. This number increases exponentially as the complexity of the problem grows. One approach to improving this inefficiency is to exploit symmetries that can simplify the problem domain. For instance, if a symmetry exists between moving a car left and moving it right, learning to move the car left can also impart knowledge about moving it right, effectively halving the required trial-and-error repetitions. However, this necessitates understanding the existing symmetries in the domain beforehand and applying this knowledge to the learning process. In our research, we present an algorithm that detects symmetries in the problem domain without requiring human guidance, achieved by mapping states to Euclidean space. Additionally, to exploit the knowledge of symmetries, we utilize the k-nearest neighbors (KNN) technique on the Euclidean space to identify symmetric state and action pairs, updating them collectively. Our method demonstrates superior performance compared to the naive RL approach when using the same number of learning iterations. To the best of our knowledge, this is a novel approach for detecting and exploiting symmetries within the realm of RL.

César Léon CC'24, Earth Science

Faculty Mentor(s) or Supervisor(s): Bethany Ehlmann, Rebecca Greenberger
Title: Investigation of Hydrothermal Alteration of Prehnite and Epidote from the Oman Ocean Crust and on other Planetary Bodies through Imaging Spectroscopy

Abstract: Earth's ocean crust covers around 60% of the surface of the planet and hydrothermal systems are very common on Earth and other planetary bodies. Yet, geochemical interactions which form, cool, and alter oceanic crust are not entirely understood. Additionally, access to samples is not easy or cheap. In this project, we are looking at (~1.2 km; 3 holes which are ~400m each, GT1A, GT2A, GT3A) drill core samples of the ocean crust from the Oman ophiolite recovered by the ICDP Oman Drilling Project. This region of oceanic crust is particularly interesting because it is an area where ocean crust and parts of the upper mantle outcropped onto the surface (ophiolite) which provides easier access. These cores were measured with imaging spectroscopy, in the visible-shortwave infrared (VSWIR), and samples were selected for scanning electron microscopy (SEM). We classified minerals using existing spectral mineral maps derived from absorption features in spectra and correlating them with elemental maps from SEM measurements. Classification maps show more detailed and higher resolution mineral groupings compared with the spectrally derived maps. Using the classification maps, we are quantifying and characterizing end member minerals. The results are important for quantifying mineral abundances and improving interpretation of imaging spectroscopy data.

Jackie Li CC'24, Biochemistry

Faculty Mentor(s) or Supervisor(s): Chien-Kuo Lee
Title: Immortalized Hematopoietic Stem and Progenitor Cell Generation and Differentiation

Abstract: Progression in hematopoietic stem and progenitor cells (HSPCs) — a subset of stem cells found in the bone marrow and blood — is a novel investigation towards harnessing such cells to develop treatments for blood-related disorders and immune system deficiencies. However, the two primary sources for HSPC — umbilical cord and blood cells — are too expensive due to the need to harvest the former from consenting postnatal mothers, and the latter are perishable. To overcome these limitations of suitable and scalable experimental systems in investigating immune-cell differentiation and function, we examine the differentiation potential of HSPCs immortalized with HOX genes — genes highly expressed in hematopoietic progenitor cells. This experiment has two primary aims: 1) Can human HOX (hHOX) genes immortalize mouse cells? and 2) If hHOX genes can immortalize mouse cells, do said cells exhibit properties similar to mouse HOX (mHOX)-immortalized mouse cells? Four experimental hHOX-immortalized groups (HOXA9, HOXA10, HOXB6, HOXB8) are juxtaposed to a mHOXB8-immortalized control to identify implications on dendritic cell populations. These five groups are cultured and observed across differentiation stages controlled by addition of estradiol with FLT3 ligand cytokine to maintain the cells' immortalized state and proliferation, respectively. Growth of immune cells derived from granulocyte-macrophage progenitor (GMP) cells is also observed by adding GM-CSF. Final results suggest hHOX genes can immortalize mouse cells as flow cytometry readings indicate the presence of common myeloid progenitor (CMP) cells in both control and experimental groups. However, the two groups did not yield similar CMP and GMP population distributions as further analysis indicated immortalization at different stages of cell differentiation between those with hHOX and mHOX genes.

Ashley Liang CC'24, Biochemistry

Faculty Mentor(s) or Supervisor(s): Sam Sternberg
Title: Structure-guided Engineering of Type I-F CRISPR-associated Proteins for Genomic Integration in Mammalian Cells

Abstract: Canonical CRISPR systems such as CRISPR-Cas9 have been leveraged for programmable genome editing. However, their utility for certain therapeutic applications remains limited because they work in a nuclease-dependent manner and consequently rely on host cell factors to repair double-strand breaks (DSBs) (Kosicki et al., 2018). Editing outcomes are thus susceptible to undesirable byproducts including large chromosomal rearrangements, deletions, and even whole chromosome loss (Zuccaro et al., 2020). CRISPR-associated transposons (CASTs), on the other hand, leverage transposase machinery that allow for genomic edits that bypass DSBs and are more suitable for inserting large multi-kilobase payloads (Klompe et al., 2019). A type I-F CAST system from Pseudoalteromonas called eCAST-3 has been engineered for integration in human cells (Lampe, King et al., 2023). Here, the structure of the DNA targeting module from eCAST-3, QCascade, is described using cryo-electron microscopy. The structure revealed several amino acid residues that were targeted for mutagenesis to help improve the DNA binding activity of QCascade and further optimize downstream integration efficiencies. This work demonstrates increased

editing efficiency of a multi-component ribonucleoprotein complex via rational protein engineering, clarifies the relationship between DNA targeting and integration, and highlights the potential of CASTs for therapeutic tool development.

Zachary Lihn CC'25, Mathematics

Faculty Mentor(s) or Supervisor(s): Mikhail Khovanov
Title: Finite State Automata and 1D Topological Quantum Field Theories

Abstract: Finite state automata are simplified models of computation that have many applications in computer science. Meanwhile, topological quantum field theories relate the underlying topological nature of a geometric object to certain state (vector) spaces that are heavily studied in physics. We present a novel correspondence between nondeterministic automata for a regular language L and oriented topological quantum field theories in one dimension—where our geometry simplifies to points, lines and circles—decorated with letters from the regular language. In this picture the basis of the state space of a single point, which is a free module over the Boolean semiring, corresponds to the states of the automaton. This geometric viewpoint allows for the language L and TQFT associated with it to be given a path integral formulation. Relaxing the requirement of being free and allowing finite projective modules as state spaces generalizes our notion of automata to finite topological spaces, extending our TQFT to a TQFT on one-dimensional foams (oriented graphs modulo a certain equivalence relation).

Meng Lin CC'24, Physics

Faculty Mentor(s) or Supervisor(s): Zoltan Haiman
Title: Searches for Periodic Quasars as Supermassive Black Hole Binary Candidates

Abstract: Supermassive black hole binary systems (SMBHBs) are expected to form as a consequence of galaxy mergers. However, these SMBHBs at sub-parsec separations are often difficult to resolve. Here, we explore a promising technique for identifying candidate SMBHBs by detecting periodic quasars using statistical methods. Substantial observational evidence suggests that supermassive black holes located at the centers of galaxies serve as engines that power the quasars. Therefore, the search for periodic brightness variations in quasars emerges as one of the most promising avenues for identifying potential supermassive black hole binary systems. Our approach to do so involves employing the Lomb-Scargle periodogram to search for periodicity in the quasar light curves. To model stochastic brightness fluctuations in our quasar light curves, we adopt a Damped Random Walk (DRW) model. In particular, we simulate realistic DRW fluctuations combined with periodic variations with sinusoidal and sawtooth shapes in our light curves. We then assess whether the periodic signals can be recovered from the power spectral density using the generalized Lomb-Scargle periodogram.

Jonathan Liu SEAS'26, Computer Science

Faculty Mentor(s) or Supervisor(s): Smaranda Muresan
Title: Automatic Fact Checking using Long Context Language Models

Abstract: This research aims at evaluating and improving the use of Natural Language Processing for the Fact Checking task. With the emergence of GPT-4 and Claude-100k, there is a need for evaluation of the efficacy of long-context language models and services on this task. By studying performance on the FEVER dataset, this study demonstrates the potential efficacy of LLMs with longer context windows when coupled with careful prompt design. The ability to feed in entire articles to an automatic fact-checker removes the challenges researchers have had with evidence retrieval and summary methods. Classification based on summaries has not had promising results so far, and this work offers an alternative approach.It builds off of previous studies on the requirements for a real-world applicable auto-fact checker, establishing temporal and domain constraints on used claims. Significant effort has been put into researching NLP Fact-checking methods that either feature data after the time of the claim, or use fact-checking website data. This study also addresses this, using strict constraints to ensure data is representative of real-world claims. Our findings demonstrate high accuracy of claim entailment prediction if a threshold amount of supporting evidence is available in an argument. Even in cases where there is limited supporting text, it showed surprising ability to identify that text amidst plentiful noise.

Andrew Lu CC'24, Computer Science

Faculty Mentor(s) or Supervisor(s): Shih-Fu Chang
Title: Efficient Alignment of Exocentric and Egocentric Video Understanding Models through Weight Space Ensembling

Abstract: In the realm of computer vision, the ability to understand images and videos has made remarkable strides in recent years. This progress is largely thanks to large scale datasets and focused benchmarks that help

computers identify objects and actions in visual content. However, most of this advancement has been from a distant, third-person (exocentric) perspective, limiting the grasp on first-person or egocentric viewpoints. Better egocentric video modeling ives numerous important downstream applications, particularly in robotics where onboard cameras deliver a first person video stream. While models trained on exocentric videos often have general world knowledge and reasoning capabilities, they fail when applied to egocentric tasks. The researchers first analyze the domain shift between exocentric and egocentric video tasks and identify key components that cause performance gaps between domains. Inspired by feature selection techniques using singular value decomposition, the researchers present a novel approach to efficiently align exocentric models on egocentric data. Given two sets of model weights, one pretrained on exocentric data, and one finetuned on fewshot egocentric data, a shared orthonormal basis for the weights can be learned where each basis vector corresponds to a feature and feature vectors are ordered by importance. By selectively filtering out features in a shared basis, knowledge about the domain shift can be isolated from the noisy egocentric model and added to the pretrained exocentric model, yielding a performance increase on egocentric tasks.

Yvon Lu CC'25, Economics and Statistics, Sophia Tu BC'25, Economics & Mathematics

Faculty Mentor(s) or Supervisor(s): George Dragomir
Title: Refining Gender Bias Detection Algorithms Using Sentiment Analysis: an investigation of gender bias levels across industries, career progressions, and top-ranked companies for gender equality

Abstract: : Despite efforts to promote diversity and inclusion, the underrepresentation of women in male- dominated fields such as engineering and finance persists, especially in leadership. The hiring process can play an important role in the recruitment and retention of women at companies. One aspect that has gained attention in recent years is the potential influence of the language used in job descriptions on gender imbalances in applicant pools. As new techniques for analyzing language emerge, we sought to counteract existing biases and build more complex models to guide recruiters. Improving on existing models for gender bias detection (Gaucher et al., 2011), we added the inclusion of tone via sentiment analysis to produce a more nuanced understanding of potentially discriminatory language. Using job descriptions scraped from popular job board sites (Indeed, Monster, Careerbuilder), we obtained over 60,000 data points ranging from a wide variety of industries and career levels. Additionally, we built an RNN model to predict these scores with high accuracy. Post-analysis results on our collected data indicated a statistical significant difference of bias amongst industries, as well as job qualifications. We observed a high negative bias (male leaning) in job descriptions specifying higher educational requirements. Furthermore, we collected job descriptions from the Forbes 2022 Worlds Top Female Friendly Companies and ran additional PSM testing to determine if a difference in bias was significant. Our refinement of existing algorithms will hopefully introduce new ways to combat discriminatory language that go beyond the base measurement of gender-coded words.

