VISIBLE THINKING

Undergraduate Research Symposium

April 20, 2021

Duke | UNDERGRADUATE RESEARCH SUPPORT OFFICE

Visible Thinking is hosted by the Undergraduate Research Support Office of Trinity College of Arts & Sciences at Duke University.

The URS Office promotes undergraduate research at Duke through workshops, the annual Visible Thinking Symposium, funding independent research, assistantships, and conference attendance, and by providing support for summer research programs.

URS Office Staff:
Dean Sarah Russell, Director
McCall Calloway, Program Coordinator
Randi Jennings, Student Support

Greetings,

It is our pleasure to invite you to join us for the Visible Thinking poster symposium for 2021. Traditionally, this event is held in-person in a central location like Penn Pavilion where peers, professors and many others on campus can view the remarkable accomplishments of our undergraduate researchers. This year, in common with so many other events at Duke, Visible Thinking will occur in virtual space, and both presenting and attending may feel a bit different. Nonetheless, we want to particularly laud our presenters this spring. Not only have these students carried on with their research through all obstacles and trials of this past year, but many have exhibited extraordinary resilience, creativity, and ingenuity as they confronted unexpected and involuntary changes to their schedules, research locations, and methodologies. We are so proud and so impressed with their work and we are delighted to have the Duke community witness all that they have accomplished.

Sarah Russell, PhD
Director of the Undergraduate Research Support Office

Table of Contents

WHAT IS URS?

MISSION

The Undergraduate Research Support Office (URS) promotes undergraduate research at Duke through workshops, the annual Visible Thinking Symposium, funding independent research, assistantships and conferences and by providing support for summer research programs.

LEADERSHIP

Director of URS Office: Dr. Sarah Russell
Program Coordinator: McCall Calloway

VISIBLE THINKING

Visible Thinking is a campus-wide symposium that celebrates undergraduate research in all disciplines. The event is held every spring.

EVENTS

URS offers outreach events that educate students about research opportunities at Duke and the research process.

RESEARCH SUPPORT

URS provides support for several undergraduate research endeavors, including the Dean's Summer Research Fellowship, the Biological Summer Undergraduate Research Fellowship, and several other term and year-long projects.

VISIT US AT UNDERGRADUATERESEARCH.DUKE.EDU

FIND US ON FACEBOOK, INSTAGRAM, AND TWITTER!

Community Engaged Research

Throughout this book, you will see abstracts with the symbol below. This identifies projects as Community-engaged Research.

Community-engaged Research (CER) projects have met some combination of the following 4 criteria:

- There were conversations with the community on the purposes of the CER.
- There was collaboration in the design of the project with a community partner.
- There was collaboration in the implementation of the project with a community partner.
- There will be public dissemination of the results of the CER.

Visible Thinking Undergraduates Abstracts

Behavioral Sciences / Psychology

Qualitative Analysis of Trust in Cross-Race Patient-Physician Interactions

Temi Adekunle

Mentor(s): Sarah Gaither and Brenda Straka

Co-Author(s): Sarah Gaither, Kathryn Pollak, Danielle Kennedy

Behavioral Sciences / Psychology

Institutional racial discrimination has negatively impacted the relationship between the healthcare system and African Americans in the U.S. Thus, prior research has shown that white patients feel more positive towards their healthcare providers compared to black patients. Knowing that positive relationships between patients and their doctors are vital for treatment and recovery, we explore if a reason for differences in the quality of patient-physician interactions can be attributed to differing levels of trust, particularly in cross-race interactions.

Previous literature has shown how patient trust differs among different races; however, these studies utilize patient self-reports which may not be as effective in assessing patient trust. In order to help expand the literature on how patient trust is assessed, fifteen audio recordings consisting of black patient-white physician dyads and white patient-white physician dyads were coded for markers of trust by assessing nonverbal and verbal cues in these interactions. It was found that white-white and black-white patient-physician interactions have shared and contrasting ways of demonstrating trust. Thus, this study helps to provide a rare look into the dynamics that lead to increased trust for same-race patient-physician interactions compared to cross-race patient-physician interactions.

Graduation with Distinction Candidate - Psychology

Enhancing Knowledge Structures Using Top-Down Processing

Molly Apsel

Mentor(s): Ruth Day

Behavioral Sciences / Psychology

How can we tell how well someone knows information about a topic? Traditional tests reveal some aspects of knowledge but not much about the structure of that knowledge. Sorting tasks can help uncover knowledge structures – participants sort concepts into piles based on similarities they perceive. This research examined the consequences of encouraging top-down processing in sorting tasks. Experiment 1 used a familiar everyday content domain (fruit) while Experiment 2 used a new technical domain (COVID-19). There were two conditions in each experiment. In the Basic condition, participants sorted items without labeling their categories. The results served as the baseline to compare with the Labeling condition. In the Labeling condition, participants labeled their piles during the sorting task, which involves top-down processing. The Labeling condition was predicted to increase overall sorting structure for the new COVID-19 category but not for the familiar fruit category. Other analyses were conducted to determine the principles used in the sorting tasks and whether prototypical items were sorted differently from other members of the content domain. The results suggest that a top-down processing task can increase overall knowledge structure for new technical domains but not for more familiar everyday domains. This research holds implications for educational practice as well as for cognitive theory.

Graduation with Distinction Candidate - Psychology

Masculinity and Novel Contraceptives: How norm conformity may influence preference

Connie Dean

Mentor(s): Dr. Nancy Zucker and Samuel Marsan

Behavioral Sciences / Psychology

Background: The impact of masculine norm endorsement on decision making regarding male contraceptive methods is a bounteous, yet unexplored, area of research.

Aim: Understanding how masculinity and attitudes towards sex impact male contraceptive usage and preference could inform strategies to improve uptake and usage. Increased contraceptive use could have profound public health and financial impact given the potential to prevent unwanted pregnancies.

Method: Male participants aged 18+ completed a self-report electronic survey assessing masculine norm endorsement, attitudes towards sexuality and likelihood-of-usage of three novel male contraceptives; namely Nestorone, MENT and RISUG. Masculine norm endorsement was measured using an adapted version of Parent and Moradi's Conformity to Masculine Norms Inventory-46, and the Sexual Opinion Survey was used to assess positive-negative attitudes toward sex. Participants were also asked which of the three contraceptive they would be most likely to use and why

Results: The data showed no significant correlation between either masculine norms endorsement or attitudes towards sexuality and likelihood-of-usage for novel male contraceptives. However, the sample did show a hierarchy of preference; Nesterone was the most preferred method, followed by RISUG and finally the sample indicated a significant aversion to MENT. For each contraceptive, common themes for preference were easily identifiable. Those who preferred Nesterone cited 'Non-invasiveness' and 'Ease of use' as their reasoning. Those who preferred RISUG indicated that the 'Convenience' and 'Longevity' of the method were the reason for preference. For those who preferred MENT, cited 'Non-daily use' and 'Less invasive [that RISUG]'. These individuals seemed to fit a niche between RISUG and Nesterone; whilst they do not wish to partake in the daily application of Nesterone, they are also opposed to the procedure involved with RISUG.

Conclusions: The results of this study have shown that the sample showed preference concerning the novel forms of male contraceptives presented. The reasons indicated by the sample regarding their preference indicate specific driving factors motivated by what the individual values. Namely ease of use, longevity and surgical procedure avoidance. Thus, this study yields important data that may help to inform future contraceptive design and research to meet the needs and preferences of young adult males.

Graduation with Distinction Candidate - Psychology

Gray Matter Volume in Adults with Attention Deficit Hyperactivity Disorder

Eleanor George

Mentor(s): Dr. Alison Adcock and Dr. Shabnam Hakimi

Behavioral Sciences / Psychology

Scientific studies of gray matter volume differences within the mesocorticolimbic system in adults with ADHD have produced contradictory results that do not relate factors such as subtype of the disorder, childhood structural abnormalities, and gender, leaving an incomprehensive understanding. This paper undertakes a systematic review of studies involved in this field to discern patterns across data sets to better understand how structural differences present in adults with ADHD and the influencing mechanisms. Across studies, the most reliable findings were decreased gray matter volume in the prefrontal cortex, anterior cingulate cortex, and the hippocampus. Inattention was correlated with decreased gray matter volume in the prefrontal cortex, anterior cingulate cortex, and right amygdala and an increase in the left nucleus accumbens. Hyperactivity-impulsivity was correlated with decreased gray matter volume in the prefrontal cortex, left anterior cingulate cortex, right amygdala, and left hippocampus. Combined-type ADHD was associated with decreased gray matter volume in the prefrontal cortex and hippocampus. Adults with childhood-onset ADHD had decreased gray matter volume in more structures than those with adult-onset ADHD. Gender differences were not significant confounding factors in adults. These findings suggest that specific regions of the mesocorticolimbic system in adult ADHD symptomatology are affected by the timing of the onset of symptoms. These structural findings isolating regions involved in each subtype of ADHD, suggest that future experiments can begin to target medications towards certain regions based on subtype.

Pledging and Pumping Iron: The Relationship Between Fraternity Membership and Disordered Eating

Dorothy Gheorghiu

Mentor(s): Nancy Zucker

Behavioral Sciences / Psychology

Eating disorder research almost exclusively focuses on the female experience, and with that, the potential contagious social influences of disordered eating among female peers. Groups that value aesthetics and status may be a particularly potent vehicle for disordered eating influence. For example, eating disorder symptoms were found to increase within a sorority, with similar increases among specific high status peer groups. Yet, despite sharing similar values, there have been no studies to date exploring the experience of disordered eating within male fraternities. In order to address this disparity, the current study evaluated 81 male fraternity members at Duke University, ranging in age from 18-22, with an average age of 20. Most students, 48% (n = 39), were sophomores, with 27% (n = 22) juniors, and 25% (n = 20) seniors. Participants completed an online survey including several validated measures, indexing disordered eating behaviors (EPSI), depression (PHQ-9), anxiety (GAD-7), loneliness (UCLA Loneliness Scale), and functionality (Sheehan Disability Scale) in addition to original questions gauging level of personal identification with their fraternity and their level of involvements. Comparing fraternity identification results with scores on the Eating Pathology Symptoms Inventory and other mental health indices indicated whether an association may exist between fraternity membership and disordered eating. It was found that there was a significant positive correlation between binge eating and fraternity membership, while there was a significant negative correlation between fraternity membership and excessive exercise and muscle building.

Graduation with Distinction Candidate - Psychology

Evaluating Controversies Surrounding PTSD and Proposing a Developmental Framework

Xinyi Hong

Mentor(s): David Rubin

Behavioral Sciences / Psychology

If you were asked to recount the most traumatic thing that has ever happened to you, would you be able to tell a cohesive story with vivid details? Or would the memory come to you in bits and pieces which are difficult to put together? The answer to this question may have drastic implications for how scientists and mental health professionals understand, study, and treat psychological trauma. The idea that trauma memories in patients with post-traumatic stress disorder (PTSD) are particularly fragmented or disorganized compared to other memories is a central tenet of many preeminent cognitive models and theories of PTSD. These theories assert that PTSD symptoms arise because memories of the traumatic event are so shocking that they are unable to be readily incorporated into an individual's existing schemata; therefore, the memory is kept active and is continually processed until they are integrated with existing memories. However, more recent studies have demonstrated that trauma memories in PTSD patients are actually particularly enhanced and vivid, not fragmented. This disconnect calls into question the validity of contemporary conceptualizations of PTSD, and is part of a broader controversy surrounding the validity of the PTSD diagnosis - and the practice of making psychological diagnoses in general. This article evaluates the debate surrounding fragmented memories in PTSD, reviews the controversies and issues surrounding current PTSD criteria, and proposes a longitudinal, birth-cohort study that capitalizes on developmental psychopathology research and a biopsychosocial approach. By moving away from flawed conceptualizations of PTSD and towards this new model, the field of traumatology can begin to shift towards a better understanding of the short- and long-term effects of psychological trauma.

Graduation with Distinction Candidate - Psychology

All Mixed Up: How Black and White Mothers Raise their Biracial Children

Ebehiremhen Izokun

Mentor(s): Dr. Makeba Wilbourn

Behavioral Sciences / Psychology

Biracial individuals are a growing population, and it has been shown by literature that Black and White mothers have different parenting styles due to reasons mostly concerning culture and history. These different parenting styles typically lead to Black and White children growing up with different experiences and also potentially having different outlooks on life as a result. Therefore, the present study examines if these variations in parenting styles translate when Black and White mothers are raising biracial children. If these variations do indeed translate, then that would most likely result in unique contrasts regarding behavior, opinions, experiences, and outlooks in biracial children. The current study evaluates the differences in biracial college students when their mother is Black and their father is White in comparison to when their mother is White and their father is Black, through the use of three online surveys. Participants were asked to complete surveys measuring their racial identity, their experiences regarding racial socialization, and their relationship with their biracial identity. We hypothesize that biracial college students with Black mothers will have a stronger centrality to their Black identity and will have received socialization about managing racism more often than biracial college students with White mothers.

Graduation with Distinction Candidate - Psychology

Coping at the Margins: Impact of Race on Students' Coping, Sense of Self-efficacy and Belonging

Jalisa Jackson

Mentor(s): Nancy Zucker

Behavioral Sciences / Psychology

Significance. There has been a dramatic increase in the prevalence of mental illness symptoms and diagnoses in college students across the United States. The need for mental health services surpasses many colleges' capacity to provide adequate resources. This discrepancy between mental health needs and available services may be exacerbated for racially marginalized students, in part due to intensified stigma and limited access to and availability of culturally competent providers.

Method. The purpose of this study was to explore the strategies college students use to maintain their mental health, their perceptions of the accessibility of mental health resources, and whether these strategies and perceptions differed for racially marginalized students. We surveyed students at a historically white university in the southeastern region of the United States and assessed satisfaction with current resources, coping strategies, sense of self-efficacy and sense of belonging.

Results. Results indicate no significant difference between marginalized and non-marginalized students. Students' scores on coping strategies, self-efficacy and sense of belonging were similar across groups with the majority reporting low satisfaction amongst all students.

Discussion. We conclude that more research be conducted to further explore these findings and recommend that universities, especially those with a legacy of marginalizing students, continue developing suitable resources that address the mental health needs of every student.

Keywords: college students, racial marginalization, coping, self-efficacy, sense of belonging

Graduation with Distinction Candidate - Psychology

Multiple Identity Mindsets, Flexible Thinking and Cross-Race Interactions

Emma Kirkpatrick

Mentor(s): Sarah Gaither

Co-Author(s): Jane Leer, Brenda Straka

Behavioral Sciences / Psychology

Interactions between people of different racial/ethnic groups can cause cognitive depletion for monoracial individuals. Less is known about how these interactions affect multiracial people, particularly as they can claim membership to more than one racial/ethnic group. However, everyone can hold multiple social identities (e.g., gender, race, religion, etc.). Thus, this online study investigated whether a multiple identity mindset (e.g., reminding people of their multiple identities) differentially impacts cross-race interaction outcomes for monoracial versus multiracial individuals. Monoracial and multiracial participants (N = 375) experienced a hypothetical cross-race interaction after receiving a multiple identity prime or no prime. We hypothesized that on a series of behavioral tasks following the interaction, primed individuals would show higher creativity, lower cognitive depletion, and higher persistence, and that these effects would be greatest for multiracial individuals. Results showed that there was no main effect of multiple identity prime nor an interaction between race and prime on creativity, cognitive depletion, and persistence. However, findings did indicate an interaction between prime and self-reported racial identity on cognitive depletion within multiracial participants. Contrary to our hypothesis, multiple identity primed multiracial participants demonstrated increased cognitive depletion as their self-reported multiracial identity increased. Not primed multiracial participants demonstrated decreased cognitive depletion as their racial identity increased. This suggests that a multiple identity mindset may negatively impact cognitive depletion for strongly identified multiracial individuals following a hypothetical online cross-race interaction. While there was a positive association between self-reported racial identity and cognitive depletion within monoracial participants, indicating that their cognitive depletion increased as their racial identity increased, there was no effect of multiple identity prime on this association. Our findings suggest the importance of the strength of racial identity in determining behavioral outcomes following cross-race interactions. They also indicate an increased susceptibility of multiracial individuals to a multiple identity mindset providing insight into the potential role of multiple identities in affecting outcomes of cross-race interaction and improving interracial communication.

Graduation with Distinction Candidate - Psychology

What is it about context? How animal group identity shapes perceived moral value and sentience

Anne Littlewood

Mentor(s): Brian Hare and Wen Zhou

Co-Author(s): Wen Zhou, Brian Hare

Behavioral Sciences / Psychology

The way animals are perceived and valued in society varies greatly across animal species and human cultures. The nature of human-animal interactions in society is highly dependent on the situational context in which the animal is viewed. Based on the group context of an individual animal, we form perceptions and judgements that influence our decisions about what is right and wrong when it comes to ethical treatment for animals. This study investigates the contextual information that may shape our attitudes towards individual animals. We hypothesize that the same individual dog will be evaluated differently when it is introduced as a pet dog, a feral dog, or a biomedical research lab subject based on social norms and predetermined beliefs about group value. We predict that contextual cues such as group identity, individuality, and societal purpose will lead participants to differentially evaluate the mental capacity and moral value of these animals. Furthermore, we predict that perceptions of consciousness, sentience, and moral value will determine decisions about appropriate treatments for dogs. We additionally predict that pet dogs will be prioritized over feral dogs and research dogs when participants are faced with ethical dilemmas. Finally, the study will investigate the role of past experiences with invasive animal research and pre-existing preferences for the group-based hierarchy in forming evaluations of animals. This study will shed light on the psychological processes which underpins the discrimination of animals, which will provide insights into the psychology of human-animal relations and have broad implications for animal welfare.

Graduation with Distinction Candidate - Psychology

Misperceptions of Black Masculinity in Cross-Race Interactions

Conner McLeod

Mentor(s): Sarah Gaither and Adam Stanaland

Behavioral Sciences / Psychology

A history of racial tension in the U.S. has given white people false, preconceived stereotypes of how Black men are supposed to act, compared to the individuality allowed for white men. Such stereotypes of black men include being “lazy, dumb, loud, and angry,” or being an ”exception” to this rule (Way, Hernández, Rogers & Hughes, 2013, pg. 410). These disproportionately exaggerated portrayals of Black men as criminals leads while people to “chronic activation”—or an instinctive use of negative stereotypes when approaching Black men in real life (Dixon and Azocar, 2007). In this study, we test whether white men are more or less comfortable in an interaction with a Black man as a function of his (1) racial prototypicality and (2) stereotypical masculinity. Using pre-test ratings to objectively compare Black male confederates on masculinity and Blackness, this study determined that there were no statistically significant interactions between the two variables and how comfortable white male participants were when interacting with the confederates.

Graduation with Distinction Candidate - Psychology

Signs of Early Implicit Bias: Children Reason Emotions on Own Race Peers and Other Race Peers

Ryan McMutry

Mentor(s): Dr. Makeba Wilbourn and Dr. Ashley Ruba

Behavioral Sciences / Psychology

It is well established that adults are better at identifying emotion expressions on people of their own race rather than on people of a different race. The inability to correctly identify and adaptively respond to emotions can have detrimental consequences for cross race relations. Some studies have shown that this racially biased emotion reasoning may begin in early childhood. However, it is generally unclear how children reason the emotions of their peers. In the present study, we test the hypothesis that children with more exposure to other races will more accurately identify emotions on other race faces. Four- to six-year-old White children will complete a delayed match stimuli task where they matched the emotions happy, sad, angry, and fear on sets of White and Black children faces. Caregivers will be given a questionnaire that asked about home, neighborhood, and school environments as well as how parents speak with their child about race to determine the child's level of exposure to other races.

Key words: emotion reasoning, racial bias, children, other-race-effect, implicit bias

Graduation with Distinction Candidate - Psychology

Episodic Simulation Reduces Social Dominance Orientation

Ian Miles

Mentor(s): Brian Hare and Wen Zhou

Behavioral Sciences / Psychology

Social dominance orientation (SDO), the desire for group-based inequity and dominance, is a psychological process that drives intergroup bias, discrimination, and violence. Intervening SDO is critical for improving intergroup relations at a cognitive level. One way to reduce SDO is to increase intergroup contact. Both real and imagined forms of contact have been found to increase prosociality and empathy toward outgroup targets involved in the contact. One particular form of imagined contact, episodic simulation, directly stimulates empathy and thus reduces intergroup bias at ideological and behavioral levels. This study (N=201) expands existing work and examines the effect of episodic simulation of helping behaviors in reducing SDO and increasing prosocial intents toward outgroup members using a between-group design. In four conditions, participants simulated the detailed helping of injured racial ingroup members, racial outgroup members, and animals. The episodic simulation manipulation reduced SDO in human helping conditions (vs control). These findings have major implications for understanding intergroup relations and designing strategies for intervening intergroup bias.

Graduation with Distinction Candidate - Psychology

Chasing Dreams or Avoiding Ruin: Neural Activation to Goal Priming in Low-Income Adolescents

Urmi Pandya

Mentor(s): Tim Strauman

Co-Author(s): Carol Daffre, Madeline Farber, Linda Burton, Tim Strauman

Behavioral Sciences / Psychology

Goals are central to our identities. An important process related to goals is self-regulation: the process of pursuing goals despite internal and external forces that might disrupt it. Adolescents particularly have been shown to struggle with self-regulation, and environmental factors, namely poverty. One framework of self-regulation is regulatory focus theory (RFT). RFT consists of two types of regulatory focus: promotion and prevention focus. Promotion focus refers to self-regulation to achieve a positive end-state, such as studying to getting a good grade on a test (i.e., an ideal goal). Prevention focus refers to self-regulation to avoid a negative end-state, such as studying to avoid a bad grade on a test (i.e., an ought goal). This work follows self-regulation as defined by RFT and centers on neural correlates of goal attainment in low-income adolescents as it is an unexplored area in the literature. It was hypothesized that the low-income adolescents will show greater activation in their right prefrontal cortex (PFC) when primed with their ought goals compared to control adolescents. The control adolescents will show greater activation in their left PFC when primed with their ideal goals compared to the low-income adolescents. This study compared performance on a subliminal priming fMRI task between a small sample of low-income adolescents and control adolescents. It was found that the low-income adolescents showed greater activation than the control adolescents in areas associated with self-focus for ideal goals that they were close to attaining but less activation in those areas for ideal goals that they were far from attaining and ought goals they were close to attaining. These results highlight that perhaps goal attainment is more influential than the type of goal and challenge traditional assumptions of self-regulatory focus in low-income adolescents.

Graduation with Distinction Candidate - Psychology

Daddy's Diction: The Influence of Parental Speech on Language Development and its Context

Samantha Peterman

Mentor(s): Makeba Wilbourn

Behavioral Sciences / Psychology

There are many influential factors for a child's language development; however, one of the most impactful is how a parent talks to their child. Past research has focused on mothers' language input. Consequently, much less is known about how fathers address their children during play and reading, and how these interactions differ from mothers and influence language development. It is hypothesized that fathers will differ in child directed speech based on the gender of their child, as fathers will most likely speak more to their daughters. Furthermore, it's hypothesized that paternal speech will include more questions and adjectives when compared to maternal speech, thus influencing their child's expressive and productive language development more. In the current study, parents of infants aged 16-36 months (N = 35, N = 20 father-infant dyads, N = 15 mother-infant dyads) completed the MacArthur Short Form, noting which words their infant understood and/or produced, and the number of words and word types were tallied. Next, parents were instructed to narrate a wordless picture book to their infant for 10-15 minutes, and afterwards play with a set of toys with their child for 10 minutes. These narrations were transcribed and coded for several features: total number of words, unique words, common nouns, pronouns/proper nouns, adjectives, verbs, total number of questions and types of questions. The different types of speech that was coded for was then related to the word inventory done on the child. Moreover, the types of speech used during paternal-infant interactions and maternal-infant interactions were compared. Preliminary results show that wh- questions, as well as the combination of proper nouns, pronouns and common nouns in paternal speech during the book task are predictors of a child's productive vocabulary. Thus, this current study demonstrates the differences in which fathers and mothers speak to their infants, which in turn influences infant vocabulary development and speech.

Key words: language development, parental speech, father-infant interaction

Graduation with Distinction Candidate - Psychology

Young Children's Production and Comprehension of the Pronoun "We"

Dayna Price

Mentor(s): Michael Tomasello

Co-Author(s): Jared Vasil and Dr. Michael Tomasello

Behavioral Sciences / Psychology

Learning to properly produce and comprehend pronouns are among the many challenges of learning a language that children must master. While there are many studies that focus on pronouns generally, there is a lack of research on children's acquisition and usage of the pronoun "we" specifically. "We" is of particular importance given that, as children are learning a language, their social perceptions of groups are changing as well. Shared intentionality theory posits that there is a shift around 3 years of age wherein kids move from understanding dyadic interactions to understanding larger groups. If this shift in group understanding occurs around age 3, then we expect a shift in the usage and perception of the pronoun "we" to be occurring at that same time. This study seeks to understand children's perception and comprehension of the pronoun "we" before and after this pivotal shift in group understanding occurs. We predict that children under 3 will be less likely to spontaneously produce "we" when referring to a 3-person interaction, as well as less likely to interpret an ambiguous "we" as referring to a 3-person group. A fully online study was conducted with 2.5-year-olds and 4.5-year-olds that included production and comprehension components in order to test these hypotheses.

Graduation with Distinction Candidate - Psychology

The Construction of Masculinity Norms in Black Men and Their Self-Perception

Breon Robinson

Mentor(s): Sarah Gaither

Co-Author(s): Adam Stanaland and Sarah Gaither

Behavioral Sciences / Psychology

Men are shaped by the pressures they experience to prove their manhood (Bosson et al., 2021; Stanaland & Gaither, 2021). In the U.S., for example, men in Cultures of Honor norms are more likely to use violence to defend their manhood than men in regions with "looser" norms (Harrington & Gelfand, 2014; Nisbett, 2018). To date, however, the psychosocial research on masculinity has tested mostly white men. We explore how race affects the development of masculinity in the U.S.

