2026 STAR SCHOLARS SUMMER SHOWCASE

DREXEL UNIVERSITY
Undergraduate Research & Enrichment Programs
Pennoni Honors College

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The STAR Scholars Program is administered by
Undergraduate Research & Enrichment Programs,
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A MESSAGE FROM THE DEAN

As Dean of the Pennoni Honors College, I am thrilled to celebrate the work of our STAR Scholars. The STAR Scholars program embodies the transformative power of undergraduate research at Drexel. As the University's flagship initiative for early engagement in research, it offers rising second-year students the rare opportunity to immerse themselves in faculty-mentored projects in research, scholarship, and creative work that shape their academic paths and expand their ambitions.

This year's STAR Scholars Showcase is the culmination of months of inquiry and innovation. Our STAR Scholars, representing a diverse array of majors and disciplines across the University, have worked side by side with dedicated faculty mentors whose guidance and expertise have been instrumental to their success.

Undergraduate research is a cornerstone of experiential learning at the Pennoni Honors College. We are committed to supporting all students who wish to explore how research, scholarship, and creative work can enhance their Drexel experience.

As we celebrate the remarkable achievements of our STAR Scholars, I extend my deepest gratitude to our faculty mentors, applicant reviewers, and the Undergraduate Research & Enrichment Programs team at Pennoni, whose dedication makes this program possible. We look forward to supporting our STAR Scholars and all Pennoni Honors College students on their academic, scholarly, and professional journeys.

Dr. Neville Vakharia
Dean, Pennoni Honors College

A MESSAGE FROM THE DIRECTOR

Welcome to the 2026 STAR Scholars Summer Showcase. The STAR Scholars Program, Drexel's flagship early undergraduate research program, engages highly motivated, rising second-year students in a full-time, faculty-mentored research, scholarly, or creative experience during the summer between their first and second years. Our STAR Scholars are intellectually curious and deeply motivated to learn, and today's presentations are the culmination of that curiosity and drive to create knowledge in their fields. This year's cohort includes 99 students from over 35 different majors who were mentored by faculty from 11 of Drexel's colleges, schools, and research centers, showcasing the breadth of research and scholarly work undertaken this summer. We thank our faculty mentors, graduate students, and all individuals involved in guiding our STAR Scholars through this summer and to this point.

Drexel University's commitment to experiential learning is exemplified through the long and storied history of the STAR Scholars Program. Through this program, over 2,500 Drexel students in the past 24 years have been able to experience undergraduate research, scholarship, and creative work early in their academic training, introducing them to an activity that they would choose to pursue sometimes throughout their undergraduate experience, to graduate school, and into careers as researchers as academics — or allowing them a better appreciation of research and scholarship in their field while determining that they would find their future paths elsewhere. To the 2026 STAR Scholars: we hope that this experience has transformed you and that it has allowed you to develop a clearer picture of what you are capable of and what may lay ahead of you!

We are so proud of our 2026 STAR Scholars and are thrilled to celebrate their incredible accomplishments. Congratulations to the 2026 STAR Scholars – we can't wait to see what you do next!

Jaya Mohan, MA
Director, Undergraduate Research & Enrichment Programs

OUTSTANDING MENTOR OF THE YEAR

The critical piece of the STAR Scholars Program that makes it such a valuable experience for the students is, without a doubt, their Mentors. The STAR Mentors give much to their students' summer experiences and do so with no compensation.

In Summer 2011, we created a process to recognize the STAR Mentors and to particularly celebrate the Outstanding Mentor(s) of the Year. STAR Scholars are given the opportunity to nominate their faculty mentors for the "Outstanding Mentor of the Year" award, which provides the awardee with a $1,000 award to futher their research with undergraduate students. Since 2011, this award has been given to 24 faculty.

Each nominated mentor receives a letter signed by the Provost that outlines the common characteristics held by all nominated Mentors, and each letter includes excerpts from the students' nomination letters to provide an individualized account of just how these Mentors have contributed to those specific students' experiences.

Based on these nominations, outstanding Mentors:

- Are passionate experts in their field who freely share their expertise with students
- Care deeply about their students and treat them with respect
- Generously foster students' intellectual and professional development
- Actively engage students in learning and celebrate their success
- Go above and beyond in supporting their students

All of our mentors go beyond the call in their work with STAR Scholars, and we are genuinely grateful for the time and effort they commit to furthering the education of undergraduate students.

2025 STAR SCHOLARS: OUTSTANDING MENTORS OF THE YEAR

Dr. Wei-Heng Shih

Dr. Wei-Heng Shih is a Professor of Materials Science and Engineering and leads the Sensor and Functional Materials Group along with Associate Professor of Biomedical Engineering Wan Y. Shih, PhD. This summer, Dr. Shih mentored STAR Scholar Gara De Alarcon Adamczyk, a biomedical engineering major. Gara's project studied gene therapy, specifically biocompatible, nontoxic ZnSe aqueous quantum dots for gene delivery.

In her nomination letter, Gara wrote, "Dr. Wei-Heng Shih goes above and beyond to create opportunities for his students to succeed. He gave [me] the chance, as [a] freshman undergraduate, to present my research at a major manufacturing conference in Pennsylvania, an opportunity very few undergraduates get to experience. By opening doors like this one, he shows this commitment to preparing students to succeed beyond the lab and share their work with the broader scientific community."

Gara added, "Through his encouragement, Dr. Wei-Heng Shih helped me to unlock a version of myself that is confident, determined and not afraid to speak up with ideas. He created an environment where students not only grow as researchers, but also as people." This term, Gara is embarking on a co-op at Harvard Medical School focusing on biomaterials and drug delivery, and plans to continue working with Dr. Shih in the Sensor and Functional Materials Group.

2025 STAR SCHOLARS: OUTSTANDING MENTORS OF THE YEAR

Dr. Niharika Sravan

Dr. Niharika Sravan is an Assistant Professor of Physics whose research uses machine learning methods to solve problems in astronomy. This summer, Dr. Sravan mentored two STAR Scholars: Tobias Safie, a physics, economics, and mathematics major, and Ashni Kumar, a data science major. Tobias' STAR project studied physics-informed neural networks for options pricing in stochastic markets, while Ashni's research focused on optimizing deep learning models on field-programmable gate arrays, a type of hardware circuit, using the Python tool hls4ml.

Both students highlighted Dr. Sravan's encouragement and support for their growth. Ashni wrote, "When I faced challenges, she never let me feel stuck. Instead, she worked with me to find a way forward and encouraged me to maintain the persistence needed to keep progressing." Tobias added, "What makes her mentorship exceptional is the way she balances rigor with encouragement: she challenges me every day to be a better student, a more curious researcher, and to one day become an expert at the things I find interesting."

Both students noted Dr. Sravan's investment in their futures beyond STAR. Ashni wrote that Dr. Sravan helped her prepare for co-op interviews and shared advice on possible career paths and pursuing graduate school. Tobias shared, "Her mentorship helped me fall in love with being a scientist."

2025 STAR SCHOLARS: QUICK PITCH COMPETITION

The Quick Pitch Competition gives STAR Scholars the opportunity to distill their STAR projects into a three-minute, one-slide explanation to a general audience.

Up to 40 students participate in the competition during four preliminary sessions scheduled in the second half of the summer term. A panel of judges comprising of Drexel staff and faculty select two winners from each session to advance to the finals. Eight finalists present their Quick Pitches at the finals, and three winners are selected.

2025 STAR Scholars Quick Pitch Competition winners:

First Place: Chi Nguyen, product design '28
"Bee-a-Reader: Designing Better Braille Learning Tools to Raise Literacy in Visually Impaired Children"
Faculty Mentor: Prof. Michael Glaser (Westphal)

Second Place: Jae Walsh, biological sciences '29
"Analysis of Museum Specimens and Community Science Images Reveals Patterns of Geographic Variation in the Versicolored Barbet"
Faculty Mentor: Dr. Jason D. Weckstein (CoAS)

Third Place: Graciella Laird, mechanical engineering '29
"Investigating Motor Neuron Degeneration between Cortical and Spinal Organoids and Assembloids"
Faculty Mentor: Dr. Liang Oscar Qiang (CoM)

2026 STAR Scholars Abstracts

Fossil Echinoids from Cuba, a hidden legacy housed in The Academy of Natural Sciences

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College of Arts and Sciences
Environmental Science

Dr. Alejandra Martinez-Melo
Faculty Mentor
Invertebrate Paleontology

The Academy of Natural Sciences houses a paleontology collection belonging to R.H Palmer. Through the years 1930-1935, he collected various echinoderms across the island country of Cuba. The geology and formation of Cuba were caused by the subduction of the north and south of Pangea in the Jurassic, forming what is now North and South America. The Caribbean plate, left above the North and South American plates, then collided with the Greater Antilles Arc, causing the west end of the plate to uplift in the late Cretaceous. Echinoderms arrived very early in the geologic timeline during the Cambrian explosion, but because Cuba formed late, most of its echinoderms date to the Eocene and onward.

The goal for the project is to make the information on the collection readily available for anyone. In inventory and rehousing, majority of previous records were out of date, so a revision on taxonomy was needed. Once reorganized, the localities of each specimen need to be georeferenced and mapped, and data can be standardized for ease of use.

With numerous taxonomic changes within the collection, the number of taxa increased, along with many more orders added. Of these, multiple were completely undescribed species.

Architecture as a Tool for Community Resilience

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Architecture

Prof. Nyasha Felder
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Architecture

Communities across Philadelphia face challenges related to displacement, food insecurity, and the loss of culturally significant land. This research explores how architecture and community-centered planning can support more equitable development through the design of the West Philly Peace Park Farm Hub. Using precedent analysis, site research, systems thinking, and iterative design, the project investigates how urban agriculture, Green Stormwater Infrastructure Systems (also known as GSI Systems), and flexible public spaces can strengthen community stewardship while preserving neighborhood identity. Rather than viewing architecture as simply the creation of buildings, this research frames design as a tool for supporting environmental justice, food sovereignty, and long-term community resilience. The project demonstrates how thoughtful, community-informed design can help create public spaces that respond to local needs, encourage collaboration, and strengthen the relationship between people, place, and the environment. Its findings offer strategies that can inform future community development projects in Philadelphia and other cities facing similar challenges.

Testing Mycelium as a Sustainable Building Insulation Material

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Architecture

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Architecture

Earth is facing challenges due to increased carbon dioxide (CO_2) in the atmosphere. Buildings contribute to 40% of CO_2 emissions. While modern sustainable architecture often relies on add-on features, true sustainability must be integrated into core design and construction materials. Insulation is rarely recyclable, is not biodegradable, and releases emissions from being extracted, made, and transported. Mycelium—the root-like structure of fungi—is biodegradable and carbon-neutral, making it a promising bio-based alternative to traditional insulation. This project evaluates the viability of mycelium as building insulation by executing its full lifecycle process: cultivating panels, drying them, and constructing a guarded hot box device to quantify their thermal performance. By testing the performance and production feasibility of grown mycelium insulation, this research provides empirical data on its potential to replace carbon-intensive, non-biodegradable synthetic materials with a net-zero material with similar thermal properties. Ultimately, this work offers architects a practical, low-carbon material choice at the foundational stage of design, advancing a tangible approach to sustainable construction for a better future.

A Garden Within Reach: Designing an In-Home Hydroponic System for Aging Adults

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Product Design

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Architecture

Aging shows in physical and motor capacities. Hands are our primary interface with the world, however, there is a lack of attention paid to hand function. As a designer learning both modeling and listening skills, my objective was to create an in-home hydroponics unit using on-site study and research. I volunteered at Sanctuary Garden, where I learned what it means to transform a neglected urban space into a thriving home. I realized the importance of not only providing fresh produce but also combating structural barriers to healthcare. Alongside Sanctuary Garden, I met and spoke with the leaders preparing for the 2026 Farnese Symposium on Aging and technology. Through my research from Sanctuary Garden and Farnese, I created the GFH nano meant to account for not only decreased motor skills, but also the comfort that nature brings us. My design uses biophilic forms and patterns, which our brain is hardwired to associate with peace and relaxation. Inside the GFH nano, a base of agar and algae work together to provide nutrients for the plant. Keeping the needs of people in mind, I wanted to encourage a connection beyond just convenience or function, providing older adults a vessel for beauty and self-efficacy.

The Witnesses Of Our Lives

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Architecture

Prof. Jacklynn Niemiec
Faculty Mentor
Architecture

Preservation is a modern concept; we value it today due to what is lost, as well as what we seek to learn and share. Buildings preserve our history as landmarks for our memory and by registering history through change. Even when we forget, the building may remember. "[...]buildings stubbornly hold their ground for days, months, and years they [...] render legible the persisting and predicting dimensions of the present."(Leatherbarrow, 11) This research seeks to understand the practice of preserving spaces and to challenge these perspectives by identifying and visualizing the lives our buildings have to share."The house has provided [...] physical but also psychological sanctuary." (de Bottom, 11) Buildings can bear witness to events that may prompt the desire to almost freeze them in time. Other buildings live out their time with us as homes or workspaces until forgotten or abandoned. Either way, buildings record parts of us in the ways we alter them and dwell within them. Buildings are witnesses to the human experience. Through research in preservation, surveying, and storytelling, this project tests the cataloging of buildings as everyday narrators and presents a prototype by documenting the fictional story of a simple rowhouse.

Game Design Research: Using Intentional Error to Relay Queerness

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Faculty Mentor

Digital Media

Queer (noun): deviation from what is expected; strange. The standard in video game design is to create a fun, engaging, and addictive experience for players to spend hours and money on. Challenging the standards by which we design is an inherently queer act. "Fun" is subjective; a queer approach to game studies might include designing "not for fun." Video games are expected to offer escapism, but can they be tools to explore and reflect on how we feel? My research is based on "reflective game design" (Khaled et al., 2018), prioritizing process, reflection, and documentation over product to challenge the ideal of immersive, escapist games. I created a demo called Wash the Dishes that uses lag, unexpected reactions, and "glitches" as deliberate gameplay to evoke frustration, unfairness, or boredom—"not fun" feelings (Ruberg 2015). The simple task becomes insurmountable, narrated by a judgmental voice, and with no end state, the player is offered the opposite of escapism: introspection. Wash the Dishes doesn't condemn having fun, but instead invites players to question and reflect on personal experience and serves as an example of how reflective design and queer theory can influence the way we study and create games.

