2025 Summer Conference

Office of Undergraduate Research

July 31, 2025

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Office of Undergraduate Research

Keri Swaby

Director of Undergraduate Research

Welcome to the 14th annual Summer Research Conference at Virginia Tech being hosted by the Office of Undergraduate Research (OUR)! Today we welcome 197 presenters from 27 organized funded programs and many independent labs, who will give 177 poster presentations. Over the course of the past 10 weeks, these undergraduate students from Virginia Tech and across the country have been engaged in a wide variety of projects tackling real world problems in many disciplines. As always, I am humbled by the quality of the work on show today and invite you to enjoy and marvel at the wealth of research that took place this summer.

I would like to extend an extra special welcome to our colleagues and their research students from Hollins University in Roanoke, VA. We are so excited that you are a part of this event today… welcome!

Throughout the summer, the OUR offered comprehensive professional development programming that would not have been possible without the expertise and time of several generous colleagues. I would like to thank: Dr. Nikki Lewis (Honors College), Dr. Donald Conner (VT Environmental Health and Safety), and Dr. Lisa Lee, Dr. Regina Allen, Dr. Stephanie Trout, and Dr. Lacey Mize Doyle (Virginia Tech Training and Compliance) for setting the stage and providing students with critical information during our summer orientation session; Amanda MacDonald (University Libraries) for providing students with valuable training through the online Advanced Research Skills Program as well as a seminar on writing proposals and creating an effective poster; and a number of faculty and students who offered a variety of seminars and workshops throughout the summer including Dr. Lisa Lee (Virginia Tech Training and Compliance), Jenn Million (VT Graduate School), Kelsey Reed, Suzanne Shelburne (Career and Professional Development), Dr. Paul Heilker (Honors College), and Monica Hunter (MAOP). Thank you all for sharing your expertise and insights with our summer students.

This summer was not only about research and professional growth, but also about having fun! A special thank you to our energetic peer mentors – Shirin, Thiviya, and CJ - who offered activities throughout the summer and were instrumental in building a vibrant research community. Without these dedicated mentors, this summer would not have been as fun and engaging for everyone.

An especially big thank you to Nicole Bottass and Truitt Elliott, who were instrumental in planning and supporting all OUR activities throughout the summer!

We would not have been able to offer programming and events throughout the summer, including today's symposium, without the generous financial support of the Fralin Life Sciences Institute, the Institute for Critical Technology and Applied Science, and Dr. David Schmale who wrote the Office into his IRES grant. Thank you!

Researchers, congratulate yourselves on a productive summer! I hope you have been inspired to continue exploring and growing. Good luck in coming academic year!

Sincerely,
Keri Swaby
Director, Office of Undergraduate Research

Brian D. Badgley, Ph.D.

Brian Badgley is an Associate Professor of environmental microbiology in the School of Plant and Environmental Sciences at Virginia Polytechnic Institute and State University. His group conducts research at the intersection of environmental microbiology with soil and water quality, focusing on two broad areas. The first area is relationships between microbial community structure and ecological functions such as nutrient cycling. The second area relates to microbial transport and water quality, with a specific focus on the fate and transport of pathogens and fecal indicators at the watershed scale. They strive to develop highly collaborative and interdisciplinary projects, working with a variety of colleagues from ecology, engineering, agriculture, chemistry, and public health. He is an active member of the American Society for Microbiology and currently the VA representative to the Council on Microbial Sciences within ASM.

Dr. Badgley holds a B.S. degree in Zoology from the University of Georgia and an M.S. degree in Marine, Environmental, and Estuarine Science from the University of Maryland. He received his Ph.D. degree in Biology from the University of South Florida and completed post-doctoral training at the University of Minnesota.

SUMMER RESEARCH PROGRAMS AT VT
PROGRAM DIRECTORS

DATA SCIENCE FOR THE PUBLIC GOOD REU PROGRAM
Research and Extension Experiential Learning Program
Le Wang, Ph.D. (Director)
Data Science for the Public Good brings teams of undergraduate and graduate students together to collaborate with faculty to address real-world societal issues. During the summer at Virginia Tech, the teams conduct research at the intersection of statistics, computation, and social sciences to determine how to leverage information to improve quality of life and support evidence-based decision-making in a wide range of domains. Our team-based experiential learning approach develops the problem-solving, leadership, and technical skills necessary for a new generation of leaders in food, agriculture, and community development. The project-focused program exposes students to how data science tools are applied to meaningful research problems confronting agriculture and rural communities, and how to interact and present their reports to Virginia Cooperative Extension and external stakeholders across various sectors.

Economics Summer Research Program
Director: Jadrian Wooten
Our faculty are engaged in a wide range of research areas, including data analytics, social network theory, the economics of education, and more. Students participating in our summer research program are paired with faculty mentors and work as research assistants over a two-month period. Given the breadth of topics and methods used in economics, students of varying skill levels can meaningfully contribute—whether by summarizing academic literature, assisting with data collection, or engaging directly in the empirical research process. The goal is to expose students to the tools and questions that drive modern economic research while contributing to active faculty projects.

FBRI CardioSURF
Director: Dr. Jamie Smyth (FBRI + VT Biological Sciences)
Manager: Dr. Alexandria Pilot-Chambers (FBRI)
The American Heart Association Fralin Biomedical Research Institute at VTC cardioSURF program gives students the opportunity to participate in hypothesis-driven independent research at Fralin Biomedical Research Institute at VTC in Roanoke, Virginia. In addition to completing a ten-week research project within a laboratory at FBRI, students will participate in a weekly workshop series to provide hands-on experience in the cutting-edge imaging technologies implemented in cardiovascular research and housed within FBRI to understand appropriate application of each technology. From functional magnetic resonance imaging of their own brains to echocardiography right down to single-molecule imaging techniques, we provide a multi-disciplinary experience for students to understand appropriate implementation

of imaging techniques in answering critical biological questions related to cardiovascular disease. The CardioSURF program is funded by the American Heart Association.

FBRI neuroSURF
Dr. Alexandria Pilot-Chambers (Fralin Biomedical Research Institute at VTC)
The FBRI neuroSURF program is a 10-week long program that gives VT and non-VT undergraduate students the opportunity to participate in independent translational neurobiology research at Fralin Biomedical Research Institute at VTC in Roanoke, VA. The program encompasses a full time, 40 hour weekly schedule and supports neuroSURF students with a competitive stipend. Housing will also be providing at no cost to the students. In addition to independent research, the program includes coursework in translational neurobiology, mentoring on science communication and presentation skills, and professional development and DEI events and activities. neuroSURF students participate in the VT symposium and FBRI symposium at the end of the program.

FRALIN SUMMER UNDERGRADUATE RESEARCH FELLOWSHIP (SURF)
Keri Swaby (Office of Undergraduate Research)
The Fralin SURF program is a 10-week training program designed to give motivated Virginia Tech undergraduates the opportunity to engage in full time research in the life sciences and related professional development activities that mirror graduate training. The goal is to offer students experiences that will help them determine if they want to pursue a career in research while they develop skills for graduate school. A unique component of the program is a specially designed Communicating Science series. For over ten years, at least 15 exceptional students from a variety of majors have been selected to participate in this competitive program each year. This program is funded by the Fralin Life Sciences Institute.

Gray Undergraduate Research Summer Research
Director: David Gray
The Gray Undergraduate Research (GrayUR) Summer Program provides students the opportunity to work individually or in small interdisciplinary teams on ongoing research projects. These projects are typically selected from the GrayUR portfolio, which runs during the academic year, and span areas such as AI for residential HVAC systems, prognostic health monitoring, and standoff optical detection systems. Summer participants contribute to persistent, long-term efforts and often work closely with returning students.

Due to the structure and funding limitations of summer research, most positions are unpaid, though efforts are ongoing to secure funding for both student compensation and faculty summer salary. Participation is typically arranged on a case-by-case basis through direct communication, and students are selected based on interest, experience, and project needs. While preference is given to returning GrayUR members, summer can serve as a launchpad for new teams to begin work ahead of the fall semester, particularly during early stages of recruitment or focused technical development.

Hume Center Summer Internship Program
Director: Ehren Hill and Sarah Downer
During this 10-week summer cohort, graduate and undergraduate interns perform novel research as a team member on existing projects with real-world stakeholders and use cases. Interns receive individual mentorship from experienced, technical researchers while sharing a summer research experience with a diverse cohort of students. Their work directly contributes to the national security and domestic prosperity of the nation.

MULTICULTRUAL ACADEMIC OPPORTUNITIES PROGRAM (MAOP)
Monica Hunter (Director)
Laila Kirkpatrick (Assistant Director)
MAOP Undergraduate Summer Research Internship (SRI)
Launched in Summer 1993, the MAOP Undergraduate Summer Research Internship (SRI) has provided a valuable opportunity for hundreds of undergraduate students from a wide range of personal, academic, and cultural backgrounds. The program allows participants to engage in faculty-mentored research on campus over a ten-week period (late May through late July/early August), where they design, conduct, and present original research projects.
A key goal of the SRI program is to introduce students to graduate education and support their academic development. Many former participants have gone on to earn advanced degrees at Virginia Tech and other institutions, strengthening representation across academic disciplines and professional fields.
We extend our sincere thanks to **Fincantieri Marine Group (FMG)** for partnering with MAOP for a 3rd year to support three students through summer research projects and scholarships. FMG, a subsidiary of one of the world's largest shipbuilders, brings deep industry knowledge and innovative solutions to shipbuilding, repair, and conversion for both government and commercial clients.

CENTER FOR NEUTRINO PHYSICS REU
Professor Thomas O'Donnell (Director)
Betty Wilkins (Coordinator)
Our physics faculty are engaged in a broad spectrum of research within neutrino experimental and theoretical physics, including dark matter, the search for sterile neutrinos, phenomenology studies, and the study of neutrino spectrum from nuclear reactors. In this rich intellectual environment, the REU students will have the opportunity to pursue independent and productive activities, guided by an established team of faculty members together with postdocs and graduate students.

STUDENTS TRANSFORMING ENERGY AND ENVIRONMENTAL RESEARCH (STEER)
Amanda Morris (Director)
Madeline Alford (Coordinator)
The Department of Chemistry at Virginia Tech, in collaboration with the National Science Foundation (NSF), presents a **Research Experience for Undergraduates (REU)** program

titled **Students Transforming Energy and Environmental Research (STEER)**. STEER will bring together undergraduate students with faculty and graduate student mentors to address the grand challenges in chemistry. STEER research will lead to advances in energy storage, energy-relevant catalysis, rare-earth element management, and green chemistry. Students will conduct research with diverse investigators at the forefront of their fields, including batteries, solar fuels, water purification, mineral sequestration, catalysis, and synthetic methodology. University partners and experts in scientific communication, leadership, career development training, grantsmanship, and community outreach for REU student professional development will be utilized to enrich the students.

Summer Undergraduate Research Fellowship (SURF@Hollins) Program
Dr. Jeanne Jégousso & Dr. Molly Lynch (Co-Directors)

SURF@Hollins offers a unique, intensive summer experience for a select group of students to engage in collaborative research with faculty mentors. Participants receive a stipend and summer housing, and work within a supportive cohort model that fosters academic growth and community. Open to students from all academic divisions, the program culminates in an "action plan" that typically includes a formal report and presentation highlighting their research and learning journey.