Eilidh MacLeod CC'25, Climate System Science, History

Faculty Mentor(s) or Supervisor(s): Ajit Subramaniam
Title: Co-Produced Evidence for Incursions of Chukchi Sea Water into Freshwater Lake of Kotzebue Sound

Abstract: As the Arctic warms, incidents of Harmful Algal Blooms (HABs) have increased, which can disrupt food webs and, occasionally, have negative effects on human health. For those who rly on subsistence food sources, like many Indigenous Arctic communities, HABs can also threaten food sovereignty and cultural identity. In Kotzebue, a majority-Indigenous village in Northwestern Alaska, concerns have been raised over freshwater HABs since 2008. The bloom-forming and paralytic shellfish toxin (PST) producing marine dinoflagellate, Alexandrium catenella, has also recently been documented throughout the neighboring Chukchi Sea (Anderson et al. 2021, PNAS). A. catenella has not previously been considered a risk for Kotzebue because its tolerance range for salinity is 15-35 ppt, whereas average salinity in Kobuk Lake is 2-3 ppt (Bill et al. 2016, J. Phycol.). As part of the initial phase of a community-led sampling project, we deployed a moored YSI EXO-2 sonde from June 24 to September 21, 2022 measuring temperature, salinity, depth/pressure, oxygen, turbidity, dissolved organic matter, chlorophyll and phycocyanin fluorescence every 10 minutes. In this period, we documented six distinct salinity spikes, up to 27 ppt, in the surface waters of Kobuk Lake. Analysis of temperature, dissolved organic matter, and other characteristics of the water showed that the high salinity spikes were consistent with water originating in the Chukchi Sea. Thus, the risk of A. catenella cannot be fully discounted in Kotzebue. High-speed winds (>10 knots) in a direction other than northeast were found to precede all spikes.

Neha Mani CC'25, Biochemistry

Faculty Mentor(s) or Supervisor(s): Meenakshi Rao

Title: Characterizing the postnatal emergence of Tacr3 as a major myenteric plexus marker in the ileum and colon

Abstract: The enteric nervous system (ENS) is a neuro-glial network that regulates the entire digestive tract, including intestinal motility and immunity. Enteric glial cells (EGCs), the non-neuronal cells of the ENS, are transcriptionally and morphologically heterogeneous—spanning the entire gut wall from the muscularis externa (nonmucosal glia) to the mucosa (mucosal glia) nearest the lumen. While EGCs are clearly diverse, it remains unclear whether their spatial distribution reflects functionally distinct classes. In the nonmucosa, myenteric plexus (MP) and intramuscular (IM) EGCs have distinct morphologies and occupy discrete microenvironments, surrounding neurons and smooth muscle respectively. Tacr3, a GPCR responsible for helping modulate the onset of puberty and ovulation, is expressed in MP glia by postnatal day 21 (P21) in mice yet absent in IM glia. Thus, it was reasoned Tacr3 may be a defining marker for MP glia during development. Tacr3IRES-Cre/+ Rosa26Ai9/+ reporter mice were employed to genetically label Tacr3-expressing cells and their derivatives, and Tacr3 expression was quantified in glia during early postnatal timepoints prior to weaning. Across P1, P7, and P14, Tacr3 onset was sexually dimorphic in ileum and colon. By P7, male mice exhibited ~30% Tacr3 expression in the myenteric plexus compared to almost no expression in females. Until P21, females continue to be a week delayed in Tacr3 expression compared to males. This finding supports an intriguing role of Tacr3 in sex-dependent glial specification, which is a crucial line of inquiry given the known sex-dependent differences in gut pathophysiology. Ongoing work, including single-cell sequencing of the nonmucosa from Tacr3 reporter mice, may help elucidate transcriptional differences in this population by sex as well as whether transcriptional states reflect the spatial organization and functional distinctions between MP and IM glia.

Lucas Martins Barreto Alves CC'24, Physics

Faculty Mentor(s) or Supervisor(s): Szabolcs Márka

Title: Artificial Pulsar Timing Array: bridging the LISA-LIGO sensitivity gap with clock satellites

Abstract: here are currently no gravitational-wave detectors in operation or construction able to see astrophysical sources emitting 0.1–10 Hz gravitational waves. This means our knowledge of the universe's history and content lacks important pieces, such as data on the merger of intermediate-mass black hole binaries and the early inspiral of lighter ones. To enable the observation of such sources, we put forth the groundwork for a new gravitational-wave detector. We propose the construction of an array of clock satellites to artificially reproduce Pulsar Timing Array, an established gravitational-wave detection technique that uses the periodic oscillations of neutron stars to detect waves in the nanohertz band. Our study shows that the proposed Artificial Pulsar Timing Array could in principle achieve sensitivity levels to observe several different astrophysical sources in the 0.1–10 Hz band.

Eithne McDonald CC'24, Astrophysics

Faculty Mentor(s) or Supervisor(s): Matthew Ashby

Title: Resolving the Golden Standards: A Flux Calibration Program of Spectrophotometric Stars

Abstract: Being able to interpret scientific data from astronomical telescopes requires that the data be accurately calibrated in physical units. Most telescopes rely on networks of stars with absolute flux densities that are well known as a result of prior surveys for calibration; these are called "standard stars." Here we describe a flux calibration program for one such mission, NASA's Spectro-Photometer for the History of the universe, Epoch of Reionization, and ices Explorer (SPHEREx), scheduled to launch in February 2025. We combine 17 Hubble Space Telescope CALSPEC stellar models and spectra and with James Webb Space Telescope (JWST) spectra to create a flux calibration program with an absolute flux prediction accuracy of 2% that will be used to carry out the SPHEREx scientific mission of measuring galaxy redshifts and interstellar absorption features from biogenic ices. The 17 CALSPEC standards were chosen based on those used for previous missions. We first examined Gaia Data Release 3 and the AllWISE Catalogs to determine any spectral contamination effects from stars near our calibrators. We then developed a custom version of stage 2 of the JWST Science Calibration Pipeline to reduce these 1D spectra. We measured the offsets between the models and observed flux densities for both the medium and high spectral resolving powers to within 5% given the provisional status of the JWST pipeline.

Jayden McDonald CC'25, Biochemistry

Faculty Mentor(s) or Supervisor(s): Anna-Lena Steckelberg, Jeanine Gezelle

Title: Structural Studies of Exoribonuclease-Resistant Virus-associated RNAs

Abstract: The successful transmission of a virus hinges upon its ability to evade a host cell's defense machinery. As a result, many viral strains have evolved mechanisms to not only evade, but also co-opt, host defense

machinery. Xrn1, the primary processive exonuclease responsible for RNA decay in eukaryotes, has been shown to stall in viral genomes due to its inability to degrade certain highly-structured regions. These Xrn1-resistant RNA elements (xrRNAs) are biologically active degradation products shown to be essential for virus-induced cytopathicity and pathogenecity. xrRNAs were first discovered in flaviviruses and were later identified in plant-infecting viruses. Despite vast divergence in sequence similarity and viral environments, both rely on the formation of a protective ring-like structure that serves as a mechanical barrier to Xrn1. The conservation of this characteristic in diverse contexts suggests that structure-dependent exoribonuclease resistance serves as a general RNA maturation pathway. Recent studies have identified potential new xrRNAs in virus-associated RNA elements. These RNA replicons, closely related to the Tombusviridae family, are dubbed tombusvirus-like associated RNAs (tlaRNAs). tlaRNAs are autonomously-replicating but require co-infection from an associated virus to transmit. This study identifies the minimal element of two tlaRNA xrRNAs and uses mutagenesis to better characterize the structure of these xrRNAs. This data, coupled with secondary structure predictions and selective 2'-hydroxyl acylation analyzed by primer extension and mutational profiling (SHAPE-MaP profiling) provides a clearer picture of the secondary and tertiary interactions that confer Xrn1 resistance in vitro. The results of this study suggest a new xrRNA subclass that is related to previously characterized xrRNAs, but possesses some strikingly distinct molecular properties.

Alex Medina CC'24, Astrophysics and Applied Mathematics

Faculty Mentor(s) or Supervisor(s): Sofia Sheikh & . Wael Farah
Title: Probing FRB20180916B at High Frequencies with the Allen Telescope Array

Abstract: Fast Radio Bursts (FRBs) are bright, highly dispersed, millisecond-duration transients. This study focuses on FRB20180916B, a unique repeating FRB which displays periodic activity with frequency-based activity windows. We conducted an observational campaign of the source utilizing the Allen Telescope Array, a 42-element radio interferometer consisting of dishes 6.1m in diameter. The campaign spanned June to August 2023, accumulating 28.5 hours of on-source time. Our observation tunings were strategically centered at 1236 MHz and 8000 MHz to target both a familiar lower frequency range and a less explored higher frequency range, enhancing our understanding of high-frequency phenomena. Using the SPANDAK, and FRB detection software, we looked for dispersed pulses with dispersion measures (DM) centered at 349.4 pc cm^-3 and signal-to-noise ratios greater than 10. Despite our efforts, no bursts were detected from FRB20180916B within the time frame, indicating an upper limit of 3.5 bursts for 100 hours of observation, under these conditions, on FRB activity. The study underscores the challenges of capturing the elusive nature of FRBs, highlighting the need for continued exploration through leveraging alternative frequency ranges and the ATA's role in advancing FRB research.

Aviral Misra SEAS'24, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): Mijo Simunovic
Title: Refining Gender Bias Detection Algorithms Using Sentiment Analysis: an investigation of gender bias levels across industries, career progressions, and top-ranked companies for gender equality

Abstract: Biomimetic in vitro models of organ systems can help elucidate complex biomedical processes and structure-function relationships. For example, the human gut is home to a diverse range of cells which enable the gut to carry out its physiological functions. The gut's function is further enhanced by a diverse and largely uncharacterized microbiome. Currently, there are few systems which have been developed to study the interactions between human tissue and the microbiome. Further, these existing models like organ-on-chips and organoids are limited due to their lack of cell-type diversity and incorrect spatial configuration. In this project, a new biomimetic system which captures the colonic-crypt micro-architecture, the diverse epithelial cell types, and provides easily accessible luminal and basal compartments is used. With these features, the obtained system can be used to investigate colon development by applying precisely controlled gradients of chemical signals and morphogens that replicate in vivo development. In addition, this system provides an avenue for mimicking the behavior of the intestinal epithelia-microbiome interface by allowing anaerobic co-cultures of bacteria that inhabit the gut. This presentation will describe investigations with the bacteria Candidatus Cibiobacter qucibialis (the most common uncharacterized gut microbe) and discuss the optimization of co-culture conditions, including length of co-culture, bacterial growth behavior, and optimal seeding density. The effect of the bacteria on the gut epithelia is characterized using bulk RNA sequencing to determine differential gene expression between gut tissue with and without the bacterial co-culture.

Angelina Moncrieffe SEAS'25, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): .Jannette Carey

Title: Computational Molecular Dynamics Discovers Ligand Binding Regions on Molybdate Transport Protein, ModA

Abstract: In the pharmaceutical industry, many protein crystal structures are labeled as “undruggable” due their lack of suitable crevices for binding of ligands, when viewed under static frames, through static docking. Our hypothesis is that the majority of proteins do have ligand binding sites when assessed dynamically. The focal point of this research was to utilize computational molecular dynamics in order to study the binding behavioral patterns of the Molybdate Binding Protein, ModA. This protein was tested on all 20 amino acids and bound to additional common functional groups, which revealed unknown binding sites on protein. The binding energies of the compounds on the protein increased by double, resembling energies considered promising for Pharmaceutical lead compounds. This molecular docking strategy mimics the ligand fragment approach used in the Pharmaceutical Industry and reveals that readily available computational tools for dynamic evaluation allow identification and improvement of ligand binding.