Black Bottom Lives On: Digital Reconstruction and Animation of the Market Street Commercial Corridor

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Digital Media

Imagine balancing on a second-story window ledge on a sunny Saturday morning, holding the window frame with one hand while washing the glass as the Market-Frankford El train roars past just feet away, and, instead of flinching, you wave at the passengers. This vivid childhood memory of Black Bottom elder Kernard Schearer is the emotional anchor of my contribution to The Black Bottom Lives On! Project, a collaborative effort between Black Bottom elders, Digital Media students, and faculty to create an interactive digital mobile tour of the historic neighborhood. While the 1960s "urban renewal" physically demolished Philadelphia's vibrant Black Bottom, our team uses 3D digital reconstruction and animation to preserve its memory. Working within this larger project, my focus is translating oral histories into living visual moments. I utilized historic photographs and elder testimonies to model missing residential structures and the El train, establishing a technical pipeline that integrates assets into a master scene, and animates the child's performance alongside the train. By spatializing both historical trauma with joy, this animation intertwines the archival data with tangible human experience for historical preservation.

From Cup to Couture: Innovating Ethical Coffee-Based Bio-Leather

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Fashion Design

Leather is an ancient material with countless uses. As modern civilization has progressed, our desire for leather goods has only increased. However, the leather industry depends on the slaughtering of animals; the inhumane conditions and fatal end that these creatures face have made animal leather production a controversial issue in ethical fashion conversations.

In the 1960s, an alternative arose; plastic leather was cheaper to produce than traditional leather and vegan. Unfortunately, plastic faux leather is an inorganic material and will therefore take thousands of years to decompose. This means that it will pile up in marginalized communities, further degrading air and water quality for locals.

Suffering should never be justified in the name of fashion. My goal was to create a biodegradable material that blended the durability and versatility of animal leather with the cruelty-free ethics of faux leather. By drying a combination of coffee grounds, water, glycerin, sodium alginate, and olive oil on a cotton fabric base, I developed a solution. My bio-leather is thick yet flexible, with a texture similar to traditional animal hide, and it can be cut and sewn into full leather garments.

Building Careers in Philadelphia's Music Ecosystem

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Music Industry

With Philadelphia's reintroduction as "America's Original Music City," the city's legacy has renewed attention on its role in the music industry. From Philly Soul, R&B, hip-hop, rock, jazz, and electronic music to its DIY and underground scenes, Philadelphia offers diverse spaces for artists to develop. Previous research suggests that accessible spaces, affordability, and community networks foster musical communities outside industry structures.

This research examines how networking, community participation, and accessibility support Philadelphia professionals. Methods included an internship with the Philadelphia Music Alliance, King Britt's Blacktronika course, interviews and shows, networking events, social media analysis, and research into Philadelphia's music history.

The internship demonstrated the importance of maintaining relationships, contributing to the community, and building a positive reputation. Over two months, social media engagement doubled the organization's following, generating 106,000 views and 5,500 interactions across 20 posts. Philadelphia's strength extends beyond its history: accessible spaces, education, community networks, and people create an environment where artists can build careers.

Material as Teacher: Developing a Relationship with Wood

Gianna Neckel

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Product Design

Prof. Michael Glaser
Faculty Mentor
Product Design

When I interact with wood, I connect to the years of growth and effort of the tree. I take inspiration from the material when I make. The tree is ever-changing as it grows, and after it is cut, the material is still alive. The grain continues to shift, expand, and react to its environment.

This material can feel gentle or organic in the context of an object, yet it is resilient and hard. Wood is humble, remaining true to its material self and fighting the maker through creation.

This creation is what I chased in my research: working with wood to intimately understand how it behaves and what the material itself could teach me. Using various woods I explored different ways of shaping, joining, and working with the material.

I created with an outcome in mind, but not as the sole focus. Taking time to learn from the process and focus on the physicality of the material felt more rewarding than seeking a tangible end achievement. My failures became just as rewarding as my successes, each taught me something new about the material and influenced what I tried next.

These discoveries ultimately informed the design and making of my final piece, allowing the object to emerge from what I had learned through research, experimentation, and making.

A Fragmented System of Multistate Tax Obligations and Startup Incentive Programs: Navigating Compliance and The Difficulty of Access

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Economics and Mathematics

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Faculty Mentor

Accounting

The 2018 Supreme Court decision in *South Dakota v. Wayfair* established that economic activity alone is sufficient to trigger state tax filing obligations, meaning a two-person software startup selling nationally can face considerable tax compliance challenges. Startups typically do not have the operational resources to navigate their tax obligations. At the same time, states aggressively compete to attract early-stage companies through a growing arsenal of incentive programs: R&D tax credits, angel investment credits, startup-specific zone programs, negotiated discretionary deals and direct grants. The same fragmented state tax system that imposes immediate compliance burdens on startups also offers substantial support through programs that most founders have never heard of, in part because they are focused on developing the product and attracting investors. This study asks whether these programs are realistically accessible to early-stage companies without the burden of incurring and tax advisor costs, and whether the information and administrative barriers between a founder and available incentives are so significant that the programs fail to deliver their intended economic impact.

Digital Access and Household Banking Status in U.S. Metropolitan Areas

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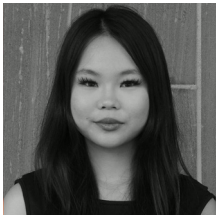
Finance

Digital access has become increasingly important for everyday financial activity, yet many households in the United States remain unbanked or underbanked. This study examines whether greater access to digital technology is associated with lower rates of financial behavior across U.S. metropolitan areas. Household banking status data are drawn from the FDIC Five Year Estimates, while broadband availability data are obtained from the Federal Communications Commission. Geographic filters are used to align the two datasets and compare different measures of digital access with unbanked and underbanked rates across metropolitan areas. Other factors beyond digital access, like education and income level, were also examined to better understand the broader influences on household banking behavior. The project aims to identify whether differences in digital connectivity correspond with differences in household banking participation, as well as to better understand the role digital activity may play in financial inclusion.

Financing the Space Economy: Capital Requirements and Risk Allocations



Selena Liu

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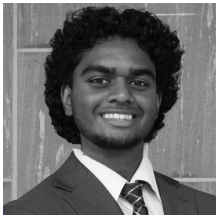
Dr. George Tsetsekos
Faculty Mentor
Finance

Over the past decade, the commercial space economy has evolved into a complex, multi-tiered ecosystem driven by high capital intensity and expanding commercial-defense partnerships. To establish a clear foundation for evaluating the industry, this research first mapped the global space ecosystem landscape. Working alongside my teammates, we reconciled multiple analytical frameworks to establish five core product segments: Access & Transport, Space Infrastructure, Ground & Operations Infrastructure, Data & Application Services, and Frontier In-Space Infrastructure across ten distinct operational activity rows and five key buyer groups.

To analyze the commercial space economy, I first mapped the global ecosystem across 10 key activities and identified core demand across commercial, government, and military buyers. Building on this framework, my current research zeroes in on the satellite manufacturing sector, detailing every enterprise that produces or builds satellite platforms, components, and payloads across LEO, MEO, and GEO orbits. Through detailed financial research on company revenues, operating expenses, government contracts, and debt, I am examining how these manufacturers fund operations and manage capital intensity.

Who Buys Space? A Buyer-Based Segmentation of the Commercial Space Economy.



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The commercial space sector is better understood by those who pay for it than by what it launches. This project is a two-axis segmentation of the ~$570 billion space economy, projected to reach $1.8 trillion by 2035.

From an AI-assisted catalog of 80 sources, our team scored 10 product categories against five buyer groups on a 1–5 demand rubric, then populated it with a company directory. The central finding reframes from the market: defense is not a standalone segment, but a buyer running through many product categories, making it the most versatile and demanding target.

Essentially, the economy has many components that are complementary to each other.

Independent research has led me to Earth observation and how its value is shifting to AI-driven analytics to SAR (synthetic aperture radar) technology, which is an all-weather radar market growing faster than optical (~$1.7 billion in 2026). Currently, SAR demand looks healthy for government and enterprises. However, it can be further embedded for consumers regarding insurance, property, and disaster products. My research of SAR applications indicates this potential uptick for an upcoming five-year growth period.

Mapping an Emerging Industry: End-User Segmentation and Defense Sector Analysis

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George Vougiatzis
Co-Mentor

This research is part of a larger project to map the structure and leading entities of the global space eco-system. In the project, I identified18 activies that characterize the industry and I began by focusing on end-user segmentation: breaking down the industry by who buys which product rather than who sells the product across 5 buyer profiles. Defense is the fastest-growing buyer group despite having the smallest commercial demand. By contrast, telecommunications is the largest potential revenue pool relying on connectivity. As an engineer drawn to the fast-growing defense sector, I narrowed my research into this buyer group specifically. This phase of research maps the key companies competing in offering space products and services in defense, tracking their growth, government contract awards, and investment activity into the sector. Ultimately, this research is aiming to identify the companies that are best positioned to have near-term and long-term demand for their products, while growing into a larger global space economy. Another aspect of this research is to sharpen my own knowledge into the space industry, one I have a deep passion for, and to position myself to explore these companies as potential future employers.

Financial Analysis of Shared Services in the Space Economy: Demand, Competition, and Investment

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Dr. George Tsetsekos
Faculty Mentor
Finance

The space economy depends on shared services that provide infrastructure and expertise. These include launch rideshare and mission integration, ground stations, satellite operations, cloud dataprocessing, hosted payloads, testing, space situational awareness, and orbital logistics. This study examines market structure, demand, competition, and finances. Using 58 sources, it mapped the value chain, compared 45 product–buyer combinations, and analyzed 25 companies. Space is not one market: demand, risk, capital needs, and revenue potential vary by service and buyer. Government—especially defense and national security—is an anchor customer, while commercial operators demand spacecraft, communications, ground infrastructure, and mission support. Growth does not guarantee attractive economics. Launch and advanced manufacturing are capital-intensive and technically risky; shared services can spread fixed costs and support recurring revenue. The analysis links services to users and dependent segments, evaluates customer and supplier concentration, and compares established and emerging providers using revenue, expense, investment, investor, and contract data. It identifies which shared-service models are best positioned for growth.

The Green Mirage

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Rikki Dong
Co-Mentor

Research Question: How do temporal purchase horizons influence consumer preference for sustainable versus conventional products?

Method: A 2×2 experimental survey (N=100) manipulated temporal distance (present vs. future) and product type (regular vs. green). Participants evaluated headsets and backpacks across purchase intention, identity alignment, and value congruence using two-way ANOVA.

Findings: Sustainability significantly boosted immediate appeal ($p=.05$): green products scored 5.67 vs. 3.65 for purchase likelihood in present conditions. This effect vanished for future purchases (green 5.00 vs. regular 4.88, $p=.2$). Across value-based measures, sustainability motivated short-term preference but failed to influence long-term decisions. Consumers prioritize functionality and durability when planning future purchases, revealing that environmental values operate as an initial motivator rather than a decisive long-term factor in deliberative purchasing behavior.

Beyond the Game: Evaluating the Benefits and Organizational Challenges of the 2026 FIFA World Cup

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Faculty Mentor
Sports Business

This project investigates the extent to which the benefits of hosting the FIFA World Cup outweigh the operational challenges associated with the tournament, and what this reveals about FIFA as a global sports governing body. Using a qualitative research design that combined academic literature and local news articles along with field observations collected while working World Cup matches at Philadelphia Stadium and the Fan Festival. Previous studies have shown there are multiple challenges to hosting an event of this magnitude.

The findings suggest that although the tournament presented significant organizational challenges during its opening matches, it improved as FIFA adapted throughout the event. Observations from the Fan Festival further demonstrated the cultural benefits of hosting the tournament.

Overall, the research concludes that the benefits of hosting the FIFA World Cup generally outweigh the organizational challenges. However, the project also demonstrates that the success of a mega sporting event depends on an organization's ability to continually adapt its operations, while improving communication between staff and fans. These findings provide recommendations for host cities of future international sporting events.

Spillover Effects of California's $20 Fast-Food Minimum Wage

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Faculty Mentor
Economics

California's Assembly Bill 1228 raised the minimum wage for large fast-food chains to $20 an hour in April 2024, leaving full-service restaurants on the state's older, lower floor. That gap works as a natural experiment, showing what happens to wages, jobs, and turnover when a wage hike hits one part of an industry but skips the business next door. We use California's Quarterly Census of Employment and Wages and Quarterly Workforce Indicators data, running a difference-in-differences model comparing fast food to full-service restaurants in the state, then checking that against California versus twenty states that never touched their own minimum wage. Wages jumped roughly eight percent once the law took effect. Employment barely moved and never got close to statistical significance, though separations dropped as much as twenty-three percent, which looks a lot like employers had real wage-setting power before the policy took some of that away. A similar look at retail turns up nothing over the full sample, but a shorter window with a flatter pre-trend shows a real drop after implementation, though that one still needs more digging. This gets at how far minimum wages can climb before they start costing people their jobs.

An Evaluation of a New Global Poverty Panel Data Set

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Economics

Dr. Christopher Laincz
Faculty Mentor
Economics

Over 800 million people globally fall below the World Bank's extreme poverty line ($3.00/day), and over 1 billion people fall below the moderate line ($4.20/day). Global poverty is declining everywhere except Sub-Saharan Africa and analyzing these shifts demands a reliable standard measure. However, the World Bank's rates are volatile due to sporadically collected survey data, especially in developing nations. The World Bank has a model addressing gaps for regional and global rates, but not country-level rates. Connors et al. (2025) developed a model that uses the more consistently available under-5 mortality rate to create a complete country level annual panel data set starting from 1970. This study calculates regional and global rates based on Connors et al. (2025) and analyzes the differences with the World Bank provided aggregate rates. We find that the rates are highly similar, though some differences exist, such as within the South Asia region. Overall, the Connors et al. (2025) data set is quite comparable to the World Bank's estimates and therefore offers a useful panel data set to researchers interested in understanding the causes of poverty rate reduction in cross-country analyses.

