



PREDOCTORAL
FELLOWSHIP AWARDS
2020

RACKHAM GRADUATE SCHOOL

Leah Abrams

Health Services Organization and Policy

Depressive symptoms in late life: The role of sociodemographic factors, retirement timing, and post-acute care

The mental well-being of older Americans is a pressing public health concern given the aging population and recent increases in midlife suicide and substance use. This dissertation uses nationally-representative longitudinal data to study population trends in depressive symptoms in mid- and late-life. I first characterize how depressive symptoms change over ages 51 to 90 by gender, race/ethnicity, education, and birth cohort. Looking at a key life event, I next examine how expectations about work at age 62 align with realized labor force status to determine whether unmet expectations about retirement timing relate to depressive symptoms across these sociodemographic groups. Finally, I consider depression as a comorbidity by comparing hospital readmissions, falls, and mortality among depressed and non-depressed Medicare beneficiaries in post-acute care settings (informal care, home-health, and skilled nursing facilities). This research identifies social forces behind trends in depressive symptoms and highlights two areas of health policy for improving healthy aging.

Edmond Atindaana

Microbiology and Immunology

Epigenetic and non-epigenetic regulation of HIV-1 expression and latency

The position of genes in a host genome is vital to when, how, and to what extent they are expressed. HIV-1 integrates semi-randomly into the host genome. However, little is known of how HIV-1's position in the host genome affects its persistence and expression outcomes under different stimuli. My thesis has developed a high throughput system to track and analyze thousands of HIV-1 integrants in order to understand how the interplay of epigenetic and non-epigenetic mechanisms influence HIV-1 expression, latency, persistence, and reactivation from latency in relation to their host integration sites. We found that only a few integrants were highly expanded and the expression levels among integrants differed by orders of magnitude even in the presence of reactivation stimuli. We are currently trying to understand how epigenetic and non-epigenetic factors contribute to the observed differences to help inform the development of targeted therapy in the quest for a cure.

Subarno Banerjee

Computer Science and Engineering

Robust, Reliable, and Repairable Systems with Targeted Program Analyses

Designing practical computer systems that are secure, reliable and easily repairable is challenging as enforcing these properties requires fundamentally more work. Careful reasoning through targeted program analyses, leveraging unsound assumptions and dynamic observations, can significantly improve software engineering tools within compilers, runtime-systems and debuggers to provide stronger security and reliability guarantees, and facilitate repairs. We demonstrate three key results: 1. Online security monitoring using Optimistic Hybrid Analysis by solving its rollback-recovery problem. This enforces information-flow security on critical server applications at practical overheads (~9% -- 4X+ speedup). 2. Sound garbage collection for the C language by tracking provenance of values derived from memory addresses. No prior GC solution for C is sound, and our work solves this to ensure temporal memory safety with low overheads. 3. Modified replay analyses to retroactively run captured execution traces with useful modifications. This enables asserting predicates that identify failure root-causes to significantly aid repairing faults in deployed software.

Marc Becker

Chemistry

Development of New Synthetic Methodologies Involving Strained Heterocycles

Over the past decades, organic synthesis has evolved to a critical component to provide molecules that have high impact in medicine, biology, and materials science. As a result, the development of novel, synthetic methods that allow for access of previously inaccessible scaffolds is of fundamental importance in organic synthesis. However, the present state-of-the-art processes for synthesizing some of the most important molecules are highly inefficient. Considering that “catalytic reagents (as selective as possible) are superior to stoichiometric reagents,” research towards my dissertation has exploited the unique features of Lewis acid catalysis and visible light photocatalysis to develop new synthetic methods that enable the construction of carbon–carbon bonds and the synthesis of strained nitrogen heterocycles. The insight and mechanistic understanding gained from this work will facilitate the development and synthesis of natural products and pharmaceutically relevant compounds.

Anne Blumenthal

Social Work and Sociology

Services or Surveillance? Contextual Differences in the Role of Trust in Parents' Engagement with Social Services Aimed at Preventing Neglect

For some time, calls have been made for a radical reform of child protective services (CPS), with particular attention to how it can better address the intersection of poverty and child neglect. However, recent CPS reforms aimed at addressing this intersection rely on strong, untested assumptions about parents' willingness to trust referrals and engage in services that are connected to CPS. I address these assumptions by asking, under what conditions do parents avoid or engage in social services that are connected to a criminal justice response from CPS? To test the theory that situational trust plays a key role in service engagement, I conduct interviews with low-income parents in two states with different CPS approaches. By taking into account the local context of CPS and by detailing the processes of engagement and avoidance from the perspectives of parents, this work will inform policy conversations on CPS reform and neglect prevention.

Jennifer Bowen

Earth and Environmental Sciences

The impact of sunlight on CO₂ emissions from freshwaters

The amount of carbon dioxide (CO₂, a heat-trapping gas) released from freshwaters to the atmosphere depends on the balance between photosynthetic uptake of CO₂ and decomposition of organic matter to CO₂. This balance is poised to change with global warming. The impact of sunlight-driven decomposition on freshwater CO₂ emissions was investigated to better predict future emissions as our planet warms. Sunlight-driven decomposition of organic matter in arctic freshwaters doubled the amount of nitrogen available for algal photosynthesis, suggesting that this process may impact photosynthetic CO₂ uptake. In temperate freshwaters, sunlight exposure of soil-derived organic matter doubled its decomposition to CO₂. In the Arctic, sunlight decomposed ancient organic matter from permafrost soils to CO₂. These findings demonstrate that sunlight-driven decomposition is currently an important process impacting freshwater CO₂ emissions, and that CO₂ emissions will increase in the future as ancient organic matter is released from thawing permafrost soils to sunlit freshwaters.

Nicole Brass

Education and Psychology

The Evolution of Peer Dynamics During Early Adolescence: Explicating the Role of School Context

This dissertation examines the role of school context in the development of peer dynamics, academic, and social well-being in early adolescence. Study 1 investigates the behavioral profiles of high-status youth in two groups of students: one that made a transition from elementary to middle school and one that attended the same school from kindergarten through eighth grade. Study 2 compares developmental trajectories of these two groups of students, but with a focus on how changes in behavioral profiles of status predict changes in students' academic and socioemotional adjustment. Study 3 examines students' perceptions of their school context as a potential explanation for differences observed in adjustment among a contemporary sample of students with diverse schooling experiences. Taken together, these studies will enhance current understanding of peer dynamics in early adolescence and provide new insights into how these processes unfold across varying school contexts, which can inform teaching practices and school policies.

Ellen Brennan

Neuroscience

Retrosplenial circuits controlling successful navigation and their impairment in Alzheimer's disease

The retrosplenial cortex (RSC) is necessary for successful memory and navigation and becomes dysfunctional in the earliest stages of Alzheimer's disease. However, the neural circuits underlying both its healthy function and progressive impairment in disease remain unknown. We have discovered a novel excitatory cell type in the RSC, which we named Low Rheobase (LR) neurons because of their ability to respond precisely, even to small inputs. LR neurons strongly encode head-direction inputs from the anterior thalamus and are thus the critical component of the RSC's spatial orientation circuit. We show that cholinergic modulation of RSC neurons is altered in a mouse model of Alzheimer's disease, impairing the encoding of orientation information. This work thus defines the unique cells and circuits that encode orientation in the retrosplenial cortex, explains why spatial disorientation is seen in 93% of Alzheimer's patients, and provides a foundation for novel therapies focused on the RSC.

Katherine Browne

Resource Policy and Behavior

Power and Politics in Climate Adaptation: Two Cases in the Western Indian Ocean

It is widely recognized that existing power structures will shape adaptation to climate change. Yet to date, only limited empirical work has explored the role of power in adaptation and no work has investigated how outcomes differ across, and as a result of, political context. My dissertation compares the impact of international adaptation policy in two vulnerable but politically distinct countries: Madagascar and Mauritius. I investigate how the power structures of each country shape adaptation, and, in turn, are shaped by global requirements of climate finance. This research is original in its empirical and comparative approach, as well as its focus on the role of national governments in supporting the adaptation of some of the world's most vulnerable communities. Findings will encourage global institutions to grapple with the sociopolitical reality in which adaptation unfolds.

Alessio Capobianco

Earth and Environmental Sciences

Integration of paleontological and neontological data reveals unexpected evolutionary histories: bonytongue fishes (Teleostei: Osteoglossomorpha) as a case study

Paleontological data are invaluable for reconstructing the evolutionary history of living organisms. Nonetheless, information derived from present-day species (neontological data) dominate macroevolutionary reconstructions of extant clades, due to either incompleteness or disregard of their fossil record. In this dissertation, I explore the fossil record of the freshwater fish clade Osteoglossomorpha (bonytongues) and integrate it with neontological data to derive an interdisciplinary perspective on the evolution of this ancient group of teleost fishes. Remarkably, bonytongue fossils reveal several major features of the clade's evolutionary history that could not be inferred from their extant members alone. These include a complex biogeographic history involving continental vicariance, long-distance dispersals and regional extinctions; the development of unusual cranial features and body plans, likely related to different ecological adaptations than observed today; multiple environmental transitions between freshwater and marine environments during the early Paleogene; and ecological release in the marine environment following the Cretaceous/Paleogene mass extinction.

John Charpentier

Immunology

The regulation of T lymphocyte growth by macropinocytosis

Macropinocytosis is a non-selective form of endocytosis that has been conserved by evolution from unicellular amoeboids to mammals. The function of macropinocytosis in various cell types, however, is distinct. In differentiated mammalian cells it has been shown to aid in, inter alia, regulation of receptor density and antigen presentation. We have discovered that mouse and human T lymphocytes engage in constitutive macropinocytosis that is enhanced significantly upon activation. We have shown that macropinocytic uptake is essential for activated T cell growth. Macropinocytosis enables T cell growth by delivering extracellular amino acids to the lysosomal compartment. There they promote the activation of the mechanistic target of rapamycin complex 1 (mTORC1) to drive G1 phase blastogenesis. This constitutes the first demonstration of a role for macropinocytosis in the regulation of non-cancerous mammalian cell growth. Modulation of T cell macropinocytosis may be therapeutic in the setting of diseases of public health interest.