SCHOOL OF NEUROSCIENCE SUMMER UNDERGRADUATE RESEARCH FELLOWSHIP (SURF-N)
Dr. Lina Ni (Associate Professor, VT School of Neuroscience)

The VT School of Neuroscience offers a vibrant research environment with faculty covering essentially every area of contemporary neuroscience. Our faculty's expertise spans a variety of experimental approaches, ranging from molecular and cellular neuroscience, neurochemistry, pharmacology, behavioral neuroscience, and brain imaging. The competitive summer fellowship program provides VT undergraduate students with 10 weeks of full-time research experience in a neuroscience laboratory, which allows them to contribute to research projects under the direction and leadership of a faculty mentor and gain valuable experience in data presentation at the end of the summer.

Space Weather REU
Joseph Baker

The Space Weather REU (Research Experiences for Undergraduates) is a 10-week summer program that brings together 3-5 undergraduate students to learn about the physics of space weather, how to analyze space physics datasets using the Python programming language, and do cutting-edge space weather research. The program is hosted by the Center for Space Science and Engineering Research (Space@VT) on the Virginia Tech main campus in Blacksburg from late May to early August. A particular emphasis is to analyze SuperDARN (Super Dual Auroral Radar Network) HF radar measurements of ionospheric plasma convection in conjunction with other ground- and space-based datasets, as well as numerical simulations and empirical models. The overarching goal is to improve our understanding of space weather influences and how they can adversely affect modern society.

UNDERGRADUATE BIOTECHNOLOGY RESEARCH FELLOWSHIP PROGRAM

Keri Swaby (Office of Undergraduate Research)

Funded by generous donations to the Fralin Life Sciences Institute (FLSI), the Biotech Fellowship Program supports up to 12 students each summer to participate in full-time undergraduate biotechnology related research with a faculty member or local biotech company.

Undergraduate Research on the Nucleation in Austria

David Schmale (Director)

This paid summer NSF International Research Experiences for Students (IRES) program supports undergraduates in conducting research on ice nucleation in Austria. The program begins with pre-departure training and peer mentoring in the Schmale Lab at Virginia Tech, followed by about seven weeks of hands-on research in the Grothe Lab at the Technical University of Vienna. Students engage in laboratory and field studies exploring the properties and behavior of ice-nucleating particles. After returning to Virginia Tech, they complete post-trip activities including data analysis, research presentations, and participation in the Summer Undergraduate Research Symposium at Virginia Tech.

VIRGINIA TECH RESEARCH AND EXTENSION EXPERIENTIAL LEARNING PROGRAM: SECURING OUR FOOD (VT-REEL)

Drs. Sasha Marine (BCHM) and Hunter Frame (SPES)

Virginia Tech's Research and Extension Experiential Learning (VT-REEL) program on Securing Our Food is a research-intensive, 10-week summer experience, which engages undergraduate students in translational plant science research via a combination of hands-on laboratory and field-based experiences. Each VT-REEL fellow is mentored by two faculty members, who are located on-campus and/or at an Agricultural Research and Extension Center (AREC). Five undergraduate students pursuing bachelor's degrees in Virginia, Maryland and Oregon were chosen to participate in the 2025 summer program. In addition to their individual research projects, fellows also participated in a "big data" workshop series. Faculty mentors were affiliated with the School of Plant and Environmental Sciences, Department of Biological Sciences, Department of Entomology, and Hampton Roads AREC. Funding is provided by the USDA-NIFA, with next year being the final year of the program.

VTCSOM Early Identification Program (EIP)

Director: Dr. Melanie Prusakowski (Associate Dean of Admissions, Virginia Tech Carilion School of Medicine)

Coordinator: Katherine Murphy (Admissions Operations Manager, Virginia Tech Carilion School of Medicine)

The Virginia Tech Carilion School of Medicine's Early Identification Program is a two-year summer enrichment program designed to assist undergraduate students in becoming competitive applicants to medical school. The first summer of the program provides participants the opportunity to engage in ten weeks of hypothesis-driven research at the Fralin

Biomedical Research Institute through the Summer Undergraduate Research Fellowship program. The second summer, selectees participate in six weeks of clinical experiences through Carilion Clinic as well as application counseling and MCAT preparation and tutoring.

INFORMATIONAL BOOTHS

We invite you to talk with representatives from several graduate programs, from across Virginia Tech's Blacksburg, Roanoke, and National Capital region campuses.

VIRGINIA TECH GRADUATE SCHOOL

ENVIRONMENTAL HEALTH AND SAFETY

SCHOLARLY INTEGRITY AND RESEARCH COMPLIANCE

Thank you, OUR Summer Peer Mentors!!

Schedules, Map and Abstracts

Aaditi Adhikari
Hollins University/Economics
Samragyi Karki
Hollins University/Applied Economics

Key Digital Literacy Elements and the Effectiveness of E-governance: A Case Study Examining the BRICS Alliance

Defined as the application of information and communication technologies (ICTs) for delivering government services, exchange of information, communication transactions, and integration of various stand-alone systems and services, e-governance has become a vital tool for modern public administration. However, much of the existing research on the scope, efficiency, and equitable use of e-governance centers on high-income countries, overlooking how factors such as digital literacy, access to ICT infrastructure, and trust in e-government services uniquely shape the adoption and uneven e-governance growth across low income and emerging market economies.

Our study offers a survey of leading sources around digital divide and e-governance, guided by interdisciplinary frameworks including the Capability Approach, Structuration Theory, Sociotechnical Systems Theory, and the Technology Acceptance Model. This study analyzes the digital development patterns of BRICS countries from 2000 to 2024 by applying K-means clustering to reveal temporal trends and using pooled cross-sectional multiple linear regression, with the E-Government Development Index as the dependent variable, to identify key drivers of e-governance adoption. Preliminary regression results indicate that key factors such as internet access, education, trust in government, and GDP per capita collectively explain nearly 94% of the variation in e-governance development across BRICS nations, highlighting their significant influence on digital governance adoption. These findings help reinforce our understanding that the relationship between digital divide parameters and e-governance adoption is most suitably addressed through a multidirectional understanding on how digital literacy influences citizens' use of e-governance platforms, which in turn shapes ongoing policy development and system design.

Mentor(s): Pablo Hernandez (Business and Economics, Hollins University)

Shambhavi Adhikari
Virginia Tech/Clinical Neuroscience

Brain injury exacerbates Lewy body pathology in cortical regions of the brain independent of T-cell activation

Parkinson's Disease (PD) is a neurodegenerative disease characterized by both the accumulation of Lewy bodies derived from misfolded alpha-synuclein (α-syn) proteins and the consequential loss of dopaminergic (DA) neurons in the substantia nigra (SN). Traumatic brain injury (TBI) is a known risk factor for the development of PD and induces the activation of neuroinflammatory pathways, including the infiltration of adaptive immune cells into the brain, similar to what is observed in PD patients. However, not much is known about how TBI and its associated neuroinflammatory events may affect α-syn pathology outside of the SN. In this study, a preclinical-mouse model involving intrastriatal injections of α-syn preformed fibrils (PFF) was used to assess how mild TBI (mTBI) may impact α-syn fibril pathology in the ipsilateral cortex. In addition to looking at whether mTBI drives difference in PFF-associated α-syn propagation, we also looked at whether in vivo depletion of immune T-cells impacts α-syn propagation in the ipsilateral cortex, as we have shown that the depletion of T-cells following mTBI is neuroprotective of DA neurons in the SN. We found that mice who received mTBI prior to PFF had an increased Lewy body load in the cortex. However, depletion of T-cells was shown to be insignificant on α-syn pathology load in the cortex. These results suggest that mTBI increases the severity of PD associated α-syn pathology beyond the SN, but the depletion of T-cells does not appear to ameliorate these differences, despite providing neuroprotection of DA neurons in the SN.

Mentor(s): Alicia Pickrell (School of Neuroscience)

Hannah Aerni
Virginia Tech /Computer Science

Investigating How Self-Guided Mental Health Apps Aid Students

College students are susceptible to mental health disorders, with increasing numbers of negative mental health symptoms over the years. COVID-19 and other events have left lingering impacts, one of which is the increased use of digital services such as financial services, e-commerce, online education, and mobile health, also known as mHealth. Self-guided mHealth applications offer an accessible, affordable, and discreet way to personally handle one's mental well-being in unique ways. This qualitative study examines the ways mobile health (mHealth) can bring comfort and compassion to students. This project aims to examine the following research question: What are the experiences of students using (or have used) mental health applications? Interviews conducted with student participants aim to gain insight on the experiences college and graduate students have with mHealth applications. With thematic analysis as the qualitative data analysis approach, recurring patterns can be identified to conceptualize the features in mHealth applications that are helpful, as well as what makes certain applications more appealing for personal mental growth. By identifying key features from different experiences, this project analyzes the aspects of mHealth that aids in self-guided mental health regulation.

Mentor(s): Qin Zhu (Engineering Education)

Ma'at Ahmed
Old Dominion University/Chemistry

An Investigation of Socioeconomic Factors Influencing Dietary Adherence in Cancer Patients

Approximately 40% of both men and women in the US will develop cancer during their lifetime. While dietary management has been shown to be a critical component in oncological care, some patients struggle with implementing nutritional guidelines. Socioeconomic factors may also play a role in dietary adherence and satisfaction. This study investigates the relationship between socioeconomic factors and nutrition related factors during cancer treatment. An online survey administered through Prolific was completed by 49 individuals who had undergone cancer treatment within the previous four years. Participants completed a survey containing questions about demographics, nutritional intake, dietary changes, satisfaction with nutrition-related care, and perceived barriers to meeting dietary goals during treatment. Results report on this outcome by socioeconomic status. These findings are informative for tailoring dietary interventions and improving cancer patient care. Future cancer care efforts should prioritize accessibility, education, affordability, and quality to promote equity across diverse populations.

Mentor(s): Roberta Freitas-Lemos (Fralin Biomedical Research Institute)

Alana Alexander-Giles
UMES/Pre-vet

MRI Canine Gliomas

Gliomas are the second most common primary brain tumors in dogs, with astrocytoma and oligodendroglioma being the two predominant subtypes. Despite their clinical significance, distinguishing between these tumor types and their respective grades using non-invasive diagnostics remains a challenge in veterinary neurology. This study aimed to evaluate whether specific magnetic resonance imaging (MRI) features differ significantly between glioma types and grades in canine patients, with the goal of identifying reliable imaging biomarkers to aid in antemortem diagnosis of tumor types and grades in dogs with gliomas.
A retrospective analysis was conducted using MRI data and medical records from canine glioma cases at a single university hospital between 2013 to 2024. A standardized scoring rubric was applied to MRI data to assess tumor characteristics including midline shift, surrounding edema, signal heterogeneity, hemorrhage, border definition, mass effect, contrast enhancement, diffusion restriction and cystic or necrotic changes. The Wilcoxon rank-sum test was used to compare the differences between tumor types (astrocytoma vs. oligodendroglioma) and grades (high vs. low).
A total of 50 cases were identified. The results demonstrated that astrocytoma had significantly higher scores for surrounding edema ($p = 0.0153$), signal heterogeneity ($p = 0.0099$), and mass effect ($p = 0.037$) compared to oligodendrogliomas. Additionally, cystic or necrotic changes were more prominent in high-grade tumors than in low-grade ones ($p = 0.0056$).
These findings suggest that certain MRI features may be useful in differentiating tumor subtypes and grades in dogs with glioma, offering important clinical relevance in cases where histopathological diagnosis is not feasible. This study contributes to the growing body of literature emphasizing the diagnostic potential of MRI. Future research will aim to integrate these findings with clinical outcomes to improve prognostication in canine glioma patients.