We are currently recruiting 400 American men (ages 18-40) who identify as monoracial white, Black, Hispanic/Latino, and Asian American (100 per group). After completing demographic questions, participants answer the open-ended question, "What did it mean to 'be a man' to the people you grew up around? What kind of men and masculine qualities were admired?" Participants will also rate the extent to which they learned these definitions from (1) people in their family, (2) their communities, and (3) the media. Next, participants will rate their endorsement of stereotypical masculine norms (MRNI-SF; Levant et al., 2016) and their conformity to masculine norms (CMNI-30; R. Levant et al., 2020; Stanaland & Gaither, 2021). Drawing on economic insecurity theory, we hypothesize that men from racial groups with histories of economic insecurity and political disenfranchisement in the U.S. (i.e., Black, Hispanic/Latino) will hold more restrictive masculinity ideals— which in turn predicts more internalized pressure— than groups who have fared better socio-economically (i.e., white, Asian). We also predict that men from cultures with more communal orientations (e.g., Black, Hispanic/Latino, Asian) will have learned masculinity norms more from their communities (e.g., non-family adults) compared to white men. Results from this study will have implications for theory and practice regarding how boys and men from understudied cultural backgrounds are socialized in response to different rigid masculinity norms.

Examining the Association between the COVID-19 Pandemic and Family Stress among Latinx Families

Ameya Sanyal

Mentor(s): Eve Puffer, Savannah Johnson, and Dr. Gabriela Nagy

Behavioral Sciences / Psychology

The COVID-19 pandemic is a large-scale public health crisis affecting the safety and well-being of individuals, families, and communities. With economic loss, work and school closures, and limited assistance programs, feelings of insecurity, emotional isolation, and stigma may translate into psychological distress and unhealthy coping behaviors. For families in lockdown, COVID-19 may increase parental stress with concerns of economic and physical health, social isolation, and lack of government support. For children out of school or child care, they may be without structured access to educational resources or opportunities for social interaction. Though the pandemic may enable families to spend a greater amount of time together, risk of harsh interactions increases with pandemic stressors and exacerbation of existing vulnerabilities. Within the United States, COVID-19 has reinforced health disparities, with marginalized and under resourced communities suffering disproportionately higher exposures to the virus, poorer clinical outcomes, and higher mortality rates. With strong links between parent and child psychological well-being, studying the parent-child relationship may yield insights into mental health interventions in the context of COVID-19. To understand the association between the COVID-19 pandemic and stress, functioning, and well-being among Latinx families, an online survey battery was developed and administered to parents with children in the American South. Questions addressed parent mental health, child mental health, family functioning, acculturative stress, and the effects of the COVID-19 pandemic on behaviors and social interactions. Data collected is relevant to a post-pandemic setting, where health and economic impacts continue to persist. By examining factors related to family functioning, strategies for adapting and implementing evidence-informed parenting interventions can be developed.

Graduation with Distinction Candidate - Psychology

Patients' attitudes toward medication, taking medication, and non-adherence

Danielle Smith

Mentor(s): Cheryl Lin and Pikuei Tu

Co-Author(s): Cheryl Lin, Danielle Smith, Pikuei Tu, and Rungting Tu (Shenzhen University)

Behavioral Sciences / Psychology

Background: Medication nonadherence is highly prevalent amongst rheumatoid arthritis (RA) patients. Previous research has focused on patients' cognitive beliefs in medication and cost/benefit analysis when reasoning their behavior. This study examined patients' perceptions and emotions toward medications in parallel with attitudes on their own nonadherence.

Methods: We applied a semi-structured interview format and included projective techniques. We conducted four 90-minute focus groups consisting of RA patients (N=20) with diverse levels of disease severity, diagnosed history, and self-reported adherence. Transcripts were analyzed in NVivo-12 using a thematic coding framework.

Results: Three themes emerged, each mixed with both positive and negative sentiments: 1) Feelings toward medication: the majority of participants expressed negative feelings of concern, dependency, and embarrassment, detailing a reliance on medications that encroaches on freedom; 2) Perceptions of medications: participants revealed identifying with their chronic medications, becoming attached despite predominant unsettled feelings towards the physical act of taking medication; 3) View on own nonadherence: negative emotions, including feeling worried and risky, were prevalent while a third of participants felt empowered when self-adjusting their regimen. Participants also stressed a greater understanding of their bodies compared to doctors, fueling self-efficacy and confidence in managing symptoms and medication.

Conclusion: For many participants, the desire to restore a sense of control that seemed lost upon diagnosis with RA and receival of a strict treatment regimen became a motivator for adjusting medications. Promoting shared decision-making in treatment and enforcing periodic discussions of medication-adjustment needs could prevent patients from feeling disempowered and encourage better adherence.

Active Coping, Acculturative Stress, and Wellbeing in the Latinx Immigrant Community

Guadalupe Tarango

Mentor(s): Dr. Moria Smoski, Dr. Gabriela Nagy, and Dr. Rosa Gonzalez-Guarda

Co-Author(s): Dr. Scott DeMarchi

Behavioral Sciences / Psychology

Latinx immigrants tend to have superior health outcomes in comparison to U.S born Latinx individuals and white counterparts upon arrival to the United States. However, these health advantages erode over time. Critical physical and mental health declines have been associated with the consistent exposure to acculturative stressors or stressors related to the challenges of acclimating to a new immigrant destination. Previous research has revealed that repetitive active coping in response to difficult social and economic stressors is a major contributor to racial and socioeconomic disparities in hypertension and related cardiovascular diseases in the African American community. This finding has been coined as the John Henryism Hypothesis. Further research is required to understand if the John Henryism Hypothesis is translatable to other ethnic minority populations. Our study seeks to fill this gap in the existing literature by understanding how active coping and exposure to acculturative stressors impacts overall mental health and well-being among Latinx immigrants. Our data is derived from a longitudinal study in the Research Triangle area of North Carolina comprised of young adult (ages 18-44 years) Latinx immigrant participants (N = 389.) In the first aim, we will characterize the sample by measuring average levels of active coping, acculturative stress (immigration, discrimination, and economic sub-scales), mental health indicators (depression, anxiety), and wellbeing indicators (physical function, fatigue, pain, emotional distress, social health, sleep disturbance.) In the second aim, we seek to characterize the unique contribution of active coping to health outcomes, after controlling for demographic covariates (age, age at migration, years living in the US, gender, socially assigned race, street race, self-reported race, household income, employment status, formal education level) and acculturative stressors. We hypothesize that greater levels of active coping behavior will predict worse scores on mental health and wellbeing measures, as seen in the John Henryism Hypothesis when studying physical health outcomes. This study uses various measures to expand the existing literature of the John Henryism Hypothesis from the African American community to the Latinx immigrant community. Results from this study have the potential to inform and strengthen current approaches to optimizing health interventions for this prevalent community.

Graduation with Distinction Candidate - Psychology

Cross-fostering Influences the Effects of Air Pollution and Prenatal Stress on Social Behavior

Jason Zhang

Mentor(s): Staci Bilbo and Dr. Caroline Smith

Behavioral Sciences / Psychology

Air pollution and stress are common environmental factors encountered in everyday life. Recent epidemiological work has demonstrated that exposure to these factors during pregnancy is associated with a greater risk of having a child that develops an autism spectrum disorder (ASD). ASD consists of a group of developmental disabilities characterized by significant social behavior and communication deficits. Recent mouse studies in the Bilbo lab demonstrate that prenatal exposure to diesel exhaust pollution and maternal stress (DEP/MS) significantly reduces sociability and social novelty preference and alters the composition of the gut microbiome in male offspring. These findings suggest that the gut-brain-immune axis may be mediating a sex-specific effect on male social behavior. However, the specific mechanisms by which these environmental factors are causing such changes remain unknown. This project sought to evaluate whether changes in the gut microbiome may mediate effects of prenatal DEP/MS on social behavior in male offspring. Cross-fostering at birth has been shown to shift the infant microbiome to that of the foster mother. Therefore, we cross-fostered DEP/MS-exposed offspring to vehicle/control (VEH/CON) exposed mothers, and vice versa, on the day of birth. Sociability and social novelty preference tests were then used to assess social behavior outcomes. This paradigm was performed for both male and female offspring to evaluate possible sex-specific effects. We found that deficits in the sociability of DEP/MS male offspring were rescued by cross-fostering to a VEH/CON dam. Male social novelty preference was not different between the treatment groups. No deficits in sociability were detected in females, but prenatal DEP/MS treatment was associated with deficits in social novelty preference when females were cross-fostered to a VEH/CON dam. We are currently verifying that the gut microbiome is indeed changed by cross-fostering. These observations suggest that cross-fostering influences the effects of DEP/MS on social behavior and that the relationship between cross-fostering and social behavior is likely complex and sex-specific.

Student-athlete or Athlete-student? How mindsets shape college athletes' experiences

Adam Zimmer

Mentor(s): Bridgette Hard and Michelle Wong

Behavioral Sciences / Psychology

Student-athletes compose a special group within top-academic schools, since they essentially have to juggle two full time jobs: their sport and their school. However, the extensive time required to play a college-level sport may impact student-athletes' performance in both their school and their sport. One way we can understand student-athletes at the university level is to explore two types of mindsets, ability and stress, which can play a role in an individual's performance and overall well-being. Our research aims to understand how the mindsets of student-athletes, within the domains of athletics and academics, impact their experiences and well-being. College student-athletes nationwide were surveyed on their ability and stress mindsets, perceived stress, perceived effort, perceived success, and identity within athletics and academics. They also self-reported their well-being both mental and physical along with their GPA. The findings showed that an enhancing stress mindset was the biggest predictor of different outcomes such as perceived stress, depression, anxiety, and general health. Academic stress mindset predicted both within and across domain outcomes, but athletic stress mindset only predicted within domain outcomes suggesting academic stress mindset might be more powerful in influencing outcomes. An exploratory analysis revealed that student-athletes attending highly selective schools (acceptance rate < 10%) had significantly more enhancing mindsets and better well-being than those at less selective schools. Future analysis will look at how school selectivity moderates the relationship between mindsets and outcomes. These results suggest that interventions to help athletes adopt a more stress is enhancing mindset in the academic domain might have a positive effect on their overall well-being and stress both academically and athletically.

Graduation with Distinction Candidate – Psychology

Biological Sciences

A moving meal: the impact of gut sensory stimulation on mouse pose

Clayton Baker

Mentor(s): Diego Bohórquez and Laura Rupprecht, PhD

Biological Sciences

To eat is to move; an individual must grab, chew, and swallow food to eat. In order to achieve this appropriate relationship, the gut and brain must communicate to accurately drive these behaviors. While it has long been recognized that nutrients entering the small intestine change behaviors at large timescales (minutes to hours), how the gut regulates behaviors on a second-to-second basis is unexplored. In 2018, our laboratory discovered that sensory gut epithelial cells form synapses and communicate rapidly to the vagus nerve, which connects the gut and the brain. These synaptically connected cells are called neuropod cells. Neuropod cells are acutely stimulated by nutrients and influence mouse eating behaviors within seconds. Preliminary work from our laboratory demonstrated that stimulating neuropod cells via direct nutrient infusion to the small intestine indicated differential locomotion based on an infusion of sugar, fat, sweetener, or control. In order to determine if nutrients elicit movement on a second-to-second timescale, the specific responses to each nutrient must be established. By classifying the behaviors produced by the gut-brain circuit, the molecular mechanisms in which nutritional value is rapidly communicated to the brain can be investigated.

To test whether nutrients evoke discrete behavioral events in mice, machine learning was applied to videos of mice during infusion of fat or control solutions. Mice were surgically implanted with chronic, indwelling catheters directly to the small intestine. Using these implants, mice were video recorded while receiving 5 infusions of fat or control solution, in 30 second intervals over 10 minutes. Then, a small subset of these video frames was labeled for mouse nose, paws, and tail. Using an open-source machine learning software package, DeepLabCut, a prediction model was trained and estimated mouse position for all videos. To detect unique behaviors, these pose estimations were further evaluated using an unsupervised clustering algorithm, Behavioral Segmentation of Open-Field. Using this system, we were able to classify clustered behaviors in mice receiving infusions into the small intestine. Moreover, as mouse emotional states are identifiable with machine learning, this experiment has created the basis for exploration of emotional states elicited by specific nutrients; surely, there is no emotion without motion.

Comparing the Module Architecture of a Novel Parasite Gene Cluster to Bacterial Systems

Elizabeth Boger

Mentor(s): Emily Derbyshire and Aaron Keeler

Biological Sciences

For the past 30 years, pharmaceutical companies have relied on natural products to create up to 50% of their approved drugs. Polyketide synthase (PKS) megaproteins provide inspiration or molecular scaffolding for a majority of these natural products. A large majority of the current knowledge of PKSs extend primarily from the study of bacterial, fungal, and plant systems, and with the growing demand for novel natural products, a search for PKS products in atypical organisms is necessary. A recently discovered gene in T. gondii, a protozoan intracellular parasite, TgPKS2, has shown to have a unique modular architecture, with 3 clear modules. In order to characterize this PKS system, we will clone specific domains of TgPKS2, encompassing module 3, into an expression vector and optimize protein expression in BL21-Codon Plus cells. Obtaining this protein in sufficient yields will allow for further structural studies and comparisons of this unique PKS system to previously described assemblies and will allow us to determine evolutionary differences, thus paving the way for potential discovery of novel natural products in parasites with similar processes.

Receptor Internalization as a Mechanism of Biased Agonism at CXCR3

Noey Boldizsar

Mentor(s): Sudarshan Rajagopal

Co-Author(s): Dylan Eiger, Cole Honeycutt, Julia Gardner, Isaac Choi

Biological Sciences

GPCRs are the largest class of receptors in the human genome. They are expressed in virtually every cell type and are implicated in numerous physiological processes. GPCR signaling is highly specific due to biased agonism, in which different ligands, receptors, or cellular systems selectively activate different signaling pathways. The chemokine system, a subfamily of GPCRs primarily present on leukocytes, serves as an endogenous example of biased agonism due to the significant promiscuity between chemokine ligands and receptors. For example, the chemokine receptor CXCR3 and its ligands CXCL9, CXCL10, and CXCL11 display bias both in vivo and in vitro. The mechanisms of biased agonism are not entirely understood, and thus present an exciting area of inquiry to further understand the specificity of GPCRs.

GPCRs are conventionally understood to signal exclusively from the plasma membrane. Therefore, the ligand-induced internalization of receptors is thought to desensitize G protein-dependent signaling. However, recent research has shown that numerous GPCRs signal from intracellular membranes, including the golgi and the endosome. This novel finding has led to the discovery that the subcellular location of a GPCR can affect its functional output.

The objective of this current study is to evaluate the contribution of receptor endocytosis to CXCR3's biased agonism. As CXCL9, CXCL10, and CXCL11 display striking differences in their ability to promote internalization, we investigated how these differences contribute to their other demonstrated bias. We engineered a location-specific biosensor that detects active G proteins at either the plasma membrane or endosome. Using this tool, we found that CXCL9, CXCL10, and CXCL11 display a biased pattern of endosomal G protein activation. Additionally, inhibiting endocytosis decreased CXCR3's ligand-induced ERK ½ phosphorylation and transcriptional reporter activation to different extents depending on ligand identity. Finally, we conducted a global transcriptomics analysis of CD8+ T cells and found that the three ligands displayed significantly different transcriptomic profiles. As endocytosis contributes to the CXCR3's regulation of transcription, we hypothesize that endocytosis is partially responsible for the differential global transcriptional profiles generated by CXCR3's endogenous ligands. These data together suggest that receptor endocytosis is a mechanism of the biased agonism of the endogenous ligands of CXCR3.

Graduation with Distinction Candidate - Biology

Characterizing the role of endfoot-localized NM myosin II in neurogenesis

Annalise Bracher

Mentor(s): Debra Silver and Brooke D'Arcy

Co-Author(s): Brooke D'Arcy, Ashley Lennox

Biological Sciences

During neurogenesis, the brain undergoes extensive genetic regulation to properly coordinate its growth and development. Radial glial cells (RGCs) are one type of neural stem cell crucial to the proper development of the brain and are known to facilitate the migration of neurons to the cortical plate via their basal processes. These highly polarized cells consist of a cell body adjacent to the ventricle and small, pod-like structures at the distal end of their basal process known as endfeet that make attachments to the surrounding basement membrane. Much is still unknown about the role that these endfeet play in neurogenesis. However, previous research suggests they are sites of local protein production, and recent unpublished proteomics data from the Silver Lab have identified various proteins enriched within RGC endfeet compared to the cell body. Non-muscle (NM) myosin II proteins are one class of protein shown to be highly and significantly enriched in endfeet. These proteins are known for their role in cell motility and adhesion, and recent experiments have demonstrated their importance in proper neuronal migration. Here, we have investigated the morphological effects from the loss of an isoform of NM myosin in RGCs using a line of cre-inducible conditional KO (cKO) mice. Comparison between embryonic day 16.5 brains of cKOs, conditional heterozygotes, and wild type mice shows myosin loss results in reduced cortical thickness and endfoot disorganization at the basement membrane. This phenotype was significant for cKOs but not for heterozygotes. Our findings implicate NM myosin in crucial local endfoot functions related to RGC morphology as well as global cortical architecture during neurogenesis. Additionally, stable cell counts of Sox2-positive progenitors across all conditions suggest these phenotypes are not driven by progenitor cell death. The exact mechanisms underlying these KO morphologies remain to be determined, but these findings are a first step in elucidating the role of endfeet and their constituents in neurogenesis.

Graduation with Distinction Candidate - Biology

Developing a Novel Fluorescent Tool to Monitor K63 Ubiquitin in Living Cells

Emma Bucklan

Mentor(s): Gustavo Silva and Nate Snyder

Biological Sciences

Eukaryotes have a conserved network of cellular signaling pathways in which a small protein named ubiquitin is conjugated to substrates as single subunit or chain modifications. The various connections formed between ubiquitin molecules generate different signals that determine the substrate fate. There is a diversity in ubiquitin functions, but we lack tools to dissect it and understand their unique functions and modes of regulation. The goal of this research is to develop a tool for observing K63-linked ubiquitination in live cells and in real time. This method will permit us to elucidate many still-unknown details of human cell response to oxidative stress, a key effect of neurodegenerative diseases. In this project, I developed a modified version of bimolecular fluorescence complementation (BiFC), a quantitative process by which fluorescence can be used as a proxy for measuring protein-protein interactions. In BiFC, one protein is linked to the C-terminus of a fluorophore, and another protein is linked to the N-terminus of a fluorophore. When the two proteins bind each other, they bring the two halves of the fluorophore in proximity, folding into a functional fluorophore, which can be excited to emit light detectable by a fluorimeter or a fluorescent microscope. In this edited version of BiFC that I have engineered, known as ubiquitin-induced fluorescence complementation (UiFC), the two ubiquitin binding domains are linked to either the C- or N- terminus of the fluorescent protein mCherry. One domain cloned was the ubiquitin interacting motif (UIM), which generally binds polyubiquitin chains. The other domain cloned was the Npl4 zinc finger (NZF) domain, which binds between two K63-linked ubiquitin subunits, providing linkage specificity. Domains were inserted into two separate mammalian expression plasmids and sequenced. Linkage specificity is determined by expressing these constructs in E. coli and reacting them with purified ubiquitin chains. The final goal is to express these constructs in human cells such that, using UiFC, fluorescence is expected to correspond to levels of K63 ubiquitination. Thus, this system will allow us to measure cells' reactions to various external stimuli and to understand more about the mechanisms by which our bodies respond to the physiological stresses that emerge from diseases such as Alzheimer's and Parkinson's disease.

Genetic variants in PEX2, PEX5L, PEX7, and FAM120B predict non-small cell lung cancer survival

Allan Chen

Mentor(s): Qingyi Wei

Co-Author(s): Hongliang Liu

Biological Sciences

Peroxisomes likely play a variety of cellular roles in lipid metabolism and regulation of reactive oxygen species, which are important for the growth and promotion of cancer. However, the peroxisomal functions in the development and progression of non-small cell lung cancer (NSCLC) remains incompletely understood, and in particular few studies have investigated how genetic variants in peroxisome-related genes are associated with NSCLC survival. Therefore, we investigated associations between 9,708 SNPs in 113 genes in the pathways related to peroxisome activities and survival of NSCLC patients obtained from the Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial (PLCO) and the Harvard Lung Cancer Susceptibility (HLCS) study. We used genomic data from 1,185 NSCLC patients from the PLCO trial and additional 984 NSCLC patients from the HLCS study for survival-association analyses. Overall, we found that 213 SNPs were significantly associated with NSCLC overall survival (OS) [$P \leq 0.05$, Bayesian false discovery probability (BFDP) ≤ 0.80). After independent validation with the HLCS data, 16 of those SNPs were found to be significantly associated with NSCLC OS. After adjusting for clinical variables and principal components using a multivariate Cox proportional hazards regression model, four independent SNPs (rs9643715 PEX2, rs79243736 PEX5L, rs6908167 PEX7 and rs4710806 FAM120B) were significantly associated with NSCLC survival [hazards ratios (HR) of 1.173 (95% CI: 1.059-1.300), 1.272 (95% CI: 1.058-1.528), 1.224 (1.105-1.355), and 1.267 (1.072-1.497), respectively]. Patients with variants in 2-4 of the genes had a significantly lower OS than patients with variants in 0-1 genes (HR: 1.405, 95% CI: 1.216-1.624). Through expression quantitative trait loci analysis of whole blood and lung tissue data, the minor allele of rs9643715 PEX2 was shown to be significantly associated with increased mRNA expression levels, while variants in rs6908167 PEX7 and rs4710806 FAM120B were significantly associated with decreased mRNA expression levels. Decreased expression of PEX7 and FAM120B in lung tumor tissue was also shown to be associated with decreased OS. Our data suggest that variants in these peroxisome-related genes may influence gene expression and are potential predictors of NSCLC OS, although further functional experiments should be done to investigate the biological mechanisms underlying associations between their variants NSCLC survival.

Basement Membrane Tissue Integrity, Maintenance, and Fibrosis in Long-lived C. elegans

David Chen

Mentor(s): David Sherwood, Ph.D and William Ramos-Lewis, Ph.D.

Biological Sciences

Basement membranes (BMs) are supramolecular matrices built on laminin and type IV collagen networks and their health reflects the body's ability to heal wounds and repair tissues across all organs. Defective BM regeneration after injury leads to the development of scar tissue (fibrosis). In humans, fibrotic diseases can be systemic or organ specific. Caenorhabditis elegans is a useful model system for studying basement membranes and fibrosis because of its genetic and morphological similarity to humans, optically clear body, and fast-generation times. The Sherwood laboratory has endogenously labelled 29 major BM matrix components and receptors with fluorescent markers in C. elegans to investigate BM regulation in vivo. We're interested in identifying a role for type IV collagen and laminin BM networks in tissue maintenance and regeneration. We have observed fibrotic tissue in the worm gonads, with older worms expressing an increased fibrotic phenotype. Mature hermaphrodite worms are bleached to provide a cohort starting from the L1 stage, plated, and maintained for up to 14 days. Using high resolution microscopy, we characterized the endogenous expression of three major proteins involved in the basement membrane: type IV collagen (emb-9), laminin (lam-2), and perlecan (unc-52) across time. Our preliminary data shows that type IV collagen and laminin tend to accumulate rapidly in the gonad and slightly in the pharynx as the worm ages. Reducing type IV collagen levels by RNAi during aging, reduces the appearance of fibrosis and BM abnormalities, suggesting that over production of collagen might cause fibrosis in C. elegans and other animals.

Graduation with Distinction Candidate - Biology

Characterization of Host Aquaglyceroporins in Liver-Stage Malaria

McKenna Crawford

Mentor(s): Emily Derbyshire and Kayla Sylvester

Biological Sciences

Malaria is caused by the apicomplexan parasite Plasmodium, which undergoes an asymptomatic liver-stage in its human host, followed by a symptomatic blood-stage. Host aquaglyceroporins, water channel proteins also involved in glycerol and small solute transport, have been previously shown to be involved in liver-stage malaria. It has been proposed that host aquaglyceroporins, particularly host aquaporin-3 (AQP3), are hijacked by the liver-stage parasites for nutrient acquisition. After having previously worked on creating and transfecting a host AQP3 overexpression plasmid, this semester I have used Western blot protocols to optimize the use of different AQP3 primary antibodies. I am also working to further characterize other host aquaglyceroporins, including host aquaporin-7 and host aquaporin-9, to determine whether they localize similarly to host AQP3 to the liver-stage Plasmodium parasite. This work ultimately aims to better understand potentially druggable host proteins that are exploited in the asymptomatic liver-stage of malaria pathogenesis.

Inferring Diet: A comparison of dentition in apes and early hominins

Kianna Dao

Mentor(s): Richard Kay and Paul Morse

Biological Sciences

Diets have been critical in determining the phylogeny of our ancestors and reconstructing the past where dental remains are highly conserved in the fossil record and can shed light on what our ancestors ate. One diet that is not fully known is that of early hominins, who are theorized to have been flexible and non-specialized eaters. Currently, available data have provided conflicting analyses of the hominin diet and are unable to differentiate craniodentally distinctive taxa such as Australopithecus africanus and Paranthropus robustus. I seek to remediate conflicting data and clarify feeding strategies by looking at the question: How do molar functional properties change with wear and how would sorting Dirichlet Normal Energy (DNE) into concave and convex values change how we measure bunodont teeth? This project implements a new method that will illuminate more information on the teeth of extant apes and early hominins using Pan troglodytes, Pongo pygmaeus, Gorilla gorilla gorilla, A.africanus, and P.robustus specimens. The molar occlusal surfaces are quantified by remeasuring Dirichlet Normal Energy (DNE) values, which measures surface curvature and is used to quantify tooth sharpness, by sorting the values into concave and convex values (Orientation-labeled DNE) as opposed to combining them in the conventional DNE measurements and using a novel molaR data analysis package to identify the topography of the molars. This is particularly useful in bunodont– teeth with low, rounded cusps– as the sulci in the teeth have shown higher values than expected which can be seen in the lower M2 molars in these extant ape species. Based on the analysis, the data shows that by using the orientation-labeled DNE, there were significant changes in the values of DNE, where the convex values that are more accurately representative of the sharpness of the tooth, but the data still shows high values for these species, which could be due to factors such as the wear of the tooth and using virtually unworn teeth. This study has positive future implications on discovering more on the diet of our early ancestors by showing that convex DNE is a better reflection of diet in hominoids, refining approaches for quantifying wear in bunodont teeth, and creating a standard for 3D topographic analysis. This method could also potentially be used to serve as a method of speciation in Australopithecus.