Steven Chavez

Chemical Engineering

Engineering light-matter interactions to enhance energy and charge carrier transport in multicomponent photocatalytic systems

Photochemical processes that utilize sunlight to renewably generate value added chemicals (e.g., H₂) are currently at the forefront of research to mitigate climate change. These processes rely on the development of light-harvesting materials that can efficiently couple the energy of visible light into chemical bonds. Effectively engineering these materials relies on a thorough understanding of the energy/charge transfer processes occurring within these materials under illumination. In my dissertation work, I am using both experimental and computational methods to elucidate the mechanisms of energy and charge transfer in light-harvesting materials (i.e., nanoparticles, photonic structures, etc.). First, I develop a physical framework describing energy/charge transfer in hybrid systems consisting of a light harvesting component and an attached medium. Next, I use this physical framework to design a highly efficient photonic system with the goal of demonstrating its improved performance in the renewable generation of H₂ from water (i.e., solar water splitting).

Wonjin Choi

Materials Science and Engineering

Kirigami Optics: Emerging tool for opening new field of spectroscopy

Terahertz circular dichroism (TCD) offers multifaceted spectroscopic capabilities for understanding the mesoscale chiral architecture and low-energy vibrations of macromolecules in (bio) materials. However, the lack of dynamic polarization modulators comparable to polarization optics for other parts of the electromagnetic spectrum is impeding the proliferation of TCD spectroscopy. Here I show that tunable optical elements fabricated from patterned plasmonic sheets with periodic kirigami cuts make possible the polarization modulation of terahertz radiation under application of mechanical strain. A herringbone pattern of microscale metal stripes enables a dynamic range of polarization rotation modulation exceeding 80° over thousands of cycles. Several biomaterials revealed distinct TCD fingerprints associated with the helical substructure in the biocomposite. Analogous kirigami modulators will also enable other applications in terahertz optics, such as polarization-based terahertz imaging, line-of-sight telecommunication, information encryption and space exploration.

Sangmin Choi

Physics

Dressings and Asymptotic Symmetries in Quantum Field Theory

In quantum field theories with massless gauge bosons, the conventional formulation of scattering amplitudes in terms of momentum eigenstates lead to infrared divergences. To resolve this one should dress charged particles with an infinite number of low-energy gauge bosons. These dressings are closely related to the asymptotic symmetries of the theory. In this thesis, we investigate this relation in detail and study the implications of dressings in a quantum field theoretical context. We show that the dressings facilitate charge conservation by carrying a definite charge of the asymptotic symmetries. This makes the dressings a natural tool to study black hole soft hairs. We show that the black hole soft hairs are planted on the horizon by particles falling into the black hole. We explore the implication of dressings for the black hole entropy and the information paradox.

Anne Clark

Sociology

The Context and Consequences of the Gendered and Racialized Development of Mathematics Self-Competence

Extensive cross-sectional research has established that girls have lower mathematics self-competence, or self-perceived mathematics ability, than boys. The few studies on racial disparities have found that, net of test scores, black and Hispanic students have higher self-competence than white students. However, it is unclear whether these gender and racial inequalities grow or shrink with age. Leveraging nationally representative, longitudinal data, this dissertation consists of three chapters. The first chapter determines whether gender and racial disparities in mathematics self-competence grow or shrink with age and what processes underlie the development of these gendered and racialized self-perceptions. The second chapter examines the consequences of one's history of mathematics self-competence for future persistence in STEM (science, technology, engineering, and mathematics), independent of current self-competence. The final chapter examines whether lower correlations between trajectories of mathematics self-competence and mathematics interest among girls and racial minorities explain lower persistence in STEM compared to white boys.

Melissa Coppola

Piano Pedagogy and Performance

Young People's Perspective: Understanding Experiential Benefits of Interdisciplinary Concerts for Student Performers

In preparing for recitals, piano students are often driven by the goal of executing error-free performances and are given little agency to showcase their creative individuality on stage. Though the traditional piano recital format has its place in pedagogy, it often comes with this critical restriction. Despite the increasing trend of interdisciplinary programming in classical concert halls internationally, few resources and opportunities are available for piano students to explore performance at the intersections of other disciplines. One critical need is an evidence-based resource to guide music educators in incorporating more creative elements into their studio recitals. To meet this need, my dissertation focuses on understanding the benefits of the growing field of interdisciplinary performance directly through the experiences of student performers participating in Young People's Perspective, a new youth-led interdisciplinary concert series, in order to produce a curriculum for teachers to empower their students with alternative modes of performance.

Justin Craft

Linguistics

The Effect of Listener Experience and Prediction on Illusory Perception

Speaker accents reflect the communities where speakers learn their language. Thus, all speakers of all languages speak with an accent that reflects characteristics about their social identity. Listeners readily adapt to accented speech as they gain experience with accented speakers and also to use this experience to generate predictive expectations about speaker accents. My dissertation uses perceptual illusions as a tool to probe how stereotyped beliefs operate during speech processing. I conduct three experiments that analyze the electrophysiological and behavioral responses of participants listening to audiovisual perceptual illusions that investigate the role that speaker race plays, when cued visually, in recalibrating listeners' auditory speech percepts. By breaking the audio-visual integration characteristic of typical speech processing, my dissertation targets whether the percepts listeners experience, when they can only rely on their expectations about an interlocutor's speech, reflect the variation present in the actual stereotyped speech signal.

Abhishek Dhyani

Macromolecular Science and Engineering

Design and application of polymers for fouling control

Solid fouling is detrimental to critical infrastructure and plays a role in spreading infectious diseases. It is therefore essential to either prevent attachment or facilitate easy removal of foulants from surfaces. Despite the numerous literature that exists on low solids adhesion materials, there is a lack of initiative in scalability and durability of these surface technologies. In my dissertation, I investigate materials to tackle two extreme foulants, water ice (non-living and hard) and bacteria (living and soft). Against ice, my work introduces a new class of low-interfacial toughness coatings that allow for removal of accreted ice from large areas by tuning interfacial toughness of ice-coating interface. Against bacteria, I have developed a new class of safe, nature-based polymer-oil composites with instant and persistent antimicrobial properties through the use of plant essential oil components stabilized in polymer networks. Such a technology would prevent cross-contamination in world food supply, transportation, and daycares.

Na Du

Industrial and Operations Engineering

Predicting drivers' takeover performance and designing an adaptive in-vehicle alert system

In conditionally automated driving, although drivers are allowed to engage in non-driving related tasks, safety issues have been a concern to the general public. Drivers decoupled from operational control of the vehicle have difficulty taking over control of the vehicle when requested. My dissertation addresses this issue by developing computational models to predict drivers' takeover performance in real-time and designing an adaptive in-vehicle alert system. The first part of my dissertation develops a standard set of driving metrics that quantify drivers' takeover performance objectively. The second part models drivers' takeover performance using their physiological signals and driving environment parameters via machine learning algorithms. According to the model output, the third part designs an adaptive in-vehicle alert system to improve drivers' takeover performance. The findings will provide guidance to automobile manufacturers on the design of in-vehicle alert systems. This will eventually enhance driving safety and facilitate the adoption of automated vehicles.

Salem Elzway

History

Arms of the State: A History of the Industrial Robot in Postwar America

The industrial robot—imagined as the pinnacle of advanced manufacturing—emerged from a wide array of activities, interests, and policies, spanning from academic research and corporate investment, to military munificence and speculative fiction. The technology, therefore, provides an interesting case study for exploring how the interaction of the manufacturing sector, policy-makers, and thinkers affected economic, political, and technological development in the postwar United States. The revolutionary potential of the industrial robot came from its ability to manufacture new modes of production, new social realities, and new ways of thinking about human-machine interaction. Yet, these abilities and potentialities were not just limited to the technical aspects of industrial robots; they are as much products of the social world they were embedded in. Understanding how the robot, in essence, became industrial, illuminates the complex and dynamic relations between manufacturing, public policy, and technological development in our supposedly post-industrial world.

Jared Eno

Sociology and Public Policy

Racialized Institutional Stratification in the Postwar U.S. Higher Education System

Inequality among institutions of higher education (IHEs) in the United States is an important source of racial inequality, with white students disproportionately sorted toward more-resourced IHEs while African American and Hispanic students are concentrated in less-resourced IHEs. Research has documented the increasing marketization of higher education since the 1980s and how this has exacerbated inequality, but less is known about how the infrastructure for this market was built during the racial contestations of the preceding decades. This dissertation draws on critical race theory, economic sociology, and organization theory to examine the development of racialized classification technologies, such as selectivity and the Carnegie Classifications, to better understand how racial inequality was institutionalized in the higher education market even as access to college was broadened.

Audrey Eshun
Chemistry

Investigation of Energetics and Dynamics of Organic Molecules Using Entangled Photons as a Novel Spectroscopic Tool

The goal of this research is to expand on the understanding of quantum entanglement as it applies to spectroscopy, and experimentally realize the utilization of quantum entangled photons in the novel applications of virtual state spectroscopy and Hong-Ou-Mandel interferometer spectroscopy. We have observed that when used to excite some organic molecules, non-classical light causes enhancements in their nonlinear responses, which aids in our understanding of molecules needed for organic electronics. The idea of using quantum entangled light as a source to measure the intermediate or virtual energy levels of molecular transitions has been theorized, but this work will be an expanded experimental achievement. Additionally, Hong-Ou-Mandel interferometry has been used primarily for metrology, but in this research the quantum interference properties of entangled light interacting with the sample's electronic states will be used to determine information about the quantum coherent responses of organic molecules.