Mentor(s): Go Togawa (Veterinary Medicine)

Dilan Angeles
Virginia Tech/Biochemistry

Tracking COVID in Leaky Pipes: SARS-CoV-2 Wastewater Surveillance and Dilution Signals in Rural Appalachia

Wastewater based epidemiology (WBE) tracks pathogen and chemical markers in sewage to provide community wide, pre clinical warning of outbreaks—a value proven during COVID 19. Most research, however, focuses on large urban utilities, leaving rural systems with data gaps and chronic infiltration and inflow (I&I), which is unwanted water entering a sanitary sewer system, that can dilute signals and mask trends. We addressed this gap by monitoring a southwest Virginia sewershed from September 2022 to August 2023. Monthly influent and up sewer samples were filtered, nucleic acids extracted, and viral (Hep A, Hep C, SARS CoV 2) plus human fecal (crAssphage, HF183, mtDNA) targets quantified via droplet digital PCR. Physicochemical proxies, especially chemical oxygen demand (COD) and dissolved oxygen were analyzed together with rainfall and groundwater data classified I&I severity by site. Model analysis on signal loss showed redundant coverage, so the network of sample sites was reduced in 2024. SARS CoV 2 RNA appeared in almost every treatment plant sample and most up sewer sites, making it the most consistently observed target during the 2024 sampling campaign. Higher COD slightly raised SARS CoV 2 concentrations, whereas higher dissolved oxygen lowered them; heavy rain reinforced this dilution pattern by sharply reducing COD. SARS CoV 2 remains a robust marker even under I&I, but enteric viruses lose strength more readily, so upstream sampling or extra normalization steps are needed in highly leaky systems. Real time checks of COD and dissolved oxygen flag when dilution may distort interpretations. These insights let health departments track infections earlier, guide rural utilities in pinpointing infrastructure weak spots, and help scale WBE protocols to other under resourced Appalachian communities.

Mentor(s): Alasdair Cohen (Department of Population Health Sciences VA-MD College of Veterinary Medicine Virginia Tech)

Elizabeth Arnulfo Candelario

Virginia Tech/Clinical Neuroscience

Independent

Investigating conserved cerebellar deficits in the neurodevelopmental disorder-associated 3q29 deletion

The cerebellum is involved in motor control and higher cognitive function, where each cerebellar region plays a distinct role. Also, disrupted cerebellar development can be linked with autism spectrum disorder. The 3q29 deletion (3q29Del) is a copy number variant that increases the risk of schizophrenia and autism spectrum disorder. Recent studies have reported that individuals with 3q29Del have a smaller cerebellum. We set out to test whether mice carrying the syntenic 3q29Del would replicate this anatomical difference. We used immunohistochemistry to stain at least three cerebellar regions (hemisphere, paravermis, and vermis) from control and 3q29Del mice at postnatal day 28 (P28). Cerebellum size and Purkinje cell (PC) density were then quantified. Overall, the surface area (SA) in the cerebellum showed significant differences in the hemisphere, paravermis, and vermis between control and 3q29Del. However, we found that PC density was not statistically different between the groups. The SA analysis confirms that mice with the homologous 3q29Del replicate the cerebellar size difference observed in humans; yet, these differences aren't due to PC density. This suggests that other cerebellar structures contribute to the cerebellar volume difference. A future direction will be to examine the SA of the molecular and granule cell layers of the cerebellum to determine which layers and cell types contribute to cerebellar size differences. The confirmation of smaller cerebellar SA in 3q29Del mice supports the possibility of their use as a model to study 3q29Del and to better understand how altered cerebellar development may contribute to 3q29Del-associated neurodevelopmental disorders.

Mentor(s): Ryan Purcell (Center for Neurobiology Research, Fralin Biomedical Research Institute at VTC)
Meike van der Heijden (Center for Neurobiology Research, Fralin Biomedical Research Institute at VTC)

Dianne Barahona Bonilla
Virginia Tech/Mechanical Engineering

How Does the Physical Appearance of Robots Influence Emotional Responses in Users?

As robots become more common in daily life, understanding how their physical appearances influence human emotional responses is crucial. Prior research shows that even small changes in a robot's appearance can sway human emotion and judgment. Adjusting facial proportions alters perceived trust; adding human-like or animal-like contours historically raises feelings of empathy; and removing expressive detail lowers comfort and attention. The purpose of this study is to determine how anthropomorphic, zoomorphic, and utilitarian robot designs evoke different emotional reactions from users. Twenty Virginia Tech undergraduates will each complete three interactions with functionally identical but visually distinctive prototypes; an anthropomorphic robot, a zoomorphic robot, and a utilitarian robot. All three polylactic acid-printed prototypes share a rectangular base geometry: the anthropomorphic unit incorporates animated LED eyes on its front panel to suggest a face, the zoomorphic units extends the base into a feline shape, and the utilitarian unit is an unadorned rectangular block with no expressive elements. After every encounter, participants will rate their interactions based on happiness, sense of emotional safety, mood uplift, and provide experience feedback. We anticipate that expressive forms will yield higher emotional scores and that open comments will highlight features such as eye movement. Findings will offer ethically-focused design guidance for building companion robots that are supportive to users.

Mentor(s): Qin Zhu (Engineering Education)
Michelle Ausman (Engineering Education)

Nicholas Beach
Radford University/Psychology

eTMS neuromodulation of the Prefrontal Cortex in Patients with PTSD: An Active Sham Trial

Electroencephalogram (EEG) personalized Transcranial Magnetic Stimulation (eTMS) is a non-invasive neuromodulation procedure that uses personalized EEG theta power to guide stimulation that may have therapeutic utility for Post Traumatic Stress Disorder (PTSD). Here, we evaluated the effect of 20 consecutive days of eTMS to the pre-frontal cortex in patients with PTSD on a threat task and questionnaires related to their disorder. Specific brain targets for modulation were selected using EEG to identify areas of higher relative activity in the theta band (4-8hz). Nineteen participants completed an 8- week trial comprised of 20 TMS sessions, with questionnaires measuring anxiety, stress, and depression symptoms every five treatments, with additional surveys before and after the full intervention. Eleven of the participants received TMS, and eight received a sham treatment. Preliminary analysis revealed no time-dependent effects, however, the Beck's Anxiety Inventory, the Positive and Negative Affect survey, and Perceived Stress Scores showed no statistically significant differences between the sham and treatment group. The eTMS group showed significant improvement compared to the sham from Becks Depression Inventory ($t(17) = -2.70$, $p = 0.008$), the Depression and Anxiety Stress Survey ($U = 17$, $p = 0.035$), and in the Moss Sleep Survey ($t(15) = 2.90$, $p = 0.004$). While these results are preliminary and data collection is ongoing the results are encouraging for a patient population that has limited treatment options.

Mentor(s): Wynn Legon (Legon Lab, Fralin Biomedical Research Institute at VTC)

Hannah Beasey
Virginia Tech/Biological Sciences

Independent

Docetaxel Impact on TNBC Tumor Growth and Metastasis to Lymph Nodes

Triple negative breast cancer (TNBC) accounts for 15% of all breast carcinomas and is the only breast cancer subtype that does not have a targeted treatment and carries the worst prognosis. After metastasis begins, the survival rate for patients with TNBC declines rapidly. This research project focuses on limiting TNBC tumor growth and metastasis to lymph nodes in a pre-clinical animal model, 4T1 tumor model in BALB/c mice. The mice were treated with 8 mg/kg Docetaxel or Docetaxel-free vehicle by tail vein cannula on day 7. This treatment was repeated on days 9 and 11. CT scans were performed on days 6, 9 and 13. Finally, an MRI is performed on day 14 and the mice are euthanized on day 15. After euthanasia, the lungs, lymph nodes, fat pads and tumor were collected for histology. After each CT scan, the volume of the tumor, the axial lymph nodes, and inguinal lymph nodes on the draining and naive sides of the mice were analyzed using the 3D Slicer software. Preliminary analysis indicates decreased volume measurements in all lymph nodes over time, and an increase in tumor size over time.

Mentor(s): Jennifer Munson (Biomedical Engineering and Mechanics, Fralin Biomedical Research Institute)

Sarah Bell
Hollins University/Sociology

Effects of maternal nativity on medicalized birth experiences

While much theorizing and empirical research has been done to explain maternal and neo-natal racial disparities in birth outcomes, less has been done to explore how maternal nativity predicts birth experiences. Existing studies on disparities in childbirth document higher rates of interventions including c-sections for Black women vs white women. Studies on the effect of maternal nativity focus on infant outcomes and find that foreign born status is protective of infant health. Our research questions shift attention to maternal experiences: (1) Does nativity predict a higher likelihood of c-section when controlling for race? (2) Does nativity intersect with race such that foreign born Black women are at unique risk for higher c-section rates? And (3) Does race, nativity, and the intersection thereof hold predictive power when controlling common risk factors for c-sections? Using the National Vital Statistics System 2023 dataset, we ran 3 binary logistic regression models with c-section as the dependent variable and key predictors of race, maternal nativity, and an interaction term for Black and foreign-born. We then added key risk factors associated with c-sections. We found that race, nativity, and the intersection thereof remain significant in predicting higher odds of c-section, even when controlling for common risk factors. The effect was stronger for race than nativity, but the intersection of Black and foreign-born was stronger than each individual variable alone. This indicates that maternal nativity is an important factor for Black mothers in a way that cannot be separated into predictors of race and nativity separately.

Mentor(s): Sadie Snow (Hollins University (Sociology)
Susan Eagle (Public Health)

Brij Bhagat
Virginia Tech/Mechanical Engineering

Designing Fouling-Resistant Surfaces: Insights from Wettability Studies

Marine fouling, the deposition of matter on water-facing surfaces, is among the foremost problems faced by the maritime industry. Material buildup on boat hulls increases drag forces, leading to increased fuel consumption, greenhouse gas emissions, and maintenance needs. Most commercial antifouling products seek to decrease surface-seawater interactions by increasing hydrophobicity, but have historically had an environmental cost. Boronization, via diffusion coating, is known to improve corrosion resistance in Fe-based alloys. The formation of an iron boride (FeB, Fe2B) layer provides a hard, inert barrier between the metal and the environment. Unlike conventional coatings that rely on toxic biocides, boronization offers a mechanical approach. Because it's economical and environmentally friendly, boronization is an attractive option to explore as an antifouling solution. This study establishes a relationship between boronization and wettability by taking contact angle measurements of molten salts on steel substrates. Contact angle measurements using simulated seawater (3.5% NaCl solution) were conducted to evaluate the wettability of boronized surfaces relative to untreated counterparts. These measurements provide insight into fluid–solid interactions, where a higher contact angle corresponds to reduced wettability and increased surface hydrophobicity. Boronized surfaces exhibited consistently higher contact angles over time, indicating enhanced hydrophobic behavior. This may inhibit surface adhesion mechanisms central to marine fouling. To accelerate degradation and fouling processes, more aggressive environments—such as molten salts at elevated temperatures—are employed. A comprehensive assessment of the boronization–wettability relationship and its antifouling effects will support the development of environmentally sustainable coatings for marine applications.