Graduation with Distinction Candidate - Biology

Generation of a Zebrafish Transgenic Line for Manipulating Notochord Patterning

Meghana Giri

Mentor(s): Michel Bagnat and Susan Wopat

Biological Sciences

As the central support structure, the vertebral column, or spine, plays a key role in the function of vertebrates. However, despite its physiological importance, many aspects of its development remain poorly understood. Recent work from the Bagnat lab showed that the outer epithelial cell layer, or sheath, of the notochord segments into alternating domains that correspond to mature intervertebral discs (IVDs) and vertebral bodies, thereby serving as a template for spine morphogenesis in zebrafish. This pattern partially arises from the segmented expression of cartilage-like genes such as col9a2 and mineralizing factors like entpd5a. Initially, col9a2 is uniformly expressed in all sheath cells. Then, cells fated to instruct vertebral body formation express both genes before exclusively expressing entpd5a. Thus, IVD segments primarily express col9a2 while vertebral bodies overlay entpd5a+ notochord segments in mature zebrafish. However, the cellular and transcriptional changes that contribute to segmented patterning have yet to be elucidated. In order to understand notochord segmentation, my lab previously generated a transgenic line, col9a2-QF2, that allowed us to manipulate gene expression in col9a2+ cells using the Q transcriptional regulatory system. However, since col9a2 expression eventually becomes confined to the IVDs, we were unable to manipulate gene expression specifically in entpd5a+ segments. Therefore, I utilized CRISPR/Cas9 to insert a novel entpd5a-QF2 plasmid into the genome of zebrafish embryos to generate a complementary entpd5a-QF2 transgenic line. Germline integration and stable inheritance of the plasmid was confirmed by visualizing notochord expression in the F1 generation through confocal imaging. The entpd5a-QF2 line will allow us to investigate patterning mechanisms that initiate entpd5a expression and vertebral body formation. Overall, this genetic tool will help uncover novel mechanisms of notochord segmentation, and it holds the potential to discover additional origins of scoliosis in humans.

Graduation with Distinction Candidate - Biology

Modeling the Cardiac Myovascular Niche Using Induced Pluripotent Stem Cells

Alex Goff

Mentor(s): Ravi Karra

Biological Sciences

Cardiac Endothelial Cells (CECs) instruct Cardiomyocyte (CM) growth and function through various signaling pathways. Many of these pathways are still poorly elucidated and likely play important roles in cardiac disorders. Currently, few models are available to investigate CEC-CM communication. Here, we seek to create a model of CEC-CM signaling by differentiating human induced pluripotent stem cells (hiPSCs) into cardiac mesoderm and then enriching for CECs and CMs, simultaneously. We have developed a novel codifferentiation protocol that ultimately isolates the two target cell populations from one differentiation via immunomagnetic selection for CECs using the VEGFR2 marker and metabolic selection for CMs. Our method differs greatly from the current accepted protocol for general endothelial cell (EC) differentiation in the field, which enriches ECs from general mesoderm with CD34 as the marker for endothelial identity. We believe that by pulling down the target cell population from cardiac mesoderm and using the VEGFR2 marker, we generate microvascular cardiac-like ECs that are more phenotypically and genetically representative of CECs than the general CD34+ ECs. In order to validate our protocol for generating CECs, we assay for endothelial identity with bright-field microscopy, immunostaining for endothelial markers, and functional experiments. Our initial findings suggest we are on our way to successful enrichment for microvascular CECs. With this success, we hope to then study the effect of hypoxia in our CECs on CM proliferation through both conditioned media experiments and coculture assays. A conditioned media effect on CM proliferation would suggest that endothelial cells secrete angiocrines in response to hypoxia that regulate CM proliferation. If we do not see an effect here, then the CECs may need to be in physical contact with the CMs, and we will need to develop a viable coculture system that models more of a juxtracrine interaction between the cell types.

Graduation with Distinction Candidate - Biology

Novel Mutations in spastin Regulate Viability and Neuronal Branching: an AD-HSP Model

Lyndsay Hastings

Mentor(s): Emily Ozdowski and Nina Sherwood

Co-Author(s): Priyanka Rao, Gloria Kim, Lisa Kim, Jonathan Avendano

Biological Sciences

Autosomal Dominant-Hereditary Spastic Paraplegia (AD-HSP) is a progressive disorder characterized by neurodegeneration of the upper motor neurons, which causes weakness and loss of coordination in the legs. Approximately 40% of all AD-HSP cases are caused by mutations in SPASTIN, a gene that encodes an AAA ATPase with microtubule-severing activity. In order to better understand the functionality of the Spastin protein, previous studies have examined microtubule severing by its ortholog in Drosophila melanogaster. 67% of the amino acid sequence of Drosophila Spastin ATPase domain is identical to that of humans. Furthermore, fruit flies lacking spastin exhibit compromised motor behavior similar to human patients suffering from AD-HSP. Therefore, flies can serve as a powerful model to understand Spastin mutations and function. In order to investigate which regions of Spastin are critical to its function, point mutations were induced by ethylmethanesulfonate (EMS), a chemical mutagen. A genetic screen for suppressors of a spastin overexpression eye phenotype led to four new potential mutant lines: EFO1, EFO5, EFO6, and EFO7. In this study, we try to locate any new mutations within the spas coding region and characterize these mutants to determine their effect on animal viability, animal mobility, and neuronal morphology.

Temporal Dynamics of Macrophages in Response to Acute Kidney Injury

Savannah Herbek

Mentor(s): Tomo Souma and Dr. Kana Ide; Dr. Shintaro Ide

Co-Author(s): Dr. Kana Ide; Dr. Shintaro Ide

Biological Sciences

Renal macrophages represent a highly heterogeneous and specialized population of myeloid cells with mixed developmental origins from the yolk-sac and hematopoietic stem cells (HSC). They dually promote both repair and injury by regulating inflammation, angiogenesis, and tissue remodeling. Recent literature suggests that ontogenetically distinct macrophage populations have differential effects in disease processes such as carcinogenesis. Moreover, an emerging body of literature indicates that persistent accumulation of macrophages inside kidneys after acute kidney injury (AKI) is responsible for the failed renal repair process by exacerbating renal inflammation. Given these recent findings, I hypothesized that ontogenically distinct macrophages differentially contribute to the expanded pool of renal macrophages in severely damaged kidneys. To test this hypothesis, I utilized complementary genetic fate mapping approaches to understand the temporal dynamics of HSC-derived resident and infiltrating macrophages and their contribution to an enlarged pool of renal macrophages after severe kidney injury. In the experiments, I used two genetically engineered mouse lines that produce a red fluorescent protein (tdTomato) in either all HSC-derived cells (Flt3-Cre; Rosa26-tdTomoato) or in adult HSC-derived cells (Fgd5-CreERT2; Rosa26-tdTomato mouse line). This approach allowed me to dissect the temporal dynamics of two distinct HSC-derived renal macrophages after ischemia-reperfusion-induced kidney injury. I performed immunostaining for F4/80 and CD64 (macrophage markers) and quantified tdTomato-positive HSC-derived macrophages with confocal imaging and Image-J software. The data obtained in this study deepened our understanding of renal macrophage dynamics and their contribution to kidney repair processes, and AKI pathology in the grand scheme.

The Role of Codon Usage Bias and Synonymous Mutations in Phospholamban Expression

Bing Ho

Mentor(s): Paul Agris and Christopher Holley

Biological Sciences

The aim of this investigation is to characterize the role of synonymous codon usage bias (CUB) in regulating phospholamban (PLN) gene expression in transfected Human Embryonic Kidney (HEK) cells as a model for gene expression changes in heart failure (HF). The PLN protein is a key regulator of heart contraction/relaxation cycles by modulating cytosolic calcium concentrations in heart cells (cardiomyocytes). HF refers to the inability for a diseased heart to properly pump blood (systolic HF) or fill with blood (diastolic HF) and accounts for 13.4% of deaths in the U.S. Several pharmaceutical treatments have been pursued to directly alter PLN gene expression or inactivate existing PLN proteins in heart failure (HF) patients and restore proper heart function. However, none have yielded efficacious results due to conflicting reports about which SNPs in the PLN gene significantly alter PLN function and impede heart function. A lack of knowledge about which specific single nucleotide polymorphisms (SNPs) in the PLN gene cause significant defects in PLN protein function severely limits the specificity and effectiveness of HF drug developments targeting PLN.

My goal is to elucidate how concentrations of PLN mRNA and protein are influenced by SNPs identified with the potential to cause HF. The characterization of how PLN expression is affected by SNPs will elucidate the relative contribution of different SNPs to deficient PLN protein function and structure and help guide HF drug development efforts targeting PLN. A better understanding of how CUB and synonymous SNPs affect PLN expression and protein stability could greatly inform gene and protein therapy developments for HF.

Graduation with Distinction Candidate - Biology

Biased ligands of CXCR3 promote differential signaling mediated by the phosphorylation barcode

Cole Honeycutt

Mentor(s): Sudarshan Rajagopal and Dylan Eiger

Co-Author(s): Dylan Eiger, Jeffrey Smith, Noelia Boldizsar, Julia Gardner, Issac Choi, Chia-Feng Tsai, Tujin Shi, Jon Jacobs, Richard Smith, Sudarshan Rajagopal

Biological Sciences

This project sought to investigate the phosphorylation barcode as a mechanism underlying biased signaling at CXCR3, a receptor that is highly expressed on T cells and implicated in a variety of disease states, including autoimmune disorders, infectious diseases, hypersensitivity reactions, atherosclerosis, and cancer. CXCR3 signals through three endogenous ligands: CXCL9, CXCL10, and CXCL11. Elucidation of the mechanisms and physiologically relevant functional effects of biased signaling at GPCRs could aid greatly in the development of more efficacious therapeutics that lack significant side effect profiles, as GPCRs are estimated to be the target of one-third of all small-molecule drugs. We cloned various mutant CXCR3 constructs with phosphorylation deficient or truncated C terminal tails, which we used to probe the role of the phosphorylation barcode in biased chemokine signaling. We utilized TRUPATH, a suite of bioluminescence resonance energy transfer (BRET) Gαβγ biosensors, to interrogate G protein signaling and BRET to assess β-arrestin 2 recruitment to WT CXCR3 and CXCR3 mutants following stimulation with CXCL9, CXCL10, or CXCL11. We performed western blots to assess ERK1/2 phosphorylation. Finally, we determined global phosphoproteomic profiles of WT CXCR3-expressing cells stimulated with ligand. We found differential G protein signaling induced by the ligands of CXCR3, with the phosphorylation deficient mutant receptors signaling differently based on the ligand identity. CXCL11 induces the greatest β-arrestin 2 recruitment to CXCR3. All CXCR3 mutants demonstrate reduced β-arrestin 2 recruitment. ERK1/2 phosphorylation at 5 minutes was found to be potentiated at all CXCR3 mutants at CXCL10 and CXCL11, but not CXCL9. Phosphoproteomics revealed a significantly more inflammatory signaling profile for CXCL10 over CXCL9 and CXCL11. Phosphorylation ensembles composing differential phosphorylation barcodes of CXCR3 are important for the induction of G protein signaling, the recruitment of β-arrestin 2, and the downstream phosphorylation and subsequent activation of MAPK signaling. These ensembles impact signaling differently based on the identity of the ligand stimulation, suggesting their importance in the regulation of biased signaling. Phosphoproteomics highlighting the inflammatory signaling profile of CXCL10 corroborates significant prior evidence for the role of CXCL10 as an especially inflammatory chemokine.

Graduation with Distinction Candidate - Biology

Structural and Functional Characterization of Engineered Human X Chromosome Abnormalities

Naeema Hopkins-Kotb

Mentor(s): Beth Sullivan

Biological Sciences

Abnormalities of the X chromosome have important implications for developmental and reproductive processes, and genetic disease. In particular, dicentric X (dicX) chromosomes – X chromosomes with two centromeres – are associated with diseases like Turner Syndrome. Although dicXs are predicted to be unstable, they persist in Turner Syndrome patients. The molecular basis for this instability remains unclear due to the lack of in vitro assays that enable tracking of chromosome stability mechanisms throughout development. This project aims to answer the question: How do abnormal X chromosomes (dicentric and deleted X) achieve structural and functional stability? To answer this question, an engineered human X chromosome model called the "Pushmi-Pullyu" assay has been used to (1) identify fates of newly formed dicX and deleted X (delX) chromosomes, and (2) map specific breakpoints in dicX and delX clones to understand their mechanism(s) of formation. Using genome browser data, identifying these breakpoints has enabled an exploration of the genomic properties making these sites prone to breakage. I am using fluorescence in situ hybridization (FISH) to characterize the chromosome structure and stability at single-cell resolution and polymerase chain reaction (PCR) to map the breakpoints. This study begins to fill a gap in our knowledge of how abnormal X chromosomes stabilize in humans, providing a basis for future study of chromosome behavior and fate. Further, the results have implications for understanding genome stability and provide a powerful model to enhance our clinical understanding of chromosome-related disease.

Graduation with Distinction Candidate - Biology

Identification and Characterization of Cis-Regulatory Elements Impacting PTEN Expression

Haley Hutchinson

Mentor(s): Kris Wood

Co-Author(s): Christian Cerda-Smith

Biological Sciences

It is now appreciated that the non-coding genome plays a major role in gene expression and can thus shape diseases such as cancer. However, although several studies have broadly investigated such mechanisms, until recently technological limitations have prevented robust identification of the cis-regulatory elements (cREs) controlling expression of important cancer genes. The development of CRISPR/Cas9-based epigenomic regulatory element screening (CERES) addressed this technological need, allowing for functional identification of candidate cis-regulatory elements (ccREs) surrounding a gene of interest. CERES technology identifies these ccREs through employment of a nuclease-deactivated (d)Cas9 coupled to an epigenetic effector (VPR activator or KRAB repressor). These are paired with custom short-guide (sg)RNA libraries selectively targeting regions surrounding a gene of interest. Thus, we are able to map the effect of both activation (VPR) and repression (KRAB) at specific genomic loci, thereby identifying ccREs for a given gene. The tumor suppressor gene phosphatase and tensin homolog (PTEN) is one of the most commonly mutated and/or lost genes among human cancers. However, many patients exhibit loss of PTEN expression without genetic alterations, indicating a potential role for non-coding mechanisms impacting PTEN expression. Additionally, increases in PTEN expression have been shown to have anticancer effects. This suggests techniques which target endogenous PTEN for overexpression, for instance through the manipulation of its cREs, could represent a promising therapeutic strategy. Leveraging CERES technology, we aim to map cREs impacting expression of this important tumor suppressor gene and have already nominated several candidate regulatory regions through preliminary experimentation. Our goal is to validate and define the cREs and the associated pathways impacting PTEN expression, work which we hope will further our understanding of PTEN regulation and may direct future design of therapeutics that target endogenous mechanisms of PTEN regulation.

Mechanisms behind maternal high-fat diet induced offspring behavior changes

Carolyn Huynh

Mentor(s): Staci Bilbo and Alexis Ceasrine

Biological Sciences

Maternal obesity is a rapidly increasing epidemic in the United States. Maternal high fat diet (mHFD) increases the risk for anxiety and depression in offspring potentially by promoting a fetal environment of chronic inflammation. With these observations in mind, we aim to analyze neurological mechanisms that contribute to offspring behavior changes in response to mHFD. One neurotransmitter that plays critical biological roles in behavior is serotonin. Serotonin levels can be negatively impacted by inflammation, and diminished levels of serotonin contribute to anxiety-like or depressive-like phenotypes in mice. Importantly, the placenta, a prime interface between the mHFD-induced maternal inflammatory state and the developing brain, is the source of fetal forebrain serotonin. We hypothesize that mHFD-associated inflammation is communicated to the fetus through the placenta and decreases serotonin bioavailability. Preliminary immunohistochemistry data from our lab indicated male-specific inflammation in mHFD placenta. Moreover, male mHFD offspring had significantly less serotonin in the placenta, fetal forebrain, and adult prefrontal cortex (PFC). Interestingly, preliminary data demonstrate sex-specific behavior changes in male and female mHFD offspring. Both male and female neonatal mHFD offspring show diminished ultrasonic vocalizations, while adult male offspring show anhedonia and juvenile female offspring show decreased social behavior. These data raise questions on sex differences in mechanisms contributing to fetal inflammation and serotonin bioavailability. My aim was to identify changes in inflammation and serotonin-related gene expression in mHFD placental macrophages, and assess whether increasing serotonin bioavailability during embryonic development is sufficient to alleviate behavioral changes in male mHFD offspring. My data suggest that toll-like receptor signaling, particularly through Tlr4, may contribute to increased inflammatory response in both male and female mHFD placenta. Further, preliminary experiments suggest that maternal tryptophan enrichment, hypothesized to increase embryonic serotonin bioavailability, rescues some male-specific behavior changes. Together, these findings point to a mechanism through which mHFD-induced placental inflammation influences male and female behavior outcomes, likely through serotonin deficiency in males and through a distinct, yet still unknown, mechanism in females.

Graduation with Distinction Candidate - Psychology

Clonality-informed design of combination chemotherapies aimed at suppressing resistance in AML

Greta Joos

Mentor(s): Kris Wood and Christian Cerda-Smith

Biological Sciences

While chemotherapy is often used as a first line approach in acute myeloid leukemia (AML), many patients whose cancer initially responds to treatment develop resistance. To overcome this resistance, many modern therapies adopt a “whack-a-mole” approach in which cell populations that emerge resistant after initial treatment are targeted with methods aimed at destroying advancing subclones. However, these methods often fail to create durable solutions because they do not take into account the polyclonal nature of heterogenous tumors. As has been seen in the treatment of non-Hodgkin’s Lymphoma, the use of combination therapies represents a promising approach. With the use of many drugs, each with non-overlapping resistance mechanisms, it becomes increasingly unlikely that any given cancer cell will possess all the necessary pre-existing variations to render it resistant to all included treatments. To characterize clonal dynamics in response to various therapies, we utilized a cellular barcoding approach. After infecting cells from the OCI-AML2 cell line with unique barcode identifiers, we subjected them to four chemotherapeutic drugs, alone and in every possible two-, three-, and four-drug combination. Post-treatment, we amplified and sequenced each barcode and compared barcode distributions both within and between treatment conditions. Our main objective was to use our dataset to identify treatments which yield non-overlapping barcode distributions, and may therefore eradicate diverse AML clones via distinct mechanisms of action. We found that the number of barcodes in each population tended to decrease as selective pressure increased (i.e. as the number of drugs in the combination therapy increased). We discovered some barcode overlap between treatment conditions, but contend that, for the most part, survival in the harshest treatment combinations was random rather than due to pre-existing genetic differences. However, we suspect that our results may have been affected by undercoverage and overbarcoding. Nonetheless, these results suggest that combination therapies have exciting potential to treat AML, though their design and implementation requires further investigation.

Graduation with Distinction Candidate - Biology

Investigating the Functional Relationship of POSTN and FASN in Ovarian Cancer

Bailey Knight

Mentor(s): Zhiqing Huang

Biological Sciences

Advanced stage ovarian cancer (OC) is frequently followed by recurrence, often accompanied with acquired chemo-resistance. Through gene expression comparisons of paired OC specimens of primary and recurrent cancer, we identified the increased expression of a handful of genes, including periostin (POSTN), overexpressed in recurrent OC compared with the primary OC from the same patients. Using RNAseq technology we also identified genes that showed differential expression within cancer cells under high-POSTN culture. Among the upregulated genes, fatty acid synthase (FASN) is of interest due to its role in cancer regulation, including suppression of cancer cell apoptosis and chemosensitivity. To elucidate the link between POSTN and FASN in OC, we analyzed the effects of FASN inhibition on cancer cell (HEY-A8) proliferation and chemo-therapeutic treatment in high-POSTN conditioned medium (CM) as compared with a neutral culture condition. As expected, we observed that cell proliferation was inhibited by the FASN inhibitor, cerulenin. Interestingly, proliferation inhibition by cerulenin was significantly attenuated in cells cultured under high-POSTN CM. This finding suggested the functional connection of FASN and POSTN in regulating cancer cell growth. Furthermore, under high-POSTN CM HEY-A8 cells treated with both cerulenin and paclitaxel chemotherapy displayed significantly lower proliferation than those treated with either agent alone, indicating a synergistic effect. Likewise, treatment with both cerulenin and carboplatin, a platinum-based chemotherapy to which HEY-A8 shows resistance, effectively re-sensitized the cells to chemotherapy. Together, this indicates that in cancers which over-express POSTN and FASN, the inhibition of FASN can increase chemosensitivity. The combined effect of routine chemotherapy accompanied by FASN inhibition in high-POSTN conditions (such as in recurrent OC) may lead to a new, more effective strategy for treatment of recurrent OC. A deeper understanding of the mechanisms of both POSTN and FASN in apoptosis, proliferation, and chemoresistance may aid in identification and implementation of new therapies for recurrent OCs.

Graduation with Distinction Candidate - Biology

O-GlcNAcylation plays a role in Sec24 Function

Caitlin Lamb

Mentor(s): Michael Boyce

Co-Author(s): Brittany J. Bisnett, Nathan J. Cox, Timothy J. Smith, Michael Boyce

Biological Sciences

Coat protein complex II (COPII) mediates forward protein and lipid trafficking from the endoplasmic reticulum via five proteins required for in vitro vesicle formation: SAR1, SEC13, SEC23, SEC24, and SEC31. While the structure and function of COPII proteins are well understood, we do not fully understand how COPII is regulated in response to environmental and cellular stimuli. We and others have found that O-linked β-N-acetylglucosamine (O-GlcNAc), a dynamic single-sugar modification added to serines and threonines of intracellular proteins, decorates many human COPII components, including all four human SEC24 paralogs. Additionally, others have shown that COPII, and specifically SEC24, may play a role in the formation of autophagosomes. However, the regulation of SEC24 functions remains unclear. To determine the function of SEC24 O-GlcNAcylation, we mapped O-GlcNAc sites on SEC24C and SEC24D using mass spectrometry and created unglycosylatable serine or threonine to alanine mutations at each O-GlcNAc site. We then used CRISPR-Cas9 to delete SEC24C and SEC24D from HeLa and HEK293T cell lines. We show that SEC24C within minutes of treatment with an O-GlcNAcase inhibitor, suggesting that O-GlcNAcylation may play a regulatory role on SEC24C. Ongoing work aims to determine the dynamics of SEC24D O-GlcNAcylation and to determine the role of O-GlcNAc modifications of SEC24C and SEC24D on trafficking of multiple cargoes. Our results enhance our understanding of the role of O-GlcNAc in COPII trafficking and SEC24 function.

Host-Parasite Interactions in Toxoplasma gondii Infection

Olivia Liu

Mentor(s): Emily Derbyshire and Maria Toro Moreno

Biological Sciences

Toxoplasma gondii (T. gondii) is an intracellular parasite that infects warm-blooded animals, including humans, causing the human disease toxoplasmosis. This disease is estimated to affect nearly one-third of the world's population, with particularly detrimental effects for pregnant women, their unborn children, and immunocompromised individuals. However, much of how T. gondii manipulates its host environment for successful infection remains unclear. My project aims to elucidate host-T. gondii interactions through two avenues. The first avenue probes how host ADP-ribosylation factor (ARF) proteins, which have been shown to be important in the infection of related parasites, may be implicated in T. gondii infection and the host interferon-gamma (IFNγ) immune response. The second avenue examines how T. gondii manipulates the host transcriptome through the differential expression of host long noncoding RNAs. Our results show that T. gondii infection causes upregulation of some ARF proteins in Huh 7 and Vero host cells but not in HeLa host cells, thus pointing to how different host cell strains respond to infection in variable ways. Immunofluorescence microscopy images reveal that ARF4 localizes to T. gondii parasites during infection, but in vitro IFNγ stimulation appears to be unrelated to this ARF response. Furthermore, our preliminary results suggest that T. gondii infection does cause differential regulation of some host long noncoding RNAs. Advancing our understanding of host-T. gondii interactions can possibly point to new targets for toxoplasmosis prevention and treatment.

Designing a Reporter System to Trace Angptl4 in Zebrafish

Tiffany Liu

Mentor(s): John Rawls and Dr. Jia Wen, PhD

Biological Sciences

Elevated levels of plasma lipid is a well-known risk factor for cardiovascular diseases and is often caused by reduced activity of lipoprotein lipase (LPL), an enzyme that aids lipid absorption from the blood by peripheral tissues. One major modulator of LPL function is angiopoietin-like 4 (ANGPTL4), which binds to LPL and inhibits its enzymatic activities. ANGPTL4 is a secreted protein that is expressed in many tissues and is conserved across various vertebrate taxa, including humans and zebrafish. Despite the importance of ANGPTL4 in regulating LPL function and lipid homeostasis, there lacks effective tools for monitoring angptl4 expression in vivo in real time, presenting a major gap of knowledge. We therefore aim to use the CRISPR-Cas9 genome editing system to develop knock-in transgenic zebrafish with reporter gene expression that mimics endogenous angptl4 gene expression. One reporter line will have a fluorescent tag within the angptl4 coding sequence, and another will have a fluorescent tag in the upstream region of angptl4. By taking advantage of the optical transparency of zebrafish larva, these reporter lines will allow us to investigate the expression and location of Angptl4 under different physiological or pathophysiological conditions in live zebrafish. These results are expected to have a significant impact because they will provide much needed knowledge on the dynamics of ANGPTL4 in human health and are likely to lead to new strategies for treating human metabolic diseases.