Kayla Fike
Psychology and Women's Studies

Examining Perceptions of Neighborhood Quality for Urban-Residing Black Adults

The construct of perceived neighborhood quality developed without enough attention to how social identities contribute to people's perceptions. Guided by theoretical frames from sociology and black feminist geography, I aim to address theoretical and methodological gaps that render black people's perceptions of their urban neighborhoods as monolithic and preferential rather than diverse products of agency and history. Using survey and interview data from a sample of urban-residing black adults, I examine contributing factors to perceptions of neighborhood quality in three studies. Expected results will illustrate the ways that demographic factors, social analysis, and participation in political activities, and physical space create a range of perceptions of urban neighborhoods and cities. Deepening our understanding of what contributes to black urban residents' perceptions of the neighborhood can allow community interventionists, urban planners, and policy makers to better address community-identified places for improvement that suit the needs of a wider range of residents.

Gordon Fitch
Ecology and Evolutionary Biology

Understanding the role of agroecosystem management in structuring plant-bee interactions

Agricultural management practices have the potential to profoundly influence ecological and evolutionary dynamics in plant-insect interactions, with important consequences for the maintenance of biodiversity and agricultural productivity. My research investigates how management of coffee agroecosystems in southern Mexico impacts mutualistic and antagonistic interactions between stingless bees and crop and non-crop plants. In particular, I study 1) how local and landscape-level management affects stingless bee foraging patterns and colony health; how these influences cascade to affect 2) coffee pollination and 3) nectar robbery of the plant *Odontonema cuspidatum*; and 4) how patterns of nectar robbery drive selection on *O. cuspidatum* floral traits. I use a combination of field surveys, manipulative experiments, and theoretical and statistical modeling to answer questions of both basic and practical importance, and I leverage partnerships with practitioners and land managers, as well as evidence-based translational science practices, to translate research findings into management recommendations.

Luis Flores
Sociology

American Households and the 'Future of Work': The Rise of Industrious Homes After the Family Wage, 1970 to 2008

This dissertation contributes to research on the “future of work,” moving beyond a focus on individual wage workers and foregrounding household responses to changes in waged employment between 1970 and 2008. Three case studies will follow the rise of direct selling (Avon, Amway, Herbalife), leasing of accessory dwelling units within homes, and rise of home equity extraction. These cases illustrate household strategies to generate resources outside standard wages—providing a lens into a rearrangement of household economic life since the 1970s. Leveraging administrative and archival data from municipalities, federal regulators, congressional records, newspapers, and industry publications, each case study interrogates (1) the motivations driving early industrious activity; (2) regulatory challenges and incorporation; and (3) trajectories of socio-economic, racial, and gendered diffusion across groups of households. This dissertation suggests that at the root of recent expansions in economic informality are not new technology platforms, but changes in the labor process.

Trenton Frisbie
Human Genetics

The role of the NF2 tumor suppressor gene product, merlin, in LINE-1 retrotransposon biology

Long Interspersed Element-1 (L1) retrotransposon-derived sequences comprise an astounding 17% of human genomic DNA. Most L1s are immobile; however, an average human genome contains approximately 100 L1s that can mobilize (i.e., retrotranspose) in the germline, during early development, and/or in select somatic cells. The resultant insertions can alter gene expression, generate structural variation, and create disease-producing mutations. Various cellular mechanisms have evolved to combat L1 mobility. Our laboratory previously established that reporter genes introduced into the genomes of human embryonic carcinoma-derived cell lines (hECs) by L1 retrotransposition are efficiently and stably silenced upon integration. Here, we performed genome-wide CRISPR/Cas9-based knockout screens in hECs and demonstrated that loss of the NF2 gene product, merlin, increases L1-mediated reporter gene expression, suggesting that merlin either helps establish reporter gene silencing upon genomic integration and/or inhibits L1 retrotransposition. Thus, these studies provide insights into how a known tumor suppressor gene may affect L1 biology.

Emily Gauld
Germanic Languages and Literatures

Composing the Musicking Woman: Gender and Nation in the Works of Johanna Kinkel

Although research on women in music and literature has increased in recent decades, most scholarship examines women as object or consumer, but rarely as producer. My dissertation analyzes nineteenth-century notions of national and gendered German identity in music and literature through the lens of female authorship. I focus on the literary and musical oeuvre of writer, composer, and revolutionary Johanna Kinkel (1810 to 1858). Through a combination of literary and musical analysis, I identify the musicking woman, a term I introduce to describe women with an active and serious commitment to musical culture. The musicking woman illustrates the ways women created space for themselves within a (bourgeois) male-dominated national imaginary and challenged expectations and representations of gender and femininity through cultural contributions. To this end, I suggest that women were uniquely well-placed to capture intermedial aesthetic values of Germanness that were fostered by the close cultural relationship between music and literature.

Aman Goel

Computer Science and Engineering

Scalably Verifying Correctness with Provable Assurance

As the world increasingly depends on complex systems to transfer messages, store our data, manage our medical devices, how can we tell whether the system is correct? In this dissertation, I suggest ways to automatically verify the correctness of complex systems using techniques that identify important information directly from the structure of the system. I explore algorithmic solutions to perform automatic and scalable verification of hardware and software systems with provable guarantees against critical functional errors. I propose a new way of separating what's important from uninteresting low-level details using syntax-guided abstraction, that allows scalable correctness checking directly at the source-code level. The approach can be further employed to eliminate tedious manual efforts required for verifying unbounded parameterized systems, with high scalability and provable security. The proposed techniques are successful in automatically checking the correctness of several real-world complex systems, even ones whose subtleties are too hard to understand manually.

Tian Gu

Biostatistics

Statistical Methods to Incorporate External Summary-Level Information into the Current Study

Disease risk prediction models are used throughout clinical biomedicine. With the discovery of new biomarkers these models could be improved and provide better predictions. However, the data that includes the new biomarkers will typically have limited sample size. This dissertation develops efficient statistical methodologies to build improved prediction models based on individual-level data from an “internal” study while incorporating summary-level information from “external” models. We first propose a novel broadly applicable synthetic data method. The procedure creates synthetic data, which is then combined with the “internal” data, and the new model build from the combined data. We next propose a meta-analysis framework that can integrate information from multiple external models. This framework simultaneously identifies the most relevant external information and gives that higher weight in the procedure. Finally, we will combine the two concepts and develop methods that can give a separate improved model for each of the external populations.

Yuequan Guo

Political Science

Protest in Autocracy with Capacity: The Case of Workers' Collective Action in China

How do people protest in autocracy with capacity? Why do they mobilize in that way? What are the consequences of that mobilization? I study these questions through examining workers' collective action in China. I argue that, due to a trade-off between capacity and risk, workers engage in “networked mobilization.” Workers want to mobilize as many co-workers as possible to force the firm and/or the government to respond, but draw attention from the firm and/or the government exactly when many participate. A few initiators therefore make the plan in a small group and then mobilize co-workers through social networks. Moreover, I show that networked mobilization has roots in the government's differentiated social control—in particular repression of the initiators—and workers' quotidian experiences in the workplace. Workers' migration status and symbiotic relationship with the management contributes to a weak sense of solidarity. Finally, I investigate the impact of networked mobilization. The return of migrants spreads strike experiences inland. The relocation of industries recruits more locals who have more connections, resources, and a stake in the community. Both indicate new frontiers of the labor movement in China. I argue that networked mobilization has potential to generalize to other types of collective action in and beyond China.

Eric Haynie

Asian Languages and Cultures

The Great Perfection of Kham: Dzokchen Monastery and the Assembling of Buddhist Tradition in Seventeenth-Century Tibet

This dissertation examines the invention of religious tradition in early modern Tibet by analyzing the seventeenth century founding of Dzokchen Monastery in the eastern Tibetan region of Kham. An important but hitherto unexamined Buddhist institution, Dzokchen was established at the confluence of the Tibetan and Chinese empires and at the intersection of all four branches of Tibetan Buddhism. As such, its emergence as specifically Nyingma, the tradition to which it belongs, was not preordained. Through a social historical lens, I scrutinize the network of Buddhist lamas and kings contributing to Dzokchen's formation in order to unravel the contending agendas that constructed authority there. This dissertation demonstrates that these actors' political, religious, and personal relationships compel us to reconsider "sect" as an analytic term, and reveals that rupture and multiplicity are not occasional but rather endemic to the formation of Buddhist tradition in the early modern Central Asian borderlands of Tibet.

Yinqiu He

Statistics

Statistical Inference for High-Dimensional and Complex-Structured Data

In the modern era of data science, high-dimensional and complex-structured data become prevalent in various application areas, such as genomics and neuroscience. The increasing size and complexity of data often result in the poor performance of many existing statistical inference methods. Motivated by the new challenges, this dissertation aims to develop novel theory and methodology to make accurate, powerful, and efficient statistical inference for high-dimensional and complex-structured data. In particular, this dissertation focuses the questions from three aspects: the first chapter addresses the foundational challenge of conducting valid and powerful tests under high dimensions; the second chapter addresses the computational challenge of quantifying rare-event probabilities in statistical inference; the third chapter addresses the methodological challenge of investigating complex data structures.

Huatse Huazejia

Anthropology

The Remaking of Gender, Household, and Community Through Rangeland Fencing and Resettlement on the Tibetan Plateau

This dissertation explores the impacts of the Chinese government's concerted efforts to end more than eight-thousand years of Tibetan pastoralism over the past two decades. It explores Tibetan pastoralists' changing relationships to and experiences of land, home, and community. The research draws on interdisciplinary approaches to the study of land and the spatial politics of land use in order to understand the consequences of recent pastoralism policies on the Tibetan Plateau. As a project utilizing the qualitative methods of ethnography, this project aims to contribute an important humanistic perspective in the interdisciplinary study of land and the spatial politics of land use. As such, its findings will contribute to and challenge the science of managing land from the vantage point of Tibetan pastoralists, which has been ignored in the Chinese state's technocratic and scientific environmental discourse. Results generated from this research will enhance understandings of indigenous cultural knowledge of land and landscape. Such work has proven effective transnationally in mitigating the environmental risks of development projects (Palmer 2015; Nadasdy 2007; West 2006; Humphrey and Onon 1996).