Mentor(s): Amanda Leong (Mechanical Engineering)

Neha Bhandari
Virginia Tech/Biomedical Engineering

Evaluating Head Motion During MRI in Individuals with Cocaine Use Disorder

MRI scans are a valuable tool in research involving individuals who use substances. However, excessive head motion often prevents researchers from obtaining stable, high-quality data—especially among those with recent substance use. This secondary analysis aimed to examine whether the degree of head motion during MRI is associated with cocaine use disorder (CUD) severity, recency of cocaine use, and number of substances use disorders (SUDs). MRI data were collected from 48 participants enrolled in a parent randomized control trial who met criteria for cocaine use disorder but varied in severity. We assessed motion using the frame-to-frame displacement of the brain (in mm) during scans. Each session consisted of five scans which we summarized and averaged to characterize a participant's motion performance for that session. We show the results of two summarizations: the average framewise displacement and the standard deviation of framewise displacement. We relate both of these characterizations to measures of use severity. CUD severity was measured by the number of DSM-5 criteria endorsed. Recency of use was assessed using a 30-day Timeline Follow-Back. The number of SUDs was determined based on how many substances each participant met DSM-5 criteria for. Pearson correlations were used to assess relationships between the motion variables and CUD severity, recency of use, and number of SUDs. The results did not indicate any significant correlation between average motion or average motion variance and CUD severity (ps > .47), recency of use (ps > .25), or number of SUDs (ps > .37). The lack of significant findings suggests that other variables might be more relevant in predicting motion during MRI in this population, such as length of history of use, use pattern (e.g., daily vs. occasional). For example, the degree of motion might be a result of cumulative cocaine use, instead of the recency of use. Notably, some limitations of the current study could explain the lack of significant findings. First, the small sample size might have limited our ability to detect significant differences. Furthermore, the majority of the sample had severe CUD and reported recent use (e.g., previous five days), reducing the heterogeneity among the sample. Second, our measures of average motion might not have been sensitive enough to capture significant differences between participants. Thus, future studies should explore other measures of motion as well as other variables that could impact motion during MRI.

Mentor(s): Rafaela Fontes (Fralin Biomedical Research Institute) Virginia Tech

Adaline Bisese
Virginia Tech/Chemistry

Defining the Sensory Rules of Host Landing Preferences in Mosquitoes

Mosquitoes are often described as the deadliest animal on the planet because they vector diseases that cause around a million deaths worldwide each year. Disease transmission occurs when an infected female mosquito lands on a host and bites to acquire nutrients contained in its blood. Guided to the proximity of the host by olfactory, visual, and thermosensory cues, mosquitoes must then decide where to land on the host's body to optimize their chances of obtaining a blood meal without being killed in the attempt. Most species don't bite randomly and prefer specific biting sites on the human body. These sites are species-specific and Aedes aegypti, the focus of this study, target the upper trunk and face, while other species, such as Anopheles gambiae target the ankles. However, the sensory rules that guide these preferences remain unclear, preventing the development of species-specific control strategies to deter mosquito landing. To better define the relationship between olfactory and visual input, we first sampled a human volunteer to determine the chemical composition of body odor at 23 body sites. Next, we performed a series of short-distance host-seeking assays using a synthetic human (mannequin). We then utilized a real-time object detection algorithm (YOLOv11) to quantify the landing preference of Ae. aegypti females. Our results show a strong preference for the head and upper torso, indicating that landing preference is largely driven by visual input.

Mentor(s): Clement Vinauger (Biochemisty)

Hannah Blake
Virginia Tech/Computer Science
Espen Lunden
Virginia Tech/Mathematics
Isaac Tucker
Virginia Tech /Computer Engineering

Spectral Warrior: Learning RF through Gamification

Radio frequency (RF) concepts are inherently hard to learn, due to their complexity and invisible nature. Spectral Warrior is a Virtual Reality (VR) software system, built in partner with the Naval Surface Warfare Center Dahlgren Division (NSWCDD), which tackles these issues by visualizing the invisible world of RF while sending its user through multiple gamified VR scenarios. Our scenario drops its user into an electric warfare (EW) search and destroy game. Built in Unreal Engine 5.5.4, this scenario has the user interfacing with a dynamic linear phased array, which they must utilize to locate and terminate incoming threats. This is done via beam steering and beam forming concepts which the user picks up though configuring the phased array to scan its environment and to jam incoming missiles to protect their ship.

Mentor(s): Dr. William (Chris) Headley (VTNSI)
Elliott Rheault (VTNSI)
Dr. Brad Davis (VTNSI)

Eleanor Boehmcke
Davidson College/Public Health

Developing novel precision treatments for brain cancer: Drug repurposing to target High-Risk Classical Glioblastoma

Glioblastoma (GBM) is the most aggressive and common form of brain cancer with a poor overall survival rate and no effective treatments. Research has identified three GBM subtypes—Classical (CL), Mesenchymal (ME), and Pro-Neural (PN)—based on gene expression. However, treatment based on these groups has failed. To address this, the Sheng lab identified a 31-gene signature, essential for tumor survival and prognosis. This signature divides GBMs into high risk (HR) or low risk (LR). Combining the risk signature with existing subtypes yielded six groups: HR-CL, LR-CL, HR-ME, LR-ME, HR-PN, and LR-PN. This project focuses on HR-CL, the most under-researched and treatment-resistant group. We hypothesize that this combined approach will reveal subtype-specific vulnerability and enable precision therapy development.
We analyzed the Cancer Dependency Map genetic and drug sensitivity data from over 1,000 cancer cell lines, including 63 high-grade gliomas. Classification was confirmed via RNA transcriptomics. Using drug efficacy data, mycophenolate mofetil, an immunosuppressant, and teniposide, a chemotherapeutic, were prioritized for HR-CL based on subtype-specific sensitivity. Using MTS cell viability assays, these drugs were tested on HR-CL cell lines, CCFSTGG1 and U251MG, and compared to the effects of drugs chosen for the other subtypes. HR-CL drugs caused significantly higher cancer cell death, compared to those for other subtypes. These drugs did not demonstrate the same toxicity in normal human cells.
GBM subtype-specific molecular features are indicative of vulnerabilities to specific drugs, offering a treatment path that is viable and precise to treat GBM and close the gap in brain cancer treatment.

Mentor(s): Zhi Sheng (VTC Internal Medicine)

Marissa Bolanos Barrera
Virginia Tech/Industrial and Systems Engineering

Composition of Indoor Particulate Matter in a Remote High-Altitude Community in Ecuador

Polycyclic aromatic hydrocarbons (PAH) have been found to negatively impact human health, so it is essential to accurately identify and detect them to reduce exposure. This research explores the general composition of air samples collected on filters from different homes in Simiatug, Ecuador. It aims to identify the various PAHs and other volatile organic compounds (VOC) based on wood burning, gas, or both fuel types used in home kitchens. The air filters were processed by collecting small punch samples from each filter and inserting them into empty sorbent tubes. These sorbent tubes then were analyzed through thermal desorption, gas chromatography, and mass spectrometry. Several common PAHs and VOCs were identified in all the kitchens sampled. The composition of compounds and total compound masses differed based on fuel type. With the given differentiation of composition between filters from the same period, analyzing the filters after the fuel type is changed in a home would further help to identify a difference in quantity of PAHs and VOCs. This research can lead to a recommendation of fuel type based on lower emissions of PAHs. These findings also contribute to the general knowledge of emissions by different fuel types and the study of VOCs around the world.

Mentor(s): Gabriel Isaacman-VanWertz (Civil and Environmental Engineering)

Julia Brady
Virginia Tech/CMDA
River Ocel
Virginia Tech/Public health

Finding optimal locations for dairy processing facilities in the Shenandoah valley

In Virginia, dairy production continues to expand, but dairy processing facilities have yet to keep up. Most dairy farmers in Virginia are forced to transport their products to West
Virginia or North Carolina to have them processed. This project determines the optimal county in Virginia to place a new dairy processing facility, factoring in proximity to
population centers, mileage between counties, overall raw milk production, and milk
productivity (measured in lbs of milk/cow/day). Furthermore, we designed a profit maximization model that minimizes transportation costs for dairy farmers and milk processors in a competitive market for processed milk goods. The model was incorporated into an interactive R Shiny app with customizable parameters such as adjustable relative priority for dairy farmers or milk processors. Also, by using the temperature-humidity index (THI), we analyzed how the changing climate can impact milk productivity, leveraging milk-producing county-level data. The R Shiny app features THI fluctuations, geographic distributions of all factors incorporated, API-sourced and dynamically updated line graphs, customizable tables, and a geospatial visualization indicating the optimal location for a processing facility.

Mentor(s): Michael Cary (Agriculture)
Yuetong Zhang (Agriculture)
Mario Ortez (Agriculture)

Shania Braithwaite
Hollins University/Biology

Understanding Neural Avalanches and Entropy in Simulated Brain Networks

Cortical neurons tend to exhibit natural firing patterns in which they fire in cascades called avalanches. The sizes of these cascades follow a scale-free pattern found in systems balanced between order and randomness known as criticality. This study investigates how brain-like networks operate at this critical point by analyzing patterns of neural avalanches. Using computer simulations, we compare two models of criticality with different network structures. In the traditional model, scale-free avalanche patterns and measures like information capacity and mutual information only emerge when observing large groups of neurons. A recent study by Jones et al. (2023) discovered a new model of criticality that produces rich patterns even when observing small subsets or individual neurons. To better understand how information is distributed in this model, we analyzed Shannon entropy across the network. We replicated the entropy analysis from Shew et al. (2011), who showed that Shannon entropy of network activity is maximized at criticality in cortical circuits. By computing entropy for the new model of criticality, we found that entropy peaks near the critical point. This supports the claim that information capacity is maximized at criticality even with the new model of criticality.

Mentor(s): Jacob Barfield (Physics (Hollins University)

Chanera Brown
Virginia Tech/Biochemistry

The ABC's in protoplasting: Advancing potato protoplast protocols

Plant transformation enables valuable insight into gene function and provides tools for genetic manipulation. For non-model systems like potato (Solanum tuberosum), developing species-specific transformation protocols is critical. For this purpose, we aimed to establish an efficient protoplast-based transformation protocol. Protoplasts were isolated and transfected with engineered vectors to evaluate transformation efficiency and signal intensity of our visual markers. This was achieved through DNA extraction of seven cultivars and subsequent PCR amplification of the Ubiquitin promoter, using primers designed based on the reference genome of S. tuberosum “Atlantic.” Successful amplification in “Atlantic” and “Lamoka” enabled promoter ligation into a modular cloning backbone for continued vector construction. These promoters support cultivar-specific module design for functional studies. To evaluate transient expression in our protoplast system, protoplasts from multiple cultivars were utilized for protoplast isolation and transfection with red and green fluorescent protein (RFP/GFP) plasmids. We tested different variables to enhance efficiency of both isolation and transformation, including the use of pre-isolation conditioning media and plasmid form (linear vs supercoiled) to optimize transformation outcomes. Being able to effectively use these tools to understand gene expression within protoplasts provides us with a suite of tools to advance our current understanding of gene functions.

Mentor(s): Courtney Leisner (School of Plant and Environmental Sciences)

Laura Bruno
Virginia Tech/Wildlife Conservation

Finding the Top Dog: Single Season Occupancy of Canid Species at Mountain Lake Biological Station, Giles County, Virginia

Carnivores influence ecosystems through top-down control; however, their elusive, wide-ranging behavior makes them challenging to study. To overcome this, I analyzed data from camera traps set up and monitored by the Virginia Tech student chapter of The Wildlife Society at Mountain Lake Biological Station (MLBS), in Giles County in 2010, 2013, 2017, 2021, and 2024. MLBS is a heavily forested, high elevation mixed-use area of both the Jefferson National Forest and public properties. Focal species include all three wild canids found in Virginia: gray fox (Urocyon cinereoargenteus), red fox (Vulpes vulpes), and eastern coyote (Canis latrans).