DNA Barcoding of Lichens at Charles Darwin's estate, Down House

Nicholas Otero-Powell

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Dr. Jason Munshi-South
Faculty Mentor
Biodiversity, Earth and Environmental Sciences

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Lichens are a symbiotic life form made up of a fungus and an alga that can be used as a system to study environmental change. This project examined lichens that were collected from trees at the Down House estate of Charles Darwin in a rural area of Greater London. The lichens were identified using taxonomic literature and DNA barcoding. DNA extractions, polymerase chain reaction (PCR), and Sanger sequencing were conducted on each specimen. These techniques created a DNA barcode of the Internal Transcribed Spacer (ITS) region for each specimen. The DNA barcodes were deposited in the Barcode of Life database (BOLD). One of the specimens assumed to be *Evernia prunastri* did not have the same barcode sequence as another *Evernia prunastri*, suggesting an undescribed cryptic species. The results of this project will support ongoing urban lichen studies by providing an updated DNA reference library for lichen species found outside the London city center. Future work will seek to understand whether the *Evernia* analyzed in this study represent distinct evolutionary lineages.

A Shorebird in the Forest: Haemosporidian Parasite Prevalence in the American Woodcock

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We investigated infection rates of Haemosporidian parasites, and which ecological factors influence these patterns for the American Woodcock (*Scolopax minor*), a forest dwelling member of the sandpiper family Scolopacidae. Most Scolopacidae occupy coastal mudflats and shorelines, making the American Woodcock ecologically unique. Though most birds can serve as hosts for Haemosporidian parasites, studies on sandpipers find low infection rates (<1%), whereas most forest-dwelling songbirds have higher infection rates (e.g. 44%)[Ku4.1]. Therefore, we studied the American Woodcock to ask whether their forest dwelling ecology leads to higher infection rates than typical shorebirds. Haemosporidian parasites are spread by dipteran insects, with *Haemoproteus* being spread by louse flies, *Parahaemoproteus* by biting midges, *Plasmodium* by mosquitoes, and *Leucocytozoon* by black flies. We screened 376 tissue samples using a nested PCR assay. We detected and identified haemosporidian infections in 27.9% of the screened hosts including *Parahaemoproteus* (17.29 %), *Plasmodium* (7.97 %), and *Leucocytozoon* (2.66%). We used statistical approaches to ascertain which ecological factors are driving variation in parasite diversity and prevalence across samples.

Effect of *Aedes* Larvae on *Anopheles coluzzii* Oviposition

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Anopheles coluzzii mosquitoes transmit malaria, causing over half a million deaths per year. Anopheles mosquitoes use their sense of smell (olfaction) to guide their egg-laying (oviposition), but the exact olfactory cues are less known than in other mosquitoes such as Aedes aegypti. Aedes larvae release the pheromone heneicosane in water, which attracts mosquitoes of the same species to lay eggs. Heneicosane also attracts oviposition of Anopheles mosquitoes even though Anopheles larvae do not release it. We therefore hypothesized that Anopheles mosquitoes prefer to lay eggs in water that contain Aedes larvae. To test this hypothesis, we used a video-recorded two-choice assay in which Anopheles mosquitoes chose between laying eggs on clean water or water that contains Aedes larvae at different densities (10, 25, or 50 larvae). We found that Anopheles mosquitoes preferred laying eggs in water containing 25 larvae, showed no preference for water with 25 larvae, and avoided water containing 50 larvae.

Because the oviposition response depends on larval density, these findings could assist in developing larvae-based mosquito attractants and repellents to divert oviposition away from human settlements and reduce disease transmission.

Investigating P10 and P13 as Tip60-Enhancing Therapeutics for Alzheimer's Disease

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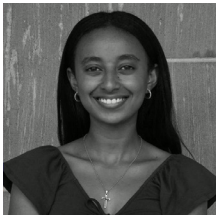
Alzheimer's disease (AD) is a progressive neurodegenerative disorder that is associated with cognitive decline, memory loss, and disrupted epigenetic regulation. Neuroepigenetics is the study of how gene function in the brain is altered by environmental factors. Dysregulation leads to multiple neurodegenerative diseases, and is caused by the disruption of histone acetyltransferases (HATs) and histone deacetylases (HDACs) homeostasis balance. The HAT Tip60 can be a promising therapeutic target due to its role in maintaining appropriate neuronal gene expression and protecting against neurodegeneration. Here, we will treat the well characterized *Drosophila melanogaster* model of AD with two novel Tip60-enhancing compounds, P10 and P13, and compare to untreated controls, to determine if enhancing Tip60 activity reduces disease-associated deficits. Evaluating the therapeutic potential of each compound at different concentrations to restore Tip60 activity and improve neuronal function will contribute to the development of targeted, disease-modifying therapies for AD.

Alternative splicing variation among populations of urban and rural house mice



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Urban areas are growing rapidly and house the majority of the world's population. Urbanization can affect wildlife through changes in diet, increased temperature, and exposure to pollution. Previous research has shown that urban habitats can impact gene regulation, but have focused primarily on gene expression. Alternative splicing is another key gene regulatory mechanism but has been largely overlooked in studies of response to urbanization because of challenges that are now being overcome. This project explores how habitat affects the regulation of mRNA splicing in house mice, a genetic model system and a widespread human commensal. Mice were collected from New York City, NY; Philadelphia, PA; Richmond, VA; and surrounding rural areas. RNA-seq data were processed using a bioinformatics pipeline suited for identification of known and novel splicing events. Preliminary analysis identified >1,000 genes with differential splicing across habitats, most of which were not previously identified in differential expression analyses. These genes were enriched for immunity, coagulation, as well as lipid, xenobiotic, and steroid metabolic processes. These results highlight the importance of including splicing in transcriptomic studies.

Invarient subspaces of block two by two matrices

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Many advancements in mathematics are related to new fields. Because these fields are new, many of the discoveries are not directly applicable to the real world in the present but could help progress certain technologies later. As a result, these new fields have a wealth of new knowledge that can be created. One of those fields is free algebra, which combines the idea of basic math with spaces that do not have the commutative property. As it is a newer and less studied field, many connections haven't been made. One such problem is the invariant subspace problem, which asks if every bounded operator in a complex Banach space results in a closed subspace that is not the trivial solution. This problem has been proven true for multiple special cases, such as finite dimensional complex spaces. Invariant subspaces are traditionally eigenspaces, which is the space covered by the eigenvalues of a matrix. Over the summer, we related the invariant subspace problem to block two by two matrices and their related eigenspaces by finding an implicit series for the projection onto an invariant subspace as the matrix varies.

Simulating Diffusion and Ion Drift in Liquid Xenon

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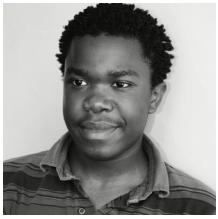
Neutrinos are particles that are difficult to detect and can't be easily incorporated into the standard theory of particle physics. The discovery of neutrinoless double beta decay, a hypothetical rare nuclear process, would change our understanding of neutrino physics. EXO-200 was an experiment looking for neutrinoless double beta decay in liquid xenon that ran in two phases from 2011 to 2018. Radon, which is normally a significant source of background radiation in double beta decay experiments, was intentionally injected into the EXO-200 detector at the end of its run. For this project, I simulated the movement of radon daughters in liquid xenon. I then compared the results of my simulations with the data collected during EXO-200's second phase and radon injection campaign.

Designing Tooling for the Deep Underground Neutrino Experiment's Charge Readout Panels



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The Deep Underground Neutrino Experiment (DUNE) is an upcoming physics experiment with the objective of studying neutrinos. Neutrinos are of interest because they exhibit behavior that contradicts current physics models; closer examination of neutrinos may give physicists a better understanding of the past, present, and future of the universe.DUNE uses large underground detectors in South Dakota to detect neutrinos from natural sources, as well as those from an accelerator produced beam originating 800 miles away in Illinois. Charge readout planes (CRPs) are one of the technologies required for these detectors to function.DUNE is a collaboration with many contributing institutions. This project was completed in partnership with Yale's Wright Laboratory, which is responsible for the assembly of 80 DUNE CRPs. I visited the Wright Lab to better understand the relevant CRP components and the lab's capacity to manufacture my designs. I used what I learned to create 3D models necessary to manufacture the tooling. Then, I conducted initial prototyping locally with a replica CRP section. This informed the designs I sent to the Wright Lab for real-world testing. Together, we arrived at a final design to be used for actual CRP assembly.

Machine Learning Analysis of HERA Data

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High-altitude balloons (HABs) equipped with low cost particle detectors provide a valuable tool for collecting cosmic ray data across a wide range of conditions. HAB data can be analyzed in various ways, including examining how different conditions relate to particle detection rates. Given the number of variables collected during each flight, machine learning provides one possible approach to analyzing these relationships. Data collected from a small number of individual flights was analyzed using regression-based machine learning methods in order to predict particle counts per second from other available measurements used as predictive features. The results show that regression-based machine learning is a possible approach for analyzing HAB data, with models providing some indication of which measured features may be most important in predicting counts per second, although more flight data would be needed to determine how consistent these results are across flights.

Analyzing User Classifications of Low Energy Neutrino Events

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Neutrinos are mysterious particles that are extremely abundant yet rarely interact with matter. Fifteen years ago, the IceCube Neutrino Observatory, a particle detector buried in the south pole, was created in order to learn more about neutrinos. Name that Neutrino, a citizen science project developed at Drexel three years ago, collects novice user classifications of neutrino events captured by the IceCube Neutrino Observatory and compares/contrasts them to a machine learning algorithm. Previous research with Name that Neutrino has had users analyze high energy neutrino events, but our team has not yet tested to see how users would do on low energy neutrino events.

Our team displayed 50 videos of monte-carlo generated low energy neutrino events for users to classify. Then, our team used confusion matrices and scatterplots to analyze and compare the overall accuracy of the users against the machine learning algorithm. We found that users are relatively accurate at classifying low energy cascades. Afterwards, our team used histograms to see if there are specific characteristics of events that make it easier for humans to classify certain events. We found that users may be better at classifying events that span longer distances.

GPU-Accelerated Bayesian Inference for Galaxy-Halo Connection with flowMC

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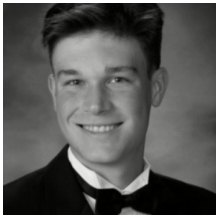
Milky Way satellites contain the faintest known galaxies and essential information about galaxy formation and dark matter, an invisible form of matter that has been discovered due to its powerful gravitational pull that it exerts on visible matter. Prior work (Nadler et al. 2020) constrained a theoretical model using emcee, a pure-Python library used to perform Bayesian inference with Markov chain Monte Carlo sampling, and constrained ten free parameters given the known population of the the smallest galaxies, ultra-faint dwarfs (UFDs). This project extends that inference framework by implementing flowMC, a GPU-accelerated Bayesian inference package built on JAX that outperforms CPU-based implementations such as emcee by combining local Markov chains with normalizing flows. flowMC especially allows for more efficient global jumps across high dimensions and computational time speedup as it can run on a GPU instead of slower CPU-bound loops. Our flowMC implementation achieves speedup compared to emcee (running on a single Intel(R) Core(TM) Ultra 9 185H CPU) on a modest NVIDIA 4050 GPU card. The acceleration allows us to efficiently explore higher-dimensional extensions of the model and accommodate newly discovered UFD populations.

Tracing Institutional Memory: The History and Leadership Transitions of Philadelphia's Community Development Corporations



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Community development corporations (CDCs) are local, typically "place-based," nonprofit corporations designed for a variety of purposes all focused around the somewhat nebulous goal of "community development." In practice, this typically refers to such things as low-income housing, workforce development, drug rehabilitation, economic development activities such as commercial corridor management and business incubation, and occasionally healthcare and education. First established in the late 1960s, CDCs were a decentralized response to the problems associated with more top-down urban renewal programs. However, because CDCs are independently governed and can do so many different things, no comprehensive, verified record of their leadership histories exists for any single city, leaving their collective functions and outcomes obscure.

This project builds a historically grounded dataset of executive leadership across roughly 105 Philadelphia CDCs, from the city's first CDC, founded in 1968, to the present, verifying each organization against IRS filings, archival collections, and public records to support a broader study of how CDCs preserve institutional memory through leadership transitions.

A Field Without Stability: Paradigm Shifts and Disciplinary Change in *Urban Studies*

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When an interdisciplinary field's dominant theories shift, is this a genuine paradigm shift, or is the field simply tracking a world that changes faster than theory can account for? Urban studies emerged from the convergence of economics, geography, sociology, and political science around a shared object: the modern city. Thomas Kuhn's model of scientific paradigms, developed for fields like physics with a stable object of study, assumes anomalies accumulate and paradigms shift without the underlying reality changing in response. Cities offer no such stability; they are continuously reshaped by the same forces scholars are simultaneously theorizing. As a case study, this research analyzes Urban Studies, a Sage-published flagship journal in the field, tracking the disciplinary composition of authors and editors, editorial turnover, and geographic and institutional concentration over time. By comparing whether these shifts appear discrete and theory-driven or gradual and event-driven, this study argues that the journal occupies an ambiguous space between science and journalism, suggesting that urban studies may be better understood not as a stable science but as a form of sustained, theorized journalism.

Does Anodal Stimulation of the Right Insula Improve Creativity?

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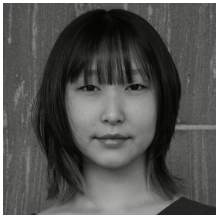
Creativity is the ability to combine existing ideas in new ways to create something original and useful. This project investigates the neural dynamics underlying creativity. Current frameworks suggest creativity emerges from the interactions among three neural networks: the Executive Control Network (ECN), Default Mode Network (DMN), and Salience Network (SN). The ECN is implicated in the goal-oriented evaluation of ideas, while the DMN has been linked to idea generation, daydreaming, and imagination. The SN is hypothesized to act as a switch between these networks. Although research has extensively examined the ECN and DMN, the SN's role as a regulator is still not fully understood. To address this gap, this project tests whether modulating SN activity influences creativity. The right insula, a primary anatomical feature of the SN, is stimulated using a 4×1 high-definition transcranial direct current stimulation (HD-tDCS) montage at 2.0 mA. During stimulation, participants complete an Alternative Uses Task (AUT) that is scored by researchers and large language models specialized in evaluating originality. AUT responses, omissions, and voice-onset reaction times will be analyzed to determine whether SN activity affects creativity.