Joshua Hunt
Philosophy

Symmetry and Reformulation

Traditional debates in philosophy of science focus on competing scientific theories, neglecting an even more central aspect of science: compatible formulations of the same theory. Compatible formulations arise whenever we have multiple, logically consistent ways of solving the same problem. They pose a unique set of philosophical challenges because although they provide different understandings of the world, compatible formulations agree on the way the world is. What do we gain by having two compatible descriptions of the same phenomenon? In Chapter 1, I propose and defend conceptual empiricism, which offers a purely epistemic account of the significance of reformulations. Chapter 2 shows how conceptual empiricism provides an agent-independent account of understanding. In Chapter 3, I argue that existing philosophical accounts of scientific explanation do not subsume conceptual empiricism's account of understanding. Finally, in Chapter 4, I argue that scientific reformulations motivate a semantic framework for laws of nature that is rich enough to accommodate meta-laws and graded modal claims.

Mitul Islam
Mathematics

Rank One Phenomena in Convex Projective Geometry

Convex projective geometry is a generalization of hyperbolic geometry that studies the properties of open properly convex domains in the real projective space. Such domains can be equipped with a canonical metric called the Hilbert metric. The resulting geometries are called Hilbert geometries. In this dissertation, we study Hilbert geometries in the spirit of Riemannian non-positive curvature and CAT(0) spaces. We introduce a notion of rank in Hilbert geometries and formalize the intuition that rank-one implies an abundance of negative curvature like behavior. We connect this with acylindrical hyperbolicity in geometric group theory. The goal of this dissertation is to characterize various such incarnations of hyperbolicity and produce a complete geometric, algebraic and dynamical theory of rank-one Hilbert geometries, akin to the case of Riemannian non-positive curvature. In the case of convex co-compact actions, our goal is to use this theory and study generalizations of the much-studied class of Anosov representations from Higher Teichmüller theory.

Louis Joslyn
Bioinformatics

Evaluating T-cell responses to Mycobacterium tuberculosis infection and Tuberculosis vaccines using a systems biology approach

Tuberculosis (TB) kills three individuals every minute worldwide. While Bacillus Calmette-Guérin is the world's most used vaccine as a preventative measure against the childhood form of TB, its protection wanes as individuals enter adulthood. New approaches are needed to make a major impact on TB vaccine development. Promising targets for vaccine design are T cells, white blood cells that provide immune memory and play an important role in fighting Mycobacterium tuberculosis (Mtb) infection. Understanding the immune response to Mtb infection is key to developing an effective vaccine. My thesis is designed to characterize T-cell response across and within various organs during infection, vaccination, or both by integrating preclinical and clinical trial data together with computational modeling. In this thesis, I refine and develop a set of computational models to evaluate questions and isolate mechanisms surrounding T-cell timing, and quantify T-cell responses following vaccination/infection across cellular, tissue, and whole-host scales.

Christina Kang-Yun
Environmental Engineering

Characterization of the genetics of metal regulation in methanotrophs

Methane-oxidizing bacteria, or methanotrophs, use methane as their sole carbon and energy source, and have a wide range of applications including methane removal, methylmercury degradation, and valorization of methane. Such applications are strongly dependent on copper and rare earth elements due to its central role in allowing these microbes to oxidize methane and also in detoxifying methylmercury. To fully utilize methanotrophs, the genetics underlying metal uptake must thus be delineated. In my Ph.D. research, I have characterized the evolution of methanotrophs to glean insights into potential uptake systems of copper and rare earth elements, and am developing strategies to optimize their production for industrial and medical applications. I am also examining how uptake of these metals controls methylmercury detoxification mechanisms. Finally, I am investigating competition between methanotrophs for copper to determine how this affects their overall ability to remove methane from the atmosphere. As a result, my Ph.D. is directly contributing to our ability to utilize methanotrophy for a wide range of applications.

Vishal Khandelwal
History of Art

Belonging Without Aligning: India and the Ethics of Design, 1955 to 1985

This dissertation examines how industrial designers, applied artists, and design critics at postcolonial India's foremost industrial design academy, the National Institute of Design (NID, est. 1961), mobilized new pedagogical initiatives, media representations, and designed objects (consumer products, graphics, textiles, and exhibitions) to emphasize national consciousness, environmental awareness, and earthly and communal belonging. In contrast to their counterparts in Western and Eastern Bloc nations where everyday goods signified values such as consumer satisfaction and efficient production—in-turn tied to Cold War soft politics—individuals affiliated with the NID extended and repurposed colonial-era design practices, foregrounding design's utility as an ethical and social force. The formulation, critique, and transformation of this institute's pedagogy and practice over a period of thirty years demonstrates how design's potential to provide models for ethical behavior gained urgency within the specific context of postcolonial India, but ultimately had implications for the world at large.

Sooyeon Kim
Earth and Environmental Sciences

Exploration of environmental and energy related reactions at mineral-fluid interfaces at the molecular level

The majority of environmentally important chemical reactions are taking place at mineral-fluid interfaces. Thus, the properties of these interfaces have a great impact on the oxidation state and the mobility of contaminants in the environment. This dissertation focuses on the fundamental principles of how radioactive contaminants (U, Np, Pu) become immobilized and oil compounds interact on mineral surfaces, in solution, and biotic/abiotic conditions by exploring molecular-level structures and electronic properties. Electrochemical approaches and high-resolution surface analysis techniques, as well as computational modeling, are applied to understand the principles underlying the observed macroscopic phenomena at mineral-fluid interfaces at a micro/nanoscale to better predict and optimize surface reactions in the environment.

Ozgecan Korkmaz
Anthropology

Ethics of Dissent: Critical Discourse, Authority, and Politics in Turkey's Kurdistan

How is dissent possible in a state that monopolizes political communication and group formation? What does the endurance of dissent have to do with ethical concerns and moral principles? The proposed work investigates these questions in the context of rising authoritarianism in Turkey's Kurdish majority Southeast region, dwelling on the question of everyday political communication from the perspective of a minority group. It demonstrates the ways in which "dissent" (muhalefet) comes to be a salient category of practice in Turkey's Kurdistan, shaping everyday life and social relations within Kurdish society, as well as between Kurds and the Turkish government. Based on extensive ethnographic and archival research, documenting the ways in which Kurds negotiate dissent in face-to-face communication, media, and legal practices, this research asks three questions: 1) In what ways does the practice of dissent shape and reconstitute social relations in Turkey's Kurdistan? 2) What can broader models of ethical conduct reveal about the rules of conduct that govern public discourse? 3) How does authoritarian power affect individuals' understandings of their own work within larger political contexts? Ultimately, this project seeks to provide a vocabulary for describing the possibility, organization, and principles of political communication in Turkey's Kurdistan in the context of extraordinary and authoritarian governance.

Sean Kramer
History of Art

Military Manhood: Visualizing the Common Soldier in French and British Art and Culture, 1871 to 1914

This dissertation investigates the prevalence of the common soldier in artworks by French and British painters, produced around the turn of the twentieth century (1871 to 1914). Artists ennobled the troops in their small-scale paintings, reproduced widely in print and geared for an international private market. These works diverged from a longstanding tradition of state-sponsored battle painting that celebrated the bravery of commanders and the drama of combat. Art historians have addressed this pictorial shift vis-à-vis the democratization of European armies, but have neglected concurrent shifts in constructions of masculinity. However, I argue that the visual arts represented increasingly mundane ideals of martial manhood by valorizing soldiers' hygiene, discipline, and professionalism over momentary heroics and hyper-masculine display. Such imagery served to normalize military service for audiences in France and Britain during this period, when expansions of armed forces and colonial holdings demanded increasing numbers of men and occupied greater public attention.

Nan Li
Aerospace Engineering

Game-Theoretic Vehicle Interaction Modeling and Autonomous Decision-Making

This dissertation develops a game-theoretic framework for modeling human-driven vehicle and autonomous vehicle (AV) interactions and for AV decision-making in traffic. In the first part, models representing drivers' interactive decision-making processes are formulated mathematically based on applications of cognitive-hierarchy and leader-follower game theories, and the formulated decision-making problems are solved numerically using reinforcement learning and receding-horizon control (RHC) to derive corresponding driver policies. The driver models are validated with data and used for verification and validation (V&V) of AV control systems. In the second part, an AV decision-making strategy for interactive traffic scenarios is proposed based on a unique integration of the developed driver models with Bayesian estimation and RHC techniques. Its effectiveness is illustrated by a series of simulation tests. The main contributions of this dissertation are formalization of the game-theoretic framework for vehicle interaction modeling and autonomous decision-making, and development of simulation tools for AV control system V&V.

Ifeanyi Madu

Chemical Engineering

Understanding the optical and photophysical properties of organic polymers and hybrid macromolecules for optoelectronic applications

Given the need for organic materials in our everyday life, it is crucial to understand their basic physical properties as they apply to certain crucial areas such as energy production and storage, and electronics. Replacing existing expensive inorganic materials with organic or hybrid materials of similar properties is highly advantageous in many ways such as cost management, ease of processing, tunability, and biodegradability. My research seeks to study the optical and photophysical properties of organic (as well as hybrid) polymers and large molecules for photovoltaic applications. In these studies, I use various laser spectroscopic techniques such as pump-probe ultrafast transient absorption, two-photon absorption, and time-resolved fluorescence, to probe the photophysical properties of materials and uncover the interesting nature these organic semiconducting materials. My overall goal is to pinpoint the underpinning processes that make selected organic materials excellent candidates for photovoltaic application, and then advise a more targeted design and synthesis procedure.