Single season occupancy models are in progress, however the average naïve occupancy results from the years 2010, 2013, 2017, and 2021 showed coyote with the highest naïve occupancy (59%), red fox with the second highest (7.262%), and gray fox with the lowest (4.767%). This suggests that coyotes will have the highest single season occupancy results with the fox species having much lower numbers. Results of this study demonstrate the need for further research in Virginia to assess the activity and distribution of mammalian carnivore species across varied habitats of Virginia's physiographic regions. Future work will include completing single season occupancy analysis and incorporating covariates thought to influence carnivore occupancy and detection.

Mentor(s): Marcella Kelly (Fish and Wildlife Department)

Emily Bryant
Hollins University /Chemistry
Su Gursoy
Hollins University/Biochemistry

Synthesis and Characterization of Heteroleptic Copper(I) and Silver(I) Complexes with Fluorinated Bipyridine and Phenanthroline Ligands

Organic light emitting diodes (OLED) have shown significant promise as cost effective alternatives to their inorganic counterparts. Within the OLED field, there is currently an effort to replace iridium(III) sensitizers with cheaper and more earth abundant copper(I) and silver(I) alternatives. One issue that needs to be overcome is the pseudo Jahn-Teller distortion in copper(I) complexes, a major quenching pathway. In homoleptic complexes, it has been shown that sterically bulky ligands can be utilized to control Jahn-Teller distortion, resulting in longer emission lifetimes and higher quantum yields. This work aims to use heteroleptic copper(I) and silver(I) complexes that contain strongly electron-withdrawing and sterically bulky trifluoromethyl groups as a way to tune the fluorescence of the complexes. Preliminary characterization of these compounds was completed with mass spectrometry and single crystal X-ray crystallography (SC-XRD). Heteroleptic structures for several compounds have been confirmed with SC-XRD, while others are still in progress. Additionally, the absorbance and fluorescence properties of the compounds were studied as films and in dichloromethane solutions.

Mentor(s): Brian Reeves (Chemistry, Hollins University)

Varun Budati
Virginia Tech/Computer Science
Naomi Udenze
Computer Science

Bridging the Code Gap: Understanding Pedagogical Patterns in CS1 Programming Courses

NEED NEW ABSTRACT FROM IHUDIYA WILLIAMS (FACULTY) Introductory Computer Science (CS1) Courses serve as foundational gateways for computer science education, yet significant gaps persist between students' prior experiences and the conceptual understanding necessary for success. The current structure of CS1 education is developed to be implemented indiscriminately across universities. It supposes that all students have equivalent access and benefit from those courses, as well. However, existing research has found that numerous communities are inadequately represented in the technology industry.
This study examines what topics are discussed to elicit examples and exercises in CS1 Programming courses. Effective CS1 curricula should be developed with the intention of accommodating diverse cultural backgrounds. To address this, an analysis of CS1 course materials was conducted, designed to identify recurring pedagogical patterns, topic presentation strategies, and the contextual frameworks used to bridge students' existing knowledge with programming concepts. It examined topics addressed, examples used, and suggested exercises across courses from top universities around the United States.
Through comprehensive content analysis, the research reveals that over 53% of the analyzed examples relied directly on references to prior educational experiences, with 43% of all examples referencing mathematical concepts, including those stemming from Calculus, Trigonometry, or Geometry. It also found that over 12% of the data included references to things unique or distinct to the culture within the United States of America.
This research offers insights for developing inclusive CS1 curricula that better serve diverse populations, contributing to equitable pathways into computer science education and enhanced technology innovation capacity across all communities.

Mentor(s): Dr. Ihudiya Williams (Computer Science)

Azhaan Buttar
North Carolina State University /Psychology

Computational Model of Extracellular Ion Cycling Predicts Complex Automaticity Responses to Cleft Modulation

Introduction: The synchronization mechanism of multicellular networks remains poorly understood. Since the compact sinoatrial node has low gap junctional coupling, a 1-D computational model was developed to demonstrate how cyclic oscillations of ions within shared clefts can drive network automaticity in the absence of gap junctions (GJ) or spontaneous oscillators.
Aims: Develop a 2-D cleft-ion oscillation model with spontaneous oscillating cells.
Methods: The fractions of sodium (F_INa) and potassium (F_IK) currents localized to clefts were varied between 40 and 45% and extracellular potassium varied from 20 to 10 in a 2-D Hodgkin-Huxley model without GJ. Cleft widths between 1 and 50nm with a single pacemaker cell in the network were investigated.
Results: With 40% of total sodium channels and potassium channels in clefts, the model predicts network level autorhythmic behavior for cleft widths between 1 and 3nm, suppressed network automaticity between 3 and 17nm, and propagated automaticity from a dominant pacemaker for cleft widths greater than 17nm. When F_INa is increased to 45%, the suppression range is increased to include narrower and wider cleft widths. Conversely, increasing F_IK to 45% and maintaining F_INa at 40% also increased the cleft width range of automaticity suppression. Finally, reducing extracellular potassium by 25 to 50%, progressively widened the cleft width range that suppresses network automaticity.
Conclusions: Models with cleft localized ion channels and ion tracking predict a range of cleft widths that suppress autorhythmic cell behavior, and this is modulated by extracellular potassium and the fraction of sodium and potassium currents in clefts

Mentor(s): Steven Poelzing (Department of Biomedical Engineering and Mechanics and Department of of Internal Medicine, VTC School of Medicine)

Jasper Cameron
Pacific University/Chemistry

Ice Nucleation Activity of Bacteria in Austrian Alpine Lakes Along an Elevation Gradient

Although bacteria are often associated with diseases, they play important roles in maintaining ecosystems and influencing weather patterns. Pseudomonas syringae, a plant-associated bacterium and effective biological ice nucleator, can catalyze ice formation at temperatures as high as -8°C and is commonly found in rain, snow, surface waters, and the atmosphere. It is also used commercially to generate artificial snow. Through a partnership between the Schmale Lab of Virginia Tech and the Grothe Lab of Technische Universität Wien, two field campaigns were conducted to study the presence and activity of P. syringae in Austrian alpine lakes. Through the Schmale Lab, American undergraduate students had the opportunity to experience Austrian culture and learn the importance of international collaboration. The purpose of the project was to determine the impact of different environmental conditions on P. syringae's ice-nucleation activity (INA), including elevation, terrain, and temperature. Water and air samples were collected from two different lake systems in Central Austria in June and July of 2025. The samples were then plated on KBC agar, and the resulting bacterial colonies were screened for ice nucleation activity. Ongoing research is examining the trend between rising elevation above sea level and INA. Preliminary results indicate a decrease in INA between June and July. Future work aims to characterize the ways in which P. syringae are transported between lakes in a connected system, and to determine the effect that has on freezing trends.

Mentor(s): David Schmale (School of Plant and Environmental Sciences)

Grayson Camp
University of Mary Washington/Chemistry

Proton-Driven Phosphoryl Transfer in β-Phosphoglucomutase

The transfer of energy through phosphoryl groups is often driven by proton transfers in the active site of β-phosphoglucomutase. Despite its importance for many biochemical processes, the exact timing of the steps involved in enzymatic phosphoryl group transfer remains unclear. Here, molecular dynamics simulations with the AMOEBA polarizable force field were used to model β-phosphoglucomutase while focusing on the catalytically essential aspartic acid (ASP) 8 and 10 residues. Electric field calculations were performed on four key reactive bonds and showed residue-specific contributions. In the ground state, residues such as ASP 8 and, glutamic acid
(GLU) 169 produced fields that help facilitate electron flow around the phosphoryl group. Similarly, residues including ASP 10, and Asp 170 promoted proton donation to the substrate. In the transition state, the electrostatic environment became more complex. ASP 8 and ASP 170 was seen to help in forming the phosphoryl bond, while lysine (LYS) 145, 122 and Mg^{2+} opposed phosphoryl bond formation. Overall, our results suggest that the electrostatic environment, supports simultaneous phosphoryl and proton transfers. Ultimately, this work supports our abilities to control metabolic pathways that may be used in the future for designing drugs that regulate or disrupt these critical biochemical reactions.

Mentor(s): Valerie Welborn (Chemisty)

Alexandra Caraus
Virginia Tech/Biochemistry

Molecular Dynamics Simulations of Heparan Sulfate in Neuronal Cell Membranes

Syndecan-4 (SDC4) is a ubiquitous cell surface proteoglycan that is highly expressed in fibroblasts and epithelial cells. SDC4 functions independently as a receptor for various heparan-binding growth factors. Heparan sulfate (HS) chains on SDC4 have been proposed to act as sensors of extracellular stress, converting mechanical force into intracellular signaling events through raft-associated interactions. Co-localization of SDC4 and other syndecan family HS proteoglycans (HSPGs) with amyloid plaques have been observed in brains of patients with late-stage Alzheimer's disease (AD). This study aims to investigate the role of SDC4 and HS in modulating membrane dynamics in neuronal cells using molecular dynamics (MD) simulations. Despite these findings, the molecular mechanisms through which SDC4–HS complexes impact membrane microdomains remains poorly understood. Using a control membrane system generated to mimic neuronal membrane composition, MD simulations were performed for 1μs with the charmm36 force field. Simulations were designed to assess hydrogen bonding interactions and their temporal influence on lipid organization. Replicate simulations of the control neuronal membrane, showed consistent lipid organization and structural stability over time. Hydrogen bonding patterns reflected the chemical diversity of membrane components, where numerous interactions were observed within hydroxyl- and amine-consisting lipids, while lipids lacking these features displayed minimal interaction activity. This work provides foundational knowledge of neuronal membrane dynamics. Future studies aim to understand atomistic interactions between SDC4 and HS chains and their impact on membrane organization and lipid raft dynamics, providing insight into Aβ internalization and progression of AD.

Mentor(s): Anne Brown (Department of Biochemistry)
PhD Candidate in Genetics, Bioinformatics, and Computational Biology: Marion Q. LoPresti (Department of Biochemistry) Virginia Tech

Falconer Carter
Virginia Tech/Wildlife Conservation

Preliminary Data on Mange Prevalence and Severity in Black Bears (Ursus americanus) in a Mange Endemic Area.

Mange is a skin disease caused by a parasitic mite species (Sarcotes scabiei) that affects a wide range of domestic and wild animals. The American black bear (Ursus americanus) was not known to contract mange until the late 1900s. Mange infection is visually identifiable as the skin becomes wrinkled and gray, and the animal may be nearly hairless. Ultimately, the afflicted black bear may become emaciated, exhibit altered behavior and die. Our study uses baited hair snares to attract black bears and remote cameras to document mange occurrence at snares in the Central Appalachian Mountains (Botetourt, Nelson, Bath, and Alleghany Counties) of Virginia. We set 79 hair snare corral traps, ~3.5km apart, and each snare consists of 4-5 trees encircled by 2 strands of barbed wire and baited by a sweet lure, to capture hair (for later genetic analysis) and videos of bears to document mange prevalence in the area. We scored the relative severity of mange infection according to the Department of Wildlife Resources (DWR) Mange Matrix scoring system. Bear mange scores are added together at each snare location and divided by the total number of bear events to estimate a mange severity for each location. With the preliminary data collected, we will create a heat map in the future, showing the range, density, and where the mange is most prevalent now. Study results will inform DWR about the location and severity of mange outbreaks, leading to future informed conservation efforts to manage the black bear population in Virginia.