Examining the Neural Dynamics of Semantic Memory Integration Using Noninvasive Brain Stimulation with Concurrent EEG



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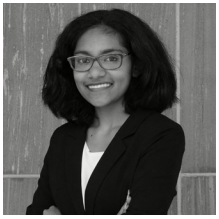
Semantic memory is the storage of long-term memory that consists of general knowledge obtained through life experiences. The neural systems that support semantic memory are crucial to human development and how we integrate knowledge into meaningful concepts. This project aims to understand the neural dynamics of semantic integration within the left inferior frontal gyrus (IFG) through electroencephalography (EEG) and transcranial direct current stimulation (tDCS). Participants complete the relatedness judgement task (RJT), where they are asked to rate the relatedness of two nouns, as well as the conceptual combination task, where they evaluate the meaningfulness of ambiguous noun-noun combinations. During the conceptual combination task, participants at separate sessions receive excitatory (anodal), inhibitory (cathodal), or placebo (sham) stimulation. This occurs between two sets of RJT, where EEG readings measure the N400 effect, a negative voltage fluctuation in response to semantic anomalies. We anticipate differences in the N400 amplitude and behavioral reflective of differential effects of stimulation types, creating an opportunity for further research toward expanding our current understanding of semantic memory.

Mapping Language in the Brain: An fMRI Study of Sentence Completion



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This pilot study tries to prove that behavioral performance and efficiency can be detected using task-related fMRI, to guide a future study targeting language networks with brain stimulation in patients with aphasia. We examined the neural mechanisms underlying sentence completion, asking where in the brain it activates and whether response time modulates language activation patterns. Five healthy participants (Mean Age = 35, SD = 3.8) completed a sentence completion task during an MRI scan. Task-related activation was analyzed in FSL FEAT, including motion correction, smoothing, and normalization to MNI space. A voxel-based general linear model identified regions activated during the task, with response time included as a parameter to test whether behavioral efficiency modulated neural activity. Results revealed activation in left inferior frontal gyrus and posterior superior temporal gyrus, along with bilateral middle temporal gyrus and frontal pole regions, indicating a less lateralized pattern than expected. Occipital activation was also observed, likely reflecting visual reading. Despite this unexpected pattern, the task reliably evoked robust brain activity, confirming its utility as a localizer for future stimulation studies.

Why Does Happiness Matter? A Blueprint for Student Well-Being

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According to the 2024 World Happiness Report, young adults in the United States report lower levels of well-being. This study investigated the world's happiest countries, lifestyle habits from Blue Zone communities, and student data collected by the Happiness Lab at Drexel University to identify ways to improve student well-being. Results suggested that Drexel students demonstrate below-average happiness, largely tied to lower self-esteem. Furthermore, five key factors stood out as significant pillars of college-age well-being: psychological safety, time in nature, social connectivity, belonging, and purpose. It is important that each pillar work together and be integrated into one's daily routine to create a happy lifestyle. The implications of the current study show how well-documented global principles of well-being could be reverse-engineered into college campus environments to enhance student well-being. By adopting behaviors such as making the healthy choice the easy choice, encouraging social connection, and fostering a greater sense of citizenship, students, staff, and faculty can become the architects of a happier campus, maximizing students' self-perceptions as they engage in college life.

Investigating Oncogenic GNAS Signaling in Early Pancreatic Tumorigenesis

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Pancreatic ductal adenocarcinoma (PDAC) is often diagnosed after metastasis, contributing to its poor five-year survival. Intraductal papillary mucinous neoplasms (IPMNs) are pancreatic cystic lesions that can progress to PDAC, but distinguishing benign from high-risk lesions remains difficult. To understand early IPMN development, this study investigated oncogenic GNAS(R201C), found exclusively in IPMNs. Human pancreatic duct epithelial cells were transduced with doxycycline-inducible lentiviral vectors expressing wild-type GNAS or GNAS R201C and selected with puromycin. Previous BioID and kinase inhibitor screens identified candidate proteins and pathways associated with oncogenic GNAS. After doxycycline induction, cells were treated with PKA inhibitors H-89 and BLU to block canonical downstream PKA signaling, and changes in total protein levels of BioID-identified targets were analyzed by Western blotting. PYK2, ARMS-CX3, and FES showed notable differences in expression between doxycycline-induced and uninduced samples. Future studies will investigate the cell-type-specific roles of these proteins in oncogenic GNAS-induced cell proliferation and provide insight into early IPMN development.

Generating Pancreatic Progenitor Cells from Human Pluripotent Stem Cells

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Pancreatic ductal adenocarcinoma (PDAC) is among the deadliest cancers, with a five-year survival rate below 13%, largely because it causes little to no symptoms until an advanced stage, when the cancer has metastasized to other organs. Human based stem cell-derived pancreatic organoids offer a promising approach to understand early stages of pancreatic cancer development, as their 3D structure better mimics native pancreatic tissue than 2D culture. This project aimed to generate pancreatic progenitor cells from the human embryonic stem cell line, HUES8 (H8), using a differentiation protocol developed in the Desai Lab, toward eventually growing ductal and acinar organoids. H8 cells were thawed, split, and seeded for differentiation - from a pluripotent state through definitive endoderm toward pancreatic progenitors. Since differentiation efficiency is sensitive to starting conditions, optimizing seeding density has been a major focus, with different densities tested to identify optimal conditions. Progenitor markers will then be assessed via flow cytometry and immunofluorescence. A reliable protocol will support future work on early pancreatic cancer, aiding in earlier detection and treatment.

The Role of PARP1 in Telomere Maintenance and Cancer Cell Survival

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Poly(ADP-ribose) polymerase 1 (PARP1) is a DNA damage-response repair and an important therapeutic target in cancer. Although PARP1 has been implicated in telomere maintenance, its role in protecting telomeres and genomic integrity remain unclear. PARP1 and TIMELESS are known to cooperate in the replication-stress response, and TIMELESS is known to maintain telomere length, suggesting that this interaction may also support telomere stability.

We investigated PARP1 function in TE-11 esophageal cancer cells using shRNA-mediated knockdown and the PARP1 inhibitor olaparib. Western blotting showed that PARP1 knockdown reduced TIMELESS and FANCD2 levels, suggesting that PARP1 functions with replication-stress response proteins to maintain genome stability. PARP1 knockdown alone did not significantly reduce TE-11 cell viability; however, combined PARP1 knockdown and with G-quadruplex stabilizer pyridostatin reduced viability more strongly than either treatment alone. Telomere length will be examined to further define PARP1 function. Together, these findings support a role for PARP1 in replication stress, telomere maintenance, and cancer survival.

Role of System xCT on Breast Cancer Brain Metastatic Growth

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Triple negative breast cancer is an aggressive subtype with high propensity to spread to the brain. Patients with Breast Cancer Brain Metastasis (BCBM) have poor prognosis, highlighting need to discover mechanisms driving progression and novel therapeutic targets. One possible target System xCT, a cystine/glutamate antiporter composed of SLC7A11 and SLC3A2 that regulates cell redox balance. Preliminary data from our lab has suggets System xCT may play a critical role in the growth of BCBM cells. In this project, we genetically targeted SLC3A2 to determine its role in extracellular matrix (ECM) regulation and BCBM growth in vitro. Proteomic analysis of SLC7A11- overexpressing breast cancer cells showed enrichment of ECM proteins. while SCL3A2 depletion decreased in ECM proteins and focal adhesion kinase (FAK) signaling. Furthermore, stable knockdown of SCL3A2 blocks anchorage-independent growth and colony formation. Thus, our data identify System xCT as a critical regulator of BCBM growth and potential therapeutic target.

Evaluating and Characterizing Cost, Structure, and Behavior in LLM Agents for HIV Drug Resistance Analysis

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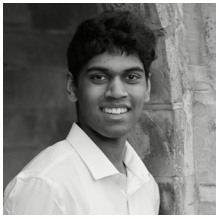
HIV rapidly mutates, often developing drug-resistance mutations that make treatment ineffective; identifying these strains requires a largely manual bioinformatics analysis. LLM agents show promise to automate this workflow, but it is unclear whether they follow instructions and disclose limits without fabricating conclusions. We built an evaluation framework testing 7 agents across 8 tasks spanning clean data, edge cases, and clinical pressure. A Judge LLM graded output against Stanford HIVDB Sierra results. We engineered and tested three components: a tool-use skill, an output skeleton, and an evidence-verification skill. Preliminary results show factual accuracy stayed high across agents, but cost varied significantly: the tool-use skill cut token cost up to 69% vs. no-skill (9-69% by model). The output skeleton raised cost on most models but corrected undisclosed overreach on a comparative-judgment task for 4 of 6 models (scoring 76% to 100%). The evidence-verification skill corrected user-pressure capitulation in 3 of 5 models (rubric gains 19-48%). These findings point toward model-specific practices for reliable, cost-effective agentic AI in bioinformatics workflows, preventing fabricated or undisclosed conclusions.

Evaluation of the Antibacterial Activity of *Lycium barbarum* Extracts Against *Cutibacterium acnes*



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Cutibacterium acnes is a normal member of the human skin microbiota and an important contributor to acne vulgaris, a common inflammatory skin disease. Recent studies have also suggested an association between *C. acnes* and Alzheimer's disease (AD) and AD-like pathology. Conventional acne treatments, particularly antibiotics, have limitations such as antimicrobial resistance with prolonged use. Natural products may provide alternative sources of antimicrobial agents. Goji berry (*Lycium barbarum*) contains various phytochemical constituents that have been reported to exhibit antibacterial and other biological activities. However, its antibacterial activity against *C. acnes* remains unclear. Therefore, this study aimed to evaluate the antibacterial activity of goji berry extracts against different phylotypes of *C. acnes*. Six organic solvents with different polarities were selected to prepare crude goji berry extracts, and their antibacterial activities were evaluated using bacterial growth inhibition and agar inhibition zone assays. These findings may help identify goji berry extracts with antibacterial activity against *C. acnes* and provide a basis for future investigation of their bioactive compounds.

Impact of Antigen Affinity and PSGL-1 on OT-I CD8+ T Cell-Mediated Killing of PDAC Tumor Spheroids

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In the US, pancreatic cancer is associated with a mortality rate of 13% within 5 years of diagnosis. Although it is one of the most lethal forms of cancer, it is also one of the least studied. Pancreatic ductal adenocarcinoma (PDAC) is a form of pancreatic cancer that is characterized by an immunosuppressive microenvironment that minimizes T cell responses. We used KPC.4662-OVA PDAC cells to generate spheroids. Two different strains of KPC.4662 cells were used, including N4 (SIINFEKL), a high-affinity OT-1 ligand, and V4 (SIIVFEKL), a lower-affinity ligand. CD8+ T cells isolated from wild-type (WT) and PSGL-1 knockout (KO) OT-I mice were activated using antibodies before co-culture with spheroids. After co-culturing for 48 hours, the spheroids and T cells were harvested for analysis by flow cytometry to show tumor-cell death. We hypothesize that N4 spheroids will exhibit greater apoptosis than V4 spheroids due to stronger antigen recognition and that PSGL-1 KO OT-I T cells will induce greater tumor-cell apoptosis than WT OT-I T cells. These findings may aid in understanding antigen affinity and how PSGL-1 signaling regulates CD8+ T cells in responses against PDAC.

Investigating Excitatory and Inhibitory Neural Activity Following Psilocybin Exposure Using c-Fos and pPDH Immunohistochemistry in Adolescent Mice

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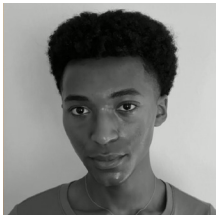
Psychedelic compounds such as psilocybin have emerged as promising treatments for neuropsychiatric disorders, including major depressive disorder and post-traumatic stress disorder. However, most studies have focused on adult animals, and relatively little is known about how psychedelic exposure alters neural activity in the developing adolescent brain. Although studies have demonstrated therapeutic potential, the neural mechanisms that induce these effects remain incompletely understood. Importantly, most studies have focused on excitatory neural activity. Whether the drugs induce any inhibitory activity in the brain remains untested. By examining both neural responses, this project aims to provide a more comprehensive understanding of how psilocybin influences brain-wide networks during different stages of development. Neuronal activation was assessed through c-Fos expression, an established marker of recent neuronal activity, whereas neuronal inhibition was detected with a newly identified indicator, phosphorylated pyruvate dehydrogenase (pPDH), in the mouse brain. Fluorescent microscopy and quantitative image analysis were used to compare patterns of activation and inhibition between treatments, age groups, and brain regions.

Dopamine D1 Receptor Antagonism and DARPP-32 Phosphorylation Following Repetitive Mild Traumatic Brain Injury in Adolescent Male Sprague-Dawley Rats



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Adolescents engaged in contact sports are susceptible to multiple episodes of mild traumatic brain injury (TBI). The acute post-traumatic phase is characterized by deficits in short-term working memory. This study investigates the effects of repeated episodes of mild TBI in adolescent male rats on dopamine (DA) signaling in the prefrontal cortex (PFC), a brain region responsible for regulating working memory. Both brain and sham-injured rats received either the DA receptor 1 antagonist SCH 23390 hydrochloride or saline. Working memory was assessed using the novel object recognition test. At 90 minutes following the completion of the test, the downstream consequences of D1-receptor activation and the activity of neurons within the PFC were evaluated. Western blot analyses will be employed to target DARPP-32 and its phosphorylated form, a crucial node in the cAMP-dependent protein kinase-A signaling pathway associated with D1-receptor activation. Additionally, immunohistochemistry will be used to identify activated neurons. Our study hypothesizes that repetitive TBI disrupts D1-mediated DARPP-32 phosphorylation, impairing working memory and elucidating the mechanisms underlying behavioral morbidity following repeated mild TBI.