Alexandra Musat CC’24, Neuroscience

Faculty Mentor(s) or Supervisor(s): Suneet Mittal
Title: Weight and Sex Influence on Severity of Obstructive Sleep Apnea in Patients with Atrial Fibrillation

Abstract: Background: Obesity is associated with obstructive sleep apnea (OSA) and both predispose the development of atrial fibrillation (AF). The correlation of weight and sex regarding severity of OSA in patients with AF remains unclear.Objective: To evaluate the degree of OSA severity in overweight and obese patients and assess differences between males and females. Methods: Consecutive patients with AF and symptoms suggestive of OSA, who underwent either at home or in lab evaluation for OSA, were enrolled in this study. Sleep apnea was defined as mild if apnea-hypopnea index (AHI) was 5-14.9/hour (h), moderate AHI 15-29.9/h and severe AHI ≥ 30/h. A BMI of < 25 kg/m2 was considered normal weight, 25-29.9 kg/ m2 overweight and ≥ 30 kg/ m2 obesity. A correlation of BMI categories and severity of OSA was performed. For each category of BMI, the influence of gender for severity of OSA was evaluated. Results: The cohort included 556 patients (age 65 ± 11 years, 69% male, BMI 32 ± 6 kg/m2, 46% persistent AF, 74% with hypertension and 21% with diabetes mellitus) and 481 (87%) patients were diagnosed with OSA [193 (40%) mild OSA, 133 (28%) moderate OSA and 155 (32%) severe OSA). Based on BMI, 49 (9%) patients had normal weight, 148 (27%) were overweight and 359 (64%) obese. Compared with normal weight patients, both overweight and obese groups had higher incidence of moderate and severe OSA [35% vs 42% (p - 0.017) and 35% vs 58% (p < 0.0001), respectively]. Obese males had higher incidence of moderate and severe OSA compared to obese females (67% vs 42%, p< 0.0001), with no gender differences in overweight and normal weight patients. Conclusions: There is a high incidence of OSA in patients with AF. Approximately half of overweight and obese patients have either moderate or severe OSA. There is a higher incidence of more severe OSA in obese males when compared to obese females, but no gender differences in other groups. Further studies are needed to identify predictors of more severe OSA.

Giovanna Napoleone CC’25, Biochemistry

Faculty Mentor(s) or Supervisor(s): Erin L. Barnhart
Title: Analyzing mitochondrial density and morphology across lobula plate tangential cells in drosophila neurons

Abstract: Mitochondria are essential for the maintenance of neuronal shape and function. However, mitochondrial morphologies, densities, and localization patterns are poorly characterized in neurons in vivo. In this work, we measured mitochondrial densities and morphologies in neurons of the Drosophila visual system. To collect measurements on mitochondria volume, neuron volume, mitochondria shape, and mitochondria distribution patterns, electron microscopy images of five different neuronal cell types — HS, VS, CH, H1, and H2 cells — within the Full Adult Fly Brain dataset was analyzed. Mitochondrial density was calculated by measuring mitochondrial volume over total neuronal volume, and distal enrichment was measured as a proportion of mitochondrial densities in distal compartments to mitochondrial density in primary compartments. The mitochondrial density across all cell types remained consistent at approximately 20%, although distal enrichment values differed between compartments. In HS neurons, dendritic mitochondria have previously shown to be large and branched, with volumes up to 20µm3. In contrast, it was found that mitochondrial volumes in VS and CH do not exceed 3µm3. Moreover, larger CH and VS cell mitochondria are seen in primary dendrites and axons instead of dendrites. Branched mitochondria only occur as potential outliers in CH and VS cells. The smaller volume and less branched morphology of CH and VS mitochondria reveal that mitochondrial morphologies vary across cell types. Overall, because mitochondrial morphology varies across cell types, mitochondria can perform different functions in different types of neurons.

Neha Narayan SEAS'24, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Barclay Morrison III
Title: Progesterone Receptor Expression in Hippocampus Following 3x Rapid Mild Blast Injury

Abstract: In 2019, over 230,000 people were hospitalized due to a traumatic brain injury (TBI) in the United States, and a significant amount of these injuries were mild in severity (mTBI). Progesterone is considered neuroprotective and has been shown to reduce long-term potentiation (LTP) deficits in repetitive mild blast injuries through the progesterone pathway, although the mechanisms of this pathway following mTBI are unclear. This study analyzed how progesterone receptor (PGR) expression levels change in hippocampal tissue within a 24-hour period following 3x rapid mild blast injury. Hippocampi from rat pups were subjected to a 3x rapid blast injury or sham and left to rest for 3 or 24 hours. Assaying methods were used to quantify total protein and PGR levels in the slices. Compared to the naive slices, both the sham and 3x rapid 24-hour injury groups had significantly increased levels of PGR. There was no significant difference in PGR concentrations between male and female rat pups or between sham and injury groups. As there was no significant difference in PGR concentrations between sham and injury groups, PGR expression levels were not upregulated or downregulated by repetitive mild blast after 24 hours. This study rules out the involvement of the progesterone receptor in causing LTP deficits. Thus, other parts of the progesterone pathway downstream of progesterone binding to the receptor may be what plays a role in neuroprotection following TBI and merit further research.

Luca Nashabeh CC'26, Physics, Math

Faculty Mentor(s) or Supervisor(s): Abhay Pasupathy
Title: Observation of Semimetallic Behavior in Vacuum Cleaved NbOI2

Abstract: Materials with strong optical responses are increasingly sought after for their potential applications in photonics. To this end, niobium oxide diiodide (NbOI2) has recently been investigated as a candidate material displaying strong, anisotropic optoelectronic behavior. Using scanning tunneling microscopy (STM), the topographic and electronic properties of bulk, vacuum cleaved NbOI2 were investigated. Contrary to expectations, STM measurements showed the samples of NbOI2 to have a nonzero local density of states down to the Fermi level, displaying a semimetallic electronic structure rather than the expected semiconducting behavior. Introducing small pressures of 10e-8 torr of oxygen into the STM chamber temporarily reverted the NbOI2 to a semiconducting state, with a 1.5 eV band gap. The semimetallic behavior can potentially be attributed to sheer stresses during the vacuum cleaving misaligning the topmost layer of the crystal, resulting in the formation of an electron gas at the surface. The return to a semiconducting state can be explained as the oxygen attacking the electron gas, allowing the underlying electronic structure of NbOI2 to dominate. Further exploration of this phenomenon—such as with time-resolved STM—could provide insight into the effects of stress on NbOI2 crystals and the dynamics of the electron gas's interaction with oxygen.

Caroline O'Connor CC'25, Chemistry

Faculty Mentor(s) or Supervisor(s): Ann McDermott
Title: Determining Potassium Ion Channel Activity with a High Throughput Fluorescence Based Assay

Abstract: Potassium ion channels are important membrane proteins that regulate key biological processes such as muscle contraction, hormone secretion and cell signaling. KcsA is a pH activated potassium ion channel expressed in bacteria. KcsA displays similarity to important regions of mammalian potassium ion channels, and thus serves as a model for biological research. The ability to confirm activity in an ion channel is an important tool for studying the function of different regions of the protein. Thus far, most assays for determining potassium ion channel activity are inefficient and low throughput. This study replicates a high throughput fluorescence based liposome flux assay to determine activity in the KcsA ion channel. To perform the assay, KcsA was suspended into liposomes in a solution of potassium chloride. A pH sensitive fluorescent dye was used to monitor the flux of protons into the liposomes. This influx of protons would correspond with the efflux of potassium ions, confirming activity. These findings were not consistent with the study we were replicating due to some issues with our pH sensitive dye. However, we are continuing to improve the assay to apply it to KcsA to confirm activity.

Simon Ogundare CC'24, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Christine Ann Denny
Title: Uncovering the Neural Substrates of Learned Helplessness using a Custom Whole-brain Pipeline

Abstract: Major depressive disorder (MDD) is a debilitating condition which affects innumerate aspects of daily life. Substantial work has developed a

large body of knowledge surrounding treatment of depression, and clinical diagnostic tools have aided in standardizing MDD diagnoses across healthcare settings. However, the neural basis of a depressive state, and the network-level interactions between brain regions that contribute to a depressive state, are less clearly defined. Furthermore, the initial interactions between brain regions which lead to a prolonged depressive state are also less clearly understood. Novel activity-dependent labelling strategies in the last decade allow for investigation of neural signatures across multiple timepoints and behavioral states. Here, we apply one such strategy, using the ArcCreER^{T2} mouse line and a custom user-friendly ensemble activity mapping pipeline to investigate brain-wide neural signatures of acquisition and expression of learned helplessness. We find that acquisition is marked by increases in functional hippocampal-olfactory-amygdalar connectivity, and that later expression in helpless mice is marked by an increase in functional sparseness. Furthermore, using our pipeline, we uncover a network of regions recruited during both acquisition and expression, and find differences in functional connectivity between the ventral tegmental area and the nucleus accumbens in helpless mice, a key circuit in depression.

Arman Ozcan CC'25, Math And Computer Science

Faculty Mentor(s) or Supervisor(s): Joost-Pieter Katoen
Title: K-Induction and Probabilistic Full-Program Induction

Abstract: K-induction is a well-established technique for proving upper bounds of least fixed points over complete lattices. However, there are some true upper bounds that one cannot verify with k-induction; in other words, it is not a complete method. One special case for complete lattices is the positive polynomial systems, which are useful for various purposes, such as to compute the expected runtimes and reachability probabilities in probabilistic pushdown automata. We show that k-induction is (almost) complete for linear positive polynomial systems but incomplete for higher degrees, except for some very specific cases. Full-program induction was first proposed by Chakraborty et al. in 2020. This technique verifies array-manipulating programs with induction over the entire program via the symbolic program parameter N. There is also a tool called Vajra that implements this technique by accepting a C program annotated with an assertion as input and checking if the assertion holds. Full-program induction was so far only considered for non-probabilistic programs, but it is possible to extend this technique to probabilistic programs. In this approach, we first convert a probabilistic program into an equivalent non-probabilistic program, then rephrase the assertion provided, and finally check the validity of this new assertion with the regular full-program induction technique. Only the assertions about the expected value of some variable in the given probabilistic program are allowed. This method is implemented with a Python program which first converts the probabilistic program and then serves that as input to Vajra.

Om Pargaonkar CC'26, Biochemistry & Psychology

Faculty Mentor(s) or Supervisor(s): Harris Wang
Title: MAGIC: Engineering the Gut Microbiome to Produce Therapeutics

Abstract: The MAGIC (metagenomic alteration of gut microbiome by in situ conjugation) editing technique has emerged as a powerful tool for rapidly modifying the genetics of entire microbial colonies. By leveraging the natural process of bacterial conjugation, this method introduces a small number of individuals carrying CRISPR-edited plasmids (DNA payloads) to induce genetic alterations in situ. To enable precise engineering and editing of these plasmids, the recently-developed CAST system was utilized, allowing for enzyme-directed microbial genomic integration of multiple kilobases of DNA. This combination, known as a MAGICaST system, surpasses the limitations of traditional genomic editing methods. However, current MAGICaST systems are limited in conjugation efficacy, exhibiting a conjugation efficiency of less than 1% in the whole microbiome. This research project aimed to enhance conjugation efficiency by iteratively testing various plasmid constructs. In particular, the investigation focused on evaluating potential plasmid backbones and promoters in order to determine the base characteristics of an ideal payload. The findings of this study revealed that the optimal plasmid backbone for achieving high conjugation efficiency is an E. coli donor plasmid: rsf1010. Additionally, the research demonstrated that weaker promoter regions resulted in greater payload conjugation efficiencies. This outcome can be attributed to the reduced metabolic burdens imposed on target cells by weaker promoters. Moving forward, future research endeavors will concentrate on refining the DNA payloads and delivery systems to further enhance conjugation efficiency. The ultimate goal is to develop a final, usable system that attains a minimum of 10% conjugation efficiency. By achieving this milestone, the MAGIC-CAST technique will become far more effective, viable, and valuable for precise manipulation of whole microbiomes.