Mentor(s): Marcella Kelly (College of Natural Resources)

Ian Cavasoz
Virginia Tech/Biological Systems Engineering

Independent

Developing ABA Loaded PLGA Nanoparticles to Induce Dormancy in Plants

Abscisic Acid (ABA) is a plant hormone which controls the stress response of plants. This could be in response to quick events such as floods, heat waves, drought, or flash freezes; but is also a part of the seasonal dormancy experienced by many plant species. Due to changes in climate, refreezes after an initial thawing wakes plants from their dormant state, have become more common and hurt the plant's ability to survive and reproduce in that transitional period from winter to spring. One solution would be to extend dormancy past the refreezes. To do this, I developed stable ABA loaded Poly(Lactic-co-Glycolic Acid) (PLGA) nanoparticles which when uptaken through the roots of plants, would increase intracellular ABA levels. PLGA nanoparticles were chosen due to their low cytotoxicity and ability to be naturally hydrolyzed into its monomeric subunits of lactic acid and glycolic acid. Using existing protein loading procedures as a baseline, an ABA loaded PLGA nanoparticle synthesis procedure was developed. This procedure routinely synthesized particles at 145 ± 5 d.nm at 0.250 ± 0.015 PDI. Using N. benthamiana as a model organism, the intracellular ABA concentration was found to be increased marginally after uptake of ABA loaded PLGA nanoparticles through the roots when compared to unloaded nanoparticles and regular water. This shows the efficacy of this method to increase intracellular ABA levels in plants over a short period of time, and provides a basis on which to extend plant dormancy.

Mentor(s): Clay Wright (Biological Systems Engineering) Virginia Tech
Mike Zhang (Biological Systems Engineering) Virginia Tech

Kenneth Chan
Virginia Tech/Biochemistry

Identification of critical amino acids of a viral protein for its interactions with host proteins

All positive-strand RNA viruses recruit host proteins and remodel specific organelle membranes to form viral replication complexes (VRCs) for duplication. We use an engineered brome mosaic virus (BMV)-yeast system as a model to examine this process. During infection, BMV's viral replication protein 1a (BMV 1a) induces the formation of VRCs at the nuclear membrane. In this process, BMV 1a interacts with several host proteins such as Cho2, Rtn1, and Lam5 and relocalizes them to VRCs. The goal of this study is to identify key amino acids in 1a that are responsible for the interactions between itself and host proteins. Nine missense mutations targeting specific amino acids were introduced into BMV 1a and each BMV 1a mutant was expressed in yeast strains with GFP-tagged LAM5, RTN1, or CHO2. Fluorescence microscopy revealed that five BMV 1a mutants failed to relocalize GFP-Rtn1, a different mutant failed to relocalize GFP-Lam5, but none affected Cho2 relocalization, suggesting that BMV 1a interacts with Lam5, Rtn1, and Cho2 differently. Future work will focus on the identification of key amino acids in Rtn1 and Lam5, and to disrupt the interactions for virus control. Our study on viral-host protein interactions in BMV may reveal novel targets for disease prevention in BMV and other positive strand RNA viruses. Our study on viral-host protein interactions in BMV may reveal novel targets for disease prevention in BMV and other positive strand RNA viruses.

Mentor(s): Xiaofeng Wang (School of Plant and Environmental Sciences) Virginia Tech
Kristopher Criscione (School of Plant and Environmental Sciences) Virginia Tech Hampton Roads AREC

Katherine Chang

Virginia Tech /Clinical Neuroscience

Independent

Humanized mouse model of lupus with patient microbiota and pristane exhibits human IgM producing plasmablasts

Authors: Md Shakhawat Hossain[1,3], Tian Xu[1], Ran Lu[2], Xin M. Luo[1,2]
Presenter: Katherine Chang[4]

Systemic Lupus Erythematosus (SLE) is a chronic autoimmune disease characterized by excessive activation of T and B cells, leading to widespread autoantibody production, inflammatory cytokine release, and multi-organ damage. Although lupus-prone mouse models have provided valuable insights into SLE pathogenesis, species-specific genetic differences limit their ability to fully recapitulate human disease. Humanized mouse models offer a promising approach to overcoming these limitations by enabling in vivo investigations of human immune responses and facilitating translational research.

To explore the complex interplay between the immune system and microbiota in SLE, we developed a double humanized SLE (DhuSLE) mouse model by engrafting NODScid-gC (NSG) mice with human CD34+ hematopoietic stem and progenitor cells (NSG-hu mice) and introducing fecal microbiota from SLE patients (SLE-FMT). A combination of SLE-FMT and pristane successfully induced plasmablasts that led to the production of human IgM and to a lesser extent, human IgG.

Mentor(s): Xin Luo (Biomedical Sciences and Pathobiology VA-MD College of Veterinary Medicine)

Joey Chen
Virginia Tech/Computer Science

MASTIFF: Malicious Adversarial Sensing Techniques for Isolating Friend and Foe

Radio Frequency Machine Learning (RFML) models have become increasingly valuable for processing large volumes of raw data, particularly in military applications. However, their effectiveness is vulnerable to Adversarial Machine Learning (AML) attacks, which can deliberately impair model performance. This vulnerability is especially concerning in the RF domain, where Test and Evaluation (T&E) frameworks to assess adversarial impacts on RFML models are lacking. To address this gap, MASTIFF (Malicious Adversarial Sensing Techniques for Isolating Friend and Foe)—a collaborative initiative between VTNSI and Peraton—aims to enhance the resilience of RFML systems. As part of this effort, we have developed a novel Reinforcement Learning (RL) framework designed to evaluate the robustness of RFML models in tasks such as detection, classification, and identification. During Phase I, we focused on simulating AML attacks against a detection-based Model Under Test (MUT). In Phase II, our efforts have expanded to include a new MUT sensor designed for modulation recognition. We are also implementing different attack techniques, including modular signal-based methods (e.g., FGSM, FGSM+ZOO) and environment-based attacks on raw in-phase and quadrature (I/Q) data. Additionally, we are incorporating both white-box and black-box attack scenarios, expanding on prior assumptions to more thoroughly evaluate model vulnerability in realistic settings.

Mentor(s): Maymoonah Toubeh (Hume Center for National Security and Technology) Virginia Tech
Alyse Jones (Hume Center for National Security and Technology) Virginia Tech
Bill Clark (Hume Center for National Security and Technology) Virginia Tech

Audrey Chiang
Virginia Tech/Biomedical Engineering

Using Artificial Intelligence to Generate Individualized Episodic Future Thinking Visual Cues for fMRI Studies

Episodic future thinking (EFT) is a promising behavioral intervention for substance use disorders where participants visualize their own positive future goals. Picture databases exist to collect standardized stimuli for cue experiments. However, none are large enough for personalized tasks like EFT. AI-generated images, however, may enable both standardized and personalized stimuli, simultaneously. This project examined whether the effectiveness of EFT could be improved using AI-generated images by comparing image properties through a composite score. For this study, we guided 20 heavy drinkers through an EFT cue generation interview and collected AI-generated and Google images that represented their future goals. Later, during neuroimaging, participants viewed their personalized, AI-generated images along with a common set of alcohol-related images in an "alcohol" versus "future" block-design task. To characterize the images, a composite score was calculated that combined an image's entropy, brightness, and RGB channels. Visual observation suggests that, for the individual metrics, the AI-generated images tend to follow a more normal distribution than the Google images. However, both types show similar distributions for the composite score. This result indicates that there is no significant difference between the image properties of the AI-generated and Google images. Characterizing these images may inform how cues can be generated to match the participants' future scenarios, which can evoke a stronger reaction during the fMRI study. Overall, the comparison of AI-generated and Google images used in the study will provide insight into which images should be used as future fMRI stimuli in EFT-related studies.

Mentor(s): Stephen LaConte (Biomedical Engineering)

Anna Choe
Virginia Tech/Wildlife Conservation

Understanding MmuPV1 E6 Oncogene Mutant R65A's Interaction with SMAD2/3 and its Role in Papillomavirus Pathogenesis

Papillomaviruses are species-specific DNA viruses and in humans, are known to cause skin and genital warts as well as various types of cancer such as cervical and head and neck cancer. MmuPV1 is a papillomavirus that infects laboratory mice and has played a vital role in understanding the pathogenesis and carcinogenesis of human papillomavirus (HPV). The MmuPV1 E6 (mE6) oncogene has been found to exhibit similar cellular interactions to the HPV E6 oncogene such as its ability to inhibit the tumor suppressor pathway TGF-β signaling. This occurs when mE6 binds to SMAD2/3, which are vital proteins that form complexes with TGF-β receptors to conduct gene transcription responsible for cell regulation. The purpose of this research is to understand the cellular mechanisms in which mE6 interacts with SMAD2/3 and determine the contribution of TGF-β signaling inhibition in pathogenesis. We utilized AI software AlphaFold2 to determine the interacting site between mE6 and SMAD2/3, which identified R65 as a key amino acid in facilitating interactions between mE6 and SMAD2/3. Through immunoprecipitation of transient transfected HCT116 cells, we confirmed the R65A mutant was defective in binding to SMAD2/3, meaning it has potential to allow TFG-β signaling to occur without interference. Confirmation of mE6 expression in mouse keratinocytes (MK) was completed via RT-qPCR. We are currently conducting a four-day counting assay to analyze the impact of the mutation on the proliferation phenotype promoted by mE6 across vector, mE6, and R65A expressing MK.

Mentor(s): James Romero-Masters (Biomedical Sciences and Pathobiology) Virginia Tech
Kayla Duxbury (Biomedical Sciences and Pathobiology) Virginia Tech

Olivia Cogswell
Hollins University/Chemistry

Synthesis and Characterization of Iron Coordination Complexes for Dye-Sensitized Solar Cells

In photovoltaics, dye-sensitized solar cells are promising due to their low production cost and lack of bulky infrastructure required to support their function. However, their low efficiency prevents them from being viable on a high-density, industrial scale. Iron coordination complexes represent a potential solution to this problem, using charge-transfer induced spin crossover to slow recombination within the cell, resulting in higher efficiency. The complexes were developed through multi-step synthesis, including ligand formation, substitution of the coordination center, and phosphonylation. Analysis of the products via proton NMR and high resolution mass spectrometry ultimately indicated successful reactions, though the yield decreases significantly with each step. Future directions include phosphonate ester hydrolysis on the current product followed by further analysis to determine the functionality of the resulting iron coordination complex as a component of dye-sensitized solar cells.

Mentor(s): Amanda Morris (Chemistry) Virginia Tech

Sophie Corbel
Colorado School of Mines/Chemical Engineering

Toward Scalable Alpha-Olefin Production from High-Density Polyethylene Waste

Recently, temperature gradient thermolysis has emerged as a promising technology for managing end-of-life plastic waste. Herein, we report the significant scale up of this process to upcycle post-consumer high-density polyethylene (HDPE) into a finely tuned oil that can be used to produce a range of downstream commodities including surfactants and adhesives. Our approach contrasts with conventional mechanical recycling techniques, which can compromise material integrity, consume substantial energy, and generate low-value outputs. Notably, our approach leverages thermal conditions across a gradient to control the distribution of carbon chain lengths while preserving high value α-olefins produced in situ. Scale-up was achieved through improved reactor design and heat transfer optimization, leading to increased oil yield within the targeted carbon range of C9 to C14. More broadly, this work reframes the role of plastic as an environmental and public health burden into a low-cost feedstock for synthetically useful oils. Thus, this approach can enhance the circularity of the olefin economy, advancing plastic waste processing.