Grace Mahoney

Slavic Languages and Literature

Behind Cream Curtains: Literary House Museums in Russia and Ukraine 1917 to Present

My dissertation is the first study to theorize Soviet and post-Soviet author house museums as institutions that generate and reflect, yet also complicate and subvert, cultural and memorial paradigms that determine interpretations of writers and their texts. I consider the phenomenon of the house-turned-museum as a major instrument in forging the literary canon in the authoritarian regimes of Soviet Russia and Ukraine and how the prominence of these institutions influenced contemporary writers. My dissertation employs the methodologies of Soviet subjectivity studies to approach author house museums as sites of complex negotiation between the official ideology, multiple actors, and the space and exhibition of the museum itself. I find that Soviet and post-Soviet author house museums critically bear on the political, social, and artistic discourses in their respective contexts through their essential connection with the home and literature.

Michelle May-Curry

American Culture

The Mirror Darkened Me: The Shifting Imaginary of Mixed Race Families

My dissertation asks: what do 20th and 21st century visual and literary representations of mixed-race families tell us about shifts in black political cultures and aesthetics? I consider how mixed-race individuals and families negotiate their relationship to putatively authentic or communal understandings of blackness conveyed throughout public life especially when these very communal understandings themselves are in flux. Contextualizing these representations within Black social movement histories, I argue that representations of these families in visual and literary culture work to define the political and symbolic potential of the mixed-race family unit, especially as this potential may serve to help or hinder the black freedom struggle. In focusing specifically on black mother-white father families, I examine how evolving understandings of gender, sexuality, and class within the struggle for black freedom have colored notions of what type of civic subject black women or mothers can be in the context of her mixed-race family.

Andrew McInnerney
Linguistics

The Argument-Adjunct Distinction and the Structure of Prepositional Phrases

The classic distinction between “arguments” and “adjuncts” has had a tremendous impact on theories of human knowledge of syntax. This thesis aims to vitalize skepticism towards the distinction. Careful syntactic analysis shows that the empirical motivation for a category distinction between arguments and adjuncts is quite poor; scientifically-grounded syntactic theories should therefore discard the distinction. Despite its poor empirical support, the argument-adjunct distinction plays a pivotal role in the analysis of diverse syntactic phenomena. The secondary aim of this thesis is therefore to show that such analyses are inadequate, and can be improved by abandoning the argument-adjunct distinction. Towards this end, I focus on the analysis of prepositional phrases, the ideal test case, as prepositional phrases are canonically thought to be “adjuncts” in some cases, “arguments” in others.

Peter Meisenheimer
Materials Science and Engineering

Disorder-engineering of ferroic materials

Worldwide energy consumption is expected to increase 50% by the year 2050, with as much as 25% of that being lost to waste heat from electronic devices. Multiferroic materials have the potential to mitigate this heating and volatility in computational devices by allowing voltage control of a magnetic state, virtually eliminating waste heat from “always-on” Si-based technologies. These systems, however, are rare, hindering the advancement in understanding of magnetoelectricity and the realization of new technologies. Existing engineering techniques utilize atomic-scale or crystal-scale ordering to access magnetic coupling in materials, but chemical and structural disorder is an oft explored technique that has been shown to lead to novel and colossal functional properties in other materials systems. This thesis explores disorder as a frontier to both synthesize new ferroics and enhance material properties for superior functionalities, an orthogonal vector to addressing the scarcity and low coupling efficiencies of state-of-the-art materials.

Hillary Miller
Cellular and Molecular Biology

The mechanisms of serotonin-based signaling in food perception and DR-mediated longevity.

As world demography continues to skew older, mitigating the effects of aging has become a major goal of biomedical research. The aging process is frequently modified by how organisms perceive and respond to changes in their environment. My thesis focuses on the cells and signals involved in dietary restriction-mediated longevity. Multiple studies, including our own, identify serotonin as a crucial neuromodulator in the nematode *C. elegans*. My thesis will elucidate components of the sensory pathway initiated by perception of decreased food that leads extension of lifespan. This work involves identifying the primary neuron(s) that initiate the signaling cascade (Aim 1), determining the secondary neuron(s) receiving that signal (Aim 2), and discovering the signaling events that occur downstream of serotonin release (Aim 3). Collectively, my findings will enhance our understanding of a conserved signaling pathway that modifies aging thus advancing my long-term goal to develop therapeutics that increase human health/lifespan.

Sriram Mohan

Communication Studies

Digital Defiance: Political Expression and Technological Citizenship in South India

The dissertation examines the digital production and circulation of political posters, memes, protest songs, and satirical videos in south India. It demonstrates how these oft-ignored forms of political expression emerge as a site of defiance in the digital age. Combining media and cultural studies and science and technology studies approaches, the dissertation traces the dialectical tensions between vernacular cultural production of political claims and the postcolonial Indian state's efforts to yoke 'good' citizenship to the adoption of digital technologies. It locates these frictions amidst shifts in state-citizen relationships, mass publicity and dissent over the last two decades. Based on 13 months of ethnographic fieldwork in media capitals across south India, the dissertation blends textual analysis of cultural artifacts with participant observation and in-depth interviews. The project charts the formation of new media cultures in postcolonial India to expand scholarship on the creative, cultural, and political dimensions of sociotechnical change.

Lindsay Moritz

Cellular and Molecular Biology

Revisiting the role of sperm protamine proteins in organismal development and fertility

Sperm and egg cells carry genetic and epigenetic information from parents to offspring, serving as a link between the past, present, and future of a species. Unlike oocytes and somatic cells, which package DNA with histones, DNA of mature sperm is bound by protamines, highly basic and rapidly evolving proteins that are essential for the compaction of paternal chromatin. This differential packaging traces back >500 million years, yet its biological significance remains largely unknown. Protamines have previously been considered passive structural elements that hypercondense and protect paternal DNA, however emerging biochemical, evolutionary, and developmental evidence suggest a need to revisit the biological function of protamines. We have employed cutting-edge molecular, biochemical, and genetic approaches to investigate the role of protamines in fertility and early development. Together, these findings will increase our molecular understanding of these ancient, yet rapidly evolving proteins and may overturn the long-held dogma of their presumed function.

Ellen Mulvihill

Chemistry

Simulating Electronically Nonadiabatic Dynamics via the Generalized Quantum Master Equation

Quantum effects play an essential role in the dynamics of molecular condensed-phase systems, making the simulation of quantum dynamics an important challenge for computational chemistry. This is pertinent to many technologically and biologically relevant processes, such as photovoltaics and photosynthesis. However, the exponential scaling of the computational cost with system dimensionality makes the numerically exact simulation of nonadiabatic dynamics in complex molecular systems non-feasible. The most commonly used approaches are based on Marcus theory and Fermi's golden rule. However, these methods are based on a number of restrictive assumptions. In comparison, the generalized quantum master equation (GQME) is arguably the most general framework for simulating electronically nonadiabatic reduced dynamics, as its derivation requires no approximations and it has the ability to capture the full electronic density matrix. My dissertation aims to develop a GQME-based methodology for simulating electronically nonadiabatic dynamics that is applicable to complex molecular systems.

Emma Nolan-Thomas
Anthropology and History

Practicing the Prophet's Medicine: Islam, Health, and Healing in Indonesia

Practicing the Prophet's Medicine examines the history and contemporary revival of Islamic medicine in Indonesia. An everyday and embodied manifestation of Islamic revival movements, interest in Islamic medicine has in recent decades been on the rise amongst Muslims around the world. In analyzing the efforts of Islamic medicine patients and practitioners in Indonesia, this dissertation challenges binary distinctions between local and global, scholarly and folk Islam, and develops a model for studying religious traditions as simultaneously prescriptive and explorative. Specifically, I trace empirically how Muslims have revived and re-imagined healing practices from the Islamic past, while remaining creatively in dialogue with forms of knowledge that exceed the obviously "Islamic," such as biomedical research and Traditional Chinese Medicine. In exploring the revival of Islamic medicine in Indonesia, this dissertation documents how Muslims from the world's largest Muslim-majority country integrate religious practices and ideas with diverse kinds of knowledge in the pursuit of human flourishing.

Edison Ong
Bioinformatics

Ontology-Based Vaccine Data Integration and Rational Design by Reverse and Structural Vaccinology

Vaccination is the most successful medical intervention in modern medicine. However, it is still difficult to develop effective vaccines against many infectious diseases such as tuberculosis, HIV, and malaria. There are challenges to integrate the high volume, variety, and variability of vaccine-related data and rationally design effective vaccines efficiently. My thesis focuses on addressing these challenges by developing: (i) an ontology-based vaccine data representation, integration, and analysis of vaccine protection mechanisms; (ii) a novel machine learning-based reverse vaccinology method for rational vaccine design; and (iii) a new structural vaccinology design program to optimize vaccine candidates for enhanced vaccine protection. The results and tools from this work are expected to greatly advance the understanding of vaccine mechanisms and the capability of developing effective vaccines efficiently against infectious diseases of public health significance.

Annika Pattenaude
English Language and Literature

Between Fruit and Chaff: Undisciplined Reading in Late Medieval England

This project maps a history of medieval reading centered on untrained readers. Whereas most studies of medieval reading chart the growth of professional literacy, my dissertation attends to moments in medieval texts that invite unschooled or undisciplined reading. This study turns to fifteenth-century texts, in particular, as a moment when increased vernacular translation and print technologies engendered new affective, uncritical, and heretical frameworks for reading. The first two chapters examine late medieval texts that were used for literacy training (fables, grammar exercises, and liturgical chants) as common sites of "undisciplined reading." The last two chapters explore how attention to "undisciplined reading" sheds new light on what have been considered the dominant paradigms of reading in the fifteenth century: affective piety and Lancastrian propaganda. Throughout this dissertation, I show that "undisciplined reading" in late medieval England raises provocative questions about the cultural power of literacy and what it means to read.