Kayla Pham CC'26, Chemistry

Faculty Mentor(s) or Supervisor(s): Milan Delor

Title: Polaritonic Recycling in Self-Hybridized Transition Metal Dichalcogenides (TMDs)

Abstract: Transition metal dichalcogenides (TMDs) are an emerging class of two-dimensional semiconductors with unique electronic and physical properties with unprecedented potential applicability and widespread availability. They have been shown to exhibit polaritonic self-hybridization, resulting in intrinsic exciton-polaritons (quasiparticles that are part-light and part-matter) without the need for an external microcavity that requires more complicated fabrication (Munkbhat et al, ACS Photonics, 2019, 6, 139-147): The atomically-smooth surfaces of TMD slabs act as low-quality mirrors, creating cavity modes that couple strongly to TMD excitons to create polaritons. At certain intermediate thicknesses, efficient population exchange between the long-lived exciton states and fast-propagating polariton states can occur, a phenomenon we term polaritonic recycling. We investigate polaritonic recycling as a mechanism to transport energy over large distances for next-generation optoelectronic devices. Utilizing stroboscat, a non-invasive ultrafast microscopy technique, we directly image the propagation of excitons and polaritons in self-hybridized TMDs in real space and time. Our key result is the observation of enhanced exciton transport at intermediate thicknesses that exhibit self-hybridization. These findings provide crucial insights into unlocking powerful new regimes of long-range transport in TMDs — addressing current limitations in the short-lived dissipative nature of energy flow in semiconductors, of crucial importance for applications ranging from photovoltaics to photocatalysts.

Sridevi Pulugurtha SEAS'25, Applied Physics

Faculty Mentor(s) or Supervisor(s): Shaloo Rakheja
Title: Theoretical Analysis of Electron and Spin Transport in Graphene Nanostructures.

Abstract: Graphene is a 2D material that shows novel electronic properties making it a compelling candidate for electronic and spintronic interconnects. Graphene supports ballistic transport of carriers due to its limited phase space for scattering. Additionally, spin diffusion lengths in graphene could be on the order of several micrometers due to graphene's weak spin-orbit coupling. These properties make graphene an excellent contender for energy-efficient electrical and spintronic interconnections. Our research focuses on evaluating the performance of graphene as an interconnect. Toward this, we have used tight-binding models, validated against ab initio Density Functional Theory (DFT) calculations, to obtain the band structures of monolayer, multilayer, and metallic nanoribbon structures of graphene. An equivalent circuit model, including quantum resistance and capacitance, was simulated in SPICE and results were compared with the solution of the voltaic-signal diffusion equation using appropriate boundary conditions. Intrinsic and extrinsic spin-orbital coupling in graphene was examined using a tight-binding model. The spin drift-diffusion equation and measurement schemes designed to extract spin diffusion lengths in graphene nanostructures were also studied. To obtain the spin-orbit coupling in graphene, a theoretical model for momentum relaxation time was developed based on phonon and coulombic impurity scattering mechanisms. Using this, the spin relaxation time was determined in graphene based on Elliot-Yafet and D'yakonov-Perel mechanisms.

Leann Qadan SEAS'27, Chemical engineering

Faculty Mentor(s) or Supervisor(s): Connor Taylor
Title: Key Differences between Flow Chemistry and Traditional Chemical Analysis

Abstract: Flow chemistry is a modern technique used for synthesis that utilizes pumps, tubing, and reactor coils rather than traditional round-bottomed flasks found in batch applications, allowing for faster reactivity, increased mass/heat transfer, increased safety, and more. This paper discusses these details, providing arguments for further adoption, practicalities, and potential disadvantages of flow chemistry. Chemical engineering concepts are covered with specific examples from the literature, that relate to reaction kinetics, plug-flow modelling, reaction analysis (online and inline), and more. As the modern laboratory attempts to diversify its skillsets and adopt optimal workflows, flow chemistry is a vital consideration that this paper highlights. These analyses will hopefully inspire today's engineers and scientists to adopt the flow chemistry technique on a larger scale, exhausting significantly less resources and thus opening the door to a future of economic viability and sustainability in science.

Tiffany Qian SEAS'24, Mechanical Engineering

Faculty Mentor(s) or Supervisor(s): Bianca Howard
Title: Lighting the Path to Building Decarbonization

Abstract: Around the world, buildings and their energy demands make up around 40% of the total energy usage. Reducing carbon emissions and energy consumption in buildings is key to slowing the harmful effects of climate change on the planet and has many related co-benefits such as cost reduction and job creation. However, improving the energy efficiency of buildings is a

complex issue due to the discrete nature of the variables and interactions between possible retrofits, causing calculations to grow exponentially. Typically, multi-objective optimization algorithms are used in the building energy space, but these tend to result in a few options with similar solutions and co-benefits. In order to provide a more compelling case to stakeholders for decarbonizing buildings, this research presents a method to obtain diverse solutions of similar quality and the associated trade-offs of co-benefits of job creation and reduced consumer cost using illumination algorithms. A viable script was produced that compares the results of a multi-objective optimization algorithm (NSGA-II) to that of an illumination algorithm (CVT MAP-elites) on multiple commercial stock buildings in the New York City area. The illumination algorithm allows for a greater understanding of the entire solution landscape and how various co-benefits change with these diverse solutions. This provides a portfolio of efficient and diverse solutions to stakeholders to ensure a possible solution no matter budgeting, resource, or even political constraints.

Tehreem Qureshi CC'25, Climate Systems Science

Faculty Mentor(s) or Supervisor(s): Scott Collis
Title: Utilizing Active Remote Sensing and Multi-Sensor Measurements for Storm and Flood Event Analysis in the Chicagoland Region

*Abstract :*In the Chicagoland region, heavy rainfall events, exacerbated by climate change, can cause flash flooding and disproportionately affect communities with less socioeconomic mobility and resources. However, there is limited understanding of storm dynamics and their specific properties. Further analysis of storm profiles will allow for better understanding of flash flooding, promoting climate justice within lower-income Chicagoland communities. This project focuses on the July 2nd rainfall event, in which some suburbs saw up to 8 inches of rainfall in a short period of time with damaging consequences. Under the Community Research on Climate and Urban Science (CROCUS) group at Argonne National Laboratory, this project utilizes active remote sensing instrumentation such as the Micro Rain Radar, Ceilometer, and data from the National Weather Service (NEXRAD) and develops Python code to visualize their data. It is found that this storm system's melting layer, where ice turns into rainops, rests at 4000 meters, with ice clouds 4500 meters above, and low cloud bases 250 meters high. The heaviest period of rainfall is found to be at about 14 UTC on July 2nd. These properties are analyzed though looking at variables such as light backscatter and reflectivity that the instrumentation output. The developed visualization code will continue to be applied to future storms to analyze changes in storm properties with global warming and the suburban and urban differences. Additionally, these analyzed characteristics will be applied to high resolution weather models to improve predictability for community preparedness.

Ananya Raghavan SEAS'25, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Anne Lare Bulin
Title: A Comparative Study on F98 Cell Viability and Survival After LuPO4 Nanoparticle Treatment

Abstract: Radiotherapy (radiation via X-ray beams) and chemotherapy are conventional therapeutic strategies for glioma, a type of malignant and highly proliferative brain cancer. Glioblastoma is the most potent form of glioma. Patients with glioblastoma are faced with a poor prognosis and a mean survival time of a little more than a year. Therefore, researchers have been attempting to enhance efficacies of existing glioblastoma therapies. One such example is using scintillating nanoparticles (NP) that enhance the radiotherapy (RT) effect. The NP absorb the X-rays more efficiently than human tissues, enhancing DNA damage in an oxygen-independent manner. Since conventional RT requires reactive oxygen species, using NP enables targeting of hypoxic cancer regions that are otherwise resistant to treatment. Radiation dose enhancement using NP is comparatively understudied in a glioblastoma-specific context. To see whether a model of NP and RT combination could apply as a potential glioblastoma therapy, we used F98 cells which were chosen for their high proliferation and pathobiological similarities to human gliomas. It has previously been shown that lutetium phosphate nanoparticles are UV-emitting when doped with praseodymium. We chose these lutetium phosphate nanoparticles for our model, hypothesizing that UV-emitting NP would yield a more robust enhancement of RT. We demonstrated that these NP are nontoxic, even at very high concentrations, suggesting they can be used to enhance RT without damage to healthy cells. Finally, we examined whether doped NP administration in conjunction with RT produced a significantly different viability response compared to undoped NP.

Montaha Rahman CC'25, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Sunil Agrawal
Title: Simulating Pregnancy Gait Parameters Using the Weight Addition Method

Abstract: Pregnant women are particularly vulnerable to the risk of falling, as demonstrated by the incidence and severity of fall-related injuries reported

between the second and third trimesters of pregnancy. Innovative training technologies, such as external balancing aids, are actively being developed to improve balance in pregnant women. Verification of external devices requires pregnant test subjects to participate in gait experiments. Gait experiments observe how people walk by measuring gait characteristics like stride length and walking speed. This may require subjects to perform activities that place additional physical strain and introduce unfamiliar movements to the mother. To minimize these risks, researchers conduct gait experiments designed with consideration of the physical limitations and potential risks associated with pregnancy. Furthermore, doing research with pregnant individuals requires meticulous analysis, owing to the physiological and biomechanical changes that occur during pregnancy. As a result, replication of pregnancy-specific gait metrics on non-pregnant human subjects may potentially eliminate the need for pregnant subjects until the final verification stages. This minimizes the risks associated with utilizing pregnant women for strenuous gait trial activities and instead replaces them with healthy participants who are less prone to fall-related injuries. The aim of this study is to compare the gait parameters of non-pregnant women to those of pregnant women, particularly during the second and third trimesters, simulated by the weight-addition method. This project has attempted to replicate pregnant conditions using an artificial baby bump with varying weights while collecting spatial, temporal, and kinematic gait data.

Ana Ratanaphruks SEAS'24, Industrial Engineering

Faculty Mentor(s) or Supervisor(s): Annaliese Cunniffe
Title: STRIKE: Soldier Training & Range Instrument for Kinetic Engagement

Abstract: Goal of this project is to design and develop a range tool for US Armed Forces. It will serve as a technological way to track human performance across multiple modalities, while soldiers perform tactical operations testing. It will involve developing optimized and streamlined data collection processes since tactical operations are complex and demanding. The buildout for this process includes low and high fidelity prototyping, software and mobile app development, database management, data analysis and visualization, as well as integration with wearables and various technology sensors. This meets the mission of assisting warfighters as they train, and helping build the Army of 2030.