Sex Differences in Behavioral Effects of Cannabinoid Combination Treatment vs Gabapentin in a Mouse Model of Chronic Neuropathic Pain

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Chronic neuropathic pain (CNP) is a debilitating condition that is difficult to treat due to limited efficacy and misuse potential of current medications. Our lab has previously identified sex differences in the ability of minor cannabinoid combinations to reduce mechanical allodynia in spared nerve injury (SNI), a model of CNP. A combination of cannabidiol (CBD) and cannabigerol was effective in males, while CBD and cannabichromene was effective in females. Current work is testing cannabinoid combinations in more translatable assays [conditioned place preference (CPP) and dynamic weight bearing (DWB)] that require supraspinal pain processing and allow for assessing sedation and abuse liability. They are further comparing efficacy to gabapentin, a first-line treatment for CNP. Using the SNI model, we found both sexes showed significant reduced injured-paw weight bearing, indicating asymmetrical weight distribution associated with SNI. While mobility time remained unaffected by injury in both sexes, rearing behavior was reduced in SNI males, but not females, highlighting the need for identification of female-specific pain behaviors. Ongoing work is focused on assessing cannabinoid combinations in abating pain-like behaviors.

Role of NF-κB and JAK2/STAT1 in Pro-Metastatic IL-1β Expression in Prostate Cancer Cells

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Clinical progression of prostate cancer (PC) depends on the activity of the androgen receptor (AR). AR is activated by testosterone and regulates the expression of a cadre of genes supporting the survival and growth of PC cells. Blocking AR activity by reducing testosterone levels or using AR inhibitors is the current standard-of-care for patients with metastatic PC. While initially effective, this treatment strategy ultimately fails to cure patients. Evidence shows that targeting the AR leads to the emergence of AR-negative cancer cells that are resistant to therapy. Our lab has shown that, depending on the cellular context, AR-negative PC cells use NF-κB and JAK2/STAT1 signaling to promote IL-1β transcription. In this study, we first investigated whether the DU-145 cell line utilizes both signaling pathways to promote IL-1β expression. Subsequently, we aimed to ascertain whether the constitutive activation of JAK2/STAT1 observed in three different AR-negative PC cell lines depends on the autocrine stimulation of one or more plasma membrane receptors. The study will elucidate the mechanisms regulating IL-1β expression in PC and support the development of novel therapeutics to be combined with the current standard of care.

EcoHIV and Antiretroviral Effects on Estrogen Receptor α Expression in the Medial Preoptic Area

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Approximately 41 million people globally are living with HIV, over half of whom are women. Antiretrovirals are effective for both prevention, using pre-exposure prophylaxis (PrEP), and for treatment, using antiretroviral therapy (ART). PrEP adherence is limited, in part, due to perceived impacts on the menstrual cycle. Our previous work indicates that infection with the chimeric HIV-1 virus, EcoHIV, disrupts estrous cycle in mice. ART reversed EcoHIV-induced estrous cycle disruption, while the long-acting PrEP, CA inhibitor 1, did not impact estrous cycle, but the mechanism by which ART impacts estrous cycle is not fully understood. This study aims to identify the effect of EcoHIV, ART, and CA Inhibitor 1 on expression of estrogen receptor α (ERα)—a key regulator of the estrous cycle—in the medial preoptic area (mPOA). Female mice were infected with EcoHIV or served as shams, then administered ART-containing or control chow, whereas the PrEP mice were injected with CA Inhibitor 1 or vehicle. Immunohistochemistry for ERα was performed in the mPOA. Both EcoHIV and CA inhibitor 1 treatment decreased ERα immunoreactivity in the mPOA. This study will provide insight into impacts on the hormonal system of those taking ART or PrEP.

Group Writing and Well-Being in Older Adults: An Integrative Review

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Group writing may support older adults' well-being through self-expression, reflection, purpose, and social connection, yet the literature varies widely in how these experiences are designed and evaluated. This integrative review examined how group writing has been studied among adults age 50 and older and how it relates to well-being. Following the Whittemore and Knafl methodology, literature searches were conducted in CINAHL, PsycINFO, PubMed, and Web of Science. A total of 1,179 records were screened, and 25 articles met the inclusion criteria. There was a mix of observational studies (n =8), intervention studies (n =15), and program reviews (n =2) occurring in a variety of settings spanning from community spaces to long term care facilities. Findings show that group writing focused on a variety of writing activities: creative writing, poetry, life review, storytelling, and reflective writing. Most articles identified an improvement in well-being. Additional benefits include emotional expression, confidence, purpose, and social connection. These findings have informed an interview guide to explore well-being among older adults participating in the London Writers' Salon.

Assessing the Acute Effect of Exercise on Microvascular Function in Women Across the Menstrual Lifecycle

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Menopause is associated with declining estrogen levels, impaired vascular function, changes in body composition, and increased risk of cardiovascular disease. Although regular exercise has been shown to improve vascular health and reduce menopause-related health risks, most studies have focused primarily on pre- or postmenopausal women, leaving the perimenopausal transition relatively understudied. This study investigates the acute effects of exercise on microvascular function across the menopausal transition to better understand physiological changes associated with healthy aging. Adult women classified as pre-, peri-, or postmenopausal complete health questionnaires, cognitive testing, microvascular perfusion testing using near-infrared spectroscopy, and blood collection before and after acute submaximal treadmill exercise. Blood samples are analyzed to examine biomarkers of aging, inflammation, and gene expression associated with vascular and cognitive health. This research aims to improve understanding of female vascular aging, inform future exercise-based interventions to promote cardiovascular and cognitive health throughout menopause, and support healthy aging in women.

Regeneration in Skeletal Muscle Following Botulinum Toxin Exposure

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Botulinum toxin (BTX) is commonly used to reduce muscle hyperactivity after stroke. However, following BTX injections, we have previously demonstrated persistent muscle atrophy and increased passive muscle stiffness lasting up to 6 months in mice. This study investigated whether active muscle regeneration occurs at 2 and 3 months after a single BTX injection in mice. Muscle regeneration was tracked by measuring the percentage of muscle fibers with centrally located nuclei, an indicator of active muscle regeneration, using hematoxylin and eosin (H&E) histological images. At 2 and 3 months, BTX-treated samples had a significantly greater proportion of centralized nuclei than controls (18.67% ± 7.01% vs. 5.22% ± 1.07%, p=0.030, 17.35% ± 4.11% vs. 3.00% ± 1.23%, p<0.001, respectively). Centralized nuclei in BTX-treated samples did not differ significantly between time points (p=0.750), indicating that muscle regeneration following BTX begins by 2 months post injection and persists through 3 months. These findings suggest BTX is associated with prolonged muscle remodeling and regeneration. Further investigation may clarify whether these changes contribute to the previously observed long-term increases in passive muscle stiffness.

Exploring Sex Differences in Caregiver Concerns Leading to Autism Diagnoses

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Autism Spectrum Disorder (ASD) diagnosis occurs later in females (age 8) than males (age 5). Further research is needed to understand these gender disparities, since diagnosis informs early intervention that affects developmental outcomes.

Caregivers of 62 children, 35 male and 27 female, who were not identified with ASD during toddler screening studies were rescreened for autism when children were 8-17 years old. Those who screened positive completed the Diagnostic Odyssey, a parent-report interview of their child's history of developmental concerns. Sex differences in several items of the interview were examined using chi-squares and descriptive analyses.

Compared to males, parents of females were more likely to report that they felt their concerns were not taken seriously, $X2\ (2, N = 55) = 5.96$, $p = .02$. Age of first concern being before vs. after 36 months and type of concern did not differ by sex ($ps > .55$), and parents were just as likely to be told there was nothing wrong ($p = .85$).

There is no sex difference in age of first concern, yet girls are diagnosed years later compared to boys. By better understanding how autism can be identified earlier in females, researchers can address gender disparities in autism healthcare.

Mental Health Changes in Adult Latinos in Philadelphia from 2021 to 2026

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Latino immigrants encounter substantial barriers to accessing healthcare, particularly mental health services, due to social, economic, and structural factors. CRISOL Mente is a community-based intervention designed to reduce mental health disparities among Latino immigrants in Philadelphia, PA through outreach, resources, and collaboration with Latino-serving organizations. This study examines differences in mental health symptomatology including depression, anxiety, and post-traumatic stress disorder (PTSD), among Latino adults in Philadelphia across two survey waves. Data was collected using respondent-driven sampling (RDS), with Wave 1 conducted April 2021-September 2022 and Wave 2 from November 2025-August 2026. Survey data will be compared across waves to examine differences in prevalence of depression, anxiety, and PTSD over time. Comparing mental health measures across survey waves provides insight into changes in mental health needs of Philadelphia's Latino immigrant community and may inform future community mental health programs and efforts to increase access to mental health services among Latinos in the region.

Characterizing Pediatric Pelvic Growth Through Three-Dimensional Morphometric Analysis

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The pelvis is one of the most critical skeletal structures in the human body, enabling us to stand, sit, walk, run, and support our upper bodies. Consequently, injuries to this region can be incredibly harmful. In children, these injuries can lead to detrimental setbacks in their development, including irregular/uneven gaits, growth plate fusions, and future joint complications. Despite this, the exact growth of the pediatric pelvis is understudied. The current study analyzes the morphology of the pelvis and how it changes as subjects age. Computed tomography (CT) scans of the pelvis, provided by the Children's Hospital of Philadelphia (CHOP), were taken from patients aged 1–18 years and analyzed using MATLAB to identify key landmark points. Using these landmark points, measurements were made, such as pelvic height, width, and other clinically relevant measures. Additionally, Generalized Procrustes Analysis (GPA) and Principal Component Analysis (PCA) were performed to quantify pelvic shape variations based on the landmark points. This greater understanding of the pediatric pelvis would provide a foundation for future research and development in pelvic injuries in children.

Comprehensive quantification of 3D vertebral morphology and growth patterns in skeletally immature normative and scoliotic piglets

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Scoliosis is a three-dimensional spinal deformity that can lead to pain and respiratory issues. The most common treatment is posterior spinal fusion, but this procedure restricts growth. Therefore, the development of novel treatments has focused on retaining growth while correcting scoliotic curvature. Before this development can begin, preclinical porcine models are needed. However, no such models currently exist. As such, this study aims to quantify and compare the vertebral growth patterns between immature normative and scoliotic Yucatán piglets. 3D reconstructions were created using chest and abdominal CT scans of piglet spines. Custom MATLAB code then extracted key measurements from the reconstructions, primarily vertebral body height and wedging angle. These measurements were then compared between groups to determine if their development as a function of age and spinal deformity progression differs. This quantification allows for the vertebral growth patterns between pigs and humans to be better understood. This can then be used to inform the future development of growth-sparing treatments for scoliosis.

NICK HOWLEY COLLEGE OF ENGINEERING AND COMPUTING
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In Vitro Modulation of CAR-T Cell Proliferation and Persistence Through Ligand Presentation on Programmable Microparticles

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Chimeric antigen receptor (CAR) T-cell therapy has achieved impressive outcomes for cancer treatment, yet limited proliferation and persistence hinder durability. I fabricated programmable PLGA microparticles functionalized with DNA scaffolds to control tumor antigen presentation and costimulatory signals. These CAR-T cell-engaging particles (CAREp) previously supported continuous CAR-T expansion for over 100 days and up to 10^{18}-fold cumulative expansion, highlighting the importance of stimulation format. This project investigates how DNA scaffold architecture and ligand flexibility affect CAREp-induced CAR-T cell proliferation and persistence. By extending the unhybridized region of DNA scaffolds and incorporating polyethylene glycol (PEG)-based presentation, we engineered particles with distinct ligand presentation formats. These particles were co-cultured with human CAR-T cells to longitudinally count viable cells and their expansion. CAR-T cell phenotype and functional responses were evaluated through flow cytometry and intracellular cytokine and IncuCyte cytotoxicity assays. This study aims to determine how ligand presentation shapes CAR-T responses and informs strategies for sustaining function for improved in vivo efficacy.

Phenotypic and Functional Characterization of CD4 BCMA CAR-T Cells Following Expansion with CAR-Engaging Particles (CAREp)

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BCMA-targeted chimeric antigen receptor (CAR) T-cell therapies, such as Abecma, have demonstrated clinical efficacy in multiple myeloma, yet durable remission remains inconsistent. While CD8 CAR T cells provide direct cytotoxic activity, CD4 CAR T cells may support long-term antitumor responses through cytokine production, proliferation, and maintenance of T-cell memory. Dr. Huang's laboratory uses CAR-engaging particles (CAREp), a biomaterial platform that provides controlled CAR stimulation, to optimize CAR T-cell expansion. Previous CAREp studies have focused on CD8 CAR T cells, leaving the role of CD4 cells poorly understood. BCMA CAR T cells from healthy donors will be separated into CD4 and CD8 populations and expanded using CAREp. Expansion, memory phenotype, and cytokine secretion will be compared between subsets. We hypothesize that CAREp will promote favorable memory phenotypes in CD4 CAR T cells and reveal distinct functions from CD8 cells. Defining these differences may guide CAR T manufacturing strategies that improve persistence and durable clinical responses.

Machine Learning for Risk Assessment of Hemorrhagic Shock

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Hemorrhagic shock causes over 80% of preventable post-injury deaths. Early detection is critical for improved patient outcomes. Current monitoring uses systemic vital signs, eg. heart rate and blood pressure, which often only change after significant blood loss. Near-infrared spectroscopy (NIRS) and diffuse correlation spectroscopy (DCS) continuously and non-invasively measure cerebral hemodynamics, which may detect early physiological changes. I developed machine learning (ML) models to predict survival using multimodal physiological data from swine models of hemorrhagic shock (N=20). Features included systemic vital signs as well as cerebral measurements from NIRS and DCS. Eight ML algorithms were evaluated using leave-one-out cross-validation. Feature importance analysis identified relative blood flow index, a cerebral index, as the strongest predictor of mortality, followed by systolic blood pressure, a systemic index. A soft-voting ML ensemble predicted death with the highest accuracy: 78% using cerebral features, 88% using systemic features, and 90% using combined features. These findings demonstrate that cerebral measurements complement traditional vital signs and improve prediction of survival after hemorrhagic shock.