Julie Philippe
Pharmacology

Distinct S-palmitoylation mechanisms within the ankyrin family of scaffolding proteins: implications for neuronal function

Ankyrins are a family of scaffolding proteins that recruit ion channels and cell adhesion molecules to specialized membrane domains, critical for cell polarity and function. The ANK2 gene, which encodes the ankyrin-B protein, is highly associated with autism spectrum disorder (ASD). In the neuron, ankyrin-B maintains distal axon cytoskeleton, controls axonal projections, and promotes axonal transport. The precise localization of ankyrin-B at the distal axon and dendrites is critical for its ability to mediate its aforementioned functions. The mechanisms underlying ankyrin-B localization at neuronal membranes is unknown. My dissertation focuses on how ankyrin-B reaches its sites of physiological function, and whether abnormalities in ankyrin-B localization could contribute to ASD pathophysiology. My results demonstrate for the first time that ankyrin-B is lipid modified by S-palmitoylation, which is likely to promote its localization and functions. With this research, we hope to uncover a novel molecular target underlying ankyrin-B dysfunction in ASD etiology.

Carlos Puentes
Neuroscience

Investigating Mechanisms for Sleep-Dependent Changes in Synaptic Strength

The Synaptic Homeostasis Hypothesis (SHY) posits that sleep regulates synaptic strengths through synaptic weakening. Researchers have found structural, molecular, and electrophysiological evidence in support of SHY. However, prior studies have only investigated specific regions of the neocortex while focusing on excitatory synapses. It's unclear how inhibitory cell types respond to sleep loss, their role in sleep dependent synaptic weakening, or whether all brain regions undergo sleep dependent weakening. My thesis work addresses these gaps by testing region- and cell type-specific responses to sleep and sleep loss through a host of novel electrophysiological and molecular techniques which isolate and manipulate specific neuronal populations. These include DREADDS, optogenetics, and translating ribosome purification (TRAP). My work suggests a heterogeneous range of responses to sleep loss in different parts of the brain and in different cell types, and is beginning to explore the role of state-dependent network activity patterns in this process.

Jacqueline Quigley
Psychology

Attenuation of drug-seeking for cocaine in males

There are sex differences in susceptibility to addiction. In females, the gonadal hormone, estradiol, enhances motivation for cocaine by potentiating cocaine-induced dopamine levels in the dorsolateral striatum, a brain region highly implicated in addiction. In this dissertation, the role of estradiol in the attenuation of drug seeking in males is investigated. Aim 1 establishes that the estradiol receptor GPER1 in the dorsolateral striatum has a modulatory role on cocaine preference of male rats, but has no effect in female rats. Aim 2 investigates how activation of GPER1 in the dorsolateral striatum affects the escalation in motivation for cocaine. Aim 3 explores the effect of GPER1 activation on cocaine-induced dopamine levels in the dorsolateral striatum. In all aims, activation of GPER-1 attenuates indices of drug-seeking only in males. Together, these findings propose a novel role for GPER1 in males and provide a potential sex-specific therapeutic target for addiction.

Richard Reinhardt

Anthropology and History

Subject in All Things: Scenes of Conversion in the Capuchin-Franciscan Atlantic

“Subject in All Things” argues that, since its medieval inception, the Franciscan movement elaborated a dynamic theory of conversion. Drawing together scenes of conversion from a scattered Franciscan archive, I focus upon surprising cases: when friars called for enslaved people to receive reparations, for example, or when Kongolese people used Franciscan repertoires to contest local sovereignty claims. Encounters with people, animals, and objects all evince different dimensions of conversion, and I work to put these moments into dialogue with contemporary theories of transformation in anthropology, religious studies, gender and sexuality studies, and psychoanalysis. Far from the shifts in identity or instances of self-making that modern scholars take conversion to entail, I argue that Capuchin-Franciscan missionaries saw conversion as a series of ongoing and incomplete itineraria, or passages, that were at once physical and spiritual. Franciscans, as well as those they (sometimes inadvertently) influenced, experienced such passages as subjectively significant and affectively charged journeys, the status of which might never be entirely discernable or knowable. Their experiences in various “new worlds” in Africa and the Americas led these missionaries to draw upon a wide range of spiritual and conceptual vocabularies, sometimes to surprising effect. Far from spinning abstract theological speculation, I show how Franciscan emphases on encounter, ongoing passage, and materiality interacted with legal, political, and economic discourses. Mining missionary correspondence, legal processes, travel narratives, as well as theological and spiritual treatises, I offer a methodologically innovative anthro-historical account of seventeenth-century Capuchin-Franciscan missionary encounter, putting historical texts in conversation with contemporary social theory and recent anthropological curiosity.

Niloufar Salehi

Chemical Engineering

Mechanistic Transport Analysis of Oral Drug Bioperformance in the Human Gastrointestinal Tract

A predictive drug dissolution transport analysis is in high demand by the pharmaceutical industry. A mechanistic mass transport analysis for oral drug product dissolution and absorption under in vivo and in vitro buffer, hydrodynamics, and pH conditions is developed. The influence of hydration–dehydration kinetics of bicarbonate–CO₂ buffer, which is the main buffering system in the human intestinal fluid, on ionizable drug dissolution is investigated. Furthermore, the implications of using surrogate buffers for biorelevant bicarbonate buffer in in vitro dissolution tests specifically for enteric-coated products are explored. Next, the effect of buffering agents in solid dosage form formulations to level the pH and buffer concentration in the human GI tract is probed. Overall, this work sets a framework for the selection of appropriate in vitro predictive dissolution methodologies.

Naganika Sanga

Urban and Regional Planning

What can cities do when states stall? Study of inclusionary housing policies in three progressive cities

Many cities in the United States are adopting inclusionary housing (IH) policies to provide integrated affording housing. IH policies require developers to designate a certain percentage of units as affordable housing to obtain planning permission approvals. However, states that prefer free-market policies often restrict city-level IH initiatives through preemptions. My dissertation focuses on three progressive cities—Austin, Nashville, and Portland—to investigate how these cities have battled state preemptions in implementing IH policies. I use the intergovernmentalism framework to identify the various actors that are involved in the IH process. I then examine what roles they have played in developing and implementing local IH policies, as well as other factors that may help explain why these communities have had varying degrees of success in IH policy development. My research will provide lessons and strategies for other cities that are considering the adoption of IH policies.

James Saulsbury

Earth and Environmental Sciences

Predators, distributions, and biodiversity: macroecology as seen by a crinoid

Macroecology studies global ecological phenomena, yet many macroecological principles are based on just a few, mostly terrestrial, study systems. Making macroecological theory general will require increasing scope to include understudied groups. I integrate simulations, fossils, microecology, biodiversity databases, and functional morphology to document and explain four novel macroecological patterns in crinoids, filter-feeding marine invertebrates. First, I explore an undocumented mode of respiration, and show that respiratory anatomy is more complex in a group of crinoids with anti-predatory adaptations —like high motility. Second, arm number increases toward the equator; this is apparently caused by a latitudinal gradient in predation intensity. Third, contrary to ecological intuition, geographic range size is larger among thermal and bathymetric specialists. Finally, analyzing living species indicates an origin of unstalked crinoids in their geographic species richness ‘hotspot,’ whereas fossil data indicate an origin outside of this hotspot; simulations indicate the fossils are more reliable.

Jonas Schollenberger

Biomedical Engineering

A combined imaging and computational modeling approach to quantify cerebral blood flow and perfusion in carotid disease

Carotid stenosis describes the buildup of plaque in the main arteries supplying the brain with blood. The vasculature’s ability to compensate for the reduction in blood flow from stenosis significantly depends on viable collateral pathways. Considering the high anatomical variability of the cerebral arteries, there is a clinical need to understand the mechanisms of flow compensation; however, clinically available imaging technologies provide limited information on cerebral blood flow and flow compensation. In this project, we aim to overcome these limitations by developing a novel workflow that combines brain perfusion measurements (arterial spin labeling MRI) and computational modeling to quantify patient-specific cerebral hemodynamics and flow compensation. The specific aims include developing vessel-selective arterial spin labeling to measure brain perfusion territories, computational modeling of patient-specific cerebral blood flow, and evaluating flow compensation in a cohort of patients with carotid stenosis.

Emily Sherman

Chemical Biology

Characterization of microRNA-binding proteins and discovery of novel modulators of LDL cholesterol uptake

MicroRNAs (miRNAs) are small noncoding RNAs that regulate protein expression via post-transcriptional silencing of target genes. These small RNAs are implicated in the regulation of nearly all biological processes, and global miR biogenesis is altered in many cancers. Additionally, miRNA-binding proteins have been shown to modulate miR biogenesis, presenting a promising avenue for targeting miRNA dysregulation in disease. Herein, high-throughput screening and proteomics-mediated approaches are used for small molecule targeting and novel characterization of miRNA–protein interactions, respectively. In a second project, regulators of cholesterol-carrying low-density lipoprotein (LDL) uptake are interrogated in liver cells. Cardiovascular diseases are the leading cause of death in the United States, and high LDL cholesterol is a major risk factor for atherosclerosis. Mechanisms outside of LDL receptor-mediated endocytosis are poorly understood; to address this gap, a genome-wide functional genomic screen is conducted to identify gene modulators of LDL uptake in hepatocytes.

Anne Elise Stratton

Resource Ecology and Management

Managing crop functional diversity to support agroecological transitions in southern Brazil

There is rising global acknowledgement that agricultural systems must shift to sustain food and nutritional security. Systemic changes to farm management that employ ecological knowledge and technologies to improve sustainability are called “agroecological transitions.” Increasing the diversity of crop functional traits in agroecosystems—functional diversity—can facilitate internal nutrient cycling and improve productivity. My dissertation asks: how does increased crop functional diversity support agroecological transitions? Through interviews and a multi-year, replicated experiment spanning 15 farms in southern Brazil, I assess two social-ecological outcomes across a transition gradient: (1) shifts in farmers’ perceptions and management of crop diversity and (2) impacts of increased functional diversity on nutrient cycling processes and crop production. In a complementary study on a Brazilian experimental farm, I evaluate (3) the relationship between increased crop functional diversity and vegetable nutrient content. This applied, interdisciplinary research contributes insights into ecological practices to facilitate sustainability transitions in global agriculture.