Ana Reif CC'24, Evolutionary Biology of the Human Species

Faculty Mentor(s) or Supervisor(s): Scott Maddux
Title: The relevance of body composition to evolutionary models of human thermoregulation

Abstract: Anthropologists widely attribute climate adaptation in human shape to Bergmann's and Allen's rules, which state that differences in skin surface area relative to internal body volume (SA/V ratio) will affect the body's thermoregulatory abilities. However, the internal volume of the human body is not homogenous, with various tissues (e.g., bone, muscle, fat) having disparate thermoregulatory properties. Furthermore, human body composition is sexually dimorphic, with females consistently exhibiting higher adiposity across populations. Therefore, differences in body composition may have played an underappreciated role in human thermoregulatory evolution. Accordingly, this project tested the hypothesis that body composition varies independently from SA/V ratio. Eight participants (4M, 4F) were imaged using whole-body computed tomography (CT). Then, body surface area, total body volume, and internal body composition (i.e., fat, lean, and bone volumes) measurements were extracted from each scan using Avizo 3D software. Total volume was significantly correlated with lean ($R2=0.581$, $p=0.027$) and bone volumes ($R2=0.580$, $p=0.027$) but not fat volume ($R2=0.074$, $p=0.512$). Additionally, fat represented a substantially larger percentage of total volume in females ($\bar{x}=42.4\%$) compared to males ($\bar{x}=28.8\%$). These results indicate that increases in total body volume involve disproportionate increases in bone and lean volumes compared to fat, and support sex-based differences in body composition. Consequently, the findings of the current study do not support the assumption that body composition is uniform. Given the differential thermoregulatory properties of various body tissues, failing to account for such variability in internal body composition may contribute to overly simplistic interpretations of thermoregulation within evolutionary contexts.

Valerie Rogel CC'25, Economics-statistics, Allison Lin CC'26, CS-Math, Aditya Jain CC'26, Undecided

Faculty Mentor(s) or Supervisor(s): George Dragomir
Title: From Climate Talk to Stock Shock: Modeling Policy Headline Sentiment and Index Fund Performance

Abstract: Significant shifts have occurred in U.S. domestic climate policy since the ratification of the 2015 Paris Climate Accords. The efficient market hypothesis expresses that market prices are driven by investor response to major shifts in news events and stories. Despite the magnitude of these

climate policy shifts, there is a lack of research on investor reactions to such policy changes. In our study, we address this research gap by attempting to determine and model the relationship between the sentiment of climate policy news headlines and the financial metrics of major U.S. index funds. Initially, we employ the Valence Aware Dictionary and sEntiment Reasoner (VADER) — a natural language processing (NLP) technique — to derive sentiment scores from 14,000 relevant climate policy headlines spanning January 2014 to June 2023. Following this, we apply Granger causality tests and compare the effectiveness of univariate autoregressive forecasting models to bivariate machine learning regression models. The latter incorporates climate policy news sentiment as a predictive feature, allowing us to assess the value of this sentiment in forecasting index fund metrics. Our findings indicate that consumer discretionary, consumer staples, and information technology funds are most effectively predicted using climate policy news sentiment. Through this study, we aim to illuminate the relationship between climate policy news sentiment and shifts in investor behavior.

Lucia Rondini CC'24, Physics

Faculty Mentor(s) or Supervisor(s): Carlos Paz-Soldan
Title: Verifying Improved Particle Trapping in Negative-Triangularity Plasmas

Abstract: Tokamaks are ring-shaped fusion devices that use magnets to create and confine plasma. Inside tokamaks, plasma can be shaped in different ways, including D-shape (positive triangularity) and inverted D-shape (negative triangularity) cross-sections. Negative-triangularity plasmas offer improved plasma core confinement, lower impurity retention, and inherent stability at the plasma edge, making them a potentially attractive choice for a tokamak reactor solution. This study seeks to verify improved particle trapping in negative-triangularity plasmas; namely, that negative-triangularity plasmas have a higher fraction of particles bouncing in the good-curvature region near the inner edge of the plasma, which improves core confinement. The effect of plasma elongation on the good-curvature trapped fraction is also investigated. Both of these factors are studied using Bounce, a particle orbit code, to generate paths of individual particles with a variety of energies and initial velocities. The particle path data is passed through a sorting algorithm to determine whether the particle bounces and if so, whether it bounces in the good or bad curvature region of the plasma. Negative-triangularity plasmas are found to have a higher good-curvature trapped particle fraction than their positive-triangularity counterparts, whereas elongation does not have a significant impact.

Emily Sarkar CC'25, Biology (math concentration)

Faculty Mentor(s) or Supervisor(s): Erin Barnhart
Title: Inhibition of mitochondrial transport disrupts dendrite stability in drosophila neurons

Abstract: Neurons are long-lived cells that must maintain a healthy population of relatively short-lived, highly dynamic mitochondria for the duration of their life. There is accumulating evidence that mitochondrial transport in neurons is negatively correlated with age. However, it is unclear how mitochondrial transport contributes to the maintenance of a well-distributed network of mitochondria throughout architecturally complex neuronal arbors. In our work, we investigated how inhibition of mitochondrial motility affects mitochondrial localization and dendrite stability in HS neurons of the Drosophila visual system. In our experiments, we knocked down the expression of Milton, an adaptor protein required for mitochondrial transport, either constitutively— throughout development and adulthood— and at various time points post-eclosion. We found constitutive inhibition of mitochondrial transport disrupted normal mitochondrial distribution and neuronal form. Inhibition of mitochondrial transport post-development (i.e. just in adult neurons) also disrupted the maintenance of a well-distributed mitochondrial network and led to neuronal degeneration. Thus, our results suggest that healthy mitochondrial motility is essential for both the maintenance and development of healthy neurons

Ratna Sharma SEAS'25, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Clark T. Hung
Title: Evaluation of Type 2 Diabetes and Hemarthrosis on Osteoarthritis Pathogenesis using a 2D In Vitro Model of Synovium and Cartilage Derived Cells

Abstract: Osteoarthritis (OA) is a degenerative joint disease characterized by inflammation and cartilage degradation. The prevalence of type 2 diabetes mellitus (DM) has been associated with OA progression, contributing to high infection rates and poor healing responses. DM is characterized by high blood glucose levels caused by insulin resistance and a deficiency of insulin secretion and/or action. Damage to the knee joint can also contribute to OA, where approximately 12% of all cases are attributed to post-traumatic injuries. Intra-articular bleeding, or hemarthrosis, is a common result of these injuries, leading to chronic inflammation in the synovium, the specialized connective tissue that lines the diarthrodial joint. The synovium's

vascularized nature makes it more likely to be stimulated by high blood glucose levels that result from DM-induced hemarthrosis, which may have negative downstream effects on the adjacent cartilage tissue. This study investigates the combined effects of DM and hemarthrosis on OA pathogenesis. We hypothesized that by varying blood glucose levels, we could model how hyperglycemic environments further exacerbate blood-induced joint injuries of synovial and cartilage derived cells in a co-culture transwell system. By trying to model the diabetic phenotype using high blood glucose culture conditions, we attempt to develop an in vitro system to observe the biochemical and phenotypic changes of synovium and cartilage. This model supports basic science and translational studies designed towards understanding DM and hemarthrosis in OA patients, allowing for future tests that investigate therapies to reverse or at least mitigate insulin resistance, blood-induced joint injury, and OA development.

Eva Sharman CC'26, Applied Math & Earth Science

Faculty Mentor(s) or Supervisor(s): Suzan van der Lee
Title: Shear-Wave Splitting across Long-Lived Seismic Stations

Abstract: The East African Rift System (EARS) is a developing divergent plate boundary. To provide geologic context for the rift, mantle flow must be characterized in the region. Seismology is used to analyze shear-waves (transverse waves or S-waves) that travel through Earth's mantle and crust. Anisotropy, or the directionally-dependent behavior of a material, is present when seismic wave velocity varies with respect to the direction of wave propagation. In an anisotropic medium, shear waves split in two orthogonal directions (a fast and slow direction) along a plane perpendicular to the original wave propagation direction. The split waves accumulate a delay relative to the strength and thickness of the anisotropic medium. SKS waves exit the outer core with known polarization, allowing for analysis of the splitting incurred while traveling to a seismic station at the surface. Since observable SKS waves come from far-away events with large magnitude and high signal to noise ratios, previous SKS splitting studies analyze few events. We identify long-lived, low-noise candidate stations near EARS for which tens or huneds of events can be analyzed. We then infer splitting parameters for each event at every candidate station. Surprisingly, we find that the apparent fast-axes for each event recorded by a single station vary with respect to the incoming direction of the earthquake. Although splitting parameters for each event are typically averaged for a station, we advocate for the per-event analysis of splitting parameters due to this variation and suggest further investigation of linear splitting parameter trends in candidate stations.

Daniel Shneider CC'26, Biology and Art History

Faculty Mentor(s) or Supervisor(s): Harris Wang
Title: Targeted Reduction of Antibiotic Resistance Via Mobilizable Genetic Payloads in Klebsiella Pneumoniae

Abstract: Antibiotic resistance is a growing cause of mortality worldwide due to the emergence and proliferation of resistance genes in bacterial pathogens. One such pathogen is Klebsiella pneumoniae, a notorious carrier of many resistance genes harbored on numerous extrachromosomal elements. Most concerning is the increase in carbapenem-resistant strains, which has drastically reduced effective treatment options. Current treatments escalate antibiotic use but fail to address resistance genes themselves. To address this problem, we developed a plasmid-based therapy to enter K. pneumoniae cells and eliminate carbapenemase resistance genes directly. This therapy combines TP114, a self-transmissible plasmid with CRISPR-Associated Transposases (CASTs) for targeted DNA insertion into custom genomic loci, and I-C/Cas3 for targeted DNA cutting and bidirectional digestion. These tools together constitute a system that can effectively target and degrade extrachromosomal elements that harbor antibiotic resistance genes. Further, targeted insertion of I-C/Cas3 by CAST eliminates genomic copies of antibiotic resistance genes and prevents re-entry of resistance elements, thus preventing future acquisition of resistance. While eliminating target genes, this approach seeks to avoid killing all recipient cells of the broad-host TP114 plasmid, aiming to reduce further dysbiosis caused by off-target cutting events. This novel therapy class offers the unprecedented chance to selectively reduce antibiotic resistance of constituents within a bacterial community by physical removal of putative resistance genes. Future work will test various combinations of these elements to achieve the optimal resistance clearance payload

Shreyas Shridharan CC'26, Neuroscience

Faculty Mentor(s) or Supervisor(s): Ai Yamamoto
Title: Using iterative indirect immunofluorescence imaging to spatially phenotype ALFY inducible knockout mouse spinal cord and brain

Abstract: Protein aggregation is a major pathological hallmark across many age-related neurodegenerative diseases. Currently, it is unclear as to whether this aggregate accumulation drives the neurodegenerative pathology, or whether the aggregates are a late-stage consequence of these diseases. To study this, we employed ALFY iKO mice, a conditional Cre recombinase

driven knockout model of the ALFY/WDFY3 gene to inhibit protein aggregate clearance and drive aggregate accumulation in the adult mouse. We then spatially characterized aggregate localization and neuroinflammatory markers using iterative indirect immunofluorescence imaging (4i), a version of standard immunofluorescence that elutes the antibodies upon imaging, allowing for multiple rounds of staining on the same tissue. Thus, cellular dynamics and pathways resulting from aggregate accumulation can be elucidated. This technique offers a spatial multiplexed understanding of which proteins aggregate, where such aggregates are localized, which cell types show the greatest aggregate burden, and what neurodegenerative symptoms happen as a result. Currently, preliminary results of initial comparisons between L3 to L5 spinal cord sections of ALFY iKO and control mice show possible differences in GFAP expression, a marker for astrocytosis. In addition, our solubility fractionation data reveals that TDP-43 and pTDP-43, which aggregate across a wide range of neurodegenerative disorders, accumulate in ALFY iKO brain lysates. Furthermore, the Yamamoto lab has shown that ALFY iKO mice show progressive motor deficits and tissue-level brain degeneration. These results together offer the ALFY iKO mouse model as a promising means to study how protein aggregate accumulation may impact neurodegenerative events.