Mentor(s): Guoliang (Greg) Liu (Chemistry) Virginia Tech

Christopher Cosma
Michigan State University/Biochemistry and Molecular Biology

Altered Growth Factor Environments Disrupt Platelet-Derived Growth Factor Receptor-β Signaling Regulation During Early Vascular Development

Pericytes (PCs) contribute to microvascular stability and function across many tissues, especially the brain; however, it remains unclear how their phenotypic heterogeneity aligns with these roles, and how PC subtypes are established during development. Here, we sought to: (i) verify this heterogeneity via alpha-smooth muscle actin (aSMA) presence in PC subpopulations, and (ii) determine how growth factor regulation orchestrates this heterogeneity. We first imaged and analyzed brain sections from adult Ng2:DsRed/+ mice also immunostained for aSMA and Platelet-Endothelial Cell Adhesion Molecule-1 (PECAM-1) on endothelial cells. We found regions where DsRed+ PCs harbored notable aSMA-positive signal, while immediately adjacent vessel segments contained DsRed+ PCs with minimal aSMA signal, reinforcing the notion of organized phenotypic heterogeneity across PC populations. Furthermore, to address growth factor coordination of PC heterogeneity, we explored how regulation of recently identified soluble isoforms of platelet-derived growth factor receptor-beta (sPDGFRb or sRb) intersects with growth factor levels during vessel formation. We exposed differentiating murine embryonic stem cell (ESC)-derived vessels to various growth factor combinations and assessed sRb protein levels by western blot, among other measures. We found that exogenous PDGF-BB alone reduced sRb levels, while vascular endothelial growth factor-A (VEGF-A) treatment induced a more modest decrease in sRb variants. Follow-on experiments will address how growth factor levels and sRb feedback regulation affect PC differentiation and heterogeneity, particularly in their aSMA expression and spatial organization. These features are key for PC contributions to microvascular stability and function and limiting vessel dysfunction as seen in hydrocephalus, cerebrovascular malformations, and intraventricular hemorrhage.

Mentor(s): John Chappell (Fralin Biomedical Research Institute at Virginia Tech Carilion School of Medicine and Research Institute)

Jason Cox
Virginia Tech National Security Institute /Computer Science

CloudD-RF

In wireless communications, collaborative spectrum sensing is a process that leverages radio frequency (RF) data from multiple RF sensors to make more informed decisions and lower the overall risk of failure in distributed settings. However, most research in collaborative sensing focuses on homogeneous systems using identical sensors, which would not be the case in a real-world wireless setting. Instead, due to differences in physical location, each RF sensor would see different versions of signals propagating in the environment, establishing the need for heterogeneous collaborative spectrum sensing. Hence, this project explores the implementation of collaborative spectrum sensing across heterogeneous sensors, with sensor fusion occurring in the cloud for optimal decision making. Last year, we investigated machine learning-based fusion methods and tested the fused model's ability to perform modulation classification, with a primary goal of optimizing for network bandwidth in regard to next-generation network applications. Our analysis demonstrated that our fusion process was able to optimize the number of features extracted from the heterogeneous sensors according to their varying performance limitations, simulating adverse conditions in a real-world wireless setting. This year, we implemented our framework in hardware for over-the-air testing and for further validation that it can operate in a real-world environment.

Mentor(s): Alyse Coulon (Virginia Tech National Security Institute) Virginia Tech
William Headley (Virginia Tech National Security Institute) Virginia Tech
Maymoonah Toubeh (Virginia Tech National Security Institute) Virginia Tech

Olivia Coyle
Oberlin College/Biochemistry

Managing Chronic Kidney Disease through Development of Spns2 Inhibitors

Chronic kidney disease (CKD), is the 9th leading cause of death in the US, resulting in 55,250 deaths in 2023. Lymphocyte infiltration into the kidneys plays a key role in the pathogenesis of CKD; thus, inhibition of lymphocyte trafficking has the potential to halt the progression of CKD. Sphingosine-1-phosphate (S1P) is a biological signaling molecule produced intracellularly that is responsible for lymphocyte trafficking, making the S1P pathway an attractive drug target for the treatment of CKD. Spns2 is an important transport protein in the S1P signaling pathway which transports intracellular S1P to the extracellular space. Once S1P is exported extracellularly, S1P is able to induce lymphocyte trafficking. Therefore, inhibiting Spns2 can potentiate lymphocyte trafficking through modulation of the S1P concentration gradient. Our group's recent work has revealed SLR1092486, featuring a phenylurea head group, an aliphatic linker, and a substituted alkyl tail, to be a potent Spns2 inhibitor with an in vitro IC50 of 48 nM. This work aims to establish in vivo activity by eliminating potential metabolic liabilities within these Spns2 inhibitors.

Mentor(s): Webster Santos (Chemistry)

Diego Cuadra Cuadra
Virginia Tech/Agribusiness
Jeffrey Ogle
Virginia Tech/International Trade and Development

Volunteer and Participant Recruitment and Engagement – Virginia Cooperative Extension

This project explores the alignment between community demographics and engagement in Virginia Cooperative Extension (VCE) with an emphasis on volunteer and participant groups across the state of Virginia. By using data from Better Impact volunteer records, PEARS, 4-H program reports, and the US Census Bureau, we developed an interactive dashboard using R and R Shiny. This dashboard allows stakeholders to explore patterns in volunteer and participant distributions at the county level across Virginia. Key metrics include participation rates per capita, volunteer to participation ratios, and a comparison of racial and ethnic representation relative to county demographics, Our analysis revealed significant disparities in engagement across regions, with some counties showing low volunteer and participant numbers indicating a need for greater resource allocation while others demonstrated strong volunteer impact. A regression analysis uncovered that home ownership and only having a middle school level education were associated with higher rates of participation in Extension programs, while speaking Spanish is associated with lower levels of participation. These findings highlight the value of data driven approaches in shaping the outreach strategies to make more inclusive programing. This project offers a replicable model for how Virginia Cooperative Extension demographic data can broaden program reach and advance equity goals.

Mentor(s): Michael Cary (AAEC) Virginia Tech

Kathryn Curran
Virginia Tech/Biochemistry

Evaluation of binding and intermolecular forces of Chloramphenicol across S. aureus, D. radiodurans, and L. monocytogenes Ribosomal Peptidyl Transferase Centers

Antimicrobial resistance is a growing concern as antibiotics become less effective in treating infectious diseases, posing a potential global health crisis. To address this growing concern, a comparative study of the peptidyl transferase center (PTC) of three different gram-positive bacterial ribosomes, Staphylococcus aureus, Listeria monocytogenes, and Deinococcus radiodurans, was performed using computational methodologies. This analysis focused on how the broad-spectrum antibiotic chloramphenicol interacted within the PTC, using molecular docking to characterize the types of intermolecular interactions formed and to determine whether interactions bind to similar nucleotides across all three ribosomes, which may influence antibiotic efficacy. After molecular docking, a fingerprint analysis was performed, which showed there was a consistent nucleotide interaction between chloramphenicol and nucleotides U-2483 through U-2485, highlighting conservation in the PTC of the species studied. Nucleotide U-2485 demonstrated hydrogen bonding with chloramphenicol throughout all three ribosomes, which displays the validity of the chloramphenicol binding pocket. This highlights U-2485 as an essential residue that aids in the binding of chloramphenicol. While there are persistent side chain interactions with nucleotide U-2483, the atoms interacting with chloramphenicol vary from halogens, nonmetallics, and benzylic rings, causing hindrances in PTC binding. Additionally, S. aureus, the fingerprint analysis displayed a polar/halogen bond between chlorine and oxygen, which exhibits a stronger binding affinity for the PTC. Therefore, conservation of the chloramphenicol binding pocket in the PTC across the three ribosomes, along with detailed characterization of residue-level interactions, provides a structural basis for the rational design of next-generation antibiotics targeting Gram-positive pathogens.

Mentor(s): Anne Brown (Biochemistry) Virginia Tech

Arpita Das
Virginia Tech/Clinical Neuroscience

Pharmacological Inhibition of CX3CR1 as a Potential Therapeutic Target for SLE

Autoimmune diseases affect approximately 8% of the United States population. One common chronic disease, Systemic Lupus Erythematosus (SLE), impacts approximately 1.5 million individuals in the U.S., with nearly 90% of cases occurring in women. SLE is a heterogeneous, chronic autoimmune disorder characterized by the immune system attacking healthy tissues and organs, resulting in widespread inflammation. Symptoms may include hair loss, swollen lymph nodes, and increased redness or inflammation. The chemokine receptor, CX3CR1, has been previously identified as a potential modulator for SLE, particularly due to its role in immune cell adhesion and regulation of inflammatory responses. This study investigates the therapeutic potential of targeting CX3CR1 in SLE by inhibiting the receptor using the small-molecule drug AZD8797. Varying concentrations of AZD8797 were administered to spleen and kidney cells isolated from MRL/lpr mice. Flow cytometry was utilized to analyze cytokine expression and protein concentration, using markers including CD45, CD3, CD4, CD8, RORγt, IL-17A, and IL-17F. Results suggest that inhibition of CX3CR1 may increase cell death, thereby reducing number of lymphocytes and in turn reducing inflammation in the kidney and spleen. These findings raise the possibility that promoting targeted cell death could serve as a therapeutic objective rather than an unintended toxic effect, prompting further investigation into the underlying molecular mechanisms. Overall, this experiment highlights that inhibiting CX3CR1 may become a potential treatment for SLE.

Mentor(s): Rana Estaleen (Department of Biomedical Sciences and Pathobiology, Virginia-Maryland College of Vetrinary Sciences)

Amour Dau
Virginia Tech/Biological Sciences

Variability in Children's Emotional Responses to Threat Over Time

The relationship between a parent and child shapes how the child's brain develops to respond to emotional and social challenges in adulthood. Bowlby's ethological theory suggests that children are born with an innate set of behaviors toward their parents in times of need (e.g. threat). Over time, these innate behaviors towards their parents are shaped by the quality and consistency of how their needs are met. Variations in these behaviors are an important part of the child's psychosocial development, and they impact emotional regulation in adulthood. In this study we investigated the variability of children's responses to an adapted Stranger Approach paradigm (SA), modeled after a portion of the Strange Situation Procedure, which assesses a child's response to threat, at 18 and 24 months of age. We predicted that the variability of children's responses to the SA would increase over time because earlier responses relied on more innate behaviors. To test this, we coded videos of the SA with their mothers. The variables coded included aspects related to the children's distress, such as avoidance of the stranger and facial cues of negative affect. Statistical analysis showed that the task worked as expected, eliciting the predicted distress responses, and that there was less variability in the responses of the 18-month-olds. This result supports ethological theory. Additionally, 24-month-old females compared to males showed heightened sadness responses to the SA. These findings aid our understanding of psychosocial developmental periods where early intervention might support long-term emotional regulation.