The Effects of Environmentally Persistent Compounds GenX and PFOA on Human Health

Joy Lu

Mentor(s): Tom Schultz and Jason Somarelli

Co-Author(s): Abbey Milwicz

Biological Sciences

Per- and polyfluoroalkyl substances (PFAS) are a ubiquitous group of man-made chemicals used in food packaging and nonstick products such as Teflon. PFAS are a threat to human, animal, and environmental health because they are environmentally persistent, bioaccumulative, and carcinogenic. Shorter chain PFAS such as GenX have been synthesized as an alternative aimed to reduce toxicity and replace current PFAS such as perfluorooctanoic acid (PFOA). Many PFAS have been shown to negatively impact human health and affect the liver, kidneys, reproductive organs, and developmental processes. The combination of inadequate data on the effects of GenX on human health and drinking water contamination in Eastern North Carolina has encouraged additional research into the potential effects of GenX exposure. Four cell lines (HepG2, HK2, NIH3T3, and NIH3T3L1) were exposed to varying concentrations of PFOA or GenX, and cell viability assays were performed to identify candidate cell lines and dosages. HepG2, human liver cancer cell line, was chosen for further analysis, and cell culture data shows that the toxicity of PFOA is higher than that of GenX, although there may be underlying mechanisms affecting cells exposed to PFAS that may not be observed during cell culture. An RNA sequencing analysis was used to identify signaling pathways and resulting toxicity of liver cells exposed to 500uM of PFOA and 1000uM of GenX with RNA collected at three time points following exposure. Ongoing studies utilize novel techniques, including RNA sequencing, pathway analysis, and time series analysis to identify and analyze the biological mechanisms and signaling pathways that result in toxicity of the cell. This project will help to identify crucial mechanistic differences between the effects of PFOA and GenX and shape our understanding of how GenX affects human health.

Graduation with Distinction Candidate - Biology

An Investigation into Polyketide Synthase's Role in Apicomplexans

Margaret Lundberg

Mentor(s): Emily Derbyshire

Biological Sciences

Polyketide synthases (PKSs) assemble polyketides, secondary metabolites with varied bioactive functions. Type 1 PKSs are modular, with each module associated with one cycle of polyketide formation and containing multiple domains that help assemble polyketides. Modules consist of a ketosynthase (KS), acyltransferase (AT), and acyl carrier protein (ACP) domain, along with a variable set of domains. The Toxoplasma Gondii parasite, associated with the disease toxoplasmosis, employs PKSs. Because of their size, PKSs cost a considerable amount of energy to translate, so they are believed to serve an important function in T. Gondii. Previous studies hypothesized that in various cycles of apicomplexans, PKS metabolites serve a role in the formation of hard cyst cell walls, which can help apicomplexans persist in unfavorable environments. This study investigates the function of PKSs in apicomplexans, particularly looking at T. Gondii, and explores what small molecules are being produced by PKSs by specifically focusing on ACP3 protein interactions with other domains in module 2 of T. Gondii's PKSs. This in turn will improve our understanding of PKS interactions and functions in T. Gondii and expand our knowledge of apicomplexan infection and life cycle.

A general mechanism for G protein-coupled receptor core coupling by β-arrestin

Symon Ma

Mentor(s): Robert Lefkowitz and Anthony Nguyen, PhD

Biological Sciences

G protein-coupled receptors (GPCRs) are a class of receptors implicated in the signaling and regulation of a wide array of physiological processes. These receptors are classically understood to signal through G proteins and are desensitized after prolonged signaling by β-arrestin (βarr), which compete with G proteins for binding to the intracellular core of GPCRs. Recently, receptor-mediated βarr signaling has also been identified, though it is not yet as extensively characterized compared to G protein signaling. Furthermore, while G protein coupling to GPCRs are highly sub-type specific, two orthologs of βarr couple promiscuously to the over 800 unique GPCRs expressed in human cells with varying specificity. βarr engages a GPCR intracellular core through a 15-residue flexible 'finger' loop, which dichotomously contains mostly charged and polar residues in its first half, followed by a second half dominated by largely hydrophobic residues. With the mechanism by which the same finger loop couples promiscuously to hundreds of different GPCRs largely unknown, we sought to answer this question by obtaining the structure of βarr bound to the intracellular core of a prototypical GPCR, the β2 adrenergic receptor (β2AR), and dissect the ability of each finger loop residue to couple to this receptor using a radioligand binding assay. We successfully obtained a structure of the β2AR–βarr1 complex at 3.6 Å, which surprisingly shows only five finger loop residues coupling to the GPCR. Out of these five, only one residue, R65 forms a hydrogen bond network with the receptor, while the other four residues (70VLGL73) form Van der Waals interactions with the receptor core. Radioligand binding confirms that single alanine substitution of the five residues led to loss of receptor coupling, and additionally identified one residue, D69, by which alanine substitution led to a gain of coupling. Comparison of our structure with other GPCR–βarr complexes reveal that this hydrophobic stretch of residues is involved in receptor coupling, while charged and polar residues in the first half of the finger loop sporadically interact with their respective receptor core. Our results suggests that the βarr finger loop utilizes hydrophobic residues to ensure promiscuous coupling to hundreds of different GPCRs, and that the ability of some GPCRs to form polar and charged interactions with the first half of the finger loop may account for the enhanced core coupling that some GPCRs exhibit.

Gamma-Carboxylation and Coagulation Factor Activity in Infants and Neonates

Griffin McDaniel

Mentor(s): Elisabeth Tracy

Co-Author(s): James C. Otto, Ph.D. and Christopher R. Reed, M.D.

Biological Sciences

Vitamin K is required for the gamma-carboxylation of the vitamin K-dependent coagulation factors. Gamma-carboxylation is a post-translational modification that is required for the factors to function. While infants and neonate have low levels of vitamin K intake, the degree to which their coagulation factors display gamma-carboxylation had not yet been shown. Thus, we designed a study to determine the degree of gamma-carboxylation to the coagulation factors of infants and neonates and to highlight the functional consequences of this post-translational modification. Two plasma samples were collected from each of 31 infants and neonates undergoing a cardiac catherization at Duke University Hospital. Sample 1 was collected after the onset of anesthesia but before fluoroscopy, and sample 2 was collected immediately prior to catheter removal. Coagulation factor II was isolated via western blotting, and the degree of gamma-carboxylation for each sample was determined by taking the ratio of the intensity of immunofluorescence for the gamma-carboxylated residues to the intensity of immunofluorescence for coagulation factor II. Using a modified activated partial thromboplastin time assay, the activities of vitamin K-dependent factors II, IX, and X and the activity of the vitamin K-independent factor XII were determined. The results showed lower degrees of gamma-carboxylation for the pediatric samples (0.81 ± 0.05) than the adult samples (1.18 ± 0.12). For the vitamin K-dependent factors, the results showed a correlation between the degree of gamma-carboxylation and factor activity that was significantly steeper than the correlation between the degree of gamma-carboxylation and age. For the vitamin K-independent factor XII, the results showed no correlation between the degree of gamma-carboxylation and factor activity. Additionally, the results showed prolonged times for clot formation for the sample collected at the second time point relative to the sample from the first time point. In summary, the present study presents evidence that the degree of gamma-carboxylation to the vitamin K-dependent coagulation factors is lower in pediatric than adult samples, and it provides another explanation besides lower concentrations of coagulation factors as to why infants and neonates display longer times for clot formation than adult patients.

The Effects of Environmentally Persistent Compounds GenX and PFOA on Human Health

Abbey Milwicz

Mentor(s): Tom Schultz and Jason Somarelli

Co-Author(s): Joy Lu

Biological Sciences

Per- and polyfluoroalkyl substances (PFAS) are a ubiquitous group of man-made chemicals used in food packaging and nonstick products such as Teflon. PFAS are a threat to human, animal, and environmental health because they are environmentally persistent, bioaccumulative, and carcinogenic. Shorter chain PFAS such as GenX have been synthesized as an alternative aimed to reduce toxicity and replace current PFAS such as perfluorooctanoic acid (PFOA). Many PFAS have been shown to negatively impact human health and affect the liver, kidneys, reproductive organs, and developmental processes. The combination of inadequate data on the effects of GenX on human health and drinking water contamination in Eastern North Carolina has encouraged additional research into the potential effects of GenX exposure. Four cell lines (HepG2, HK2, NIH3T3, and NIH3T3L1) were exposed to varying concentrations of PFOA or GenX, and cell viability assays were performed to identify candidate cell lines and dosages. HepG2, human liver cancer cell line, was chosen for further analysis, and cell culture data shows that the toxicity of PFOA is higher than that of GenX, although there may be underlying mechanisms affecting cells exposed to PFAS that may not be observed during cell culture. An RNA sequencing analysis was used to identify signaling pathways and resulting toxicity of liver cells exposed to 500uM of PFOA and 1000uM of GenX with RNA collected at three time points following exposure. Ongoing studies utilize novel techniques, including RNA sequencing, pathway analysis, and time series analysis to identify and analyze the biological mechanisms and signaling pathways that result in toxicity of the cell. This project will help to identify crucial mechanistic differences between the effects of PFOA and GenX and shape our understanding of how GenX affects human health.

Graduation with Distinction Candidate - Biology

Serotonin as a Biomarker of Sudden Infant Death Syndrome

Ellen Mines

Mentor(s): Andrew Landstrom and Andrew Landstrom

Co-Author(s): J. Will Thompson

Biological Sciences

Sudden Infant Death Syndrome is the sudden and unexplained death of a child under one year of age. There are currently no diagnostic or predictive tests for infants at risk of Sudden Infant Death Syndrome (SIDS), and the underlying mechanisms are unclear. However, elevated levels of circulating 5-HT have been found in as many as one third of SIDS cases postmortem. The goal of this project is to determine whether circulating serotonin (5-HT) may serve as a biomarker of patients at risk of SIDS.

ELISA and LC-MS were used to compare levels of 5-HT in cord blood plasma between SIDS cases (n = 3) and controls (n = 9). In addition, we explored the viability of newborn blood spot cards as a potential future sample pool. 5-HT concentration was measured in the rehydrated blood spot cards using ELISA (n = 11), comparing variables such as elution volume, storage temperature, and storage length.

Sex Differences in Pelvic Robusticity and Stress Fractures: Implications for Parturition

Lizzy Nist

Mentor(s): Steven Churchill

Biological Sciences

Sex differences in Homo sapiens pelvic structure are well known, like a larger anterior-posterior pelvic inlet in females due to birthing large-brained neonates. However, it is not known if these sex differences in the pelvis result in different rates of pelvic injuries. Preliminary investigation by Kibii et al. (2011) indicates that females are biomechanically 'under-designed' when it comes to repetitive normal stresses on the pelvis. Building on Kibii et al.'s initial observations, I evaluated sex differences in acetabulosacral buttress robusticity, which is a measure of strength to normal locomotor loads, such as bipedal walking and running. To determine if female pelves are more susceptible to mechanical failure, I also analyzed whether females have a higher rate of pelvic stress fractures relative to overall stress fractures than males by pooling data from previously published studies of military personnel and athletes. In this study, females exhibited less robust acetabulosacral buttresses than males on average (F: 0.42± .08; M: 0.48± .08; p=7.09 x 10^-8), even relative to body size. This is attributed to females having a longer acetabulosacral buttress load arm to maintain a large pelvic inlet and thinner acetabulosacral buttress thickness for their body size. Our results also show a greater incidence of pelvic stress fractures relative to all stress fractures in females (M: .034, F: .098, p= < 1.00 x 10^-5). We propose that increased susceptibility to mechanical failure and decreased robusticity in females is a byproduct of selection for more compliant pelves in females. We propose this as the compliant pelvis hypothesis: less robust pelves in females have been selected for during human evolutionary history, as it could potentially increase the pliability of the pelvis and could therefore allow for more room for the neonate's large head during childbirth. This could reinforce the importance of parturition as a selective pressure during late Homo evolution.

Kibii, J. M., Churchill, S. E., Schmid, P., Carlson, K. J., Reed, N. D., De Ruiter, D. J., & Berger, L. R. (2011). A partial pelvis of Australopithecus sediba. 333(6048), 1407-1411. doi:10.1126/science.1202521

Investigating ATM regulation of the cohesin complex in the DNA damage response

Mihir Patel

Mentor(s): Michael Kastan and Thomas Bass, Ph.D.

Biological Sciences

Ataxia-telangiectasia (A-T) is a rare heritable disorder characterized by mutation of ATM and consequent cancer predisposition and radiosensitivity. ATM is a kinase that phosphorylates numerous proteins at S/TQ motifs in response to DNA double-strand breaks (DSBs), which result from ionizing radiation (IR) among other sources. One of the substrates of ATM is cohesin, a ring-like complex comprising SMC1A, SMC3, and RAD21 that maintains sister chromatid cohesion during cell division. Phosphorylation of SMC1A and SMC3 is necessary for the auxiliary role of cohesin in promoting DSB repair and maintaining genome integrity following DNA damage. Cohesin is loaded onto DNA by NIPBL and unloaded via the interaction of WAPL with cohesin-associated PDS5A or PDS5B. Hitherto, ATM regulation of these proteins remains uncharacterized. Using two unbiased mass spectrometry-based screens, we identified NIPBL, WAPL, and PDS5A as ATM interactors that were phosphorylated following IR exposure. Next, we validated that NIPBL, WAPL, and PDS5A are phosphorylated in an ATM-dependent manner following IR exposure using co-immunoprecipitations with the phospho-S/TQ antibody. Focusing specifically on PDS5A, we generated an S1278A mutant, where the postulated phosphorylation site was mutated to a non-phosphorylatable alanine residue. Mutation of this site abrogates phosphorylation of PSD5A by ATM. Given the functional importance of SMC1A and SMC3, we hypothesized that ATM regulation of PDS5A would impact cellular response to DNA damage. Specifically, we identified that PDS5A is necessary for adherence to the S-phase cell cycle checkpoint following irradiation. However, abrogation of PDS5A phosphorylation eliminates the checkpoint and allows DNA replication to continue in the presence of DNA damage. In addition, ATM phosphorylation of PDS5A is necessary to promote homologous recombination to repair DSBs. Finally, we found that ATM regulation is important for promoting cohesin residence on chromatin following DSB induction. Together, these findings reveal the importance of cohesin-associated proteins as downstream effectors of ATM regulation in the DNA damage response.

Graduation with Distinction Candidate - Biology

Novel Mutations in spastin Regulate Viability and Neuronal Branching: an AD-HSP Model

Priyanka Rao

Mentor(s): Nina Sherwood and Dr. Emily F. Ozdowski

Co-Author(s): Lyndsay Hastings, Lisa Kim, Gloria Kim, Jonathan Avendano, Syed Ameen Ahmad, Max Beck, RaKavius Chambers, Devon Dietrich, Raksha Doddabele, Lielle Elisha, Juliette Gerber, Nathaniel P. Hernandez, Phuong Huynh, Ankit Jajoo, Abigail Judge, Sweta Kafle, Ila

Biological Sciences

Autosomal Dominant-Hereditary Spastic Paraplegia (AD-HSP) is a progressive disorder characterized by neurodegeneration of the upper motor neurons, which causes weakness and loss of coordination in the legs (Hazan et al., 1999; Fink, 2002). Approximately 40% of all AD-HSP cases are caused by mutations in SPASTIN, a gene that encodes an AAA ATPase with microtubule-severing activity (Errico et al., 2002). In order to better understand the functionality of the Spastin protein, previous studies have examined microtubule severing by its ortholog in Drosophila melanogaster (Roll-Mecak and Vale, 2008). In this experiment, four point mutations were created from the spasT32 gene using ethylmethanesulfonate (EMS), a chemical mutagen. A genetic screen for suppressors of a spastin overexpression eye phenotype led to four new potential mutant lines: EFO1, EFO5, EFO6, and EFO7. Three screens were then conducted to assess the severity of these point mutations on mobility. The first screen looked at how these point mutations increase branching at the larval neuromuscular junction. It was found that of the EFO lines, EFO6 and EFO7 had significantly more branched morphology, comparable to the T32/5.75 line, the most genetically similar control group (p<0.05, p<0.00001 respectively). Our second screen looked at climbing rate. Flies were timed to see how quickly they could climb 5 cm. No significant differences between EFO lines were found. The final screen tested how spastin mutations may reduce adult viability by looking at eclosion rate. It was found that viability is significantly reduced in flies with spasEF06/spas5.75 (p<0.01) and spasEF07/spas5.75 (p< 0.001) genotypes when compared to spasT32/spas5.75. Overall, based on the screens conducted, it was concluded that the point mutation EFO7 conferred the most severe phenotype of the novel lines, followed by EFO6, EFO5 and EFO1. This study is significant as mutations in the conserved AAA ATPase domain of the Drosophila Spastin homologue may aid in the study of disease mechanisms and therapeutic targets for patients with ADHSP.

Impact of altering C. elegans MANF protein expression on dopaminergic neurodegeneration

Riccardo Romersi

Mentor(s): Joel Meyer and Jessica Hartman

Biological Sciences

Parkinson's Disease is a neurodegenerative disease whose attributability to genetics alone is only possible in a small minority of cases. This has led to the necessity of elucidating how environmental interactions with biological systems can impact major pathways in neurodegeneration. In this study, we examined Mesencephalic Astrocyte derived neurotrophic factor (MANF), one of several neurotrophic factors that has also been implicated in the protection of dopaminergic neurons from degeneration in Caenorhabditis elegans. Nematodes were exposed to 6-hydroxy dopamine, a toxic form of dopamine, as a model for Parkinson's Disease. MANF expression was altered by deletion or overexpression of the MANF gene, which is conserved in C. elegans. Fluorescence imaging and subsequent quantification of the degeneration of GFP tagged neurons revealed that either increasing or decreasing MANF levels decreased neurodegeneration overall, but increased the severity of degeneration when it occurred. Additionally, in wildtype MANF expressing worms tagged with RFP, it was found that there was no correlation between severity of degeneration and MANF expression, even after controlling for toxicant dose. Finally, reverse transcription PCR was used to examine MANF's impact on the expression of protein folding chaperone genes, oxidative stress response genes, and mitochondrial biogenesis genes. Preliminary data showed that, of the genes examined, both the overexpression and deletion of MANF from C. elegans most consistently downregulated the expression of mitochondrial biogenesis genes. Together, these data suggest that MANF levels are regulated to an optimal level to minimize the severity of dopaminergic neurodegeneration, such that either loss or constant overexpression is deleterious. Further study should investigate the effect of shorter-term and smaller changes in MANF level.

Examining the Function of Adhesion Receptors DDR-2 and PTP-3 in C. elegans

Ryan Sellers

Mentor(s): David Sherwood

Co-Author(s): Sara G. Payne, Qiuyi Chi, David R. Sherwood

Biological Sciences

Basement membranes (BMs) are conserved, dynamic sheets of extracellular matrices underlying tissues of nearly all multicellular organisms. BMs confer structural properties which stabilize tissues to resist splitting under mechanical force. While the majority of BMs of neighboring tissues slide past each other, there are particular instances in which juxtaposed BMs form specialized adhesion sites, known as the basement membrane linkage (B-LINK) system. Disruptions in B-LINK interactions can lead to: tissue blistering, renal and eye development failure. While the B-LINK interactions have been found to be critical for adhering tissues, our knowledge of how the B-LINK sites are established is limited due to the transience of the interactions during development and the poor understanding of the mechanisms directing these associations. Recent studies in the genetically and visually tractable model C. elegans have started to advance our understanding of these poorly understood associations. A major B-LINK component is type IV collagen, which can activate two receptor classes: integrins and discoidin domain receptors (DDRs). To date, integrins are the only receptors known to function at the B-LINK adhering the epithelial seam and uterine tissue in C.elegans. Loss of integrin results in the splitting of these tissues and consequent animal rupture. While integrins have been shown to be critical for maintaining the B-LINK, the role of DDRs at the B-LINK have not been investigated. Using CRISPR/Cas9 gene editing, we found that a DDR-2 knockout exhibits a 15% rupture defect. In an RNAi screen for interactions with DDR-2, we found that this rupture penetrance was enhanced by loss of protein tyrosine phosphatase PTP-3, a poorly understood protein that has been shown to interact with BM proteins. Consistent with recent studies in neuron development, we have evidence suggesting that COL-99, an ortholog of type XIII collagen, may activate DDR-2 since loss of COL-99 did not enhance the rupture penetrance. Our findings demonstrate that DDR-2: (1) acts synergistically with PTP-3 to maintain weight bearing tissue in the B-LINK and (2) is likely activated by the COL-99 ligand.

Graduation with Distinction Candidate - Biology

Implications of seasonal hormone variation in the female-dominant blue-eyed black lemur

Alizeh Sheikh

Mentor(s): Christine Drea and Dr. Nicholas Grebe

Biological Sciences

In the decades since researchers first observed female social dominance in strepsirrhine primates, notably lemurs, studies have sought to uncover the proximate and ultimate explanations for the development of this phenomenon. The hormonal correlates of behavior in various female-dominant species, including lemurs, suggest that androgens may be linked to the development of traits in females that are more typically observed in males, such as high levels of aggression; as a result, androgens could play a decisive role in the maintenance of aggressively mediated female dominance. While one would neither expect nor typically observe a reversed sex difference in circulating testosterone, some female-dominant species show greater than expected androgen concentrations, particularly during pregnancy. Thus, any relationship between dominance and androgens is likely qualified and complex. It is possible that activational effects of androgens and other hormones may, in fact, manifest seasonally to facilitate competition during the mating season and parental care during the birth season. To measure seasonal fluctuations in hormones and dominance interactions in an aggressively female-dominant species, we comprehensively measured cortisol and sex hormone concentrations across the breeding and nonbreeding seasons in the blue-eyed black lemur (Eulemur flavifrons). Whereas the typical mammalian sex difference in androstenedione (A4) and testosterone (T) was observed, seasonal hormone changes coincided with changes in behavior for both sexes, with female-to-male aggression, female A4, and male cortisol peaking during the intensively competitive breeding season. These results align with predictions generated by a synthesis of the female masculinization and Challenge Hypotheses, in which females of seasonally breeding, female-dominant species are expected to show elevated aggression and androgen concentrations during the breeding season to facilitate mating competition and reject advances from certain potential mates. Meanwhile, elevated male cortisol and T during the breeding season is consistent with observations of exceptionally high levels of intrasexual male competition during this period. Altogether, these results suggest a seasonally mediated relationship between hormones and dominance interactions, one that may manifest in other seasonally breeding female dominant species.

Assessing combination anti-B7-H3 antibody and cancer vaccine therapy for TNBC

Lauren Sheu

Mentor(s): Smita Nair

Co-Author(s): Adam Swartz and Smita Nair

Biological Sciences

Triple negative breast cancers (TNBCs), which make up about 10-20% of all breast cancers, lack expression of estrogen receptor, progesterone receptor, and human epidermal growth factor receptor 2 (HER2). Compared to hormone- and HER2-positive breast cancers, TNBCs have higher recurrence rates and poorer rates of overall survival, largely due to a lack of targeted therapies. Thus, there is a clear and urgent demand for targeted TNBC therapies. One promising TNBC target is the immune checkpoint B7-H3 (CD276), a marker selectively expressed on solid tumor cells. Unfortunately, anti-B7-H3 antibody therapy alone has not resulted in resounding antitumor benefits. A recent phase IIb clinical study with HER2+ breast cancer patients revealed that individuals treated with anti-HER2 antibody therapy (i.e., trastuzumab) followed by a HER2-targeting vaccine exhibited greater survival rates compared to individuals treated with trastuzumab alone. These data suggest a combinatorial antitumor benefit against breast cancers when administering an antibody-based therapy with a cancer vaccine. In this study, we will examine whether the combination of a B7-H3 monoclonal antibody (mAb) and a cancer vaccine targeting a TNBC-associated antigen can promote synergistic antitumor effects against a mouse TNBC (e.g., 4T1). We hypothesize that B7-H3 mAb-mediated antibody-dependent cellular cytotoxicity (ADCC) of TNBC cells will improve cross-presentation of TNBC-derived antigens in the tumor microenvironment, leading to improved antitumor effects by vaccine-induced immune cells. Preliminary results suggest that the mouse B7-H3 mAb clone is capable of mediating ADCC of B7-H3-expressing tumor cells. We will treat 4T1 with the combination therapy and assess targeted antigen immune response, intratumoral immune-cell infiltration, and orthotopic tumor growth over time.

Understanding the evolution of prehension and the primate forelimb: a kinematic analysis

Denise Shkurovich

Mentor(s): Daniel Schmitt and Dr. Addison Kemp

Biological Sciences

Manipulative and grasping abilities, especially a prehensile (one-handed) and precision (thumb to index finger) grasp, have long been considered a distinctive feature of the primate order, which includes humans, apes, monkeys, and lemurs. When primates reach and grasp they generate coordinated motions at the shoulder, elbow, wrist, and fingers. Previous studies have suggested that the coordination of these movements is influenced by both body size and biomechanical constraints of the shoulder-joint complex. These biomechanical constraints depend on the way in which species use their forelimbs during locomotion, with some having more mobile shoulders because they swing by their arms or because they are arborealists who bear more weight on their hindlimbs. By quantifying limb movements and joint angles, kinematic studies allow for a more precise analysis of the different use of forelimbs during grasping across primates. Previous studies suggest that all primate species exhibit a similar wrist velocity profile during grasping, yet the relative velocities and grip type vary significantly among different species. To assess how body size, morphology, and locomotor behavior affect grasping kinematics in a species at one extreme of the body size spectrum, we conducted a kinematic analysis of reaching and grasping in small bodied (~70g) Microcebus murinus (mouse lemurs) at the Duke Lemur Center. A total of 17 landmarks on the individual's torso and right forelimb were manually digitized in a series of grasps from two distinct camera angles using the DLTdv program in MATLAB. There were limits on marker visibility (on average only 42.2% of the landmarks were visible over the course of 212 total frames). As a next step we will pursue future studies adjusting camera angles and digitizing space using new techniques. In addition, further studies including more primate species that vary in body size and locomotor patterns will be used to test specific hypotheses about how locomotor adaptations influence the evolution of precise grasping across primates and specifically in humans, a question key to understanding the origins of primates and the evolution of human precision grip.