Marija Simjanoska CC'24, Biochemistry

Faculty Mentor(s) or Supervisor(s): Henning Stahlberg
Title: Ultrastructure of cortical Lewy bodies in human brain afflicted with Parkinson's Disease

Abstract: Parkinson's disease is a neurodegenerative disorder characterized by the progressive loss of motor function. Its hallmark pathological feature is the presence of Lewy bodies (LB) in the brain, which are neuronal inclusions marked by abnormal aggregation of filamentous alpha-synuclein protein. The mechanisms underlying LB development and its contribution to neurodegeneration are still not fully understood. The "prion-like" hypothesis suggests that misfolded alpha-synuclein proteins can act as seeds, inducing the misfolding of normal alpha-synuclein in neighboring cells, thereby propagating pathological aggregates throughout the brain in a self-perpetuating manner. LB morphology varies depending on location in the brain (brainstem, limbic, neocortical), which may reflect various stages of LB maturation and spread. The morphology of cortical LBs has been poorly characterized in existing literature. Here, we employed correlative light and electron microscopy (CLEM) to investigate the ultrastructure of cortical Lewy bodies in two distinct brain regions, the cingulate cortex and the entorhinal cortex, in postmortem brain tissue from Parkinson's disease donors (n=5). We identified, localized, and imaged alpha-synuclein immunopositive Lewy pathology and consistently found LBs with only fibrillar aSyn aggregates. Notably, our findings align with the Braak hypothesis which suggests that LBs initially form in the brainstem (often with a membranous appearance) and subsequently progress to cortical regions where they take on a more fibrillar structure. Our observations highlight the potential sequential evolution of LB morphology and provide insight into the mechanism of LB formation and spreading. This contributes to our understanding of the pathological progression of the disease and its correlation with clinical symptoms.

Rohan Singh CC'24, Biology

Faculty Mentor(s) or Supervisor(s): Thomas Lozito
Title: Combined Immunofluorescence and In Situ Hybridization Staining in Lizard Tail Samples

Abstract: The study of lizard tail regeneration has proven highly productive, generating results that are revolutionizing the field of bioregenerative research. In researching the progression of the regenerating lizard tail, several relevant proteins and mRNA transcripts have been identified. The ability to stain, via fluorescence, these areas of interest is a valuable tool to scientists studying the function and role of said areas. This project sought to identify a combined staining protocol by which both a mRNA transcript and a protein could be stained in the same sample, a task that has proved difficult to achieve in lizard tail sections. The primary objective was to produce high quality images of both the MyoD mRNA transcript and the Pax7 protein. The procedures used were in situ hybridization staining, a method of staining mRNA transcripts with probes specific to a particular transcript of interest, and immunofluorescence staining, a method of staining proteins by a specific conjugated antibody. Variations of a sequential procedure were performed, with optimizations made in attempts to produce compatibility between the two techniques. The results indicated that the sequential procedure is limited in its ability to provide high quality images of Pax7 protein staining. This suggests that the combined procedure, limited as it may also be, should be the preferred method of co-staining mRNA and proteins.

Ankhit Singhal CC'26

Faculty Mentor(s) or Supervisor(s): Mohammed AlQuraishi
Title: Prediction of structural features as a result of point-based and other small-scale mutations

Abstract: Despite advances in the 3D structural prediction of proteins through evolutionary algorithms such as AlphaFold2, the prediction of structural features as a result of point-based and other small-scale mutations remains a difficult problem to solve. As a result of a novel dataset utilizing 'high-throughput' thermodynamic measurements of mutational effects in proteins (~850,000 measurements vs. <10,000 measurements previously), the ability to apply more robust deep learning models can be realized. After reproducing the ABYSSAL (current state-of-the-art algorithm) algorithm and datasets, we created multiple novel datasets - also including embedding layers for structural details. Additionally, we explore the ability of language models connected to six different downstream networks to predict the ΔΔG of small-scale mutations in approx. ~350 natural and ~200 de novo proteins in a fashion that is more accurate than previously published methods. These results were validated against known datasets.

Sophia Sorid CC'26, Biochemistry

Faculty Mentor(s) or Supervisor(s): Michelle Jin
Title: Pharmacological enhancement of slow wave sleep as a therapeutic strategy in Alzheimer's disease mice

Abstract: Alzheimer's disease (AD) is the most common cause of dementia characterized pathologically by amyloid-beta plaque and neurofibrillary tangle aggregation. The neurodegeneration that accompanies this pathology damages many aspects of cognition and behavior. One of many neuropsychiatric symptoms is disordered sleep, with damage to both the sleep-wake rhythm and sleep architecture. The deepest stage of sleep is known as slow wave sleep (SWS), and it is thought that a neuroprotective waste clearance mechanism in the brain is heightened during this period. When SWS is disrupted, less AD pathology is cleared from the brain, leading to more plaque aggregation. To intervene with this positive feedback loop of AD progression, we chronically pharmacologically enhanced slow wave activity (SWA) to assess changes in plaque burden and memory performance in an AD mouse model. While previous research has shown that chronic SWA enhancement can improve memory performance, the improvement of cognition in an AD model has not yet been shown. Here we show that enhancing SWA in an aged group of AD mice can ameliorate memory deficits. This finding reveals that it is possible to alter the trajectory of AD progression after the onset of pathology aggregation and deficits in cognition. As sleep disturbances in dementia increasingly present a major burden to caregivers and patients alike, there is a major need to target these symptoms for therapeutic benefit. This work demonstrates a promising strategy for rescuing memory retrieval deficits following the onset of AD.

Lucas Souto Manning GS'24, Neuroscience and Behavior

Faculty Mentor(s) or Supervisor(s): Alfredo Spagna
Title: Investigating the Effect of Mental Rotation on Bistable Motion Perception

Abstract: There isn't much humans do more in a day than think and see. Many of those thoughts are visual, so the two systems must be connected. This project, done in Columbia's The Living Lab with Dr. Spagna, goes beyond imagination affecting perception, it investigates decay of this effect over time. Interpretation of bistable illusions was the perfect variable here—a visual component observed to be rotating either one of two ways—a visual illusion. However, illusions never last forever, and must wear off at some point. The question here is: when? Unfortunately, there have not been very many relevant studies to this conducted. Naturally, existing literature was reviewed, and was used to set experimental parameters. Soon piloting began, and subjects were asked to sit in front of a monitor, mentally rotate various irregular shapes or letters varying amounts of hours on a clock (counter)clockwise, report results of and confidence in their rotations. After, subjects were presented with a circle of moving dots creating the bistable illusion, and report which way they saw it rotating, despite no rotation occurring. This was repeated periodically, with time between imagination and perception increasing steadily from 0.5 seconds to 8 seconds. An effect between direction of mental rotation and direction of perceived rotation was observed in the initial study, in addition to a heavy clockwise bias, suggesting overlap in the brain. There is also a decay being observed early on, but data collection is in its early phases, and piloting isn't done yet.

Ana Stratan CC'24, Biology

Faculty Mentor(s) or Supervisor(s): Stuart Firestein
Title: A Novel Framework for Investigating the Microenvironment of Olfactory Stem Cells

Abstract: Stem cells can be found throughout the body in compartments called stem cell niches. These niches have specific chemical microenvironments and intricate spatial organization. Most niches are also characterized by a particular oxygen distribution, with the stem cells generally residing in a low-oxygen or hypoxic environment. This low-oxygen environment helps maintain low DNA damage levels, leading to long-lasting

healthy stem cell populations. The current project seeks to investigate the oxygen landscape of the stem cell niche containing olfactory stem cells in the olfactory epithelium, a scientifically neglected tissue with great potential for neurodegenerative disease treatment. Stem cells in the epithelium are of two types: HBCs (horizontal basal cells) and GBCs (globose basal cells), both with different morphologies and roles. Located at the base of the epithelium, these stem cells are expected to reside in a hypoxic environment as correlated to their morphology and subsequent fate as bipolar olfactory neurons or their support cells. In order to assess the oxygen environment of the tissue, mice were treated with a hypoxia-responsive substance. Tissue was then harvested and treated with a fluorescent antibody against the previously mentioned reagent. Preliminary results show an oxygen gradient ranging from hypoxic regions at the base of the epithelium, in the area where stem cells reside, and higher oxygen concentrations in other cell layers. Current findings can lead to a better understanding of this stem cell niche, providing insight into the maintenance and use of an important and therapeutically accessible stem cell population.

Maria Stuebner CC'24, Mathematics

Faculty Mentor(s) or Supervisor(s): Francesco Lin
Title: The quotient dimension of hyperbolic three-manifolds

Abstract: For any finitely generated group Γ, the quotient dimension of Γ refers to the minimum dimension of a complex linear group containing an infinite quotient of Γ. In his work, How often is 84(g−1) achieved? Michael Larsen shows that the quotient dimension determines the asymptotics of the set of orders of finite quotient groups of Γ; furthermore, he computes the quotient dimension of various groups of hyperbolic surfaces and orbifolds. In this project, we explore further conditions for determining the quotient dimension of finitely generated groups, specifically focusing on the fundamental groups of hyperbolic three-manifolds.

Lauren Subramaniam CC'25, Environmental Biology

Faculty Mentor(s) or Supervisor(s): Tom Gabel
Title: Mating Reluctance and Remating Potential in Ae. aegypti Lab and Field-Derived Strains

Abstract: One of the most dangerous modern disease vectors is the yellow fever mosquito, Aedes aegypti, which can spread pathogens that cause dengue fever, chikungunya, and Zika fever. Female mosquitoes typically only mate once throughout their lifetime due to male paternity enforcement: male accessory gland (MAG) fluids transferred during mating leave females refractory to further mating. However, when Ae. aegypti females encounter the Asian tiger mosquito, Ae. albopictus, Ae. albopictus males will attempt to mate with Ae. aegypti females and transfer their own paternity-enforcing MAG fluids, rendering Ae. aegypti females sterile and resulting in reproductive interference. This process is known as satyrization. Low satyrization rates in cohoused Ae. aegypti and Ae. albopictus populations have been previously observed in-lab and in the wild. Evolved resistance to satyrization has also been observed; however, the mechanisms behind this process are poorly understood. The mating strategies of multiple Ae. aegypti strains are investigated to determine if differences in mating behaviors may have evolved as resistance to satyrization. Two potential mechanisms of satyrization defense were investigated: overall lowered female receptivity to mating to reduce the likelihood of being satyrized, and female receptivity to multiple mates to avoid paternity-enforcing MAG signals. Significant differences in the mating timelines between strains were found, demonstrating the potential for repressed mating behavior as a means of satyrization resistance. Additionally, low rates of demonstrated remating across strains were observed, indicating variability in the mating behavior of lab and field-derived mosquito strains.

Pranay Talla CC'24, Biochemistry, Computer Science And Mathematics

Faculty Mentor(s) or Supervisor(s): Matthias Mann
Title: 3D deep visual proteomics for complete single-cell and subcellular profiling of hepatocytes

Abstract : Mass spectrometry-based single cell proteomics is poised to unravel heterogeneity of tissue composition and cellular states. Deep Visual Proteomics (DVP) has been demonstrated previously to profile cellular proteomes in an untargeted manner. The DVP method relies on high-content imaging, AI-based segmentation, and subsequent laser microdissection for the isolation of shapes from single 2-10µm tissue slices. To increase the completeness and interpretability of spatial proteomics data, we propose extending the profiling of tissue into the third dimension, allowing for the study of subcellular and tissue-level proteome variations. Here, we develop a pipeline to align segmented images from serial tissue sections in silico, enabling selective microdissection of individual cells' cross sections across 3D space followed by LC-MS/MS-based analysis. We used a multiplexed DIA (mDIA) workflow to allow for high-throughput and in-depth proteomic profiling of samples on a timsTOF SCP (Bruker) in dia-PASEF mode. We

demonstrate the viability of this technique on FFPE mouse liver samples to first obtain the proteome of complete hepatocytes, and then to examine their proteomes at the subcellular level, identifying organellar enrichment along different cellular cross sections. Notably, the proteome of a complete hepatocyte contains 25% more protein groups than the proteome of a single hepatocyte cross-section. This work highlights the potential of DVP with 3D spatial profiling to deepen our understanding of cellular and subcellular proteomics.