Xin Sun

Education and Psychology

The Myths and Truths of Cross-Cultural Differences in English-Chinese Bilingual Reading

Learning to read is one of the most important early childhood skills. Unfortunately, young bilinguals often fail to meet national standards in reading achievement in the United States and other countries. To improve reading in bilinguals, we must first understand how bilingual experiences influence children’s literacy development. Theories of bilingualism suggest that bilinguals’ two languages interact thereby influencing English literacy development. My dissertation tests this perspective by examining how bilingual exposure to a structurally-distinct orthography, Chinese, influences children’s English literacy. In Chinese, learners associate meaning with characters whereas in English, learners associate sounds with letters. Should bilinguals’ two languages interact, Chinese bilinguals will have stronger meaning-based literacy skills in English. To test this hypothesis, I assess Chinese-English bilinguals and English monolinguals (grades 1 to 3) using literacy tasks in each of their languages both behaviorally and during fNIRS neuroimaging. The findings will inform theories of bilingualism and literacy instruction for children from diverse socio-linguistic backgrounds.

Amirmahdi Tafreshian

Civil and Environmental Engineering

Shared Mobility: Operations and Economics

The recent increasing interest in shared mobility services among communities, especially in large metropolitan areas, has resulted in several operational and economic challenges that highly impact the performance of such systems in the long run. This work attempts to address some of these challenges by proposing high-quality solutions that are developed based on well-known techniques from the fields of operations research, data mining and game theory. These solutions can be roughly divided into two major parts. The first part merely looks at such systems from the prospective of operators, and devises some techniques to efficiently serve customers while taking system-wide considerations into account. The second part of this work, however, aims to couple the expectation of operators with that of customers to design a matching and pricing scheme that respects some important economic properties, including, but not limited to, budget-balancedness, incentive compatibility, individual rationality, and efficiency.

Mohsen Taheri Andani
Mechanical Engineering

Fundamental Understanding of Mechanical Response of Anisotropic Metals at Macro, Micro, and Nanoscale

Improving the fundamental relationships between the microstructures and mechanical properties is key to enhance the functional properties of metallic materials. The objective of this thesis is to utilize a combined multi-scale experimental and computational framework to better understand the origins of the weakness in the mechanical properties of anisotropic metallic materials including 3-D printed metals and magnesium alloys. This work is intended to (i) gain fundamental understanding of the three-dimensional microstructural characteristic of metallic alloys, (ii) unravel the role of interfaces such as grain boundary and melt pool boundary on the mechanical response of materials, (iii) develop a comprehensive computational model for accurately predicting the mechanical response of anisotropic metallic materials, and (iv) optimize the manufacturing process conditions to reinforce the mechanical response of metallic parts. Obtaining such unrivaled knowledge would provide the scientific underpinning crucial to the design of future metallic alloys.

Morteza Taiebat
Environment and Sustainability

The Energy, Environmental, and Equity Impacts of Emerging Connected and Automated Vehicle Technology

Connected and automated vehicles (CAVs) are poised to reshape transportation and mobility. While CAV-enabled improvement in safety, mobility, and energy efficiency will yield large benefits to the society, the environmental outcomes as well as the net equity effect of CAV adoption on different socioeconomic groups are unclear. This research initially attempts to identify the system-level interactions between CAV technology and the environment. Then, the environmental externalities associated with travel behavior change and consumption pattern shift, stemming from CAVs are assessed. A microeconomic approach is used to estimate induced travel demand and energy rebound effect from reduction in travel time cost (TTC). Given higher elasticity of travel demand and greater utility gained in case of replacing current cars with private CAVs, it is established that disproportionate benefits go to the affluent while they entail larger environmental impact. This finding represents the case of “mobility and energy injustice.” Next, I examine the distributional effect and equity implications of CAV adoption for different socioeconomic groups. The preliminary findings show that only ubiquitous availability of CAVs in form of on-demand mobility improves the transportation cost equity for low incomes, while private ownership exacerbates it. This research contributes to providing a better understanding of energy use trade-offs and fills the knowledge gap on the equity effect of CAV adoption.

Roya Talibova
Political Science

Why Fight? The Causes and Consequences of Joining an Autocrat's Army

Over the course of history, authoritarian states have raised strong armies that waged deadly conflicts. Why would any individual fight in defense of a regime that represses its citizens? How does the previously disenfranchised individual's exposure to the battlefield affect his political behavior during and after conflict? This project presents a plausible mechanism for explaining systematic differences in combat motivation, battlefield behavior, and post-war political attitudes against the backdrop of a long-term repressive rule. I argue that individuals who belong to a group facing demographically-targeted repression will be more likely to join an autocrat's army to signal loyalty; further, their decision to direct the acquired wartime skills to support or subvert the state will be based on war outcomes. To unpack these mechanisms, I use a mixed-methods approach that includes a formal model, qualitative and computational text analyses of wartime correspondence, and statistical analyses of original large-scale administrative and conflict datasets constructed from declassified archival documents.

Weijing Tang
Statistics

Statistical learning for partially observed large-scale and complex data with applications to healthcare

The past decade has seen an explosion in the amount of valuable information stored in large datasets with diverse formats in many different scientific fields such as biology, economics, health, and medicine. Further, in real-world data collection, data is often partially observed due to technical reasons, high cost, and limited observation duration, posing additional challenges for data analysis. This thesis focuses on developing statistical machine learning methods for partially observed data in large scale and diverse formats and their applications to healthcare problems. First, we study the classification problem where only a minority of the data is accurately labeled. In particular, we develop semi-supervised learning methods for input data in two different formats: sequence and graph. Second, we study time-to-event analysis where event times are not observed for all data points. Specifically, we propose a novel and general statistical framework for scalable survival analysis based on ordinary differential equations.

Adam Thelen
Biological Chemistry

DNA Searching and Damage Recognition By a Human DNA Glycosylase

DNA damage arises regularly in human cells and can lead to cell death and cancer. Glycosylase enzymes catalyze the removal of DNA lesions to initiate the repair of DNA. These enzymes are faced with the challenge of locating rare sites of damage in the cell and distinguishing those lesions from a vast excess of undamaged bases. Human alkyladenine DNA glycosylase (AAG) recognizes diverse DNA lesions, making it an attractive model for understanding searching and recognition in DNA repair. Biochemical reactions with mutated AAG variants and fluorescently labeled DNA allow for the assessment of the importance of AAG structural elements and DNA bending steps in lesion recognition. Facilitated diffusion during DNA searching is also examined using engineered human cells. These findings lay a foundation for understanding the sensitivity of human cells to DNA damage and could ultimately lead to improved cancer therapies that involve deliberate DNA damage to sensitized cancer cells.

Alyssa Travitz
Macromolecular Science and Engineering

Multiscale Modeling of Polymer-Colloid Interactions in Waterborne Coatings

Formulations containing rheology-modifying polymers and nanometer-sized colloids have widespread use in pharmaceuticals, personal care products, and water-borne coatings. When combined in solution, the polymers temporarily “stick” to the colloids and act as bridges, forming a dynamic network with characteristic timescales spanning many orders of magnitude. Because it is computationally infeasible to capture the full range of relaxation times while maintaining atomistic resolution, our group has developed a hybrid population balance-Brownian dynamics model (Pop-BD). I have redesigned Pop-BD to be more accurate, simulate experimentally relevant system sizes, and capture long timescale behavior. In doing so, I am developing the first multi-scale model to understand and predict the behavior of these formulations with the ultimate goal of aiding the formulation development process for waterborne coatings.

Konstantinos Tsouvalas

Mathematics

Topological restrictions on Anosov representations

Anosov representations form a rich and stable class of discrete subgroups of Lie groups with special dynamical properties introduced by Labourie in his work of the Hitchin component and are considered as the higher rank generalization of classical convex cocompact subgroups of rank one Lie groups. In this thesis, we obtain a complete characterization of the domain groups of projective Anosov representations into the Lie groups $SL(3, \mathbb{R})$ and $SL(4, \mathbb{R})$, of Borel Anosov representations into $SL(d, \mathbb{R})$ when $d=4q+2$ and new characterizations of Benoist representations. Moreover, we develop characterizations of Anosov representations in the spirit of the work of Kapovich-Leeb-Porti and Gueritaud-Guichard-Wienhard in terms of divergence of singular values of elements and the existence of a pair of equivariant maps from the Gromov boundary of the domain group into the corresponding flag spaces.

Justin van Geest

Music Theory

From Musical Work to Musical Example: A Genealogy of the Chorale in American Music Theory

My dissertation offers a Foucauldian genealogy of the chorale in American music theory. Part I presents a snapshot of the field currently. Chapter 1 comprises the results of a questionnaire distributed to music theorists, and follow-up interviews, Chapters 2 and 3 a corpus study of leading undergraduate music-theory textbooks, and Chapter 4 a corpus study of recent advanced research publications. Part II is historical: Chapter 5 elucidates the formation of chorale-based music theory in J. S. Bach's circle following his death, Chapter 6 its institutionalization through the Leipzig Conservatory's founding and its subsequent transmission to the United States, and Chapter 7 the chorale's naturalization by American music theorists. Through this investigation, I demonstrate both the profound influence that the chorale has exerted on music theory and, simultaneously, how its role as a nexus of commitments—ranging from music-theoretical to ideological—illuminates the history of the field.

Natalie Warsinger-Pepe

Molecular and Integrative Physiology

*Nucleolar dominance during male *Drosophila melanogaster* development and barrier formation between species*

Ribosomal RNA (rRNA) genes exist in hundreds of copies in clusters that form ribosomal DNA (rDNA) loci which are transcribed to meet the demand of cellular metabolism. rRNA levels can be regulated through the entire silencing or transcription of rDNA loci (termed nucleolar dominance). Nucleolar dominance was originally noted to occur in interspecies hybrids and has been shown to occur within a species, however, its regulation and implications in speciation in *Drosophila* remain unknown. By utilizing sequence variations between two rDNA loci in *Drosophila*, within and between species, my dissertation work characterized nucleolar dominance within the species *D. melanogaster* and in interspecies *Drosophila* hybrids. This work begins to uncover the mechanisms underlying nucleolar dominance within a species and aims to understand how these pure species regulatory mechanisms may have genetic consequences that manifest in barriers between species.