Response of C. elegans gut microbiome to Aflatoxin B1

Tymofii Sokolskyi

Mentor(s): Joel Meyer

Co-Author(s): Tess Leuthner

Biological Sciences

Gut microbiome is a vital component of most animal taxa. As a functionally and systematically diverse community, it is always on the frontlines against external stressors, ranging from pathogens to xenobiotics. In the present study, we analyzed community changes within gut microbiome of a soil-dwelling nematode Caenorhabditis elegans in response to a common soil pollutant aflatoxin B1 and whether it impacts host response to this toxicant. It is known that nematodes tend to acquire their microbiome diversity from their substrates. Therefore, we extracted a bacterial community from compost, a native environment of C. elegans, and exposed lab-grown N2 worms and wild species from the same habitat to it over multiple generations with the addition of aflatoxin. Over the course of the experiment, we regularly sampled worms to assess worm growth, levels of mitochondrial DNA damage and community composition of the microbiomes using miSeq technology. Additionally, we exposed initial bacterial cultures and those from the gut to aflatoxin to observe their response. Our research has shown that diverse microbiome presents a protective effect against aflatoxin to the host, with an increase in taxa capable of converting aflatoxin into non-toxic metabolites being one of the possible effects.

Graduation with Distinction Candidate - Biology

Elucidating the regulation of host gene expression during liver-stage Plasmodium infection

Tamanna Srivastava

Mentor(s): Emily Derbyshire and Maria Toro-Moreno

Co-Author(s): Maria Toro-Moreno

Biological Sciences

Plasmodium, the parasite responsible for malaria, affects millions of people each year. *Plasmodium* adopts a complicated life cycle where the parasite infects mosquito midgut epithelium, human hepatocytes and erythrocytes. During the liver stage of infection, the parasite and human host cells undergo morphological changes, which facilitate progression to bloodstream infection. Liver stage parasitic development is an important target for biochemical studies, as many events that occur during the liver stage of development remain to be elucidated. To better understand these events, we performed RNA-sequencing on *P.berghei* (*Pb*) infected human hepatocytes. Comparing to uninfected hepatocytes, we identified hundreds of human genes that are differentially expressed during infection. Since we found that pathogenic infection modifies host gene expression, in this study we aimed to identify transcription factors (TFs) and non-coding RNAs (lncRNAs) most differentially expressed in Pb-infected hepatocytes, with the goal of understanding regulation of host gene expression during liver stages of infection. Using the RIF criterion, a metric that indicates how a transcription factor is differentially expressed and co-expressed with putative target genes, we identified the top ten host TFs with the highest RIF values for analysis: *ELF1, ZNF563, CDCA7, ZNF626, BBX, RNF138, ZNF561, ZNF451, RBPJ*, and *ZNF529*. The top hit, *ELF1*, has been implicated in modulating host genes during viral infection. Furthermore, we found that different clusters of host lncRNAs were expressed at different time points, indicating that specific host lncRNAs may be activated to facilitate *Pb* progression at specific time points of liver stage infection. Overall, this study highlights the potential of combining computational analyses of gene expression data with experimental assays to study host reprogramming during liver-stage *Plasmodium* infection.

Identifying and characterizing a novel class of mechanically-sensitive genomic enhancers

Alan Su

Mentor(s): Charles Gersbach and Dr. Brian D. Cosgrove

Biological Sciences

The stiffness of the cellular niche is a key determinant that can drive disease progression and has been shown to be an important factor in cellular processes such as differentiation, regeneration, and migration. While some signaling pathways underlying the translation of physical forces into chemical signaling cues have been established, the exact mechanisms through which cells transduce these mechanical forces into regulatory changes in specific genes are largely unknown. To establish a link between mechanical force and precise changes in genomic regulatory regimes, we looked for genomic enhancers that themselves were epigenetically regulated by force. Using ATAC-seq in human neonatal fibroblasts, we identified a variety of non-coding regions that showed differential chromatin accessibility across a range of substrate stiffness conditions. To identify which of these regions were active enhancers, we utilized epigenetic editing with dCas9-KRAB to repress these non-coding sites and assess enhancer activity based on transcript knockdown levels. Mechanically-sensitive genomic enhancers were identified that regulate Myosin-IIA (MYH9) , Bcl2 modifying factor (BMF), and Frizzled-2 (FZD2) gene expression. The MYH9 and FZD2 enhancers showed increased activity when cells were grown on stiffer substrates, while the BMF enhancer showed decreased activity with high-stiffness substrates. Luciferase assays were used to further validate these putative enhancers and conduct perturbative studies in which cell contractility was chemically modulated to assess the long time-scale effects of mechanical force on these enhancers in an episomal reporter construct. Supporting this initial evaluation of the identified enhancers with CRISPRi methods, the FZD2 enhancer showed a lower activity, while the BMF enhancer showed an increase in activity with a reduction in cell contractility. Taken together, this suggests that these mechano-enhancers have intrinsic properties that allow for a response to mechanical force even outside of their native chromatin contexts. Ultimately, this work identifies a novel class of enhancers that can be regulated by mechanical cues and may provide a useful foundation for understanding how to precisely modulate gene expression within pathogenic mechanical states.

Investigating cathemerality through an examination of the activity of ruffed lemurs (Varecia)

Rebecca Supple

Mentor(s): Charles Nunn

Biological Sciences

Cathemerality, an activity pattern in which individuals are active both day and night, is seemingly maladaptive. Unable to specialize for either diurnal or nocturnal vision, cathemeral species are at a disadvantage when foraging and avoiding predators. Yet, the majority of the family Lemuridae exhibits this unusual activity pattern. One genus, Varecia, the ruffed lemurs, lacks much published research to define their activity pattern. Investigating whether or not they are cathemeral, as well as what factors (i.e. light availability, temperature) may mediate their nocturnal behavior can help illuminate the broader picture of this activity pattern. Preliminary results from my field research in 2019 support cathemerality and tie their nocturnal activity to lunar phases and temperature. To corroborate those results in a more controlled, captive setting, 12 Varecia at the Duke Lemur Center (DLC) were fit with actigraphy collars that can track an individual's activity levels. Animals showed greater amounts of nocturnal activity than would be expected if diurnal. Nocturnal activity was positively correlated with light availability when outside, as well as negatively correlated with rainy and hot days, especially when inside.

Characterizing Histone H1.4 Expression Throughout Brain Development

Wendy Tan

Mentor(s): Anne West and Martine Tremblay

Biological Sciences

Rahman syndrome is an extremely rare form of intellectual disability caused by frameshift mutations in the H1-4 gene. Histone linker protein H1.4 is an H1 subtype belonging to a family of proteins responsible for regulating chromatin structure and stabilizing DNA bound in nucleosomes. Although H1 linker proteins play an important role in influencing higher order chromatin structure, the individual functions of each H1 subtype are unclear given the compensatory actions of other H1 subtypes when one is knocked out. However, although the intellectual disability phenotype in Rahman syndrome implicates a role for H1.4 in the brain, systematic studies of the function of histone linker H1 have not been performed in neurons. To determine the contribution of Rahman syndrome mutant H1.4 in neurons, we overexpressed a mutant frameshift H1.4 in rat hippocampal neurons. This showed no changes in dendrite complexity compared to the wild-type by Sholl analysis, but interestingly showed neurons expressing frameshift mutant H1.4 results in reduced firing and synchrony in culture. These results showed that overexpression of H1.4 can result in a phenotype in neurons. However, not much is known about endogenous expression (rather than overexpression) and function of wild-type H1.4 in neurons. This project aims to characterize the expression of H1.4 throughout brain development at different development time-points and in specific brain regions. A dual FLAG and Myc tagged H1f4 mouse line was generated in order to study the endogenous expression of histone linker protein H1.4 throughout development. Specifically, expression of H1.4 was investigated at developmental time points p1, p7, p14, p21, and p60, in the olfactory bulb, cerebellum, hippocampus, cortex, and liver. The H1f4 tagged mouse line was validated by performing acid extraction of histones and verifying expression of the tagged H1.4 protein by Western blotting.

Graduation with Distinction Candidate - Biology

Elucidating the Role of Host Aquaporin-3 During Apicomplexan Liver-stage Infection

Michael Tran

Mentor(s): Emily Derbyshire and Kayla Sylvester

Biological Sciences

The liver-stage infection of malaria remains a poorly understood yet crucial part of Plasmodium development. In P. berghei liver-stage schizonts, the tubovesicular network (TVN) has previously been identified. This network is derived from the parasitophorous vacuole membrane (PVM) that extends into the host cytosol and exhibits features including extended membrane clusters, tubules, and vesicles. We utilized high-resolution confocal microscopy to discover and characterize the TVN in P. vivax schizonts and biologically quiescent hypnozoites throughout liver-stage infection. Unexpectedly, a majority of P. vivax-infected primary human hepatocytes exhibiting TVN features were hypnozoites. This study also demonstrates that host aquaporin-3 (AQP3), a water and solute channel, is one of the few known host proteins to associate with TVN-derived vesicles and extended membrane clusters during P. berghei and P. vivax liver-stage infection. To further investigate AQP3, we analyzed AQP3 recruitment to Toxoplasma gondii, a fellow apicomplexan parasite, and found AQP3 upregulation in T. gondii-infected hepatocytes. Additionally, AQP3, among other host aquaglyceroporins, were subjected to RNA interference in Plasmodium-infected hepatocytes; the corresponding Plasmodium parasite load and cell viability of treated hepatocytes were also analyzed. These experiments implicated AQP3 as essential to liver-stage infection and suggested a possible compensatory mechanism among aquaglyceroporins. The aquaglyceroporins may serve redundant functions for Plasmodium development in the liver. In total, our study revealed a key aspect of P. vivax liver-stage biology and enhanced our understanding of the role of AQP3 in apicomplexan infection.

The Mechanism of Silence: Amygdala Neurons Non-aversively Suppress Vocalizations in Mice

Shuyun Xiao

Mentor(s): Richard Mooney and Valerie Michael

Biological Sciences

Vocal communication is crucial for the survival and social functions of a wide range of vertebrates. In humans, maladaptive vocalizations typify various neuropsychiatric disorders including autism spectrum disorders and schizophrenia. Notably, effective communication requires appropriate control of both vocal production and suppression. Nonetheless, despite decades of research on brainstem circuits that are necessary for vocal production, little is known about the forebrain networks that input onto such brainstem vocal circuits and suppress vocalizations in response to appropriate environmental cues. The present study examined an amygdalar cell group (AmgC/M-PAG) in mice that projects to midbrain periaqueductal gray (PAG), a structure obligatory for gating vocal production. When activated optogenetically, AmgC/M-PAG neurons transiently suppressed ongoing ultrasonic vocalizations (USVs) in both males and females across courtship and non-sexual contexts without eliciting apparent aversive behaviors such as freezing and fleeing. Immunofluorescence and optogenetic experiments in transgenic mice expressing Cre in estrogen receptor alpha (Esr1) positive cells suggested that Esr1+ AmgC/M subpopulation was sufficient to suppress courtship USVs in male mice. Moreover, as evidenced by neural activity marker c-Fos, AmgC/M-PAG neurons became active in both sexes following interactions with conspecific intruders but did not respond robustly to neutral stimuli or fear-eliciting stimulus such as fox urine. Finally, monotranssynaptic rabies tracing experiments revealed that AmgC/M-PAG neurons received various cortical and subcortical inputs. Optogenetic activation of the input cells from the bed nucleus of the stria terminalis (BNST) suppressed courtship USVs. Results from the current study better our knowledge of adaptive vocal control on the neuronal level.

Graduation with Distinction Candidate - Biology

Role of the Nucleoporin 153 in transcription and spatial positioning of X-linked genes

Amy Zhao

Mentor(s): Eda Yildirim

Co-Author(s): Yuming Shi

Biological Sciences

Several nuclear structural proteins have been shown to interact with specific sites across the genome affecting transcription. One of these structures is the nuclear pore complex (NPC), which is composed of >30 Nucleoporin proteins. Recent evidence shows that the NPC basket protein Nucleoporin 153 (NUP153) regulates binding of the chromatin architectural protein CTCF, which influences transcription and higher order chromatin organization. Subnuclear positioning of chromosomes has been associated with gene regulation, and in interphase cells, X chromosomes exhibit peripheral subnuclear positioning. Here, I used X chromosome inactivation (XCI) as a model to study the role of NUP153 in transcription and spatial positioning of X-linked genes. XCI is a dosage compensation phenomenon which results in transcriptional silencing of one of the two X chromosomes in females, equalizing X-linked gene expression between females and males. XCI relies on Xist RNA, which coats the inactive X chromosome (Xi) and triggers chromosome-wide silencing. Preliminary studies have shown that NUP153 deletion results in altered spatial positioning of the Xist gene on the Xi to the nuclear periphery, without affecting the position of the Xi chromosome territory, suggesting internal reorganization of the Xi. These data led to the hypothesis that NUP153 might influence the chromatin organization of the Xi. To test this hypothesis, I utilized control and NUP153 shRNA knockdown mouse embryonic fibroblasts (MEFs) to determine changes in the transcription and spatial position of X-linked genes encoded at different positions across the X chromosome. I found that out of the five genes tested, only one presented significant change in spatial positioning, while transcription of the majority of the genes was altered in NUP153 deficient cells. These findings suggest that NUP153 impacts X-linked gene expression independent of significant changes in spatial positioning. It is important to note that several of these genes are found in close proximity to the nuclear periphery in control cells. Thus, in the future, it will be critical to investigate how the NPC affects interchromosomal dynamics of X chromosomes and define the role of this mechanism in X-linked gene expression.

Graduation with Distinction Candidate - Biology

Probing Substrate-Specificity of Fatty Acyl-AMP Ligases in Natural Product Biosynthesis

Jeffrey Zheng

Mentor(s): Dewey McCafferty, Lydia M. Stariha, and Kelsey T. Morgan

Biological Sciences

Fatty acyl-AMP ligases (FAALs) are enzymatic biosynthesis machinery that activate fatty acids for subsequent addition to various non-ribosomal peptides (NRPs). Recent work in our lab has identified Micromonospora chersina as a producer of the NRP chersinamycin which belongs to the ramoplanin family of lipid-II binding antibiotics. However, these compounds possess low solubility and poor tolerance in the blood stream caused by the fatty acid tail added to these peptides. Thus, we proposed analyzing the tolerance of FAAL active sites for non-native fatty acids to understand the gating mechanism that controls addition of the native fatty acid. To this extent, we conducted feeding experiments utilizing synthesized N-acetylcysteamine (SNAC) derivatives to explore incorporation of various fatty acids into the native chersinamycin. Additionally, activity assays for the ramoplanin and chersinamycin FAALs were performed utilizing a library of non-native fatty acid derivatives varying in both size and structure. Here we report the successful synthesis of fatty acyl-SNAC and hydroxamic acid. Feeding experiments performed with both the fatty acids and SNAC derivatives did not result in successful incorporation of non-native fatty acid tail into the NRP. However, our in vitro experiments demonstrated that FAAL activity for branched fatty acids were increased relative to non-native straight chain fatty acids. Additionally, a degree of tolerance exists for fatty acids of slightly longer length while shorter fatty acids resulted in a reduction to activity. The results identified for FAAL specificity of various fatty acids enable further investigations into the biosynthetic machinery responsible for NRP production. Holistic understanding of the biosynthesis could enable creation of mutant strains with modified fatty acid tails to improve solubility and tolerance.

Creative Arts

#NoNewClothes: A Campaign for Advancing Sustainable Practices in the Fashion Industry

Milagros de Souza

Mentor(s): Christine Folch

Creative Arts

Milagros de Souza is a Program II major—Intersectional Sustainability in the Fashion Industrial Complex. Originally from Washington D.C., Mila is passionate about and participates in all things sustainable fashion. In her daily life, Mila only buys sustainable or second-hand clothing while also trying to live a more sustainable life in general. In her career, Mila is a stylist, model, designer, blogger, and entrepreneur in the fashion industry. In all of these roles, Mila incorporates social and/or environmental sustainability. For her project, Mila worked with Remake, a non-profit committed to making fashion a force for good. In this role, she organized a #NoNewClothes campaign where she supported pledgers who decided to not buy any new clothes for 90 days through virtual events and community-building. She was also responsible for managing the logistics of a sustainable fashion conference for fashion students all over the United States.

The Blackfeet and The Backbone of the World

Quinn Smith

Mentor(s): Lalita Kaligotla, Suzanne Katzenstein, and Susie Post-Rust

Co-Author(s): Ernie Heavy Runner, Darrell Norman

Creative Arts

Created virtually at the height of the COVID-19 pandemic, this documentary accepts the difficult task of overcoming immense technical obstacles to uplift indigenous voices at time when elders are unable to safely do so themselves. Storytelling is vital. It is the only way that we can change public policy. It is history, culture, and survival. From an archive spanning 1880-1970, photographs of the Blackfeet Nation, the Great Northern Railway, and Glacier Park are brought to life through narration by tribal elders Ernie Heavy Runner and Darrell Norman. Together, they exemplify how storytelling serves as peaceful and powerful resistance to acculturation and discrimination. Structured as a series of profiles situated in a historical narrative, the elders give us many stories including one about early Blackfeet feminist Daisy Norris and another about Two Guns White Calf, a model for the buffalo nickel. Mr. Heavy Runner tells several powerful war stories and details historical Blackfeet spirituality which continues to thrive today. Both elders conclude by describing the current state of the Blackfeet Nation, and it becomes evident that we need policy to promote The Blackfeet Nation's right to physical and cultural subsistence. Thus, institutional support of authentic Native arts is crucial in advancing tribal sovereignty. Made in collaboration with the Indian Arts and Crafts Board.

Health / Clinical Research

Saving Intestines at Birth: Gastroschisis Silos for Sub-Saharan Africa

Arushi Biswas

Mentor(s): Ann Saterbak and Dr. Tamara Fitzgerald

Co-Author(s): Caroline Salzman, Patrick Wilson, Nolan Burroughs, Muthu Arivoli

Health / Clinical Research

Gastroschisis is a congenital anomaly in which intestines protrude through a defect near the umbilicus. In high-income countries (HICs), a preformed silo (a plastic bag with a semi-rigid opening) is used to protect the intestines. Over several days, the intestines can be reduced back into the abdomen, and mortality is < 5% in HICs. Silos are generally not available in sub-Saharan Africa, and mortality from gastroschisis is > 90%. Our team of engineers and surgeons from the U.S. and Uganda have collaborated over 18 months to develop a low-cost silo from locally available materials in Uganda. With a prototype that meets all the design specifications, next steps include animal testing and the launch of an IRB-approved clinical study at Mbarara Hospital in Uganda. With an effective distribution plan to hospitals and clinics, we propose that the low-cost silo can substantially assist in lowering the mortality rate of neonates with gastroschisis in sub-Saharan Africa. Our team aims to have locally-made silos into the hands of pediatric surgeons in Uganda by 2022.

Sex differences in patellar stabilization and knee joint contact pressures: a cadaveric model

Brian Chavez

Mentor(s): Daniel Schmitt

Health / Clinical Research

Patellofemoral pain (pain when the kneecap is drawn across the surface of the knee joint) is a common complaint for athletes and older adults, and it is particularly common in women. Patellofemoral pain is often associated with degradation of cartilage (osteoarthritis) on the patella (kneecap). One of the causes of damage to cartilage may be when the kneecap is pulled laterally (to the side) across the joint by muscles that also extend (straighten) the knee. These muscles—the vastus lateralis, vastus medialis, rectus femoris/vastus intermedius—pull the kneecap upward and extend the joint by also pulling on the attachment of the patella to the tibia (part of the lower limb below the knee). The largest of these muscles—the vastus lateralis—pulls up and to the side and can pull the patella across the knee. This muscle is thought to be balanced by vastus medialis, especially its most distal portion called the vastus medialis oblique (VMO) with its fibers running horizontally. However, the size and orientation of the VMO varies widely and its role in stabilizing the patella is not well understood. In addition, one of the hallmarks of human bipedalism is a valgus knee, in which the femur points inward to the midline. This angle (quadriceps angle or Q-angle) is more extreme in women, and the VMO is thought to be weaker in women. To explore these effects, I acquired ten knees from cadaveric donors (5 males and 5 females; average age = 74.7 years). I measured the Q-angle of each limb and muscle fiber orientation angle of each VMO. The average Q-angle for females was 13.9 +/- 2.34 and 8.94 +/-2.27 while the average fiber angle of VMO was 30.0 +/- 11.2 for females and 34.5 +/- 5.77 for males. To test the role of the muscles in balancing the pull on the patella, I built a hydraulic system that pulled on wires with specific weight values for each quadricep and oriented the wires to simulate the angle of pull of the four muscles. The device also allowed me to position the knee at different degrees of flexion (0, 30, 60, and 90) and at a proper Q-angle representing the orientation of the knee in life for each cadaver donor (measured on the donor). The load on the knee, especially on the lateral side was measured with pressure sensitive Fuji Film. The movement of the patella was tracked by a 3-D motion camera system. The results show that increased load on VMO does balance sideward pull of the kneecap and help lower lateral load on the patella at greater Q-angles.

Signal-to-Noise Analysis of TBX5 Variants Suggests Presence of Expression-specific Hotspots

Alexandra Markunas

Mentor(s): Andrew Landstrom

Co-Author(s): Jordan E. Ezekian, MD, MPH, Andrew P. Landstrom, MD, PhD

Health / Clinical Research

Variants in the T-box transcription factor 5-encoding gene (TBX5) have been traditionally associated with Holt-Oram syndrome (HOS), a condition characterized by congenital heart defects and upper limb malformations. Prior HOS studies have revealed a lack of correspondence between variant location and malformation severity. Recently, cardiac phenotypes ranging from cardiomyopathy to long QT syndrome have been associated with TBX5 variants. This underscores the need for analysis of the phenotypic diversity associated with TBX5 variants. Therefore, we hypothesize the presence of pathogenic variant hotspots in TBX5 that are cardiac phenotype expression specific. We aimed to identify pathogenic variant hotspots within the TBX5 gene through signal-to-noise (SN) analysis to determine whether variant location may be associated with variable disease expressivity. We collated 4 cohort studies of individuals diagnosed with HOS (n=696) that were sequenced for TBX5 variants and 17 case studies describing cardiac-specific TBX5 variants. Re-evaluation of variant pathogenicity was performed by referencing the ClinVar database and PredictSNP. Amino acid-level SN analysis was defined as disease-associated relative risk at an amino acid position vs. rare population-based variant at the same location derived from gnomAD (MAF< 0.01). Protein features were mapped using the UniProt database. We identified 16 unique cardiac phenotype-associated variants from 17 case studies. SN analysis identified 5 pathogenic hotspots, 4 located within the DNA-binding domain (DBD) of TBX5 from residues 58 to 238. 75% of the cardiac phenotype-associated variants were similarly located within the DBD, and 59% of these variants were associated with a hotspot. Of the cardiac-specific variants that were not associated with a hotspot, 83% were localized to residues 132-161. Variants with a dilated cardiomyopathy phenotype were localized within residues 143-154 and 237-264. These findings suggest a potential relationship between cardiac disease expressivity and variant location relative to TBX5 pathogenic hotspots. Further analyses are needed to determine whether cardiac phenotypes are associated with characteristic pathogenic hotspots and therefore whether SN analyses can be used to predict TBX5 missense variant-associated phenotypes.

Exploring the Quality and Understandability of Hospice-Related Educational Videos on YouTube

Sarabesh Natarajan

Mentor(s): Arif Kamal

Co-Author(s): Ezra Kalmowitz; Mihir Patel; Simran Prakash; Kaylianna Ritz; Erik Tran; Arif Kamal, MD, MBA, MHS

Health / Clinical Research

Currently, due to insufficient knowledge and predominant misconceptions about hospice services, about 40% of eligible hospice patients do not receive hospice care. We examined the use of YouTube for hospice care education, as YouTube is the principal form of health-related social media use. We used the YouTube Data API (v3) to search YouTube for the top 100 videos under the keyword “hospice,” and we excluded videos that were hospice irrelevant (n=4), longer than 6 minutes (n=41), not in English (n=4), and duplicative (n=1). We developed a question set to characterize the comprehensiveness with which videos addressed information about hospice services, team-based care, and misconceptions. We also examined the quality and reliability of videos using the mDISCERN measure and their understandability using the PEMAT-A/V measure. Finally, we recorded demographic characteristics of patients, caregivers, and members of the hospice care team in videos. Among included videos (n=50), we found that only 38% of videos addressed the definition of hospice, and only 40% addressed services offered by hospice or members of the care team. Further, less than 20% addressed various misconceptions around hospice. While 64% of videos were rated high quality, few (18%) provided additional resources for patients. While 62% of videos had high understandability, they lacked key strategies that otherwise promote retention, as only 24% of videos organized information into sections and only 4% provided summaries. Interestingly, mDISCERN and PEMAT-A/V scores showed moderate negative correlations with views, likes, dislikes, and number of comments. Finally, comprehensive representation of the hospice care team was sparse, as 2 or fewer social workers, chaplains, therapists, and hospice volunteers were shown among all videos. Further, 89.3% of characters in the videos were Caucasian. Our findings, overall, suggest that hospice-related video purveyors should publish more comprehensive content about hospice. In doing so, the diversity of the hospice team should be prioritized, and videos should aim to be more understandable and informative for patients.