Cytotoxicity Screening of Glutaraldehyde-Crosslinked Gelatin Scaffolds for Diabetic Foot Ulcers

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Every year, diabetic foot ulcers send hundreds of thousands of people to the hospital. A wound that doesn't heal means amputation or complications. The problem is not a lack of treatments, it's that most are costly or inaccessible to patients who need them the most. The lab is developing a low cost biomaterial that is designed to be placed in the wound and promote healing and regeneration. The focus is on influencing the behavior of macrophages, a type of white blood cell and major regulator of the wound environment. The biomaterial is made up of a sponge-like scaffold that is coated with gelatin and a pro-inflammatory agent called glutaraldehyde. The glutaraldehyde is an inflammatory stimulus that will take the impaired inflammatory macrophages and stimulate them to be the correct inflammatory phenotype. The scaffold gives the cells a base to make regeneration easier. Before this biomaterial can be used on patients, it needs to be safe for cells. My project tests if cells can survive in different solutions of glutaraldehyde and compares the survival rates of cells to identify a threshold for the concentration of glutaraldehyde. This threshold is a necessary step before the scaffold can progress further into a clinical treatment.

Characterizing the Release of Glutaraldehyde from a Crosslinked Gelatin Scaffold for Diabetic Foot Ulcer Treatment

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Diabetic foot ulcers (DFUs) affect nearly 1 in 4 people with diabetes and are a leading cause of lower-limb amputation, with about 20% of infected ulcers progressing to amputation. As part of a larger effort to develop a low-cost, biodegradable scaffold for DFU healing, this project characterized glutaraldehyde release from a gelatin-coated scaffold. Surgifoam scaffolds were dip-coated in 2% w/v gelatin combined with 1%, 2.5%, or 10% v/v glutaraldehyde, then quenched with glycine and washed in PBS. Release was assessed in PBS or media with 5 or 50 ng/mL collagenase, measuring fluorescence over seven days. Gelatin-coated scaffolds released glutaraldehyde gradually, while uncoated scaffolds showed an early burst followed by inconsistent release. Higher collagenase concentrations produced greater release at later timepoints, indicating enzymatic degradation drives release. These findings establish a reproducible release profile to guide future scaffold formulations, though replicate variability and the physiological relevance of tested collagenase levels warrant further study.

NanoCT-Assisted Pore Analysis of Scaffolds to Promote Diabetic Foot Ulcer Wound Healing

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Diabetic foot ulcers are a serious complication marked by a dysregulated wound environment with slow or negated healing, leading to other complications including death. Macrophages are key immune cells that drive tissue regeneration by switching from an inflammatory to reparative phenotype. In foot ulcers, wound healing is severely impaired by a lack of number and correct type of pro-regenerative macrophages, resulting in overexpressed inflammatory signals that create a hyperinflammatory environment. Cells cannot transition to a reparative state, and tissue repair cannot occur. Existing treatments are often expensive and inaccessible, so the Spiller lab is developing a low-cost biomaterial via glutaraldehyde-coated scaffolds implantable at the wound site. Glutaraldehyde is a pro-inflammatory stimulus released from the 3D scaffold over 7 days. Current microscopy can estimate scaffold pore size but cannot confirm whether pores are large enough for cell migration or sufficiently interconnected for nutrient and waste flow. NanoCT enables 3D reconstruction of the entire scaffold using captured X-ray absorbance. Scans from this project will support method development and analysis of pore structure and size for this novel biomaterial.

Engineering *de novo* synaptic connections between defined neuron types in *Drosophila melanogaster*

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Synapses are the junctions that allow neurons to communicate, and engineering neural connections could restore damaged circuits involved in disorders such as schizophrenia or Parkinson's disease. Here, we have developed a new tool called syn-Stick to create novel synapses. Preliminary experiments suggest that syn-Stick can increase connectivity between nearby neurons. In this STAR project, we developed an assay to evaluate syn-Stick's ability to create functional connections. We have identified T2 and LPLC2 neurons as ideal for wiring experiments because they interact during development but are not synaptically connected in adult animals. We screened genetic expression tools and selected the best options based on timing and expression patterns. Using GAL4/UAS and LexA/LexAop systems, we independently controlled T2 and LPLC2 neurons and expressed syn-Stick components. We compare three conditions: no synthetic components, engineered T2 neurons, and engineered T2 and LPLC2 neurons. We image the T2–LPLC2 interface by confocal microscopy and look for colocalized signal as evidence of new synapse formation. Our findings suggest that synapses can be engineered rather than relying only on built-in wiring instructions.

Optimization of a tethered flight behavioral assay to incorporate red-light optogenetics in neuroscience research.

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To navigate through the environment, an animal's nervous system transforms sensory information into movement. The fruit fly Drosophila melanogaster is a valuable model organism for studying these sensorimotor processes because we have unprecedented genetic access to its nervous system. One emerging optogenetic tool RubyACRs enables investigators to use red light to turn off specific neurons in the fly's brain and directly observe changes in its behavior. However, it is unknown whether red-light exposure alone alters behavior. Here, we investigate how red-light exposure might affect a fly's ability to avoid collision with approaching objects during tethered flight. To determine how red-light stimulation might alter behavior, we record head and wing movements with a high-speed camera. We apply machine learning algorithms to track and analyze body and wing positions. These results are essential controls for future work using RubyACRs optogenetic inhibition during tethered behavior experiments.

Scaling a Hydrogel-Based Local Minocycline Delivery System for Spinal Cord Injury in a Minipig Model

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Spinal cord injury affects millions worldwide, causing lasting loss of motor, sensory, and autonomic function. Minocycline hydrochloride (MH) is a promising neuroprotective drug for spinal cord injury, but effective systemic doses cause liver toxicity, limiting clinical use. Prior work in Dr. Zhong's lab showed that local MH delivery via dextran sulfate-MH complexes in an agarose hydrogel achieves neuroprotective concentrations at the injury site in rats without systemic toxicity. The next step is scaling this formulation for a minipig model, whose spinal cord more closely resembles a human's. Since the minipig spinal cord needs 40-50 times more drug but only 10 times more hydrogel volume, daily release must increase 4-5-fold. This project develops modified formulations by varying DS/MH ratio and MH loading, then characterizes them by assessing loading efficiency, release profiles, and bioactivity, including cytoprotective effects via an H2O2 assay and anti-inflammatory effects via an LPS-stimulated macrophage assay. This will determine whether a scaled formulation can deliver sufficient bioactive MH over a sustained period, advancing this therapy toward clinical translation.

Verification of the 9 Qubit Shor Error Correcting Code

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Quantum computing is an emerging field within computer science with the potential to perform certain tasks at a significantly higher efficiency compared to classical computers. Specifically, quantum computers show strong potential within the realms of cryptography, machine learning, and simulation. However, quantum computers are extremely fragile, as they can be affected by general environmental noise, which makes large-scale quantum computing difficult to realize. To combat this, quantum computers use quantum error correcting codes, circuits that can identify and correct errors. While there are more effective codes, the 9 qubit Shor code was the first to be discovered. This project formally verified the correctness of the Shor code using symbolic computation to evaluate the circuit implementing the Shor code.

BudgetGS: Gaussian Selection for Compact Object Representations

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Three dimensional Gaussian splatting represents scenes using translucent particles called Gaussians. Separating an object for reuse or editing is difficult because one Gaussian may contribute to both the object and its surroundings, especially when the final representation must be compact. We developed BudgetGS to select object focused Gaussians directly for a fixed final budget using masked views, appearance value, object coverage, and a guard against background dominated Gaussians. Rather than extracting first and pruning afterward, BudgetGS considers object membership and representation value together. On two synthetic scenes evaluated from unseen views, direct selection better preserved object structure under severe compression in one scene and showed a smaller low budget advantage in the other. Tests on five LLFF and two Hypersim scenes showed no consistent quality advantage, although the Hypersim runs suggested a modest speed advantage. At larger budgets, ambiguous Gaussians could cause background bleeding. These results suggest that direct selection can benefit compact Gaussian objects at very low budgets, while traditional extraction is generally cleaner when more Gaussians are retained.

Teaching AI to See: Modeling Multiple Brain Regions for Decision-Making

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Learning through experience is a fundamental property of the brain that allows organisms to adapt to unfamiliar environments, yet replicating this ability with artificial intelligence (AI) remains a challenge. To investigate whether AI can acquire problem-solving through reinforcement learning, we expanded a cybernetic automaton (CA), an automata theoretic model of learning. We developed two new CAs to account for vision and spatial recognition, applying them to a virtual rat in a maze, inspired by the Skinner Box. My focus on the visual component enabled the rat to see obstacles around it, learn to avoid walls, and find the reward. Combined with spatial awareness, the structure provided crucial information to traverse more complex environments, extending the capacity of the original CA. Experimental results showed their capacity to learn, so we combined multiple CAs into a decision-making mechanism that integrates sensory and contextual information to guide behavior with initial training of vision and spatial awareness, increasing performance when solving more advanced problems. This architecture emulates how distinct brain regions connect to support higher level coordination, showing potential for devising more sophisticated AI.

"The Virtual Rat": Modeling Brain Function for AI to Learn Maze Navigation

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The brain is responsible for cognitive functioning, yet its inner workings are still largely a mystery to science. Artificial intelligence research has simulated neurological processing to study the development of learning in Cybernetic Automaton (CA) models. Existing implementations show learned behaviors in simple situations with a single CA, such as a virtual Skinner Box experiment; however, the decision-making process of biological brains is substantially more complex. To address this, I expanded the CA model to take in visuals of its surroundings and added spatial orientation for navigation via a mental map of the environment. Training data showed that using vision and spatial reasoning allows for generalizable learning within grid and maze settings, getting the CA to successfully find the designated endpoint reward. I combined several CAs to interpret this sensory information and make problem-solving decisions, emulating the coordination of multiple lobes within the brain. Pre-training the individual components before combination demonstrated improved outcomes in mazes over other models. The results of the integrated multi-CA systems show promise for modeling more advanced intelligence based on biological brain mechanisms.

Beyond Burnout: How EMS Stress Spreads Across People, Teams, and Care

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Burnout in emergency medical services (EMS) is usually discussed as something happening to one provider, but its effects often show up around that person too. My STAR project looks at how burnout is described by coworkers, partners, trainees, and other people who see its effects from the outside. I reviewed 111 Reddit posts and coded 68 that met our "not in first person" criteria, noting who was burned out, who was posting, what caused the burnout, and what happened because of it. Across the data, the same pressures kept showing up: staffing shortages, mandatory overtime, long shifts, poor sleep, low pay, and burned-out partners or supervisors. Some posts also showed burnout reaching beyond the workplace through relationship strain, career exit, and reduced patience with patients. Looking at burnout through other people's experiences makes a wider pattern visible: it can shape team culture, home life, retention, and patient care. These findings suggest that EMS burnout is not only an individual problem, but something that can spread through the people and systems around it.

PrivacyLens: An Explainable Risk-Scoring System for Data Breach Exposure

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Data breaches and online exposure of personal information are accelerating privacy risk. In the first half of 2026, victim notices reached 471 million, already surpassing 2025's full-year total of 297 million. Americans lost $15.9 billion to fraud in 2025, highlighting the growing consequences of personal information exposure. Existing tools, such as Have I Been Pwned, only confirm whether an email appeared in a breach, while paid services like DeleteMe offer broader monitoring and removal at a cost, leaving a gap between minimal free tools and expensive comprehensive ones. PrivacyLens addresses this gap by querying information from breach databases, data broker websites, and other publicly available sources to generate an interpretable 0-100 risk score. The Python/Flask pipeline engineers features across data sensitivity, breach frequency, and domain-based institutional risk to estimate an individual's overall privacy exposure. The web interface breaks each score into contributing factors, explains key terms and delivers risk-specific recommendations, including data-broker opt-out guidance for reducing exposure. This rule-based model serves as the baseline against which a trained ML model will be evaluated for improved accuracy.

Evaluating the Transferability of Recommender System Tunings Across Datasets

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From the 1990s to now, recommender systems have evolved from simple similarity-based filtering to artificial intelligence models trained on content and behavioral data to predict user preferences across industries such as e-commerce, social media, and entertainment. However, a major drawback of AI-based systems is the large amount of energy consumed during model training and tuning, especially when models need to be adjusted for individual datasets.We trained and evaluated a set of recommender algorithms, comparing tuned and untuned versions of each across multiple widely used datasets collected by the INERTIA Laboratory. Using Kendall's tau-b, we measured agreement between algorithm rankings across different domains and datasets to identify where results diverged or remained consistent. Our goal was to reveal which settings produced the most accurate recommendations, determine how transferable tunings were across datasets, and reduce unnecessary retuning. By sharing the most efficient tunings through the INERTIA Laboratory's open-source infrastructure, our work can help reduce the environmental impact of recommender-system experimentation, improve efficiency and reproducibility, and contribute to open-source research.

Development of a Video-Based Personal Protective Equipment Monitoring System

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In healthcare, personal protective equipment (PPE) is essential in protecting providers and patients from infection. Yet compliance remains inconsistent across hospitals due to workflow interruptions, environmental stressors, and human error. These lapses increase the risk of infections and contribute to preventable harm. This project evaluates and refines a redesigned PPE-monitoring user interface (UI) for clinical usability. By offering real-time information on the PPE compliance status of care providers, the system aims to support nurses monitoring compliance. This work contributes to safer clinical workflows by improving how PPE compliance data is interpreted and acted upon in high-stakes environments. To refine the UI design, we performed secondary analysis of two rounds of user testing with a total of 29 clinicians. The first round featured initial thoughts on the detection software, while the second round explored usage and specific features in the revised version. Based on these analyses, we proposed and prototyped new features and functions that will further improve PPE compliance monitoring. Future work will focus on refining the interface and identifying the most effective design for clinical use.

Designing PPE Reminders for Nurses in Clinical Care

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Personal protective equipment (PPE) noncompliance can increase infection risks for healthcareworkers and patients, especially in emergency care settings. This research focuses on designingand prototyping a physical PPE reminder system that supports healthcare workers before andduring patient care. Before room entry, the system displays situation-specific PPE requirements,scans for compliance, and identifies missing or incomplete items. During care, wearables conveyclear, timely reminders to providers while accounting for urgent patient needs and minimizingdisruption to clinical workflows. I analyzed two rounds of interviews with emergencydepartment (ED), intensive care unit (ICU), and transport nurses to understand how clinicalknowledge and workplace pressures influence responses to alerts. I also created a journey map ofthe donning and doffing process from patient to patient. These findings informed sketches andhigh-fidelity prototypes based on healthcare workers' behaviors, needs, and preferences. Futurework will evaluate the prototypes through usability testing. By making alerts understandable andcontext-sensitive, this project aims to improve PPE compliance and create safer environments forworkers and patients.