Laura Torre SEAS'24, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Mark Zeidel
Title: Characterization of a Partial Bladder Outlet Obstruction Mouse Model Using X-Ray Videocystometry

Abstract: Partial bladder outlet obstruction (pBOO) commonly occurs in patients with benign prostatic hyperplasia (BPH), causing lower urinary tract symptoms (LUTS) such as increased urinary frequency, decreased urine flow, incomplete bladder emptying, and incontinence. To understand how pBOO leads to LUTS symptoms we developed a pBOO mouse model and characterized bladder filling and voiding using a novel x-ray videocystometry method. Urethral obstruction in pBOO was created by constricting the urethra using a ligature against a 26G blunt needle as reported. Following a recovery period, a catheter was implanted into the bladder dome and exteriorized through the nape of the neck. After a week of recovery, cystometrograms were performed in conscious, lightly restrained mice, using contrast in saline and a mouse fluoroscopic apparatus, permitting simultaneous recording of pressures and volumes during repeated fill/void cycles. From the x-ray video recordings and pressure records we calculated the bladder volumes and urethral flow rates in control and pBOO mice. Compared to control mice, pBOO mice showed significant voiding dysfunction, with decreased maximum urinary flow rates (UFRs)—control 86.13 ± 7.6, pBOO 51.55 ± 6.1, $p < 0.001$. More importantly, pressure-flow analysis showed that even at higher bladder pressures pBOO mice flow rates are significantly lower compared to control mice, indicating significant increased urethral resistance to flow. The model will be used to determine how pBOO alters all aspects of bladder filling and voiding, including afferent neural traffic to the brain, efferent neural traffic to the spinal cord and bladder, and bladder wall function.

Erik Trebilcock CC'25, Chemistry

Faculty Mentor(s) or Supervisor(s): Makeda Tekle-Smith
Title: C-H Functionalization and [3+2] Cycloaddition through Radical Photoredox Catalysis

Abstract: Photoredox Catalysis has enhanced the synthetic capabilities of C-H functionalization and cycloaddition by utilizing photocatalysts as Hydrogen Atom Abstractors. These photocatalysts are excited by specific UV light wavelengths, leading to the production of radical intermediates. These reactive radicals exhibit a high potential for generating new C-C bonds. In this process, C-H bonds undergo functionalization through selective hydrogen atom transfer by both a photocatalyst and an alkyne. The remarkable reactivity of these radical intermediates enables their addition into an alkyne, initiating a selective 1,5-hydrogen atom transfer. The resulting new radical adds into the alkene to initiate cyclization and then abstracts a proton from the photocatalyst, completing the [3+2] cycloaddition. The application of radical photoredox catalysis introduces innovative synthetic methods for forming five-membered cycles with improved control over stereo- and regiochemistry. Additionally, this approach reduces reaction time, lowers reaction temperature, and minimizes the need for hazardous reagents. By capitalizing on the radical stabilization and hydrogen abstraction properties of the substrates, the reaction achieves enhanced regioselectivity while maintaining reduced reaction times and complexity. Verification of the cyclized products was performed through 1H/COESY/NOESY NMR, High-Resolution Mass Spectrometry, and Compact Mass Spectrometry. This synthetic method holds promise for advancing further research in synthesis, pharmaceutical development, and materials science.

Danelle Tuchman CC'25, Computer Science

Faculty Mentor(s) or Supervisor(s): Brian Plancher
Title: Optimized Additions to GRiD, a GPU-Accelerated Library

Abstract: Efficient implementations of robotics algorithms leverage rigid body dynamics to compute the different components of motion for each joint within a robotic system. These algorithms have been implemented with the Central Processing Unit (CPU), and although they are highly accurate and optimized, they are limited by a lack of parallel processing. This can be solved through using alternative computer hardware like Graphing Processing Units (GPU). The GPU parallel processing functionality enables the components of motion of different joints to be computed at the same time, thus decreasing the overall processing time. However, this requires software to be heavily modified and adapted in order to achieve performance results. Over the summer the GPU-Accelerated Rigid Body Dynamics with

Analytical Gradients (GRiD) team of the Barnard Accessible and Accelerate Robotics Lab (A2R Lab) worked to port many key algorithms over into GPU-friendly formats. These algorithms include the Articulated Body Algorithm (ABA), Composite Rigid Body Algorithm (CRBA), and Inverse Dynamics using Spatial Vector Algebra (IDSVA). For ABA and CRBA, the GRiD team implemented parallel versions for the GPU that have proved successful for robots with up to 30 joints. For IDSVA, the GRiD team used the Matlab of the second order gradients of these algorithms to create a python version of the code, which is a significant step towards running these algorithms on a GPU. The python version will be leveraged to output a custom code-generation framework to output CUDA C++ code specialized for the GPU.

Richard Tuddenham CC'25, Physics, Mathematics

Faculty Mentor(s) or Supervisor(s): Brian Cole
Title: Search for diffusion wake jet quenching at ATLAS

Abstract: This project centered on processes in relativistic heavy ion collisions for the ATLAS experiment at the Large Hadron Collider. High energy jets produced in these collisions lose energy in the quark gluon plasma formed from the colliding nuclei, a process known as quenching. One of these quenching mechanisms is the formation of a diffusion wake, analogous to a classical Mach cone. The diffusion wake has thus far eluded experimental searches, but new phenomenological calculations have suggested it would result in a noticeable depletion in track counts directly opposite the quenched jet. This prompted their investigation into diffusion wake quenching in photon tagged events as well as ongoing work on dijet events. Photon tagged events do not appear to show signs of the track depletion, confirming recent results from another group. The dijet event studies appear very promising as jet-tagged events provide greater volumes of data than photon-tagged events, at the cost of complicating the mechanism leading to additional acceptance effects. This leaves open the possibility of a small diffusion wake effect, not apparent in photon-tagged studies. The work on dijet events is still ongoing as significant efforts were needed to limit acceptance effects introduced by the requirements of jet-tagged events.

Sarah Ufearo CC'24, Neuroscience And Behavior

Faculty Mentor(s) or Supervisor(s): Sade Spencer
Title: Effects of Metformin on Cocaine CPP Acquisition

Abstract: The use of highly addictive drugs, such as cocaine, oftentimes results in the creation of drug-associated cues for the user. This association threatens long-term sobriety by increasing the likelihood of relapse when exposed to said cues. One method of simulating drug-associated cues is conditioned place preference (CPP), where a subject is conditioned to associate a certain location with a certain reward; in the case of this experiment, the reward is cocaine. Recent studies have determined that AMP-activated protein kinase (AMPK) in the nucleus accumbens is fundamental to this cue-induced cocaine-seeking behavior. AMPK is an enzyme involved in coordinating cell growth and metabolism. Increasing phosphorylated AMPK in the NAc has been found to decrease the reinstatement of cocaine-seeking behaviors. Metformin is an anti-diabetic medicine that acts on the AMPK pathway to enhance insulin sensitivity by inhibiting complex I of the mitochondrial respiratory chain in the liver, leading to the activation of AMPK. For this study, Metformin was used as a pre-treatment to cocaine exposure, in order to reduce CPP acquisition in rats. Intraperitoneal injections of metformin followed by injections of cocaine were done, and then the rats underwent locomotion tracking to ensure that cocaine would have its intended effects as well as determine location preference over the duration of the experiment. Metformin pre-treatment showed decreased CPP acquisition in female rats; however, male rats showed no CPP acquisition whatsoever. Altogether, these results show sex differences in CPP acquisition as well as a tempered impact of metformin on cue-induced reinstatement of cocaine-seeking behaviors.

Rana Urek CC'24, Physics

Faculty Mentor(s) or Supervisor(s): Norman Christ
Title: Gauge Fixed Fourier Accelerated Hybrid Monte Carlo Algorithms in Lattice QCD

Abstract: Quantum Chromo Dynamics (QCD) is an asymptotically free theory where the coupling constant decreases at high energies or short distances. For lattice QCD calculations, this means that lattices with finer lattice spacings simulate weaker interactions between quarks and gluons. Working in this weakly coupled regime presents challenges in lattice QCD simulations such as autocorrelation times for observables being extremely long. This problem is usually referred to as Critical Slowing Down (CSD). The Hybrid Monte Carlo (HMC) algorithm we use to evolve our lattice through Monte Carlo time, evolves all the energy modes with the same velocity and therefore slows down the generation of new gauge configurations resulting in CSD. We modify our previous HMC evolution algorithm by a Gauge Fixed Fourier Accelerated (GFFA) algorithm, where we impose a physical gauge condition and use a simple Fourier acceleration

to treat the evolution of different modes more efficiently to reduce CSD. We compare the autocorrelation times of observables between the pure HMC and GFFA algorithms and show significant improvement with GFFA. We are currently working on studying the effects of varying trajectory lengths in the GFFA algorithm.

Clara Victorio SEAS'25, Chemical Engineering

Faculty Mentor(s) or Supervisor(s): Nicholas Sawyer
Title: Folding-Assisted Peptide Disulfide Formation and Dimerization

Abstract: Disulfide bonds form covalent bonds between distal regions of peptides and proteins to dramatically impact their folding, stability, and oligomerization. Given the prevalence of disulfide bonds in many natural products, considerable effort has been invested in site-selective disulfide bond formation approaches to control folding of chemically synthesized peptides and proteins. Here we show that careful choice of thiol oxidation conditions can lead to monomeric or dimeric species from a single, fully deprotected linear bisthiol peptide. Examination of reaction conditions indicates that the use of disulfiram (DSF) in denaturing conditions predominantly leads to the formation of intramolecular disulfide bonds while reaction with DMSO in aqueous conditions yields disulfide-linked, antiparallel dimeric species. Preferential disulfide formation is also influenced by peptide secondary structure and sequence. Intramolecular disulfide formation is promoted when peptides fail to fold and associate, e.g., under denaturing conditions or when the sequence lacks α-helical folding propensity. On the other hand, the presence of three hydrophobic residues – namely F, W, and L – along one face of α-helical peptides may enhance intermolecular hydrophobic interactions and encourage peptide association, leading to the formation of dimers in aqueous conditions. These results provide an approach for using disulfide bonds to control peptide folding and oligomerization to better understand how these properties influence interactions with diverse molecular targets.

Manan Vij CC'26, Computer Science

Faculty Mentor(s) or Supervisor(s) Professor. Aleksandar Obradovic
Title: Systematic comparison of single-nucleus and single-cell RNA sequencing for biological inquiry

Abstract: This research study delves into investigating whether single-nucleus RNA sequencing, a cutting-edge technique that isolates cell nuclei to extract RNA, offers a method that is at least as robust as traditional single-cell RNA sequencing for biological inquiry. The primary goal is to benchmark single-nucleus RNA sequencing against conventional single-cell methods, identifying the unique biological questions that single-nucleus datasets can address effectively. This investigation also aims to discern the optimal data processing techniques to harness the predictive power of single-nucleus data and further refine or develop existing pipelines dedicated to this innovative sequencing approach. Furthermore, the study aims to investigate key distinctions between single-cell and single-nucleus RNA sequencing methods, delving into their effectiveness in capturing different cell types and revealing distinct gene expressions. Additionally, the research addresses the phenomenon of gene dropout, a phenomena where certain genes are observed at a low or moderate expression level in some cells, particularly in the context of single-nucleus sequencing where it's theorized to be non-random and more frequent. This analysis began by assessing how quality control filtering impacts the identification of differential marker gene expression, in the context of patients with non-small lung cancer. The impact of various biological criteria and thresholds on gene expression quality was systematically tested. Subsequently, the traditional pipeline was employed to cluster datasets and explore gene expression patterns across different cell types, shedding light on associated biological processes. Protein level targets of genes and data imputation techniques, to help fill in missing values and boost data quality, were also systematically analyzed and benchmarked, respectively.