Edward Washabaugh
Biomedical Engineering

Functional Resistance Training During Walking: Design of Passive and Semi-Passive Rehabilitation Robots and Testing Their Biomechanical, Physiological, and Neuroplastic Effects

Robotic rehabilitation is a promising approach for treatment of neurological injuries, but current robots are too expensive and bulky to be widely utilized in clinic or at home. The goal of this dissertation is to develop innovative low-cost, wearable robotic technologies to provide functional resistance training during walking and test their efficacy in healthy and stroke populations. First, I will develop two low-cost, passive robotic devices that provide scalable/controllable resistances to the leg during walking. I will then use these devices to determine the mechanistic and neural underpinnings of functional resistance training during walking, first by comparing resistance types in healthy subjects, then by testing these robots against clinical standards in stroke survivors. This dissertation introduces a new class of wearable robots that could greatly impact the field of rehabilitation robotics and will inform clinicians how to best perform functional resistance training to address gait deficits after neurological injuries.

Tim Williams
Industrial and Operations Engineering

Evaluating robust strategies for enhancing smallholder farmer resilience

Smallholder farmers constitute one of the world's most vulnerable populations. To confront the many challenges they face, smallholder agricultural systems must transform to become more resilient. In my thesis, I address a concept critical to the ex-ante assessment of resilience-enhancing strategies (RESs) for smallholder agricultural systems: reducing the potential for maladaptation. Maladaptation describes a situation in which a RES inadvertently increases vulnerability. Given this potential, there is a pressing need to identify future RESs that are "robust" in their benefits to social and environmental systems. Yet, research in this field rarely addresses this idea. Conceptually, my thesis makes advances that facilitate the assessment of the robustness of RESs, which are of relevance both for agricultural systems and more broadly. Substantively, I assess the robustness of the benefits of selected RESs to smallholder agricultural systems, providing insights relevant to sustainable agricultural development.

Leighton Wilson
Applied and Interdisciplinary Mathematics

Development and Application of Numerical Methods in Biomolecular Solvation

This thesis describes several innovations in numerical methods for modeling biomolecular interactions. I first discuss the development of a new class of treecodes, numerical methods used to efficiently approximate the interaction of N particles, using polynomial interpolation, and their implementation on modern heterogeneous and GPU-driven compute systems. I next discuss work on the Poisson–Boltzmann equation and the Treecode–Accelerated Boundary Integral Solver (TABIPB), an implicit solvent model and software package for biomolecular solvation. This work includes several algorithmic improvements and feature additions, including GPU parallelization. Then, I discuss work on the reference interaction site model (RISM), a statistical-mechanics based implicit solvent model, including the application of treecodes and further developments employed in the AMBER molecular dynamics software package.

Xuan Xiao

Nuclear Engineering and Radiological Sciences

Broadband Long-Wave Infrared Few-Cycle Pulse Generation via Optical Parametric Chirped-Pulse Amplification

Owing to the fundamental constraints imposed by broadband laser gain media, optical parametric chirped-pulse amplification (OPCPA) has become the most promising method for intense few-cycle pulse generation in long-wave infrared (LWIR) spectral regime. This dissertation presents the first-ever demonstration of LWIR OPCPA. Amplification is performed in GaSe crystals and produces the bandwidth compatible with sub-three-cycle pulse generation, consistent with the accompanying numerical model. Other novel contributions that enable this result are presented: a 2.75- μm , nanosecond, high-energy parametric pump, ultrashort LWIR seed generation, and the first demonstration of nanosecond-long LWIR pulse stretching and compression. Complete ultrashort pulse characterization in the challenging LWIR region reveals detailed pulse characteristics. The developed LWIR OPCPA scheme, designed for pumping by future high-energy, coherently-combined Er:ZBLAN fiber lasers, is scalable to high peak and average power. This novel source will offer unique opportunities for investigation of strong-field physics, laser pulse filamentation, and will support other attractive applications.

Sunhay You

English and Women's Studies

The Morbid Erotic: Sexuality Without Identity in Postnational Asian and Asian American Women's Literature

In the aftermath of U.S. interventions in Korea, Vietnam, and the Philippines, heteronormativity resurfaces as a hegemonic ideology to restore the integrity of postcolonial nations and their respective diasporic communities in the United States. "Morbid Erotics" reads across Asian and Asian American (A/A) women's literature to outline how such sexual politics predetermine A/A women's sexuality as primarily monogamous and heterosexual, reproductive of original ethnic identities. This dissertation critiques these terms of the heteronormative nation, a reaction to U.S. Empire, which turns A/A women's non-heteronormative desires inconsequential if not morbidly self-destructive and taboo. The A/A novels of this study utilize morbid scenes of A/A women in erotic rapture to reflect the deadly violence that undergirds nationalist attachments to origins, an attachment that requires the containment of women's sexual capacity to create communities of their own imagining, evocative of post-identitarian and post-nationalist politics of belonging.

Félix Zamora Gómez

Romance Languages and Literatures and Museum Studies

Foundational Landscapes: On the Constitution of a Visual Regime of History and Heritage in 20th-Century Spain

This project studies the relation between the shift in state-form that took Franco's Spain from full fascism to a self-proclaimed model of economic progress and the creation of official historical narratives as a tool of assertion for the ideological projects of the state. This is accomplished through historical, cultural, and theoretical reflections on television, film, architecture, museum exhibitions, and the importance of visual culture in the construction of a national understanding of heritage and history promoted by the state in 20th century Spain.

Dehui Zhang

Electrical and Computer Engineering

Ultrafast Light-Matter Interactions in Graphene Heterostructures: From Science to Applications

Graphene was first experimentally studied in 2004. Since then, lots of unique photonic and electrical properties of graphene and other 2D materials has been reported. Additional efforts have to be made to bridge these findings in physics with successful industry applications. In this thesis, I will present works exploiting the picosecond-scale ultrafast light-matter interactions in graphene to meet the growing industry demands. We start with a micrometer scale graphene spectrometer design by electrically tuning the sub-picosecond hot carrier transport in a 2D heterostructure. We also exploit the transparency of our photodetectors to build a 3D camera. Lastly, we prove the potential of graphene 2D-3D heterostructure as a strong THz emitter that can improve the emission amplitude over an order of magnitude. The works are concluded with a discussion on how machine learning can boost the development of nano-systems for industrial applications.

Xiaoxi Zhang

Comparative Literature

Decentering Modern Language(s): The Case of Chinese, Portuguese, and Swahili

The Eurocentric connotation associated with the term “Modern Languages” appears apparent from its definitions in both the *Cambridge Dictionary* (“languages that are spoken at the present time, especially European languages such as French, German, and Spanish”) and the *Merriam Webster Dictionary* (“the living literary languages especially of Europe considered as a department of study or teaching”). What these definitions fail to consider is the fact that many non-Western languages have also gone through a process of modernization in order to meet with the pressures and the promises of modernity, which also often go together with people’s experiences of colonialism. My dissertation examines and compares the histories of the modernization of the Chinese, Portuguese, and Swahili languages in order to enhance people’s understanding of “modern languages” in a decentered manner, and provide a nuanced account on people’s varied experiences of modernity, colonial history, and imperialism as expressed through languages.

Xin Zhang

Mathematics

Topics in Control and Optimization

Optimal control theory has numerous applications in both science and engineering. In this dissertation, optimal control problems related to stochastic processes are investigated, which include online learning, mean field game, and mathematical finance. For online learning, an unprecedented solution to the 4-expert problem with finite stopping was provided, via an explicit construction of the solution to a nonlinear partial differential equation. For mean field game, the convergence phenomenon of $N+1$ -player Nash equilibrium was studied by using the entropy solution to scalar conservative laws. For mathematical finance, 1) the embedding problem in multi-dimension was solved via excursion theory in probability, 2) a martingale optimal transport problem with bounded volatility was studied, which allows to calibrate not only current observation (option prices), but also historical data (stock prices). The present work sheds light on both theoretical and applied aspects of optimal control theory.

Xueru Zhang

Electrical and Computer Engineering

Human-centric machine learning: on the preservation of individual privacy and fairness

Machine learning (ML) techniques have seen significant advances over the last decades. While their potential societal benefits are enormous, they can also potentially inflict harm if not developed or used with care. In this thesis, we focus on two critical ethical issues in ML systems: privacy violation and discrimination, and investigate a number of mitigating solutions. On the first issue, when ML algorithms are trained using sensitive data, it's critical to preserve individual privacy while maintaining the usefulness of computational results. Using the notion of differential privacy, we design privacy-preserving algorithms in various settings which are shown to significantly improve the privacy-accuracy tradeoff over existing methods. On the second issue, ML algorithms developed using real-world datasets can inherit pre-existing bias in the data such that the algorithms exhibit discrimination against sub-populations. We focus on measuring such unfairness embedded in the algorithm and designing algorithms that can promote long-term social equality.

Yang Zhang

Sociology

Wealth Inequality, Diverging Union Experiences, and Consequences for Mental Health

Scholars have long sought to understand the reproduction of inequality through marriage institution in society. However, as cohabitation has become a normative experience in western countries and a gradually acceptable setting in non-western countries, new questions regarding its economic determinants and consequences for well-being emerge. My dissertation examines the link between wealth and union formation contingent on varied social contexts and birth cohorts, and the consequences of cohabitation dissolution for mental health. The first chapter examines whether wealth predicts cohabitation and marriage formation differently in the United States and China. The second chapter investigates if wealth explains racial gaps in marriage and cohabitation differently in the United States and whether cohort differences exist. The third chapter studies whether cohabitation dissolution harms mental health and how parenthood status moderates this association. Together, these papers provide new insights into the reproduction of wealth and mental health inequality through marriage and cohabitation.