Evaluating the usability of YouTube as a platform for hospice education

Simran Prakash

Mentor(s): Arif Kamal

Co-Author(s): Ezra Kalmowitz, Sarabesh Natarajan, Mihir Patel, Kaylianna Ritz, Erik Tran, and Arif Kamal, MD, MBA, MHS

Health / Clinical Research

Currently, about 40% of eligible hospice patients do not receive hospice care, in part due to insufficient knowledge and misconceptions about hospice utilization. Because of the increasing relevance of social media platforms, particularly YouTube, as a source of health information, we examined the landscape of hospice information on YouTube. To select videos, we used the YouTube Data API (v3) to search YouTube for the top 100 videos under the keyword “hospice”. We collected user engagement metadata for these videos. Then, as per viewing behaviors of average YouTube users, we excluded videos that were hospice irrelevant (n=4), longer than 6 minutes (n=41), not in English (n=4), and duplicative (n=1). For included videos (n=50), we collected information for each video regarding search rank, user engagement metadata (likes, dislikes, views, and comments), purveyor characteristics, style of information presentation, and use of teaching tools. Among all 100 retrieved videos, 96 were hospice-relevant, but 4 were related to music, television shows, or gaming. Importantly, these 4 videos accounted for 31.8% of total views, and two of these videos were within the top 20 search results. For included videos, user engagement was poor or absent. Among these videos, videos published by hospice or palliative care organizations, on average, had fewer total views (3.41e5 ± 6.65e5) than those published by multi-specialty healthcare providers (1.87e7 ± 2.87e7) ($p = 0.0019$) or media, advertising, and/or news organizations (3.23e8 ± 6.37e8) ($p = 0.000042$). Hospice and palliative care organizations also had, on average, fewer subscribers (5.45e3 ± 7.63e3) than multi-specialty healthcare providers (4.04e4 ± 6.49e5) ($p = 0.0081$) or organizations involved in media, advertising, and/or news dissemination (8.52e5 ± 2.24e6) ($p = 0.00178$). Finally, the use of teaching tools, such as examples (n=3), visual emphasis (n=3), and illustrations (n=1), was sparse, and closed captioning was auto-generated and erroneous (n=37). Our findings suggest that video purveyors should publish more hospice-related content on YouTube, and when doing so, should prioritize using strategies to improve user engagement. Recommendations include producing shorter videos, manually categorizing videos, using engaging graphics and teaching tools, designing informative titles and descriptions to improve search rank, and standardizing closed captioning across videos.

ArchGuard: A novel cerebral protection device for transcatheter aortic valve replacement (TAVR)

Kelly Yang

Mentor(s): Eric Richardson

Co-Author(s): Kevin Rosenthal, Pratik Doshi, Anish Nigade, Len Assakul

Health / Clinical Research

Aortic stenosis (AS) is a serious condition in which the aortic valve does not fully open. If left untreated, AS can lead to heart failure. Around the world, 13% of those over the age of 75 suffer from AS. Transcatheter aortic valve replacement, or TAVR, is one of the main treatment options; however, despite its increasing prevalence, there remains a devastating complication that has yet to be resolved.

TAVR uses a minimally invasive approach to deploy a prosthetic valve over the existing, diseased valve, but as it does so, it can dislodge calcifications, sending debris up the cerebral arteries and into the brain. Once in the brain, this debris can physically obstruct blood flow, causing ischemia and stroke.

The post-TAVR stroke rate for the first 30 days is 4%, and that number goes up to 7% for the first year. Furthermore, MRI imaging has revealed 4 out of 5 TAVR patients will suffer from silent ischemic lesions, which are associated with an increased risk of future stroke, mortality and dementia. There is a real, unmet need to protect the brain during TAVR.

To address this, our team has developed ArchGuard, a novel cerebral protection device that will be deployed in the aortic arch during the TAVR procedure, offering complete protection to all three cerebral arteries. ArchGuard is comprised of a shape-memory frame and porous mesh that will deflect debris away from the cerebral arteries while at the same time allowing sufficient cerebral perfusion.

We have taken a multi-disciplinary approach throughout the development of our device. Beyond traditional testing in the lab to validate functional endpoints of our device (i.e., deflection, perfusion, deployment), we are continuously seeking and integrating feedback from our faculty advisors, who have industry experience with TAVR product lines, and interventional cardiologists at Duke University Hospital. To ensure our product will successfully go to market, we are also in conversation with key stakeholders with expertise in business, intellectual property and regulatory pathways.

Recently, we have partnered with a medical device manufacturer to produce a high-fidelity prototype and plan to move into animal and cadaver studies to further validate our device. A provisional patent application was filed last spring to protect the intellectual property of this research, and we are in the process of converting it into a full patent.

Humanities

Seventeenth-Century Female Petitioning Across the British Isles and Atlantic World

Lizzie Bond

Mentor(s): Philip Stern

Humanities

Women across the seventeenth-century British Isles and its burgeoning Atlantic empire exercised a right—and, indeed, engaged a duty—to petition. Historians have widely acknowledged that Britain's seventeenth century saw petitioning function both as a conventional practice and as a subversive impetus contributing to the rise of a modern democratic culture. The historiography has simultaneously contended that, during this same revolutionary century, British women found themselves bereft of full legal and political subjecthood, theoretically relegated by the doctrine of couverture in law and custom to the status of unspeaking, inferior subjects. Yet, as the historical archives demonstrate, women were active petitioners in both Britain and its colonies, routinely accessing the law and seeking redress of grievances via the petitionary form. They both authored and signed petitions as individuals and collectives, while their petitions figured in manuscript or print forms as they sought redress from diverse seats of authority, from the House of Lords to the Virginia Company of London, on an infinite array of issues, from property disputes to pleas for mercy. In so doing, they carried out an act of petitioning that was not merely inherently gendered by their self-declared female status, but that staked their claims as members of a public order which was said to exclude them. Their petitions thus proved a unique forum for seventeenth-century British women at home and across the Atlantic to impart aspirational female political speech as they articulated their visions about their rights, duties, and place in the emerging imperial polity.

The Gospel of Luke as a Case Study for the Reexamination of Bios

Caleb Cooke

Mentor(s): Mark Goodacre

Humanities

In 1977, Charles Talbert pioneered the understanding of the Gospels as Graeco-Roman bioi in his response to Bultmann's assertion that the Gospels are sui generis. Richard Burridge later expanded Talbert's thesis in his What Are the Gospels? and is often credited with the field's widespread adoption of the reading of the Gospels as Graeco-Roman bioi. This paper calls for the reexamination of the understanding of the Gospel of Luke as an ancient biography. As Richard Burridge has argued, an interpretation of the genre of the Gospels must consider the genres available to writers at the time. What he has missed, however, is the importance of the Septuagint's historical writings on the Gospel writers, including Luke. The evangelists were familiar not only with Greek genre and style but also with the Septuagint, which they regarded as "Scripture." My call for a reexamination of the reading of the Gospels as Graeco-Roman bioi begins upon consideration of trends in genre theory. Using many aspects of Richard Burridge's thoughts on genre, our discussion of genre will attempt to approach an understanding of genre that will serve useful for the Gospel of Luke, specifically. Then, a discussion of the term "Old Testament historiography" is warranted on account of its centrality within this paper. After that, these concepts will be synthesized in an examination of the Gospel of Luke and its forms, content, and context. Throughout the discussion, it will become increasingly clear that proposing the possibility of pinpointing Luke's genre as anything more than an improbability is, well, hopeful at best. As a result, the claim of this project is not one that likens itself to the discovery of the "true" genre of the Gospel of Luke. Instead, this paper hopes to bring forth evidence from within the Gospel of Luke and surrounding literature that necessitates the discussion of the unanswered questions that arise from the reading of the Gospels as Graeco-Roman bioi. Luke's authorial decisions, explicit and implicit, were affected by his previous exposures to literature of several kinds, including Graeco-Roman historiography, Graeco-Roman biography, and Old Testament historiography. Our discussions on the genre of the Gospel of Luke should reflect this, and, as a result, should take seriously all the texts that may have composed Luke's immediate literary and historical context.

The Risk of COVID-19 Denialism on Vaccine Confidence

Anne Crabill

Mentor(s): Lalita Kaligotla

Humanities

If large percentages of the public deny that COVID-19 exists or poses a severe threat to their health, public health officials will struggle to build confidence in a COVID-19 vaccine. Public health officials who wish to build robust COVID-19 preparedness programs will need to understand and counter COVID-19 denialism as part of their efforts.

Denying the existence of a new virus is not a new phenomenon. Karo Taro Greenfeld outlined a pattern the response to emerging diseases tend to follow: denial, followed by panic, fear, and rational response.1 South African President Thabo Mbeki led AIDS denialism; researchers estimate his denial resulted in over 300,000 unnecessary deaths between 2000 and 2005.2 In 2003, the Chinese government was accused of denying the existence of a SARS outbreak.3 Likewise, early messaging surrounding Ebola denied the virus was real and a grave threat.4

Based on preliminary social media analysis, I will present a brief overview of the forms of COVID-19 denialism found in a two-week snapshot of US Twitter data from late July and early August of 2020.

In order to examine COVID-19 denial on social media in the United States, I used Meltwater, an AI-based social media monitoring tool, to search for and aggregate Twitter data. I created a Boolean search framework to collect data. I began my research by drafting a list of common phrases used to refer to COVID-19. These terms include “corona, coronavirus, COVID, Chinese virus” and others. I then drafted a list of terms related to COVID denialism. Initially, these terms included “lies, lying, hoax, cover up, and scam.” In the Boolean, I limited the search results to Tweets containing references to both COVID-19 and terms that referenced an aspect of COVID denial.

Social media is rife with various forms of COVID-19 denialism. Twitter users who share their denial of COVID-19 may perceive a COVID-19 as being unimportant. This may cause them to forgo a COVID-19 vaccine.

Developing a Repository of Unique Lesson Plans for 6th Grade Students in Eastern NC

Caroline Doherty

Mentor(s): Lalita Kaligotla and Kelsey Ballard

Humanities

This past summer I paired with Edgecombe County Public School system to create curriculum for their new micro-school, Imagine West. This school is specifically for 6th graders who have applied and been accepted. The school's goal is to create an environment that fosters collaboration and creativity within the educational system. I worked with the Eastern North Carolina Internship Program (ENCIP) to help me find this opportunity and facilitate the partnership. I had a mentor from ENCIP and from Imagine West that I utilized to assist me in researching and creating the curriculum. This curriculum included prompts about current events, photos, articles, poems, maps, math puzzles, and more paired with unique discussion questions for each prompt. The goal of the discussion questions was to incite communication between the students and none of the questions had a "correct" answer. The topics were meant to challenge the students and uncover disagreement between their perspectives and opinions. I purposefully included topics and ideas that are not usually covered within the traditional academic setting. I met with my mentors on a weekly basis and even visited the school once over the summer. When I visited the school, the principal showed me the construction layout for the new micro-school, Imagine West, where my curriculum would have been implemented. Given that the school district decided to go completely online for the year, the principal and I decided that a virtual presentation of the topics would be best. I have met with the principal of Imagine West a few times during the school year to discuss how the curriculum was being received by the students and teachers. I've learned that the teachers like to present the curriculum early in the morning to their students to get them engaged in class, which is difficult, especially in the virtual setting. Teachers have reported an increase in debate among their students and recounted lively discussions surrounding the topics in the curriculum. This engagement has permeated into subjects that are part of the traditional academic curriculum as well, such as social studies and even math.

Envisioning Africa in Venetian Print Culture, 1500-1650

Noah Michaud

Mentor(s): Kristin Huffman

Humanities

This poster summarizes Michaud's original research for his art history honors thesis. His research project investigates Venetian representations of Africa and Africans in the mid-sixteenth century, what he calls "the Veneto-African imaginary." Such representations are manifest in Venetian maps, book illustrations, and engravings (each comprising a section of his thesis). Much as the Venetian state adopted imagery and myths to form its worldly image, Venice's preeminent role in creating geographic knowledge established iconography and legends about other societies. Venetian images of Africa merged art with science, generics with specifics, and facts with fiction so as to inspire exotic encounters from afar. Major texts of interest include Giovanni Battista Ramusio's seminal travelogue anthology, Delle navigationi et viaggi (1st ed., 1550); Cesare Vecellio's global costume book, Degli habiti antichi et moderni di diverse parti del mondo (1590); Donato Bertelli's illuminated map of Africa (1573), after that by Giacomo Gastaldi (1564); and Livio Sanuto's Geografia dell'Africa (1588), the first atlas on Africa ever assembled. Michaud's project employs close reading of early modern ethnographies and close looking at maps, reproduced at the highest resolution for digital humanities archives. Such critical observations illuminate ongoing cross-cultural and cross-textual interactions between art history, anthropology, and geography; Venice, Africa, and Europe.

“Estorbando y Trabajando:” The COVID-19 Experiences of Latinx Construction Workers in Durham

Maria Pita

Mentor(s): Christopher Daley, Anne Allison, and Orin Starn

Humanities

In his famous Anatomy of the Classes, Fussel argued that all work is divided into two factions, safe and dangerous, and these are the factors that stratify our society into classes. This has never been truer than for essential workers during the 2020 COVID-19 pandemic. The precarious and essential labor of construction workers, who continued to work during the national stay-at-home orders, is made more hazardous in our current COVID era. During this time, lack of paid sick leave, disproportionately low COVID-19 testing among Latinx populations, and poor working conditions have revealed the expendability of these workers, even as they perform essential, life-sustaining labor.

What's more, in over-attributing agency as the driver of personal decisions during this pandemic, the hazardous work of essential labor has been dangerously altruized, in part to soothe the discomfort of the many working safely from home. While this pandemic has created a new, dramatically different realities for many, it has simply uncovered the unsettling realities of others. Some factions of our workforce, like healthcare workers, were confronted with a new and overwhelming demand for care, exposed to highly infectious working conditions, and made to navigate a health crisis with little structural support. However, the similarly hazardous reality of construction work has been existing already and was only exposed by the disproportionate morbidity and mortality of construction workers during this pandemic. This research aims to access these realities as experienced by my interlocutors, Latinx construction workers living and working in Durham during the time of the pandemic. Interviews were conducted remotely to gather and translate the stories of Durham construction workers, who build the landscape of this city, and with it our memory of this place. Through their words and mine, a joint narrative is constructed about their lives during the pandemic, the debilitating burden of essentialness, and the ways in which our current labor guidelines and the vaccine rollout program reiterate their expendability.

The Politics of Memory: The Meaning of Home to Armenian Genocide Survivors (1919-1991)

Stefanie Pousoulides

Mentor(s): James Chappel

Humanities

What do post-genocide communities call home? I study Armenian Genocide survivors' writings, narratives and memories to uncover the post-genocide Armenian home. Using oral history archives and the League of Nations archives, I analyze Armenians' strategies in legal and political discourses and unifying threads throughout Armenian stories of the genocide and the diaspora based on the writings of Armenian political elites and petitioners as well as interviews of Armenian Genocide survivors conducted by Armenians. My study centers Armenian perspectives and their resistance against attempts to deny them a homeland to contextualize typical debates on recognition of the Armenian Genocide with their strategic claims for land and property. Despite their promises, the League of Nations repeatedly denied Armenians any restitution, though the League claimed its institutions would provide safeguards for nations and minority groups. I show through my analysis of oral histories that the lack of confidence of Armenian Genocide survivors in international institutions pervaded the Armenian diaspora in the United States, where many Armenians immigrated after the genocide. Even decades in the aftermath of the genocide, their memories of the genocide and commitment to preserving Armenian culture and traditions survived. Armenian Genocide survivors' dedication to establishing an Armenian home prevailed and took the form of a political memory independent of western institutions. Archival documents and oral histories must be studied together to capture why the Armenian home lives through political memory, not through the writings of statehood and petitioning attempts. Researchers of post-genocide Armenia need to decenter political elites and institutions and combine studies of the international system with political memory, as shaped by genocide survivors' narratives. What is at stake is the long disregard for situating Armenians within the post-WWI international system and emphasizing their stories as actors, rather than objects of humanitarianism or geopolitical strategy. The Armenian home is a collective memory of resilience.

What happens in the Pulpit?: Exploring Privileging the Black Theological Imperative

Tatayana Richardson

Mentor(s): Jennifer Knust and Joseph Winters

Humanities

Paul Tillich asserts that a theologian, "is obliged to argue for a philosophical decision in the name of the universal logos and from the place which is not place: pure reason." Assertions like this fail to account for the fact there can never truly be a universal logos; logos is situational, and thus theology must be situational as well. As theologian James Cone articulates, "theology is subjective speech about God, a speech that tells us far more about the hopes and dreams of certain God-talkers than about the maker and creator of heaven and earth." Using the understanding of situational logos, this paper will analyze the intertwining of American Christian theology and white Eurocentric ideologies, in an examination of how they became the perceived universal logos of this nation. This research will then go on asses how this is harmful to both the Church and Religious academic communities.

Following the deconstruction of the dominant theological narrative, this study will posit that in order to rectify the theological chasm, both the church and academia must privilege marginalized theologies. Through an analysis of Black Church History, the Black Biblical Hermeneutic, and an examination of Black Theological constructions, the pedagogical imperative of Black Theology will be developed. This pedagogical imperative will ultimately serve as a case study to assert that marginalized theologies, such as Black theology, along with Womanist theology, Latinx theology, and Queer theology, are relevant and important. And that as such they deserve to be privileged in the mainstream theological canon in the same ways as the current dominant theological constructions.

What Happens in the Pulpit? Exploring the Consequences of Privileging the Black Theological Imperative in the Church and Academia, aims to examine how our faith constructs have the deep and profound ability to change the way that those in faith work, academic and communal, inform the dialogue for justice and equality in our nation. Through the deconstruction of the traditional canon and an analysis of the Black theological imperative, this work suggests that Black theology has the power to be a tool of redefinition, rectification, and restoration in both the church and academia.

Female Founders in FinTech: Navigating Gender in Money's New Frontier

Miranda Wolford

Mentor(s): Emma Rasiel, Professor Catherine Mathers, Ph.D., and Grazina Bielousova

Humanities

Female founders of financial technologies (fintech) startups are few and far between, with even fewer female founders in this space receiving institutionalized funding for their ventures. Fintech, despite being one of the most highly-regarded sectors for innovation and progress, continues to serve as host to gender inequalities in leadership, funding, and consumption of its products and services. This thesis shares the stories of female founders of fintech startups to highlight the culture of entrepreneurship shared amongst these individuals, as well as underscore some of the barriers they face that may not be immediately visible in industry data. A series of eight interviews, in the form of a podcast, detail the women's origin stories as founders, experiences financing their ventures, and how their fintech startups impact female consumers. These interviews take place in two sites for analysis: Francophone Africa and the United States. While both regions share strong innovation in the fintech sector, both feature dramatically different socio-cultural contexts. Yet, as the resulting interviews suggest, a culture of female entrepreneurship has developed across both contexts. Common trends voiced across these interviews point to a fear of the implications of failure amongst female founders, a higher degree of risk taken in starting their ventures, and more personal sacrifices being made in pursuit of their ventures. Although the female fintech community is continuing to grow, all interviewees echoed the strength and closeness of the global female fintech community as well. Looking forward, both structural and cultural changes are warranted in the fintech space to ensure the inclusion of more female founders. As these interviews demonstrate, female founders add diversity to the fintech space not purely on the basis of their gender but also on the basis of who they address with their fintech products and services. Including more female founders in the fintech space is by no means eliminating opportunities for male founders but rather it is expanding the playing field — there are still so many female consumers excluded from financial services and product offerings that until these gaps are closed, female founders in fintech are direly needed to address and innovate for these populations.

Physical Sciences

Thermodynamics and kinetics: Sometimes forgotten but still quite important in organic chemistry

Michael Blue

Mentor(s): Charlie Cox

Co-Author(s): Alexis Witherspoon

Physical Sciences

Chemical reactions are a central theme of undergraduate organic chemistry courses, which generally emphasize structure, reactivity, and synthesis. This research is seeking to expand upon existing literature regarding students' understanding of organic mechanisms using a three-dimensional approach. Students' abilities to successfully write reaction mechanisms will be coupled with their understanding and abilities to explain how the product mixture is impacted by both kinetics and thermodynamics. The primary focus upon the first stage of the research is to analyze substitution and elimination reactions, which are generally introduced in the first course in the sequence. By targeting the first course, we seek to identify potential barriers that may hinder students' success in the first and subsequent courses in the sequence. Specific correlations between general chemistry performance and students' success in using these embedded concepts will be presented and discussed. The goal of the research is to develop teaching interventions in the first course to promote a deeper understanding of mechanisms and greater success in subsequent courses.

Examination of Selenium-Alloyed Bournonite: A Prospective Semiconductor for Optoelectronics

Eric Chang

Mentor(s): David Mitzi and Volker Blum

Co-Author(s): Gabrielle Koknat, Volker Blum, amd David Mitzi

Physical Sciences

In the search for solar absorber materials for thin-film photovoltaics (PV), the materials class of complex chalcogenides has maintained consistent interest. In the past two decades, the kesterite $Cu_2ZnSn(S,Se)_4$ (CZTSSe) has proven promising as an earth-abundant, nontoxic solar absorber. However, with an efficiency plateauing at 12.6%, a necessary search for novel earth-abundant and nontoxic chalcogenide PV candidates continues. Recently, bournonite ($CuPbSbS_3$) has been identified as a potential ferroelectric photovoltaic material with a bandgap (1.2-1.3 eV) appropriate for single junction photovoltaic devices (1-1.6 eV). Bournonite is an appealing candidate for a number of reasons, including its structural and electronic three dimensionality, absorption coefficients comparable to that of $MAPbI_3$ and GaAs, an optical dielectric constant similar to that of hybrid perovskites, high predicted defect tolerance, and the potential for Rashba/Dresselhaus splitting, a phenomenon that has been linked to slow electron hole recombination in lead-halide perovskites. Additionally, as a naturally occurring mineral, bournonite is predicted to be stable, avoiding the instability challenges that face the highly popular perovskites. In the past year, progress in bournonite's application for PV has accelerated with two studies reporting thin-film processing of bournonite. One such study also reported the first PV device to employ bournonite as the absorber layer (PCE of 2.23%). In an effort to explore band gap engineering of bournonite, we report the solid state bulk synthesis of selenium-alloyed bournonite ($CuPbSb(S_{1-x}Se_x)_3$) across the full range of selenium concentrations (x = 0.0 - 1.0). We characterize the crystal structure and band gap of the samples using x-ray diffraction and diffuse reflectance spectroscopy, reporting a band gap that approaches 1.1 eV near x=0.5. We compare these results with computational band structure predictions.

Second-Semester Organic Chemistry Students' Misconceptions about Acid-Base Chemistry

Sean Gao

Mentor(s): Charlie Cox

Co-Author(s): Alina Feng, Colton Melnick

Physical Sciences

Acid-base chemistry is a foundational topic in undergraduate chemistry curricula, and student understanding of acids and bases has been studied extensively in introductory general chemistry courses. However, most existing research on acid-base chemistry in an organic chemistry context is related to acid strength and applications of the Lewis definition of acids and bases; there has been limited focus on identifying more nuanced misconceptions that organic chemistry students have about acid-base chemistry. To fill this gap, a survey for second-semester organic chemistry students was designed to probe the connections between acid-base chemistry and fundamental organic chemistry concepts, and its results are reported here. Building on existing research, molecular structure, hybridization, and important reaction mechanisms were identified as topics highly dependent on an accurate understanding of the Lewis definition. The misconceptions that students harbor about acids and bases in a second-semester organic chemistry course were analyzed using clustered quantitative, qualitative, and metacognitive methods. Prominent misconceptions include confusion of Brønsted acids and bases with electrophiles and nucleophiles when comparing elimination and nucleophilic substitution reactions, inaccurate applications of resonance to acid strength, and conflation of kinetics and thermodynamics in the aldol condensation. Between 15-30% of respondents demonstrated these misconceptions for each survey question, and these students were just as confident in their responses as their peers who answered correctly, suggesting inadequate metacognitive reflection on individual understanding. Future work will be focused on conducting interviews with second-semester organic chemistry students to further probe the justifications for these misconceptions. Additional surveys will also be designed for general chemistry and first-semester organic chemistry students to identify how misconceptions originate and propagate. The results from this and future surveys will provide insight into how undergraduate chemistry educators can revise their curricula to address these misconceptions and improve student learning outcomes.

Quantitative and Mechanistic Interrogation of Si-O Bond Mechanochemical Scission

Logan Glasstetter

Mentor(s): Stephen Craig and Zi Wang, Tetsu Ouchi, Brandon Bowser, Patricia Johnson

Physical Sciences

The unique chemical reactivity profile of the Si-O bond is salient from the perspective of polymer science, as it may be leveraged for self-healing, recycling of thermosets, controlled degradation of biomaterials, and design of adaptable networks, yet the effects of incorporated Si-O functional groups on polymer mechanical stability are not entirely clear. Rational design of mechanically robust polymers exploiting this multifunctional repertoire may be enriched by a detailed understanding of the behavior of the Si-O bond under force, with an emphasis on relative mechanical strength and rupture mechanism. Mechanistic studies may also resolve outstanding questions regarding the source of macroradicals generated under mechanical stress in siloxane-based bulk materials. These mechanoradicals have demonstrable functional implications for failure of sensitive electronic circuitry, the triboelectric mechanism of flexible nanogenerators, force-responsive drug-delivery platforms, and mechanochromism. We utilize sensitive sonication experiments and computational simulations to obtain mechanistic insights and quantitative structure-activity relationships describing the mechanical reactivity of the Si-O bond in polymer-embedded functional groups. Our solution-phase mechanical lability screening strategy leverages sonochemistry, multi-mechanophore ROMP polymer architecture, and non-scissile gem-dichlorocyclopropane (gDCC) internal standard mechanophores to report on the relative mechanical strength of the most scissile bond in the polymer main chain. Through a readout of the internal competition of two mechanochemical processes - polymer chain scission at Si-O bonds and gDCC electrocyclic ring opening - and through DFT calculations based on the CoGEF method, we show that chemically cleavable siloxane functional units are mechanically robust, yet weaker than the C-C polymer backbone. We further employ this sonication methodology to resolve mechanistic ambiguity in the mechanochemical scission of the siloxane bond: Radical trapping experiments reveal a homolytic contribution to the scission mechanism; however, given that the presence of TBA sulfate salt decreases the extent of gDCC ring-opening normalized to one polymer chain scission cycle, a significant contribution from the heterolytic mechanism of scission is also operative. Additional experiments will be necessary to capture the extent to which our solution-phase observations translate to bulk polymeric materials.