Evaluation of Immunomodulatory Microparticle-Conditioned Dendritic Cells for Kidney Transplantation Tolerance

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Kidney transplantation, a necessary treatment for renal failure, carries the risk of immune-mediated rejection of the transplanted kidney. This issue is combated with immunosuppressive drugs; however, these increase the risk of infection and cancer. As an alternative solution, recently developed immunomodulatory microparticles (MPs) were designed to selectively tolerize dendritic cell (DC) function via sustained release of immunosuppressive drugs to generate long-lived tolerance. This research uses mixed lymphocyte reactions (MLR) of primary human immune cells to evaluate the immunomodulatory effects of MPs loaded with a novel combination of two synergistic drugs, termed Push-Pull Immunomodulators (PPI), enabling the DCs to induce a tolerogenic response in DCs and reduce allogeneic immune activation.DCs from five donors were treated with PPI-loaded MPs and then analyzed for release of various immune markers: TNF-α, an inflammatory cytokine, IL-10, an anti-inflammatory cytokine, and IDO. Analysis was similarly repeated after MLR. PPI-MPs increased tolerogenic and decreased inflammatory response both on their own and in MLRs, supporting our hypothesis that PPI-MPs can be a more targeted therapy for transplant patients.

Engineering Adhesion Between Mechanically Laminated Layers of Perovskite Solar Cells

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Halide perovskites are one of the most promising materials for next-generation thin-film photovoltaics, offering high efficiencies, excellent defect tolerance, and low-temperature processability. However, conventional sequential deposition, metal electrode evaporation, and encapsulation remain constrained by the perovskite's chemical sensitivity and limited scalability. This work side-steps both issues via pneumatic-press lamination of a prefabricated superstrate (glass/Ni/NiO_x) onto a substrate (ITO glass/ SnO_2/$MAPbI_3$) under controlled conditions to form a reliable electronic interface for efficient charge transport in working solar cells. This approach requires sufficient interfacial adhesion to survive fabrication. Optimization of the external process layers showed that mechanically driven adhesion at the perovskite/ NiO_x contact is stronger than that between other layers; however, weaknesses at other interfaces caused undesired delamination in most cases. Iterative optimization using an epoxy adhesive achieved full-stack adhesion, enabling the study of the interface's electrical quality. This strategy offers a scalable, low-cost pathway to accelerate perovskite solar cell commercialization and advance global clean-energy goals.

Investigating Crystal Size and Purity in Reactive Crystallization

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Pharmaceutical manufacturing requires processes that produce high-quality products to ensure medicines are safe and effective. Crystallization is a key unit operation, as crystal size, shape, and purity can affect the quality and efficiency of the final product. In reactive crystallization, crystal formation is influenced by reaction progress, temperature, nucleation, and crystal growth. This project investigates the relationship between crystal size and purity using a model system of paracetamol and rhodamine dye. Temperature-controlled crystallization cycles are monitored using in situ microscopy to observe crystal formation and morphology, while high-performance liquid chromatography (HPLC) measures solution composition at selected time points. Experimental data are collected to examine how changes in reaction and crystallization conditions affect crystal size distributions and product purity. Future work will synchronize microscopy images with temperature and concentration data and explore image-based analysis and machine learning to relate crystal morphology to reaction progress. Ultimately, this work aims to improve control of reactive crystallization processes to support more efficient pharmaceutical manufacturing

Optimization of Crystallization Methods and Automation with a 6-Axis Robotic Arm

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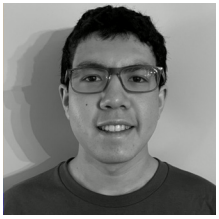
Pharmaceuticals are purified before they are commercially available to ensure user safety. Crystallization is the most widely used process for purifying pharmaceuticals and consists of dissolving an active pharmaceutical ingredient (API) in a solvent, followed by a cooling to drive the API out of solution selectively. This work investigates varying parameters such as heating-cooling cycles and cooling rates for crystallization of paracetamol and Rhodamine 6G - a fluorescent pink dye representing an impurity - to determine methods yielding the purest crystals. Impurity concentrations are quantified based on dissolving crystal samples and measuring Rhodamine 6G absorbance by a UV-Vis spectrophotometer. From these results, optimal crystallization methods are determined based on their corresponding impurity concentrations. Alongside determining optimal crystallization methods, this work also explores crystallization process automation by utilizing a programmable 6-axis robotic arm. The arm is programmed in Python to perform tasks such as weighing, scooping, and pouring the API into a crystallizer. This results in a process that is both streamlined and repeatable.

Multi-Robotic Thermal Monitoring and Fan-Based Cooling Intervention for 3D-Printed Concrete Curing



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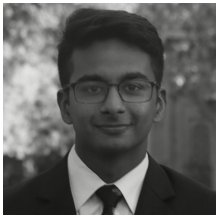
Cement hydration generates internal heat during curing, and excessive core temperatures can crack 3D-printed concrete (3DCP) before it gains strength. This project focuses on two interconnected problems: estimating core temperature based on non-contact surface measurements and intervening with a fan to reduce surface and core temperatures. The first problem is motivated because core temperature is hard to measure non-destructively, and the latter by a delay in effectiveness of the intervention. This project uses a custom-built dual-arm robotic system for real-time thermal monitoring and intervention, validated using air-dry clay as a curing material. One arm carries a thermal camera to scan surface temperature; the other a pulse-width modulator-controlled fan. Abaqus simulations estimate core temperature based on surface measurements. The model was validated against experimental core and surface temperatures under passive cooling using a calibrated thermocouple–thermal camera sensor pipeline. Fan tests at varying speeds are time-aligned against this baseline to determine how active airflow changes core cooling behavior. The results show that for all 3 fan speeds, core cooling behavior was quantitatively faster than the baseline.

Autonomous Robotic Eddy Current Inspection for Condition Assessment of Riveted Aircraft Fuselage Structures



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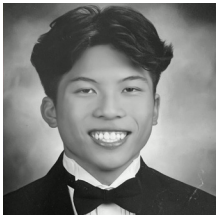
Fatigue cracking and corrosion in aircraft structures often initiate at rivet holes and lap joints, making early detection critical for structural integrity and airworthiness. Eddy current testing (ECT) is a widely used non-destructive method for detecting such defects; however, manual inspections are often inconsistent, since measurement quality depends on the operator's ability to maintain a constant probe orientation, lift-off distance, and scan speed. This study develops a robotic solution to automate eddy current inspection of riveted aircraft fuselage structures. The system integrates an eddy current probe with a UR3 robotic manipulator through a custom, 3Dprinted end effector, enabling automated scanning of curved, riveted panels. A depth camera acquires a point cloud of the surface, reconstructed as a B-spline surface. Surface normals from the fitted model generate robot waypoints that keep the probe perpendicular to the surface throughout the scan, ensuring consistent positioning and less measurement variability. The system was validated on flat aluminum specimens and a real, curved aircraft panel, demonstrating feasibility on complex aerospace structures. This work is a step toward robotic non-destructive evaluation.

Carbonated Lightweight Aggregates from Industrial Waste: Optimizing Strength for Sustainability



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Concrete relies on finite sand and gravel, while cement production is a major CO2 source. This project optimized waste-derived lightweight aggregates that could replace conventional aggregate while sequestering CO2, addressing resource depletion and emissions simultaneously. Waste blends were tested using staple percentage matrices, pelletized through a disc-pelletizer, then oven-dried and carbonated across varying durations. Crushing strength was measured fresh, dried, and dried-plus-carbonated, and analyzed with Shapiro-Wilk, Welch's t-tests, and Cohen's d to confirm significant trends. A 75% FGDG/25% Ca(OH)2 mix nearly doubled in strength after one hour of drying (1.7x) and rose further after carbonation (1.73x). A newer 75% FGDG/25% wollastonite blend was even more promising, rising from 15.4N to 32.1N after one hour of drying alone. These results show that short, low-cost processing can substantially strengthen carbon-sequestering aggregates. However, real-world implementation is complicated by environmental variability, since humidity, temperature, and weather conditions can all affect strength outcomes. As a result, global standardization and reproducibility are the primary barrier to scaling this material beyond the lab.

The Use of Microbially-Induced Calcium Carbonate Precipitation for Self-Healing Concrete and the Need for an Effective Manufacturing Solution

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It is an understatement to say we live in a "concrete jungle," as modern infrastructure is reliant on concrete due to its practical strengths; however, decades of stress on concrete materials have caused severe degradation via crack propagation and consequent chemical deterioration, reducing structural integrity in critical infrastructure. To address this, research has focused on developing technologies for autonomous self-healing concrete that extends concrete lifespan. One of these is BioFiber, which is being developed at Drexel's Advanced Infrastructure Materials Lab. BioFiber utilizes Microbially-Induced Calcium Carbonate Precipitation and fiber reinforcement. It consists of a core fiber, a hydrogel containing bacteria, and a protective responsive coating. The current method for creating BioFiber is inefficient due to time and manual labor. Several sodium-alginate concentrations were tested with a syringe, allowing for optimal ratio selection based on viscosity for design. From this data, I have been designing, modeling, and using 3D printing for an effective, small-scale manufacturing solution that streamlines the 3-part BioFiber composition, as well as testing its viability for future automation and large-scale production.

How Design Modifications Affect Corsi-Rosenthal Box Performance

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The Corsi-Rosenthal box (CR Box) is a low-cost high-performance Do It Yourself (DIY) home air purifier that uses a fan to pull air through high-performance filters, known as MERV 13 filters. This experiment investigated what happens to the Clean Air Delivery Rate (CADR), sound in decibels (dB), and cost-effectiveness, as measured by CADR/dollar, when parts of the box are modified. Five CR Boxes were constructed each roughly cubic shape (i.e., with 6 equal-sized faces) as follows: 1) a CR Box with dimensions of 20" x 20" x 20" that uses four filters, a solid base, and a box fan (Regular Box), 2) a CR Box with the same fan, base, and dimensions as the Regular Box but using filters from a different manufacturer (Alternate Filter Box), 3) a CR Box with dimensions of 10" x 10" x 10" using four filters, a solid base, and a 10" box fan (Mini Box), 4) a 10" x 10" x 10" box using four filters, a solid base, and two computer fans on the same face (Pc Box) and 5) a CR Box with dimensions of 20" x 20" x 20" mounted on a stand that allowed a filter to be placed on the bottom, such that the CR Box used five filters and a box fan on top (5 filter Box).

A Machine Learning Approach to Understanding Winter Freshwater Salinization

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Freshwater salinization is an increasing water-quality concern, mainly in regions with snowfall and road salt application. Data driven approaches have performed better in analyzing freshwater salinization compared to traditional models. Machine learning (ML) is a common data driven approach, but how it varies among different watersheds hasn't been studied. This study aims to develop ML models for predicting freshwater salinization across multiple monitoring sites with differing characteristics in the northeastern U.S.. Physiochemical & hydroclimatic data were used for ML. For geospatial analysis, land cover, urbanization, road density, & fractional impervious surfaces were characterized in ArcGIS. Random Forest & Extreme Gradient Boosting ML models will initially be trained and evaluated using python in their ability to represent nonlinear relationships between salinity and its potential drivers. Model performance will be evaluated using statistical metrics like Root Mean Square Error, R2, and NRMSE. Predictor importance will be further analyzed using explainable AI. The study is expected to improve understanding of site-specific freshwater salinization processes and support more targeted monitoring and road-salt management.

Eliminate edge AI power bottlenecks without losing accuracy - Visual Signal Processing -

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Intelligent systems and autonomous robot AI devices rely heavily on deep learning models, which continuously process thousands of calculations and massive streams of spatial data points, to navigate and understand a complex 3D world. In this architecture, chip RAM & VRAM is an engine to store and execute these heavy workloads in real time. However, the development of AI robots is severely straining hardware manufacturers, leading to the rapid depletion of physical chip RAM& VRAM capacity at the edge. Existing optimization methods are fragmented, isolating software compression from hardware constraints rather than addressing the memory bottleneck at the system level. Therefore, this research introduces a three-layer optimization hardware-software co-design framework - integrating 2.5D spatial simulation surrounding space, Spike-Transformer sparse binary computing, and a custom chip architecture - to eliminate stored data and reduce memory overhead for resource-constrained autonomous AI systems.

Detecting Brain Patterns in Newborn EEG: A Step Toward Fetal Brain Monitoring

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During labor, a baby's brain can be deprived of oxygen, and if no one detects the distress in time, the result can be lifelong injury or death. Monitoring today mostly tracks the fetal heartbeat, which only indirectly reflects how the brain is doing. Reading the brain directly would be far more informative, but this has never been practical before birth, because the brain's signal is roughly a millionth of a volt and is buried under maternal signals about a thousand times larger. Our team works toward capturing this signal non-invasively through electrodes on the mother's abdomen; my part is the detection system that finds meaningful brain patterns within the noise. I first tested whether this approach works at all, building a neural network that detects a clear, labeled pattern (seizures) in newborn EEG and confirming it reaches about 80% accuracy on recordings it has never seen. Having shown the pipeline is reliable and reusable, the same system is designed to extend toward the true goal: first recognizing the patterns of a healthy, full-term newborn brain, and then identifying the injured brain, most often harmed by a lack of oxygen during birth.

Iterative Teacher-Student Model Trained on Compositional Data

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A major problem in machine learning is limited availability of labeled data. While unlabeled data are abundant, labeling them is costly and time consuming. Semi supervised learning addresses this by using a small labeled dataset to create pseudo labels for a larger unlabeled dataset. This project focuses on microbial data, where samples represent microbial communities as relative abundances. Many microbial datasets contain measurements without classification labels, making them difficult to use for supervised learning. The goal is to develop a fast, simple, and accurate pipeline for classifying datasets using an iterative approach similar to a teacher-student model. A Random Forest model is first trained on a small labeled dataset to create a base model. Unlabeled data are then augmented using AugCoda techniques designed for compositional data. The augmented samples are passed through the model to generate pseudo labels and confidence scores. Low confidence predictions are discarded, while high confidence predictions are added to the training data. The model is retrained, and this process repeats over multiple cycles. I aim to find the best combination of training and augmentation techniques to maximize classification accuracy.