Josephine Watkins SEAS'25, Biomedical Engineering

Faculty Mentor(s) or Supervisor(s): Gordana Vunjak-Novakovic
Title: The molecular mechanism of TGFBR2 degradation in cardiac fibroblasts

Abstract: BAG3 protein levels have been found to be diminished in patients with heart failure and several mutations have been identified to cause dilated cardiomyopathy with cardiac fibrosis. BAG3's four binding domains are critical to its function to facilitate proteostasis. BAG3's role has been extensively studied in cardiomyocytes, where it aids sarcomere protein turnover through chaperone-assisted selective autophagy, through BAG3's complex with HSP70, HSPB8, and E3 ligase CHIP. However, BAG3 is ubiquitously expressed and its role in non-myocytes has been overlooked. Cardiac fibroblasts are responsible for the excessive matrix deposition leading to fibrosis, mostly through TGF-beta signaling. Previously, the importance of BAG3 in cardiac fibroblasts through its role in TGF-beta signaling and identified BAG3 to facilitate the degradation of the type II TGF-beta receptor

(TGFBR2) has been demonstrated. As BAG3 does not have inherent E3 activity, this study aimed to identify the specific E3 ligase of TGFBR2 and the binding domains of BAG3 that are crucial to this interaction to gain insight into the effects of the clinical mutations of BAG3. In conclusion, we have uncovered the molecular mechanism of TGFBR2 degradation in cardiac fibroblasts mediated by the BAG3-HSP70-HSPB8 complex, with clinical implications for the loss of BAG3 and several common DCM-causing mutations in the development of cardiac fibrosis.

Ari Willner SEAS'25, Applied Physics

Faculty Mentor(s) or Supervisor(s): Latha Venkataraman
Title: Computational Analysis of Local Electric Fields in Dielectric Solvents under an Applied External Electric Field

Abstract: Applied external electric fields (EEFs) have been shown to catalyze biochemical reactions in solution. For some specific reactions, it has also been demonstrated that the reaction rate in an EEF increases linearly with the dielectric constant of the surrounding solution. This is counterintuitive, as basic electrostatic considerations would indicate that stronger dielectrics should screen EEFs. To shed some light on this problem, we model a system of dipoles as a proxy for the solvent with a central reaction cavity and evaluate, following laws of electrostatics, the effect of an EEF on the local field within the cavity. We place the dipoles in a face centered cubic structure (FCC) of small volume and then sample configurations of the dipole orientations at three values of EEF. For each configuration, we evaluate the total electrostatic energy of the configuration and the electric field in the cavity. Using the total energy and applying a Boltzmann distribution at room temperature, we determine the distribution of fields within the cavity. We demonstrate that at the nanoscopic level, the expected magnitude of the electric field is larger than the applied EEF. We suggest that in our simulation the dipole-dipole interaction energy overpowers the energy of the EEF on the dipoles, causing little change to the thermodynamic distribution. We suspect that the limitation of our model, which uses a pure dipole approximation, could explain our results and in the future we will improve our model to overcome this problem.

Madeline Wiseman CC'25, Biology

Faculty Mentor(s) or Supervisor(s): Margaret Rice
Title: Anatomical Evidence for GABA-A Receptors on dopamine axons for Autoregulation of Striatal Dopamine Release by Co-released GABA

Abstract: Parkinson's disease is caused by the loss of dopamine producing neurons in the brain that send their axons to the striatum. These axons are known to co-release dopamine and the inhibitory transmitter gamma-aminobutyric acid, or GABA, but the function of this GABA co-release is unclear. Data from the Rice Lab (NYU Sch. of Med.) shows that co-released GABA acts to limit dopamine release in mouse striatal slices via GABAA receptors. This project investigated whether there is a substrate for inhibition of dopamine release by co-released GABA on dopamine axons. To visually establish the presence of GABAA receptors on dopamine axons immunohistochemistry with fluorescence confocal microscopy was used to optimize conditions and validate specificity of a primary antibody for α3-GABAA receptor subunits in mouse tissue sections; mRNA for α3-subunits are in 90% of dopamine neurons. Immunostaining was seen when the antibody was applied at either a 1:1000 or 1:200 dilution. However, only immunofluorescence with 1:200 was eliminated when the α3-GABAA receptor antibody was preincubated with its corresponding blocking peptide. Importantly, high magnification of immuno-stained images in striatum showed evidence of co-localization of α3-GABAA receptors on tyrosine hydroxylase immunolabeled dopamine axons. These data were vital to validate other findings in which immuno-electron microscopy was used to visualize the subcellular location of α3-subunits using the same antibody and concentration. Quantification of these data revealed that approximately 50% of dopamine axons express α3-GABAA receptor subunits. Together, these functional and anatomical data introduce a novel mechanism by which co-released GABA acts to auto-inhibit dopamine signaling..

Vivian Wu CC'25, Ancient Studies

Faculty Mentor(s) or Supervisor(s): Calvin Pan
Title: Impact of the COVID-19 Pandemic on Access and Quality of Care in Patients With Liver Diseases

Abstract: This study aimed to investigate the factors affecting access and quality of care during the pandemic in liver patients and aimed to address their needs for post-pandemic care. This study utilized a cross-sectional study design from 12/2020 until 5/2023, and semi-structured interviews with a survey of 36 questions in 9 domains. Consecutive patients in the liver clinics and healthy individuals receiving routine checkups in primary care clinics in New York City were invited. Those with diseases were excluded from the control group. We assessed frequencies of adherence to vaccinations, in-person follow-up office visits, and tele-visits.

Among 182 patients screened, 176 were enrolled (55 liver diseases/121 healthy controls). Patients in the liver group were mainly Asian, >45 years, and had hepatitis B, or metabolic-associated fatty liver disease. When compared to the healthy controls, the liver disease group had a significantly lower frequency of attending prescheduled in-person visits during the pandemic (81% [98/121] vs. 62% [34/55], p=0.006); and a significantly higher portion of patients felt unsafe to visit doctors with fears of COVID-19 infection (25% [30/121] vs 40% [22/55], p=0.04). However, there were no statistical differences between groups in the frequency of attending pre-scheduled visits before the pandemic, educational levels, receiving vaccination recommended by providers including COVID-19 vaccines, lifestyle factors including smoking, alcohol, or recreational drug use, and participation in telemedicine. Post-pandemic care to address the lack of maintenance care for liver patients is critical, particularly in those with advanced liver diseases who missed the liver cancer surveillance during the pandemic.

Nicole Xiao CC'26, Climate Systems Science & Statistics

Faculty Mentor(s) or Supervisor(s): Ed Cook and Karen Heeter
Title: Testing the efficacy of blue intensity on montane Douglas-fir to provide 500+ years of historical temperature estimates across Mexico
.
Abstract: Understanding the spatial-temporal patterns of climatic change is critical because of the intrinsic connection between climate variability and ecological, food, water, energy, and socioeconomic systems. However, regions across North America have differing levels of vulnerability and unequal resources to adapt to the consequences of climate change. Identifying spatial climate patterns improves the understanding of changes to interacting synoptic processes and internal modes of climate variability and forcing, while characterizing temporal variation in the rates of environmental change and frequency of extreme events is critical for better estimating drought and extreme heat risk (constraining future impacts) and informing policymakers and communities about strategies for climate change adaptation. This research took advantage of preexisting tree ring collections from a network of high-elevation, low latitude Pseudotsuga menziesii (Douglas-Fir) across Mexico, and conducted a comprehensive analysis of the efficacy of blue-intensity (BI) methods (measurement of amount of blue light reflected from tree ring cores) on Douglas-fir across the southern portion of its natural species range for the creation of new paleotemperature records for the Mexican peninsula. Results provide support for further efforts pursuing BI methods on low-latitude, high-elevation Douglas-fir as a strategy for improving the spatial coverage of the continental-scale North American Temperature Atlas (NATA) over the Mexican peninsula. Future work indicates continued use of BI to provide comprehensive data to fill gaps in the paleoclimate record of climatically vulnerable areas.

Selina Yang CC'24, Astrophysics

Faculty Mentor(s) or Supervisor(s): Melissa Ness
Title: The Making and Properties of Lithium-Rich Stars Using COSMIC

Abstract: Stars experience evolution phases throughout their lifetime. Current theoretical models predict that by the time stars evolve from the main-sequence (MS) stage to the red giant (RG) stage, lithium in the star will not remain. However, this does not align with observations that show that 1 percent of RGs are anomalously lithium-rich. This means that there is a mechanism of lithium production that happens in RGs, which is either associated with stars evolving in binary systems (with companions), or else a not-yet-understood internal process that can happen within single stars. New survey data from the large Gaia space mission as well as ground-based spectroscopic surveys like GALAH have provided the information to both discover lithium-rich stars and place constraints on what kinds of binary systems these stars would be consistent with. We use the binary evolution code COSMIC, to evolve binary systems to test if the observed parameter space of lithium-rich stars could be explained by binary systems in theory, and if so, what types of binary systems these are. One possibility is stars become lithium-rich via the mass transfer of a companion star, resulting in an RG-white dwarf binary system. Another is a companion spins up the RG primary and triggers lithium production, likely a wider separation white dwarf companion. We compare the theoretical mass ratios and separations of the binary systems we evolve that undergo different types of evolution, with the parameter space of the identified lithium-rich RGs from GALAH and Gaia. In this poster, preliminary results, and possible implications, are presented.

Heyuan Yao GS'24, Mathematics-Statistics

Faculty Mentor(s) or Supervisor(s): Víctor H de la Peña
Title: An Alternative Proof, via Conditional Independent Decoupling, of the Hanson-Wright Inequality

Abstract: The realm of sub-Gaussian distributions comprises a large family of probability laws. A sub-Gaussian random variable, in its essence, features an upper-bounded tail probability akin to a Gaussian function. Within this context, we unveil an important inequality closely associated with this family:

the Hanson-Wright inequality. This inequality serves to establish an upper limit, locally Gaussian and generally exponential, for the concentration probability of any quadratic form of independent sub-Gaussian variables. A modern proof of this inequality is advanced by Rudelson and Vershynin (2013). Their approach dissects the concentration probability into distinct components: the diagonal portion, and, the more intricate off-diagonal part. In this paper, we present a classical decoupling technique—conditional independent (tangent) decoupling—further introducing a renowned decoupling inequality attributed to de la Peña in 1994.Leveraging the power of this inequality, we subsequently offer an alternative proof for the off-diagonal segment. Through meticulous computation, we further furnish the precise constant associated with this inequality.

Mel Yuan CC'24, Physics

Faculty Mentor(s) or Supervisor(s): Zsuzsanna Márka
Title: End-to-End Testing of Open-Source Hardware Documentation Developed in Large Collaborations

Abstract: Large scientific collaborations, often with hundreds or thousands of members, are an excellent opportunity for a case study in best practices implemented while developing open source hardware. Using a publicly available design of timing equipment for gravitational wave detectors as a case study, we evaluated many facets of the open source hardware development, including practices, awareness, documentation, and longevity. Two diverse student teams, composed of high school and college students, participated in an end-to-end exercise of testing publicly-available documented hardware that originated from more than a decade ago. We found that the primary value of large collaborations lie in the ability to cultivate teamwork, provide a diverse set of role-models, and explore the possibilities of open hardware development of varying complexities. Learning from the experiences of the student groups, we make constructive recommendations where the open source hardware community can learn from the collaborations and vice versa.