Relative Mechanical Strength of Alkyl-Substituted Silyl Ethers Using Internal Competition

Ben Howell

Mentor(s): Stephen Craig, Zi Wang, Tetsu Ouchi, Brandon Bowser, and Patricia Johnson

Physical Sciences

Rubbers and plastics are useful for countless applications, but eventually their use wears out and they must be disposed of. From the standpoints of both sustainability and biomaterials, polymers that are easily degradable while maintaining functionality are desirable. These thermosets can be synthesized by incorporating a small percentage of “weak” bond copolymers within the backbone. Silyl ethers have been successful in enhancing the degradability of polymers, and the chemical strength of the silicon-oxygen bond has been determined in relation to methyl, ethyl, and isopropyl substituents on the silicon atom. However, the relationship between these various alkyl substituents and the mechanical strength of the silicon-oxygen bond has not yet been determined. Knowledge of the mechanical strength of these “weak” bonds in conjunction with existing knowledge of their degradation kinetics will prove useful in selecting which species of the silyl ether is best suited for individual applications. Ring opening metathesis polymerization with Grubbs II catalyst was used to copolymerize the silyl ether weak bond monomers with the mechanophore gem-dichlorocyclopropane (gDCC). Then with sonication, gel permeation chromatography (GPC), and 1H NMR, the relative mechanical strengths of the polymers were determined by comparing the extent of gDCC ring opening to weak bond scission cycle. Spartan ’18 energy profile calculations were also carried out to compare against experimental results. Preliminary results have shown that the ethyl-substituted silyl ether bond is the most mechanically labile. Depending on degradation and functional needs, the methyl- and isopropyl-substituted silyl ethers each have their own advantages. All three silyl ether comonomers could be implemented to serve specific purposes in different existing thermosets.

Synthesis of Xanthocillin X Dimethyl Ether for Biological and Metal-Binding Research

Iona McWhinnie

Mentor(s): Jiyong Hong

Physical Sciences

As natural products have long been and continue to be important in drug discovery and development, obtaining an understanding of their properties and biological activity is essential in determining their potential applications. The aim of this research is to synthesize the natural product xanthocillin X dimethyl ether so that its antibiotic, antiviral, and metal-binding properties can be investigated, and thus mechanisms of action and further potential treatment applications of the compound can be determined. Although it is a natural product, xanthocillin is not easily harvested in large quantities from biological systems, so the synthesis is essential for research to be conducted. Starting from p-anisaldehyde, we embarked on a known nine-step stereoselective sequence. Reaction progression was monitored by TLC, and intermediates were confirmed by 1H NMR. Although this sequence can produce the desired natural product, it is not incredibly efficient, especially with respect to the first four steps (cumulative yield of 8.04 %). Therefore, a secondary aim of this research is to shorten and optimize the synthesis. The optimization has focused on the synthesis of an alkynyl amide intermediate. Our new route involves palladium-catalyzed Sonogashira reactions to produce an alkynyl carboxylic acid, which can subsequently be converted to the amide, or an alkynyl amide directly. This new approach gives up to a 50 % yield under current optimized conditions. Other reaction conditions may be tested to attempt to further improve the overall yield and synthetic efficiency. Other potential routes for the alkynyl amide formation include the oxidation of an alkynyl primary alcohol to form a primary amide and the reaction of 1-alkynyltrimethylsilane with chlorosulfonyl isocyanate. Currently, we are trouble-shooting the late-stage of the synthesis. Once we accomplish the synthesis of xanthocillin X dimethyl ether, we plan to investigate the antibacterial and metal-binding properties of xanthocillin X dimethyl ether.

Fabrication of a Galvanized Steel Plasmonic Solar Absorber

Nicole Patterson

Mentor(s): Po-Chun Hsu

Physical Sciences

This work aimed to fabricate a cost-effective selective-solar absorber (SSA) from commercially available hot-dipped galvanized steel through copper nanoparticle deposition. Through a simple galvanic replacement reaction, copper reacts with the galvanized steel's protective zinc coating. Previous work showed that in the copper-zinc reaction, Cu2+ concentration and reaction time can be adjusted to control particle clumping size and layer thickness in order to tune optical properties. The "dip and dry" procedure followed can be used on commercially available galvanized steel or incorporated into the industrial galvanizing line. This approach serves as a direct alternative to thin-film SSAs where the film must be adhered to a structural material through an intermediate adhesion layer. The result is a cost-effective SSA which can be directly used in structural applications.

Synthesis of N-(Hetero)aryl Sulfamate Esters and Sulfamides With a Nickel-Iridium Dual-Catalyst

Georgia Scott

Mentor(s): Jennifer Roizen and Suraj K. Ayer

Co-Author(s): J. Miles Blackburn, R. Thomas Simons, and Anastasia L. G. Kanegusuku

Physical Sciences

The biological activity of many sulfamate ester and sulfamide-containing compounds means the synthesis of N-(hetero)aryl sulfamate esters and sulfamides has important implications in the development of pharmaceutical small molecules. Therefore, the goal of this proposed research study was to develop a method for the production of N-(hetero)aryl sulfamate esters and sulfamides through the coupling of unsubstituted sulfamate esters and sulfamides with aryl halides. The new reaction cascade employs a nickel-iridium dual catalytic system that takes advantage of mild reaction conditions and improves upon previous palladium-catalyzed techniques. This method offers a wide variety of potential substrates, with a wide variety of (hetero)aryl reagents acting as potential electrophiles. It is our hope that this process will be used as an alternative to traditional Buchwald-Hartwig coupling processes in the production of pharmaceutical agents.

A Novel Solar Selective Absorber

David Smoot

Mentor(s): Po-Chun Hsu

Physical Sciences

The development of solar selective absorbers is a promising avenue toward the harvesting of renewable energy. These materials have high absorptivity in the solar spectrum and low emissivity in the infrared, allowing them to capture and retain a large percentage of incoming solar energy as heat. Recent literature has reported the high performance of solar selective absorbers that function by the plasmonic resonance of nanoparticle deposits of a scale similar to the wavelengths of solar radiation. One such system was achieved by the deposition of copper onto zinc by galvanic replacement. The present work explores several methods for the fabrication of selective solar absorbers on an aluminum substrate to reduce cost, increase thermal conductivity, and increase the potential operating temperature. Higher thermal conductivity facilitates heat removal from the absorber, and a higher operating temperature can improve efficiency in some applications, such as concentrated solar collector systems. Very toxic and environmentally hazardous chemicals are avoided to facilitate the potential for large-scale industrial application as their use could negate the cost advantage of aluminum over zinc. Consideration is given to the primary challenge of removing the passive aluminum oxide layer and to the optical properties and tunability of the resulting material produced through several deposition methods. While many means of depositing copper onto aluminum are known, their potential for use in solar selective absorbers to the author's knowledge has hitherto not been explored.

Impacts of online learning -- Lessons learned and future directions

Nicole Stepovich

Mentor(s): Charlie Cox

Co-Author(s): Alexandra Bennion, Jessie Fauconier, and Nicole Izquierdo

Physical Sciences

Historically, effective undergraduate chemistry teaching strategies have been hallmarked by engaging, in-person learning. However, in response to the COVID-19 pandemic and subsequent transition to online learning in universities across the globe, effective chemistry education has been challenged by the new digital learning landscape. In response to the shifting perceptions of online chemistry education during the COVID-19 pandemic, a survey assessing how online education has impacted students' sense of community, motivation, and study habits was given to undergraduates at Duke University enrolled in chemistry courses. The participants consisted of 321 chemistry undergraduate students incorporating students of all class year, first-generation status, gender, academic major, and race. Significant to informing faculty of emerging practices to facilitate teaching undergraduates, this survey also generated qualitative responses voicing concerns and feedback from students. Among these qualitative responses, the most frequently discussed issue was students' lack of engagement and motivation due to feeling socially disconnected from faculty and peers, hindering learning achievement. However, it is important to note that positive feedback from students was also received as students noted the flexibility and additional resources such as recorded lectures offered by online learning were helpful. A coding scheme was developed to assess student perceptions of workload, satisfaction, sense of belonging, understanding of course material, learning environment, use of outside resources or technology, and motivation. The most significant finding was the difference of perception of online education between students of different class years. There was a statistical difference between freshman and other students with regard to the satisfaction they felt in their assignments, while there was also a statistical difference between sophomores and other students with regard to the perceived amount of work. As the pandemic continues to impact universities, it is Important to leverage the results of this survey to optimize the online chemistry course experience. Following these research trends, it is suggested that faculty create an online learning environment where students feel like the workload is manageable, and incorporate social connection in the virtual classroom.

Development of Prochelators as a Strategy to Selectively Inhibit Metallo-β-Lactamase

Christine Suh

Mentor(s): Katherine Franz

Physical Sciences

Antibiotic resistance is an urgent medical threat as pathogenic bacteria continue to evolve and produce new enzymes that render many current drugs ineffective. Common treatment options include β-lactam antibiotics that bind to a key enzyme in bacterial cell wall synthesis, penicillin binding protein, resulting in bacterial cell death. However, β-lactamases can hydrolyze these once-effective drugs, so inhibitors of β-lactamases were developed. Metallo-β-lactamases (MBLs) contain two catalytic zinc ions that prevent current inhibitors from remaining in the active site. We have synthesized and tested a prodrug as a strategy to selectively inhibit MBLs. This prodrug has a core that, once hydrolyzed by an MBL, removes a chemical masking group to release a metal chelating agent. This metal chelating agent can then inhibit MBLs through chelation of the zinc ions in the active site. In order to increase strain specificity, an altered core structure was synthesized to increase its affinity for resistant strains, using a modular and efficient synthetic route. The improved strain selectivity of the prodrug is a promising strategy to increase drug efficacy, avoid off-target effects, and reduce the spread of resistance.

Investigation of Inhibitors of the Chorismate Biosynthesis Pathway in Chlamydia Trachomatis

Charlotte Thomas

Mentor(s): Dewey McCafferty and Brianne Dudiak

Physical Sciences

Chlamydia trachomatis is a bacterial pathogen that causes chlamydia, the most prevalent bacterial sexually transmitted disease (STD) in the United States. In 2018, the CDC reported the occurrence of chlamydia increased 19.4% between 2014 and 2018. Development of novel therapeutics to treat and prevent the further spread of STDs such as chlamydia are essential, especially as global incidence of antibiotic resistance in STDs continues to rise. C. trachomatis contains genes for chorismate biosynthesis, and chorismate is hypothesized to be used in several downstream pathways including the production of folates, some amino acids, and menaquinone. Virtual docking studies utilizing AutoDock Vina were performed to identify potential inhibitors for enzymes within the chorismate biosynthesis pathway. The enzymes CT370 and CT368 were shown to have the strongest inhibitor-enzyme binding energies, thus ideal pathway inhibition targets. One of the enzymes hypothesized to be essential to the chorismate biosynthesis pathway is CT370, shikimate 5-dehydrogenase, which, in an NADPH-dependent manner, reversibly reduces 3-dehydroshikimate to D-shikimate. The in silico results for CT370 were translated into an in vitro analysis using recombinant enzyme technology. The CT370 gene, ct370, was introduced into an expression plasmid. The plasmid was then transformed into Escherichia coli, and overexpression conditions for ct370 were optimized. CT370 was overexpressed and purified using column chromatography. Ongoing investigations are being conducted to determine the baseline KM and kcat for the reverse reaction through an activity assay that measures absorbance at 340 nm, the wavelength of maximum absorbance of NADPH. Additionally, assays of the reverse reaction will be conducted to test the effectiveness of the inhibitors identified by virtual docking. The chorismate biosynthesis pathway is a prime target for antibacterial drugs because of the downstream essential roles of chorismate. These results not only provide novel information about chlamydial biology but also key information about the function of CT370. If the chorismate biosynthesis pathway is found to be essential for chlamydial survival, knowledge of this enzyme would support antimicrobial investigations.

Quantitative Sciences

Ligand Tether Optimization for Selective Targeting of B. burgdorferi Heat Shock Protein HtpG

Lucas Dingman

Mentor(s): Timothy Haystead

Co-Author(s): Dr. Philip Hughes and Dr. David Gooden

Quantitative Sciences

Borrelia burgdorferi is the principal bacteria responsible for the development of Lyme disease, which can lead to the development of chronic symptoms including arthritis, neuropathy, encephalomyelitis, and impaired cognitive function. Even after antibiotic treatment some patients report persisting symptoms referred to as post-treatment Lyme disease syndrome (PTLDS). PTLDS is hypothesized to be caused by persistent infections unable to be treated by antibiotics. Photoactive toxins capable of generating localized superoxide provide the potential to treat persistent infections but require the localization of a photosensitizing agent inside B. burgdorferi (Bb). The Haystead lab has found that tethering a photosensitizer to a targeted ligand presents the opportunity to selectively dose B. burgdorferi cells while avoiding exposing human tissues to the lethal effects of locally generated superoxide. The chaperone protein HtpG is the prokaryotic homologue of human Hsp90 and was identified as a candidate for ligand targeting. Existing ligands with high binding affinity for both BbHtpG and Hsp90 were identified, and structural modification is hypothesized to enable the design of novel ligands selective for BbHtpG. Previous structure-activity research indicates general structural motifs, while X-ray crystallography provides the location of essential residues for binding. Using this information, a series of ligands were synthesized in order to further probe the structure-activity relationship of BbHtpG. Binding affinities of these ligands was assayed for competitive elution from immobilized ATP from both BbHtpG and Hsp90 using the chemoproteomic platform fluorescent-linked enzyme chemoproteomic strategy (FLECS). Results from these ongoing SAR studies and areas for further investigation are described herein.

Images from Outer Space: The Impact of Satellite Data on Fire Prediction and Operations

Mac Gagne

Mentor(s): Dr. Hubert Bray (Duke Mathematics), Dr. Peter Roohr (NOAA NWS), and Wendy Marie Thomas (NOAA NWS)

Quantitative Sciences

Satellite data is quickly playing a prominent role in influencing both the forecasts and operational decisions that surround emergency wildfire situations. This investigation uses the 2019 Kincade fire as a case study into what forms of satellite imagery can most effectively be used in predicting the spread of wildfires and executing emergency evacuations and protocol; this analysis will provide a cornerstone for assessing the economic value of satellite data for firefighting support. This study details a great deal of potential satellite imagery resources that can be used for prediction and investigation including those from polar-orbiting and geostationary platforms alongside surface and upper observations, output from weather models that var in resolution, and video from new camera systems. Overall, the Kincade Fire allows for an analysis in the context of assessing what forms of information are most essential to fire incident operations and forecasting needs of emergency responders and meteorologists. In a cross-sectional assessment of the information each form of imagery provides, this study concludes that operations should rely heavily on geostationary imagery for immediate directions and polar orbiting imagery for confirmation of ongoing evacuation and emergency procedures. It also concludes that predictions should rely heavily on the HRRR smoke and wind models in order to forecast the spread of the fire and its relevant smoke plume(s). Finally, GLM imagery should be reviewed post-hoc when trying to determine the ignition source for the wildfire, should that ignition be suspected as dry lightning; it can also be used to help identify convection to properly locate potential new fires, especially in areas where weather radar coverage is very poor.

ARM-HD: Adaptive Risk-aware Multi-armed bandit framework for High-Dimensional investment choice

Lavonne Hoang

Mentor(s): Simon Mak and Rebecca Steorts

Co-Author(s): Simon Mak

Quantitative Sciences

The Markowitz mean-variance analysis provides a fundamental framework for maximizing expected return of a portfolio given a fixed risk level. However, due to its reliance on simplistic financial models and difficulty in estimating key model parameters, such a framework can sometimes yield poorer empirical performance than simpler strategies, such as equally-weighted or value-weighted portfolios. A recent solution is a popular reinforcement learning method called multi-armed bandits (MABs), which uses historical market data to adaptively identify an ``optimal'' portfolio strategy. While MABs have been studied extensively in machine learning, existing applications to portfolio optimization are quite naive and have key practical limitations: they consider only simple portfolio strategies and ignore correlations and risks between such strategies. We tackle this via a new Adaptive Risk-aware MAB framework for High-Dimensional portfolio optimization (ARM-HD). The key novelty in ARM-HD is the integration of a Bayesian interaction model, which models correlations on binary rewards between different portfolio strategies, with a coherent risk measure that provides risk-awareness for reward maximization. This allows ARM-HD to explore a wider class of investment strategies, by learning market correlations from historical data and integrating this within a risk-aware framework for sequential optimization. We demonstrate the effectiveness of ARM-HD for portfolio optimization on exchange-traded funds, where we show the proposed method offers improved empirical performance over standard benchmark investment strategies.

Graduation with Distinction Candidate - Statistics

Block truncated Compound Confluent Hypergeometric Priors for Bayesian Model Selection

Pin-Chian (Cathy) Lee

Mentor(s): Merlise Clyde

Quantitative Sciences

Model and variable selection are crucial for scientific studies, in which competing hypotheses are presented and evidence for and against them are evaluated. Issues with significance claims and scientific reproducibility under p-values of 0.05 motivate the switch to the Bayesian paradigm, which provides a coherent methodology to conduct inference in the presence of multiple models. However, there is no singular method for choosing a prior. Our work builds upon previous work done in the field by constructing block g-priors that unify mixtures of independent priors and multivariate g-priors. Specifically, the extended family of g-priors, the truncated Compound Confluent Hypergeometric (tCCH) prior, is used to derive Bayes factors under a block orthogonal design matrix. The tCCH prior, along with some its special cases, are evaluated under a set of model selection desiderata and the conditions under which each criteria is fulfilled are analyzed. In particular, we note that satisfying intrinsic consistency is needed for null model consistency. Next, we make possible posterior approximation under relaxed conditions (e.g. no block orthogonality) by building a block-g MCMC sampling algorithm that has comparable performance to ordinary least squares, fixed-g MCMC, and BAS methods. In addition we construct and demonstrating the feasibility of a scheme to group covariates into blocks when there is not a known grouping structure using the Dirichlet Process. Our work makes mixtures of g-priors more applicable to real datasets by reducing assumptions about the data and by creating a more formal approach to guide prior choice.

An Investigation of Racial Disparities in Traffic Stops and Citations in Durham County, NC

Christina Liang, Bob Qian, Andrew Qin, and Katie Nash

Mentor(s): Maria Tackett

Quantitative Sciences

This project investigates if there is any evidence of racial bias in traffic stops and citations in Durham County, North Carolina. We used data from the Stanford Open Policing Project to inves- tigate the relationship between a subject's demographic attributes (primarily race, with some insight into sex) and the likelihood of being stopped by police in traffic or receiving a traffic citation in Durham. We hypothesize that race and the likelihood of being stopped by police in traffic or receiving a citation in Durham are associated, with black people disproportionately more stopped relative to their population proportion and more likely to receive a citation upon being stopped. Our conclusions are 1) black people are disproportionately stopped in traffic as compared to their demographic makeup within the Durham population; 2) black people are not the most likely to receive a citation upon being stopped in traffic—rather, Hispanic people are the most likely to receive a citation; 3) black females are more likely to be receive a citation upon being stopped than are black males.

Mechanical siloxane bond strength of silyl ether monomers with various alkyl substituents

Brooke Silverstein

Mentor(s): Zi Wang and Tetsu Ouchi

Quantitative Sciences

Copolymerization allows for the superimposition of physical properties to increase recyclability without forfeiting tensile strength. Increased degradability is accomplished through the implementation of a weak bond into the polymer carbon chain backbone. This research will focus on determining the relative strength of the silicon oxygen bond within a silyl ether monomer in the context of the size of its substituent groups. In doing so, a polymer can be utilized with its exact rate of degradability in mind. To test these strengths, the silyl ether monomer will be copolymerized with gem-dichlorocyclopropane (gDCC) and sonicated. The rate at which the gDCC ring opens will be compared to the scission cycle of the weak siloxane bond. It is expected that the smaller the substituent, the more mechanically labile the siloxane bond will be. Preliminary results showed that the ethyl substituted molecule was marginally more mechanically labile than those of other substituent groups. Implementing a weak bond will increase recyclability in addition to biodegradability. More specifically, a quantified variation in biodegradability rates will allow for the selection of biomaterial scaffolding with consideration of a specific desired rate of decay.

Predictive Modeling Using Transcriptomic Signatures of COVID-19 and Other Infectious Diseases

Harshavardhan Srijay

Mentor(s): Ricardo Henao

Quantitative Sciences

We build supervised classifiers to predict disease state for four acute upper respiratory infectious diseases, to enable targeted, multi-disease therapy. There exist several pathogen-specific diagnostic methods including RT-PCR and rapid molecular assays. However, given clinical signs and symptoms of such infections are not pathogen-specific, we here are attempting to illuminate transcriptomic differentiation between relevant respiratory infections using host transcriptomic signatures, a relatively responsive and precise modality in terms of pathogen exposure response, to predict patient disease state. We use representation learning to obtain multiple reduced representations of the original expression data, that are used to train simpler supervised machine learning classifiers that will be more effective during deployment. We use whole blood RNA-Seq expression data, obtained from the Duke Center for Genomics and Precision Medicine, which after quality control, contains 13,569 genes and 195 samples, each belonging to 1 of 5 cohorts: Bacterial pneumonia, viral (influenza), seasonal coronavirus, COVID-19, and the healthy control group. We first train lasso regularized logistic regression models on the original data to establish a baseline performance of the most complex model with the highest expected performance on the training data (due to the likelihood of overfitting). We then train neural network classifiers using learned gene embedding co-expression representations. We also train the logistic regression model on a reduced representation obtained using non-negative matrix factorization (NMF). We cross-validate our models and generate predictions using leave-one-out cross validation. We find that the embeddings model is as strong as the baseline model (mean AUC = 0.96), while the NMF model is stronger than the baseline model (mean AUC = 0.97). This suggests the potential for simple, generalizable, and powerful classifiers using representation learning that enable more effective multi-class disease state prediction. We then implement an attention mechanism into the neural network classifier, to identify genes/features most important for the discrimination of samples, and cross-validate these identified pathogen-specific gene sets using gene set enrichment analysis. We are currently working on incorporating a new validation dataset to evaluate our models on previously unseen data.

Functional Effects of Incurable Blindness and Novel Gene Therapies for Treatment

Mishek Thapa

Mentor(s): Jason Xu, PhD and Greg Field, PhD

Co-Author(s): Miranda Scalabrino, PhD; Emily Davis, BS; Lindsey Chew, BS

Quantitative Sciences

Retinal degeneration occurs in most forms of blindness. Retinitis pigmentosa is one such form that initiates death of rods -- which are responsible for night time and peripheral vision -- and eventually affects the cones -- responsible for reading and vision at daylight levels. Using a mouse model, we analyze the effects of rod death on cone-mediated vision. We found that cone vision is consistently robust to rod death until all photoreceptors have died. In addition, retinal degeneration has been shown to extensively rewire bipolar cells, which are the immediate recipients of rod and cone signals. As a result, improving vision outcomes may require therapy of bipolar cell connections to rods. Through an analysis of the transcriptomes of bipolar cells, we found two genes RGS5 and GRIN2B were regulated during treatment. As a result, we suggest these two genes can be used as targets for gene therapies of RP.

Graduation with Distinction Candidate - Statistics

Budget Sharing for Multi-Analyst Differential Privacy

Yikai Wu

Mentor(s): Ashwin Machanavajjhala

Co-Author(s): David Pujol and Brandon Fain

Quantitative Sciences

Large organizations that collect data about populations (like the US Census Bureau) release summary statistics that are used by multiple stakeholders for resource allocation and policy making problems. These organizations are also legally required to protect the privacy of individuals from whom they collect data. Differential Privacy (DP) provides a solution to release useful summary data while preserving privacy. However, most DP mechanisms are designed to answer a single set of queries and optimize the total accuracy. In reality, there are often multiple stakeholders that use a given data release and have overlapping but not-identical queries. This introduces a novel joint optimization problem in DP where the privacy budget must be shared among different analysts.

In this work, we initiate study into the problem of DP query answering across multiple analysts. To capture the competing goals and priorities of multiple analysts, we formulate three desiderata that any mechanism should satisfy in this setting -- The Sharing Incentive, Non-Interference, and Workload Adaptivity -- while still optimizing for overall error. We demonstrate how existing DP query answering mechanisms in the multi-analyst settings fail to satisfy at least one of the desiderata. We present novel DP algorithms that provably satisfy all our desiderata and empirically show that they incur low error on realistic tasks.

Social Sciences

Creating Response Networks to Address Victims of Incel Activity

Chitra Balakrishnan

Mentor(s): Lalita Kaligotla and Valens Global

Social Sciences

Incels, or involuntary celibates, are beginning to be considered a security threat due to their recent mass attacks and violent rhetoric concerning women. Compared to other national security threats, incels are unique in the way that they marginalize themselves while contributing to a phenomenon of misogynistic violence that is widespread throughout the United States. Through primary and secondary research along with information gathered from interviews with academic analysts, security experts, and nonprofit advocates, this paper discusses incels in three parts: first, it examines incels with the help of existing research and incel forum dialogue; then, it situates incel violence in the context of misogynistic violence and describes incels' conceptions of masculinity along with their perceived victimization; and finally, it outlines possible community solutions and partnerships to curb incel violence. This paper is an initial step toward building a community response network for responding to incels in a way that addresses the needs of both incels and their victims.