Energy-Efficient Ising Machine Embedding for 3-SAT Using Bistable Latches

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The Boolean Satisfiability Problem (SAT) is a fundamental NP-complete problem with applications in optimization across AI, operations research, and hardware design. Ising machines offer an alternative approach by mapping such problems to binary spins that minimize an energy function. This project investigates a lower-power Ising machine for solving 3-SAT benchmarks using bistable latches arranged in a two-dimensional king's graph. Unlike oscillator-based Ising machines, the latch architecture requires neither ring oscillators nor sub-harmonic injection locking (SHIL), reducing circuit complexity and inverters per spin. Bistable latches were first demonstrated to solve Max-Cut problems accurately. The Minorminer graph-minor embedding algorithm was then used to map SATLIB 3-SAT instances onto the king's graph by chaining physical spins to represent logical variables while maintaining required connections. Python, SystemVerilog, SPICE, and Cadence Virtuoso were used to generate and simulate the circuits. The resulting Ising embedding achieved an average 3-SAT clause success rate of approximately 92%, demonstrating a pathway toward compact, locally connected Ising hardware with reduced power usage.

Assessing Performance and Scalability in One All-to-All Oscillator-Based Ising Solver Architecture

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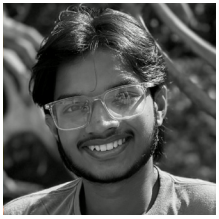
Oscillator-based Ising machines (OIMs) prove an effective, semiconductor based alternative to expensive and noise sensitive quantum computers in solving quadratic unconstrained binary optimization (QUBO) problems. OIMs rely on the phase of an oscillator (node) to determine the binary state of a variable (equivalent to a quantum spin). For a problem, interactions between nodes are calculated such that the spins at the ground state of the system of oscillators are a solution to the problem. The difficulty in creating these OIMs is determining how to organize and connect nodes to minimize time, resources, and power.In this work, one all-to-all OIM chip architecture (all nodes connected to every other node) is benchmarked in Cadence against various sizes of 3SAT QUBO problems. Benchmarks identified issues around the scalability of the architecture, including a ~70 ps increase to wave period per node and a quadratic relationship between power draw and node count. Analysis of the architecture finds that the count of inverters used to buffer couplings between nodes increases with every node, introducing more delay and power draw. These results allow for direct comparison of this architecture to other OIM implementations in literature.

Accuracy and Latency of Small Language Models in Multi-Agent Simulations



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As artificial intelligence rapidly advances, engineers have harnessed it for real-world applications like drone swarms used in wildlife monitoring and search-and-rescue operations. My research explores whether small, locally run AI models can safely control flocks of robots traversing in specified formations. Unlike large models such as GPT or Claude, smaller models are cost-effective and run with lower latency but are more prone to inconsistencies. I simulated decentralized multi-agent formations through compact Qwen models via Ollama and vLLM. To understand the inconsistencies, I prompted the AI to provide chain-of-thought (CoT) reasoning. Through numerous tests, I analyzed each agent's movement logs and geometric outputs to identify recurring failures, including incorrect coordinate geometry, flawed centroid placement and divergence between an agent's CoT reasoning and its final output plan. Through the CoT, I found that agents displayed logically valid steps but performed calculations incorrectly or fabricated results entirely. These findings highlight weaknesses of smaller, faster AI models, but plans for fine-tuning offer a promising outlook for their mathematical reliability, crucial for real-time AI-powered robot swarms.

Autonomous Traffic Control for Smart Cars

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This project aims to autonomously direct traffic in zones that normally require flaggers, and it uses a live camera feed and object detection software to analyze vehicle positions to determine how to direct traffic. It communicates with cars using a screen displaying red or green to signal stop or go. One application is a two-lane road with one lane closed for road work. Here, the system can communicate with autonomous cars and drivers while lowering the need for human flaggers. This frees personnel for other tasks, which could lower human error.

The project has progressed substantially. The test robot's hardware has been upgraded to support the system's software, it has been programmed to respond to green or red lights detected by its camera, and the full pipeline for real-time autonomous vehicle detection on the road has been developed. Already, this technology is significant because it may be the foundation of the solution to modern self-driving car technology's lack of preparedness for unusual traffic situations. If successful, this design could greatly improve the performance of autonomous cars while reducing the need for human flaggers in road work areas.

Synthesis and Photocatalytic Performance of Tantalum Oxynitride

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Dr. Jill Wenderott
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Tantalum oxynitride (TaON) is a promising semiconductor compound due to its proficiency at visible light absorption, stability, and appropriate band edges. Unlike conventional metal oxide photocatalysts that are activated by ultraviolet light, oxynitrides have tunable optical and electronic properties that can extend light absorption and increase the efficiency of catalytic activity using abundant visible light. This research investigated both the synthesis and photocatalytic activity of TaON to establish a relationship between performance and factors such as synthesis temperature, molar ratios of reactants, structure, and surface area. TaON samples were synthesized via traditional ammonolysis and via a calcium-assisted reaction that circumvented the use of corrosive and toxic ammonia gas. By varying different molar ratios of precursors, it was found that increased calcium reduces nitridation. In addition, using the organic dye 1H-benzotriazole (BTA), TaON's capability to absorb light, react, and break down dye was quantified through changes in dye absorbance intensity. It was found that TaON produced from a maximum ammonolysis temperature of 1050 K was the most effective at photodegrading BTA.

The investigation of polymer composites and coffee grounds

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As plastic pollution continues to increase, biodegradable polymers are being investigated as alternatives to conventional plastics. Polyhydroxybutyrate (PHB) and poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHB-HHx) are biodegradable polyesters produced by microorganisms and have potential applications across industries. In this study, used coffee grounds were incorporated into PHB and PHB-HHx to investigate the potential to enhance degradation of polymer composites. The natural oils and compounds in coffee grounds may influence the properties and degradation of the resulting polymer composites.

The degradation of I-bar samples containing PHB or PHB-HHx, coffee grounds, and plasticizers was evaluated using an at-home composting system. Plasticizers were incorporated to improve the flexibility and durability of the composites, decreasing their crystallinity allowing them to better withstand deformation. Future plans could investigate injection molding of these composites for larger-scale manufacturing, as well as evaluating the biotoxicity of the resulting compost and its effects on plant growth. These studies could provide insight into the environmental impact and applications of biodegradable coffee-ground polymer composites.

Implementing Coffee Grounds in Biodegradable Material

Gavi Spanier

Pennoni Honors College
Custom-Designed Major

Dr. Caroline Schauer
Faculty Mentor
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With an increase in plastic pollution, bioplastics and their composites are becoming an increasingly sought after alternative. Polyhydroxybutyrate (PHB) and poly(3-hydr oxybutyrate-co-3-hydroxyhexanoate) (PHB-HHx) are forms of natural polyester derived from microorganisms, and pose as promising biodegradable materials. Literature exists on the properties of PHB and PHB-HHx, but there is minimal research on incorporating food waste as a composite into these materials. An estimated 6-8 million tons of waste is generated annually from coffee production, but combining spent coffee grounds into biodegradable material, such as PHB and PHB-HHx, is one avenue to divert this source of waste away from the landfill, as is composting. Using an at-home composter, we studied how the machine digested I-bar samples of PHB and PHB-HHx combined with coffee grounds and plasticizers. Through studying how these mixtures degrade, one can better understand the lifecycle of these materials, and their ability to be broken down at a non-industrial scale. Further studies may entail more mechanical tests, and investigating the ecological impact of our materials.

Optimization of Emissivity for Different MXene Thin Films

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MXenes, which are a family of 2D transitional metal carbides and nitrides discovered at Drexel in 2011 have had a massive impact on Materials Science. The field of application of MXenes ranges from energy storage and sensors to biomedical and water purification. They exhibit unique properties such as high electrical conductivity, hydrophilicity, flexibility, and chemical tunability. Additionally, MXenes have low emissivity, and are thermal insulators. By minimizing the outward flow of heat, these materials can be tuned for special applications with radiative heat loss and IR reflectance. Several types of MXenes were tested through differing ratios of carbon and defects as well as altering concentrations. The emissivity was measured by spray coating films of the MXene ink on a glass substrate and examining it under FTIR (Fourier Transform Infrared) and XRD (X-ray Diffraction) spectroscopy. The coated substrates were heated by a hotplate and viewed under a thermal camera at varying temperatures. Results from the different types of analyses show a peak of 63.58% reduction in temperature and around 0.55 emissivity. Coatings with low emissivity can be applied to fields such as defense and aerospace to electronics and textiles.

Optimizing Dry Battery Electrode Fabrication: Mechanical Twin Screw Extruder Fitting and Automated Digital Image Correlation

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André Matthew Tayamen
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For my research under Dr. Wesley Chang during this program, I worked on two projects focused on dry battery electrode manufacturing. Majority of my focus was on a twin screw extruder, where I designed and 3D-printed several iterations of a back bearing plate using a Bambu A1 printer and used various tools to adjust parts so they helped the extruder run smoothly.

Alongside the extruder work, I also worked on an automated camera system that measured how much an electrode stretched or shrank after being pressed. We put a black piece of electrode tape next to a small reference tape on a white surface, used terminal commands to take pictures with a Canon camera, and ran a Python script that counted the pixels to calculate the area and physical dimensions. The code previously got within about 10% accuracy, so my goal for this project was to fix up the script and setup to get that measurement accuracy down to 2%.

Martian Regolith MGS-1 Thermal Analysis for In-Situ Resource Utilization

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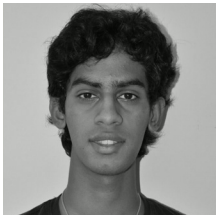
Mechanical Engineering and Mechanics

As NASA begins their Moon-to-Mars strategy through the recent launch of Artemis II, researchers begin to consider methods to make long-term human colonization of Mars and other non-terrestrial bodies feasible. Due to astronomical costs and logistics of Earth based shipment in combination with maintaining sustainability for interplanetary existence, Martian colony development cannot entirely depend on Earth's resources. The primary solution to eliminate this dependency is in-situ resource utilization (ISRU). Before ISRU can be implemented, Martian material must be proven sustainable for colonization through various environmental tests. This study analyzes the thermal properties of Martian regolith type MGS-1 simulant and epoxy composite material, specifically thermal conductivity and specific heat capacity. These properties are obtained for neat epoxy, 10%, and 20% Martian regolith composite by volume, using ASTM E1225 and ASTM C351 standard samples sizes for each test respectively. The objective of this study is to gain a deeper understanding of Martian regolith composites' thermal properties and determine its ISRU viability in Martian construction and manufacturing applications.

Modular Auxetic Cell Robots: Achieving Decentralized Locomotion via Cuboctahedron-Based Unit Cells



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Modern robots are complex mechanical machines that rely on a multitude of parts working together to achieve functionality. However, a single mechanical failure can render a robot unusable — and in disaster rescue or space exploration, failures like these can be fatal. Inspired by nature, this project seeks to create modular robots, much like biological cells that combine to form complex living organisms, so that robots can keep functioning even when individual cells fail. Using an auxetic cuboctahedron mechanism actuated by a servo motor, we created a unit cell that expands uniformly in all directions through internal rotational movement, growing from 40mm to 68mm in diameter while manipulating three axes simultaneously for predictable, controlled motion. Controlled using Arduino microcontrollers, we developed a two-celled system that reliably crawled forward and sideways by timing expansion and contraction cycles between cells. These results demonstrate that decentralized, cell-based coordination can produce reliable locomotion without a central mechanical structure, laying the groundwork for larger, more fault-tolerant robotic systems suited to unpredictable environments such as disaster zones or extraterrestrial terrain.

Laser-Induced Graphene Soft Actuators: Optimizing Aspect Ratio Under Fixed-Voltage Benchtop Testing

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Soft, heat-driven bilayer actuators offer a lightweight alternative to electric motors, providing customizable motion for soft robotics. Actuation depends on layer thickness, which governs thermal mass and stiffness mismatch driving bending, making uniformity critical for predictable motion. While cleanroom fabrication relies on spin-coating for uniform thickness, benchtop methods like gravity draining offer a low-cost alternative. Timoshenko bilayer beam theory offers an idealized baseline, predicting that bending scales with leg length under constant thermal input and uniform thickness. This study evaluated how leg aspect ratio (5:1-8:1, constant 6mm width) influences actuation in hand-fabricated PI/LIG/PDMS actuators at 25V. Since trace resistance increases with leg length, fixed-voltage operation delivers less power to longer legs, deviating from theory's monotonic prediction: deflection peaked at 6:1 (10°) before declining at 7:1 (4°) and 8:1 (2°), while 5:1 showed localized thermal degradation. These results identify 6:1 as the empirically optimal geometry under fixed-voltage benchtop operation, offering practical design guidance for accessible, soft robotic actuators.

FRANCIS VELAY FELLOWS

The 2026 STAR Scholars cohort includes our 11th cohort of Frances Velay Fellows, thanks to the generous support of the Panaphil Foundation. This year's cohort of 12 women in STEM are participating in the full STAR experience, including faculty-mentored research, while also having the opportunity to engage with each other in weekly meetings throughout the summer. These sessions have included meetings with women in STEM mentors. Through this program, we are able to provide these exceptional young women with the structure and time to reflect on what it means to be a woman in STEM, to help them build their identities as women in research, and to introduce them to others at Drexel who support and encourage them in their future goals.

The Frances Velay Fellowships have been created in the memory of Frances Velay, a remarkable scientist, artist, musician, and citizen, to assist undergraduate women in the Greater Philadelphia area increase their opportunities to pursue science careers. This opportunity is provided to support individual research efforts in the hope that the Fellowship recipients will embody the spirit and determination Frances Velay brought to her work and life.

This program is jointly managed by the Center for Advancement of STEM Teaching and Learning Excellence (CASTLE) and Undergraduate Research & Enrichment Programs. We would like to thank the Panaphil Foundation for their generous support of undergraduate research and women in STEM, as well as the faculty mentors, graduate students, and industry professionals who come together to support these exceptional women.

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SPECIAL THANKS

We would like to extend our sincere gratitude to all Faculty Mentors, Graduate Students, and others at Drexel University who have helped teach, guide, and mentor these STAR Scholars.

The STAR Scholars Program helps shape these students' academic and profesional futures for years to come, and it would not be possible without your participation.

We applaud and thank you.


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