Caregiver Perspectives on Genetics Research and Cures for Sickle Cell Disease in Uganda

Autumn Barnes

Mentor(s): Kearsley Stewart and Dr. Charmaine Royal

Co-Author(s): Krystin Jones, Joel Kibonwabake, Catherina Nazziwa, Charmaine Royal, Kearsley Stewart

Social Sciences

Sickle cell disease (SCD) is the most prevalent genetic disease in Sub-Saharan Africa. SCD research and management traditionally focuses on high-resource/low-burden countries. However, the WHO and other global health actors are now recognizing and addressing SCD's effects on low-resource/high-burden populations. However, within this progress towards inclusive SCD genetics research and intervention, a critical gap remains—an understanding and integration of community perspectives. This study investigates perspectives on genetics research and cures for SCD among Ugandan SCD stakeholders. It explores the understanding of, and facilitators and barriers to, SCD genetics research and its related technologies within these communities. We conducted 40 in-depth interviews with SCD caregivers, patients, policy makers, and health care providers. Here, we report on caregiver data only. We interviewed caregivers from the sickle cell clinic at the government health facility in Kalangala, Uganda. After 17 in-depth, 60-minute qualitative interviews, we achieved thematic saturation. We conducted interviews in Luganda then translated and transcribed them into English. We analyzed transcripts using NVivo 12 and applied thematic analysis. Participants described using both traditional and biomedical therapies to treat SCD, though opinions on their relative effectiveness varied. They credited health care workers and radio broadcasts as significant sources of information for SCD treatment and management. Though most had a limited understanding of genetics research, all participants reported a general openness towards it while expressing concerns about data confidentiality. Participants emphasized that they made decisions about managing their child's health individually. Finally, participants recognized the SCD cures' potential to end their children's suffering, though many cited concerns about the potential side effects and the cost. Global health actors are beginning to prioritize SCD genetics research and gene-based cure development in low-resource/high-burden settings. Use of traditional and biomedical therapies, reliance on both the media and medical providers for health education, and emphasis on individual decision-making, all point to the complex sociocultural context researchers must navigate before introducing advanced gene-based research and therapies in low resource settings.

Dive Into Dolphins: Does Perceived Interspecies Similarity Impact Conservation Behavior?

Gabby Bunnell

Mentor(s): Brian Hare, Sarah Gaither, Dr. Aleah Bowie, and Hannah Salomons

Social Sciences

Gordon Allport's contact hypothesis has been widely demonstrated to mediate intergroup contact: positive intergroup interactions under the right circumstances reliably lead to decreased prejudice and enhanced relations between groups of different racial or cultural backgrounds. Because there has been little application of the contact hypothesis to human-animal relationships, this study aims to understand contact in the context of humans and bottlenose dolphins. Specifically, this study will highlight how successful interspecies contact can inspire greater conservation behavior. Using Allport's original mediators of the contact hypothesis – knowledge and empathy – the current study will test various conditions of interspecies contact and observe how these conditions impact conservation behavior. Contact will be in the form of a virtual education presentation, either highlighting human similarities with dolphins or differences from dolphins. Conservation behavior will be operationalized by measuring the amount of money donated and amount of time spent on a conservation-oriented sorting task. Findings indicate that conditions inspiring greater knowledge and empathy towards bottlenose dolphins do not significantly impact conservation behavior in this virtual setting. However, additional analyses reveal the possibility that past visits to zoos and aquariums, as well as involvement with wildlife organizations, may positively impact conservation behavior, regardless of experimental condition. These findings indicate the importance of in-person contact when applying the contact hypothesis to human-animal interaction. Future studies should further investigate whether in-person interactions under Allport's mediators of knowledge and empathy more easily inspire human conservation behavior to protect 'outgroup' species.

Graduation with Distinction Candidate - Psychology

Can we socially connect online? The role of social perception in videoconferencing

Kayley Dotson

Mentor(s): Mike Tomasello

Co-Author(s): Wouter Wolf

Social Sciences

Humans use joint attention in social interactions as a way to foster social bonding. While this effect has been well documented in in-person contexts, the effects online remain widely unknown. With the increase in online social interaction due to COVID-19, understanding how joint attention may influence social bonding online could have implications for educators, workers, and friends. The present study seeks to examine joint attention situations in an online videoconferencing context. Our hypothesis is that individuals in a joint condition (versus disjoint) on a video conferencing platform will experience a higher level of social bonding, following with results from similar in-person studies. To examine this relationship, we recruited young adults to join a Zoom call and watch a video either with (joint) another participant (confederate) or one after the other (disjoint) another participant (confederate). The confederates in the study were pre-recorded videos, and the confederates used a script of either watching the video (joint) or looking at their phone (disjoint). Participants then rated their feelings about the other participant through a self-reported survey. Our results show that there is no difference of subjective social bonding between conditions, indicating that joint attention may not have the same effect on social bonding in an online context as in an in-person context. Establishing no difference between conditions suggests that social bonding may not be achieved in the same manner in an online videoconferencing platform, possibly helping to explain why COVID-19 may still prompt loneliness, despite multitudes of available online social platforms.

Graduation with Distinction Candidate - Psychology

The Nuclear-Cyber Comparison and Public Support for War

Joshua Gohlke

Mentor(s): Kyle Beardsley

Social Sciences

This paper focuses on nuclear and cyber weapon proliferation, intervention, modern deterrence theory, and the role, particularly in democracies, that the public plays with regards to corresponding foreign policy decisions and the pursuit of armed conflict. The research is focused on threat perception of nuclear and cyber weapons when they are considered in even light with regards to potential danger to a state. The data collection is designed as a survey experiment, seeking to understand how citizens in a democracy view the threat of powerful nuclear and cyber weapons as well as the costs of armed conflict to prevent a potentially hostile state from acquiring or using these weapons. Treatment arms of the survey refer to modern deterrence theory, which states that support for war should be lower when a state has already acquired powerful weapons, compared to when they are working towards getting them. The main research question to be answered is as follows: When comparing nuclear weapons to cyber weapons, and imminent acquisition vs. recent acquisition, is there a significant difference in the public's perception of threat and cost that could influence a citizenship to actively support or oppose international armed conflict? The research found that there were similar levels of support for armed conflict in cases of nuclear vs. cyber weapons, as well as when comparing situations in which a hostile nation is developing these weapons and situations in which the nation has recently acquired these weapons.

A Report on the Status of Native Voting in the Era of COVID-19

Carlee Goldberg

Mentor(s): Sunshine Hillygus

Social Sciences

Native voters face immense burdens to vote, and that was before COVID-19. An estimated 34% of eligible Native Americans are not registered to vote, a number that translates to more than 1.2 million potential voters. Faced with unique challenges and with the opportunity to determine election outcomes, Native Americans compose an important and often overlooked portion of the electorate. As states and jurisdictions grapple with COVID-19, their election responses present a formidable hardship to native voters. My report examines the ways in which state changes to elections impact Native American voters living on reservations and offers recommendations to implement future elections.

Athlete Retirement, Well-being, and Coping Strategies in College Students

Lauren Grzelak

Mentor(s): Sarah Gaither and Kim McNally

Social Sciences

Athlete retirement is an understudied phenomenon, yet it affects nearly 7.5 million high school athletes each year. Previous research has shown that it can be a difficult transition for a multitude of reasons, ranging from social to psychological to neurological factors. When individuals lose their sport, they lose structure, a purpose, and a support system. They also go through a number of physical changes that can be detrimental to their body satisfaction, and thus, their mental health. Lastly, exercise enhances protective factors in the brain, but retirement typically comes with reduced physical activity. The loss of these protective factors may be felt as a cognitive decline. Despite these struggles, research on athlete retirement is limited. Most of the data collected are subjective and use unstructured interviews. The current research also focuses on the most unique population of athletes: Olympic athletes. This study plans to address those issues by using objective data and surveying college students who retired from sports after high school. Athlete identity and mental health will be measured, as well as coping strategies, in order to provide a direction on what may aid this transition. There is expected to be a negative relationship between athlete identity and mental health, and further, significant relationships between different coping strategies and mental health. This study will aim to fill gaps in the literature, but hopefully, it will do something more; open up the conversation about the difficulty of athlete retirement.

Graduation with Distinction Candidate - Psychology

Impact of COVID-19 on Young Child Mental Health

Karina Heaton

Mentor(s): Michael Gaffrey

Social Sciences

COVID-19 has impacted the world and can be defined as a collective trauma. It has brought extreme stress into society. A stressful environment can affect an individual's mental health. Although children are not at high risk of getting COVID-19, they are susceptible to stressors. Extreme stress has been found to increase the chance of a child developing depression and anxiety. Thus, it is important to investigate how COVID-19's stressors have affected children. A child's temperament and parenting can exacerbate or mitigate stress. Survey data was taken from parents before COVID-19 and a few months into COVID-19's lockdown. Measures of children's anxiety, depression, and temperament and parents' parenting style and pandemic changes were assessed. Hierarchical regressions were conducted on reported anxiety and depression. The results of this study will discuss the independent and interactive effects of COVID-19, children's temperament (I.e. fear, low intensity pleasure) and parenting style on children's depression and anxiety. We anticipate that COVID-19 will have increased depression and anxiety symptoms in children. This increase will likely be higher for children with a fearful or low intensity temperament. Authoritative parenting is anticipated to buffer against this increase in depression and anxiety symptoms. Altogether, these findings would imply that authoritative parenting and low depressive and anxious temperament will buffer the child against developing mental health issues post COVID-19. However, we acknowledge that only certain variables may be significant while others not. This would imply that some aspects of the child's life are more impactful than others on mental health.

Graduation with Distinction Candidate - Psychology

The Hollywood Asian - A Study of Asian Americans in Film & Television in the Early to Mid-20th

Daniel Kim

Mentor(s): Esther Lee

Social Sciences

The purpose of this project is to analyze the roles of Asians and Asian Americans from the early to mid 20th century in film and television. An investigation was conducted into the careers of three case studies: Chinese American actress Anna May Wong, Japanese silent film actor Sessue Hayakawa, and Korean American actor Philip Ahn. These individuals were chosen due to their relative long-lasting presence in 20th-century media and their diversity of roles, genders, and various countries of origin, which represent each major American population of East Asian descent.

In the early decades before World War II, perceived threats of Japanese imperialism and Chinese labor competition led to the villainization of Asian characters. Sessue Hayakawa famously portrayed distorted Japanese and Chinese characters in films such as The Cheat (1915), propagating fears of “Yellow Peril” in mainstream United States culture. Asian characters also often served to provide backdrops of exoticism to films such as the Thief of Baghdad (1924), where Anna May Wong played a treacherous Mongol slave opposed to two white protagonists.

However, in the late 1930s, more favorable depictions of American Chinese became common as China was viewed as an ally to the United States against Japanese aggression. Two unusual films aligned with this trend are the Daughter of Shanghai (1937) and King of Chinatown (1938) which featured Anna May Wong and Philip Ahn as its two lead characters. However, even these films served as testaments to racial barriers set by anti-miscegenation laws in the 1930s known as Hay’s Code, requiring that Anna May Wong find an Oriental co-star for her movies.

Following the attacks on Pearl Harbor in 1941, anti-Japanese sentiment soared as the United States entered World War II. Propagandist films became a Hollywood staple, and corresponding with these events, Philip Ahn’s career shifted as he almost exclusively portrayed violent, immoral Japanese villains in the following decade. Viewing it as a doubly patriotic duty on behalf of America and a Japanese-occupied Korea, Philip enthusiastically propagated such stereotypes in American media.

In conclusion, the careers of the aforementioned Asian American actors were dramatically impacted by these historical events. From decade to decade, the roles of Asians and Asian Americans in film and television evolved due to geopolitical tensions, reflecting or causing prejudices towards “Orientals” as a whole or specific ethnic groups.

Understanding and Rebranding Perceptions of Refugees in the United States

Olivia Kramer

Mentor(s): Lalita Kaligotla

Social Sciences

How does the U.S. public perceive refugees? During the summer of 2020, I worked with the Tent Partnership for Refugees to determine how societal perceptions of refugees shape public support for them. Drawing upon desk research, this project sought to understand how Tent's communication strategies could most effectively shift perceptions and narratives around refugees going forward. Research found that while general support for refugee populations has increased, that this support has seen a growing partisan divide. Political ideology was found to be a significant predictor of attitudes towards refugee resettlement, indicating that nationwide polarization has shaped public opinion on refugees. I conclude that discourse on refugees must draw upon a shared values- based approach going forward in order to de-politicize the narrative around refugees and build universal support for this population.

Speaking of Stress: Predictors & Consequences of Stress Mindset in College Students

Janette Levin

Mentor(s): Bridgette Hard

Co-Author(s): Bridgette Hard and Michelle Wong

Social Sciences

Some students may perceive stress to be motivational or enhancing, as it supports their learning and productivity. Others internalize the effects of stress as inhibiting to their academic and personal progress, in turn causing more harm than good. Both of these ideas are supported throughout psychology literature. Given all we know about the consequences of stress, our implicit beliefs about it, or mindsets, are important to unpack. More specifically, how might we be able to predict stress mindsets in order to gauge a better understanding of them within the college student population? This project aims to explore college students' beliefs or "mindsets" about the nature of stress. My thesis is composed of 2 studies (one run using a sample of approximately 800 Duke Psychology 101 students — analyzing 3 semesters worth of data — and the other run using a randomized sample of approximately 300 college students in the US). Both studies aim to analyze these three primary research questions:

1. Is there a relationship between students' stress mindsets (their beliefs about stress as either more enhancing or debilitating) and the language that they use to describe the role that stress plays in their lives?

2. Can a student's "Big 5" Personality Traits (measured levels of Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism) predict their stress mindset type?

3. Can we learn about students' academic and well-being outcomes (i.e. procrastination habits, GPA, perceived stress, and overall well-being) from their stress mindset score?

Graduation with Distinction Candidate - Psychology

Devlopment of Online Comperhensive Sex Education in China

Leslie Li

Mentor(s): Lalita Kaligotla

Social Sciences

I worked with MAYLOVE, a social organization in China to develop a set of online sexual education courses for young Internet users during the pandemic. I focused on the evaluation strategy of the course and independently designed an evaluation test package to assess the effectiveness of online teaching. I collected the background knowledge and identified the barriers to promoting sex education in China through interviews with college professors, sex-ed experts, and long-term volunteers from different organizations. I also reviewed the past hundreds of sex-ed articles that MAYLOVE published and analyzed the ongoing sexual health education projects. Together with MAYLOVE, we creatively incorporated feminism, nonviolent communication in intimate relationships, and minority rights into the traditional sexual education that focused more on biology knowledge and established a more comprehensive course structure.

The impact of norm- and criterion-referenced grading systems on student course expectations

Jingxuan Liu

Mentor(s): Bridgette Hard

Co-Author(s): Michelle Wong

Social Sciences

Grading systems are an important component of courses that may impact the class environment and student perceptions. However, the effects of different grading systems on students warrant more exploration. The present study examined the effects of norm- and criterion-referenced grading, two common grading systems used in higher education, on student expectations regarding key course-related beliefs and behaviors. In an online experiment, we prompted participants (n = 547) with a hypothetical course setting that used either norm- or criterion-referenced grading, and asked them to complete several anticipated belief and behavior measures. Results indicate that norm- and criterion-referenced grading systems differentially impacted participant beliefs and behaviors, including achievement goals, course self-efficacy, perceived instructor mindset, and help-related behaviors. Such findings may have implications for course design.

The Embodiment of Humility

Camden Nelson

Mentor(s): Sarah Gaither and Patty Van Cappellen

Social Sciences

Research on embodiment has demonstrated that one's body and specifically one's posture can have significant influence on emotions, thoughts, and decision-making. In particular, much of this research has focused on two main postural dimensions: how expansive or constrictive the body is and whether the body is oriented upward or downward. Despite the growing amount of research into embodiment and the body's ability to construct cognition, there is limited research on the effects of the body on the experience of humility. Humility is typically defined as having an accurate view of one's strengths and weaknesses, an other-focused orientation, a lower focus on oneself, and open-mindedness. Power poses, or upward-expansive poses, have been shown to promote feelings of power, a conceptual opposite of humility. We therefore reasoned that a downward-constrictive posture may induce humility. This study investigates the effect of three specific body postures on humility: an upward and expansive posture, a downward and constrictive posture, and a neutral posture. In a within-subject design, U.S. community participants (N = 175) were asked to adopt each posture and complete humility measures repeatedly after each posture through the Humility Implicit Association Test. This test measures reaction time and accuracy in matching categories. People that exhibit more humility should be faster and more accurate at associating synonyms of humility (e.g., down-to-earth, modest, tolerant) with descriptors of themselves and slower and less accurate at associating synonyms of arrogance (e.g., immodest, conceited, egoistical) with themselves. We found that there was a statistically significant difference between the downward-constrictive postures and the neutral posture, with the downward-constrictive posture eliciting greater humility in participants. There was, however, no significant difference between high, expansive postures and either of the other conditions.

Ije Umu-Nwanyi: Young Nigerian Women Activists and the Politics of Imagination

Anwulika Okonjo

Mentor(s): Catherine Mathers and Samuel Fury Childs Daly

Social Sciences

Young women have been relegated to the margins of sociopolitical discourse and activities in Nigeria. But in the past half decade, amidst an upsurge of social movements, young women activists have begun to challenge the dominant Nigerian social imaginary through their social justice efforts. My thesis seeks to understand how young Nigerian women's activism emerges under the conditions of perceived state-level malgovernance, violence and political disenfranchisement, in addition to gendered inequalities and suppression. From 2020-2021, I interviewed 13 activists from across the country, some of whom I organized alongside. The goal was to understand how young Nigerian women form their political identities and embed themselves in social justice and transformation efforts.

I argue that young women are creating alternative pathways for political engagement that attempt to subvert and de-centre the state, and destabilize male-supremacist hegemony. This is a condition where pervasive beliefs in the superiority of males and their domination all spheres of life shaped the foundations of society. In response, young women activists adopt strategic actions aimed at disrupting conventional thought and practices. They use technology to command discourse and transgress physical, mental, and temporal boundaries. Their accounts illustrate how acts of wilfulness, expressing discontent, and community engagement projects function as transformative mechanisms that enable young women to shape their counter-consciousnesses and to develop different modes of meaning-making that challenge how their social world is constructed. Additionally, grassroots and digital collectives, hold space for critical reflections and collective care. The wealth of knowledge created and exchanged in these spaces informs their resistance and expands their conceptions of what is possible. They ground themselves in African and black feminist principles of interiority, equality, empathy and intersectionality.

Transformative action is a way of enacting imaginaries, and a process which reveals all that they must dismantle and all that they must build. The politics of imagination speaks to how activists negotiate and contest power over their imaginations- including the knowledge and resources they have at their disposal-with dominant forces. The narratives of the women in my work reveal that the politics of imagination is a politics of resistance, hope, and possibility.

A Case Study of the Motivations for the Pursuit of STEM amongst US-bound Kenyan Students

Priya Parkash

Mentor(s): Jenny Wood Crowley and Dr. Tori Akin

Social Sciences

Much warranted attention over the past few decades has been devoted to the problem of retaining minorities, particularly women, in areas where they are poorly represented such as in science, technology, engineering, and mathematics (STEM) fields. Race and ethnicity are salient factors in STEM retention and minorities comprise fewer than 1 in 10 scientists or engineers. However, minimal, if any, attention has been directed towards the motivations for the pursuit of STEM and STEM retention amongst international students. This study specifically seeks to examine the motivations for the pursuit of STEM amongst US bound Kenyan students and uses both, qualitative and quantitative methods to identify motivating factors within four broad themes: financial correlations, cultural attitudes, US foreign policy, and STEM identity. The goal of this study is to advance knowledge on international students in their pursuit of STEM careers; it aims to provide information about the impact of societal and cultural aspects as well as attitudinal, character and educational achievement in the career selection process and persistence in the STEM disciplines for international students. Although, currently the study focuses on Kenyan students enrolled in a US college access program called KenSAP, I hope to be able to expand this research to several developing countries over the years, which may have implications for higher education practices and support US institutions in their drive to better understand and develop strategies for the successful retention of international students in STEM.

Policing Youth: Effects of School Safety Measures on the School-to-Prison Pipeline

Swathi Ramprasad

Mentor(s): Lalita Kaligotla and Harold Jordan

Social Sciences

Working closely with the ACLU of Pennsylvania, this research project aims to track school safety grant funding and find information about where such funding gets allocated. This grant tracking is important to see how much funding is dedicated towards school police officers versus surveillance equipment and other school safety mechanisms and programming. Policing in schools is a serious issue because it is many students' first interactions with the justice system.

By tracking this grant funding and placing Right To Know requests to isolate this information, we aim to see how the state and federal governments indirectly contribute to the school-to-prison pipeline. We collect and collate data from disparate government departments based on what is already publicly available. The RTK requests will help the research team get more granular information on this issue and analyze correlations between state and national grant funding and student arrests, suspensions, and other disciplinary action.

We expect that the more funds that go towards student surveillance, safety programming, and school police officers, the higher the number of cases of disciplinary action against students. When students are surveilled more frequently through equipment or policing, there may be an increased likelihood of severe disciplinary consequences.

Due to constraints related to the COVID-19 pandemic, no decisive conclusions could be drawn. However, the issue of state and national safety grants in schools remains an important area of study because such research can shed light on the extent to which government entities contribute to the school to prison pipeline.

Creating Cybersecurity Recommendations for the Next Presidential Administration

Micalyn Struble

Mentor(s): David Hoffman

Social Sciences

I created nonpartisan cybersecurity recommendations for the next presidential administration for my internship at the Center for Cybersecurity Policy and Law. By interviewing cybersecurity policymakers and researching legislation, I identified opportunities for the Executive Branch to improve U.S. cybersecurity policy over the next four years. Specifically, I recommended that the President create a new position called the National Cyber Advisor within the Executive Office of the President, increase transparency of the Vulnerabilities Equities Process, revise the government's approach to cyber threat intelligence collection and sharing, and review the 2018 National Cyber Strategy.

Structural Inequities and Infant Feeding in Durham

Katie Waeldner

Mentor(s): Orin Starn and Chris Daley

Social Sciences

This Cultural Anthropology Honors Senior Thesis examines the historical, socioeconomic, cultural, and structural influences on infant feeding behavior in Durham through cross-discipline literature analyses, interviews with professionals, and interviews with lactating individuals living in Durham. Ultimately, this project demonstrates that infant feeding decisions are simultaneously influenced by external forces, such as structural racism and poverty, and deeply personal and complex.

The thesis project is broken into four chapters. The first chapter details the history of infant feeding in the United States, with some focus on North Carolina and Durham. The chapter discusses the cultural evolution of infant feeding between the period of enslavement and the end of the twentieth century, ultimately suggesting that contemporary behaviors are influenced by a long backstory. The second chapter discusses the modern structural barriers that lactating individuals face, suggesting that individuals are often forced into certain infant feeding behaviors based on uncontrollable external factors. The third chapter highlights professionals' perspectives, centering the perspectives of those constantly working within the infant feeding landscape in Durham. Finally, the fourth chapter is a collection of conversation transcripts from interviews with lactating individuals in Durham, emphasizing their individuality and the nuances of their experiences.

Analyzing Impacts of COVID-19 at Friends of the Global Fight Against AIDS, TB, and Malaria

Emily Woodrow

Mentor(s): Lalita Kaligotla

Social Sciences

The direct and indirect effects of COVID-19 threaten to derail decades of progress in fighting the deadly diseases of AIDS, Tuberculosis, and Malaria. The pandemic is also seriously affecting already vulnerable communities, weakening health systems, causing increases in gender-based violence, preventing children from attending school, and creating large disruptions to supply chains.The work of Friends of the Global Fight Against AIDS, Tuberculosis, and Malaria directly recognizes COVID-19 as the leading global health threat. Friends is actively involved in actions to mitigate the spread and effects of COVID-19 and is currently focused on boosting U.S. investment in a global response to the virus. During my time with Friends, I engaged in a variety of daily experiences ranging from drafting memos about virtual Congressional hearings, working on policy recommendations to urge U.S. global health funding, tracking pertinent legislation, researching specific impacts of COVID-19 in low-income countries, and writing about human rights violations across the world. The larger-scale project I completed during my time with Friends focused on research, analysis, and writing about COVID-19 effects on the key population of adolescent girls and young women (AGYW). The Policy Team worked on this project and the end-product includes the Policy Brief titled “The Impact of COVID-19 on Adolescent Girls and Young Women and Needed Responses.” The piece concludes with policy recommendations and will be used by Friends for advocacy outreach efforts. Through my work, I feel fortunate to have grown my own perspective on and knowledge of global health advocacy during such unprecedented times of disease outbreak.

Personal and Contextual Predictors of Straight Men's Negative Evaluations of Gay Men

Michael Xie

Mentor(s): Sarah Gaither and Adam Stanaland

Social Sciences

In the US, men's violation of heteronormative standards (e.g., sexual orientation, masculinity) can put them at risk of social rejection or physical danger. Given these important consequences—and the increasing number of men who identify as non-heterosexual (Morales, 2021)—surprisingly little research has explored whether men's sexual orientation (being gay) or masculinity (not being masculine) is what may cause adverse outcomes. In a series of 3 studies + 1 pre-test (total N = 890), we used novel vocal stimuli to simulate real-world interactions and test how sexual orientation and masculinity affect young straight men's (ages 18-30) evaluations of gay men. In Study 1 (N = 204), male participants were assigned to hear either a more masculine or less masculine-sounding man who was presumably giving them a "personality test". We found correlational evidence that when a target man was perceived to be gay, how masculine he sounded determined how well liked he was. Therefore, in Study 2 (N = 490) we experimentally manipulated the target's sexual orientation and confirmed Study 1's findings: telling male participants that a less masculine-sounding target man was gay made them perceive him as less masculine and like him less. Considering these findings about less masculine gay men, Study 3 (N = 98) participants only heard a less masculine gay man but received either manhood-threatening or affirming feedback. We found that men who were most aggressive toward or most negatively rated a less masculine gay men in a manhood threatening context were those with fragile masculinities. In other words, these men felt that they had to be masculine out of social pressure, compared to men who were masculine because of innate motivations or didn't want to be masculine at all. Thus, we conclude that in general, straight men prefer other men who are straight and masculine presenting. However, this phenomenon may be motivated by the preferences of men who are insecure about their own manhood.

Graduation with Distinction Candidate - Psychology

Index