Mentor(s): Brittany Howell (Neuroscience, Fralin Biomedical Research Institute) Virginia Tech

Tamanna Deedar
Hollins University/Psychology

Growing Up Around Conflict: How Childhood Parental Disputes Shape Emotional Well-Being and Relationship Regulation in Afghan Adults

This study explores how growing up around parental conflict affects Afghan adults' emotional well-being and their ability to manage close relationships later in life. While past research has linked interparental conflict to their children's psychological problems, little attention has been paid to these effects in non-Western populations, particularly among Afghans. In Afghan culture, where family honor and emotional restraint are highly valued, expressing emotions or addressing conflict tends to be discouraged, potentially leading to long-term emotional challenges.

Forty-nine Afghan adults living outside Afghanistan participated in an anonymous online survey distributed through snowball sampling. Participants reported their experience of interparental conflict they witnessed during childhood using three subscales frequency, intensity, and resolution from an adapted version of the Children's Perception of Interparental Conflict Scale (CPIC; Grych et al., 1992). They also completed the Depression, Anxiety, and Stress Scale (DASS-21; Lovibond & Lovibond, 1995) to assess emotional well-being, and the attachment anxiety subscale of the Experiences in Close Relationships-Revised (ECR-R; Fraley et al., 2000) to measure relationship insecurity. Average scores were used in Pearson correlation analyses.

Results showed a significant positive correlation between parental conflict and emotional distress, $r(46) = .49$, $p < .000$, and between parental conflict and attachment anxiety, $r(46) = .50$, $p < .000$. These findings suggest that greater exposure to parental conflict in childhood is associated with higher emotional distress and insecurity in adult relationships. The study supports the importance of culturally sensitive approaches to understanding how early family dynamics affect long-term psychological outcomes in Afghan populations.

Mentor(s): Seung-Hee Han (Department of Psychology Hollins University) Virginia Tech

Xander Dellinger
Virginia Tech/Biochemistry

Inducing Genome Editing in Barley Using Barley Stripe Mosaic Virus

Virus-induced transgene free gene editing (VITFGE) is a commonly used method in plant genomics. This technology uses a virus to deliver a guideRNA (gRNA) to a plant expressing CRISPR-Cas9, allowing the target gene to be modified. VITFGE bypasses some of the difficulties of editing certain crops (e.g. barley), as well as tedious and time-consuming procedures. Recent breakthroughs have allowed this tool to be applied in staple monocotyledonous crops such as wheat and corn, using Barley Stripe Mosaic Virus (BSMV) as the gRNA vector. This study's primary goal is to further explore VITFGE as an efficient method of genomic editing in barley. BSMV was used to deliver gRNA of the phytoene desaturase (PDS) gene into a line of barley which constantly expresses Cas9. Sixteen of these barley plants were inoculated with BSMV carrying PDS gRNA: 8 at both the 5 and 6-leaf stages. A knockout mutation in the PDS gene causes bleaching in leaves, a phenotypic indication of successful genome editing. This bleached phenotype began to appear around 4 weeks post infection. In the plants infected with BSMV, somatic editing of barley was widely successful, with leaf bleaching phenotype in 100% of subjects. Sanger sequencing confirmed insertion mutations in all plants infected at the 5-leaf stage. Heritable editing was also demonstrated phenotypically in over half of offspring from a previous line. Our results show VITFGE in barley using BSMV as a vector is an effective and efficient method of genetic transformation.

Mentor(s): Xiaofeng Wang (Plant and Environmental Sciences) Virginia Tech

Roma DiGiacomo
Virginia Tech/Microbiology

Antivirulence against Type IV pilus assembly ATPase PilB: Validation of identified PilB inhibitors from a virtual screening

Antivirulence targets virulence factors. Virulence factors are bacterial structures or components that are vital for pathogenesis. They are not essential for cell viability. Antivirulants, in contrast to antibiotics, disarm bacteria rather than killing them. This approach reduces the chance for bacteria to develop resistance.

Type IV Pilus (T4P) is a key virulence factor in many important antibiotic-resistant bacterial pathogens. One of its primary roles is enabling bacterial attachment to both biotic and abiotic surfaces. In our study, we aim to target PilB, the pilus assembly ATPase that is essential for the biogenesis of T4P. Targeting PilB to disrupt pilus formation and functions makes PilB a promising candidate for antivirulence strategies.

Virtual screening enables testing numerous drug compounds for interaction, binding, and inhibitory activity with a model enzyme. This computational approach saves time and resources compared to a physical high-throughput screening method involving benchtop work. Previously, a virtual screening was conducted in the Yang Lab to identify potential inhibitors of the model enzyme Chloracidobacterium thermophilum PilB (CtPilB). Four potential inhibitors were identified: zoledronate, fenoterol, mepiroxol, and acipimox. In our current study, we aim to validate the activity of these inhibitors both in vitro and in vivo. We used purified CtPilB to evaluate the inhibitory effects of these compounds. Our results showed that only zoledronate (IC50 = 38 μM) and fenoterol (IC50 = 481 μM) inhibited CtPilB activity. Zoledronate, with an IC50 of 38 μM, demonstrated higher potency and was selected for further in vivo testing.

Mentor(s): Zhaomin Yang (Biological Sciences) Virginia Tech

Collin Doyle
Seton Hall University/Physics

Characterization of a Nuclear Orientation Thermometer

Nuclear orientation thermometers exploit the angular asymmetry in gamma ray emission that occurs when an appropriately prepared gamma ray source is cooled to millikelvin temperatures. Here we report on the characterization of such a thermometer, which is based on an embedded Cobalt-60 sample in a hexagonal close packed Cobalt single crystal. The characterization was carried out in the temperature range of 10-60 mK in a 3He-4He dilution refrigerator, and specific attention was paid to the difference in the intensities of gamma radiation measured by high purity germanium detectors placed on-axis and 90 degrees off-axis with the angle of orientation of Cobalt-60 nuclei. We compared the nuclear orientation thermometer to a thermometer that relies instead on the temperature dependence of electrical resistance measurements in Ruthenium (IV) Oxide to assess the effectiveness of this method of nuclear orientation thermometry.

Mentor(s): Thomas O'Donnell (Physics) Virginia Tech

Varsha Durai
Virginia Tech/Biochemistry

Independent

Low-Cost Detection of Airborne Microplastics Using 3D-Printed Aerosol-Capturing Devices, Liquid Chromatography-Mass Spectrometry (LC-MS), and Fluorescence Microscopy

Fine particulate matter (PM) in aerosols contributes to over 60,000 premature deaths annually, primarily due to deep alveolar deposition linked to respiratory and cardiovascular diseases. Among these particles, microplastics have been associated with granuloma formation, fibrosis, and chronic inflammation. Inhalation is a major route of microplastic exposure, emphasizing the need for effective airborne microplastic detection methods. However, current aerosol sampling techniques are often costly and technically demanding. This study reproduces a published inertial impactor (0.5 mm nozzle) design using low-cost, scalable stereolithography (SLA) 3D printing methods with the FormLabs 4 SLA 3D printer. The device captures microplastics ≤100 µm, which are small enough to reach the lower respiratory tract. The design was modified using TinkerCAD and Preform, with powdered polypropylene (PP) micropipette tips used to validate device performance. These particles were drawn through the device at 1.2 L/min, and the collected particles were resuspended in water using a peristaltic pump at 0.3 ml/min. Samples were then analyzed using mass spectrometry and image analysis using an inexpensive and readily available commercial pink dye, which enabled visualization under a fluorescence microscope. Labeled particles exhibited bright fluorescence under the red fluorescence channel (excitation: 540-560 nm, emission: 580-620 nm). This low-cost and scalable airborne microplastics detection system has potential applications in assessing indoor air quality, evaluating air filter performance, and enabling broader environmental monitoring efforts. Further work will involve characterizing captured particles using FTIR- and Raman-based microscopy, modifying the impactor design for improved performance, and evaluating efficiency in real-world settings, including extended-duration air sampling.

Mentor(s): Rich Helm (Biochemistry) Virginia Tech

Ken Edmison
Virginia Tech/Computer Science

Demystifying Quantum Computing

We seek to introduce the concepts of quantum computing to students in their high school years, (grades 10-12). Because the usual notation for quantum computing involves bra-ket notation and a good bit of vector math students at that age simply haven't learned yet, Dr. Sikora and his collaborators created a pictorial formalism which abstracts away most of the scarier mathematics. My task was to take that formalism and lay out a curriculum plan that covers elementary quantum computing topics in a way that is both engaging and comprehensible to someone with our target level of education. The curriculum covers the basics of quantum states and superpositions before moving on to quantum logic gates and the concept of entanglement. It also covers measurements, as they relate to quantum mechanics in general and quantum computing in specific, before moving on to teaching basic QC algorithms, notably Grover's Search Algorithm. This curriculum will be given to another group later, who will animate it into an app, so that students can access it and guide themselves through the material. This is important because quantum computing is an important emergent field in the computer science, engineering, and physics. Large companies including IBM, Microsoft, and Intel are investing significant resources in the field, as is the federal government. Because of this, there is a high demand for skilled workers as the field expands. We hope to stimulate interest in the field and encourage students to pursue it in their further education.

Mentor(s): Jamie Sikora (Computer Science)

Lucie Farrell
The Pennsylvania State University/Aerospace Engineering

Aerial–Ground Measurements of Forest-Sourced Bioaerosol Emissions in Lower Austria

Forest ecosystems in Central Europe are increasingly threatened by outbreaks of the European spruce bark beetle (Ips typographus L.), driven by rising temperatures and intensified heatwaves. Such outbreaks may shift the abundance and composition of forest-sourced bioaerosols, with potential implications for their cloud-nucleating abilities, optical properties, and atmospheric lifetimes, which collectively influence air quality and regional climate. To investigate bioaerosol signatures in a bark-beetle-impacted forest, optical particle counters (OPC) and wideband integrated bioaerosol sensors (WIBS) were deployed within the Vienna Woods of Lower Austria across three adjacent land-cover types: a mixed-species (deciduous and spruce) forest, a grassy open field, and a spruce monoculture. Aerosol sampling was conducted over two days in mid-June using two drone platforms (one hovering at 40 m above selected canopy locations; the other flying systematic transects) alongside synchronized ground-level instruments. OPC recorded particle size distributions from 0.3 to 10 µm to assess spatiotemporal variability in fine-mode concentrations among the three sites. WIBS fluorescence measurements (excitation at 280 nm; emissions at 310–400 nm and 420–650 nm) were partitioned into seven compositional classes to infer relative contributions from fungal spores, insect fragments, and other bioaerosols. Ongoing analysis compares particle number concentrations and fluorescence class distributions to identify characteristic bioaerosol profiles in beetle-affected stands. This work also highlights key logistical and analytical challenges encountered during rapid field deployment to inform future studies. This integrated aerial–terrestrial approach aims to produce high-resolution spatiotemporal maps of forest health, offering a novel tool for early detection and monitoring of pest-induced perturbations in forest–atmosphere interactions.

Mentor(s): David Schmale (School of Plant and Environmental Sciences) Virginia Tech

Brooke Ferguson
Virginia Tech/Computational and Systems Neuroscience

Using Nanofabricated Fiber Networks to Probe the Role of Sensory Feedback in Animal Locomotion

Proprioception, an animal's sense of its body's joint positions, balance, and force production, is crucial for survival in an ever-changing environment. Proprioceptive feedback enables an organism to maintain robustness and stability during locomotion. However, despite its importance, we lack an understanding of how this feedback is utilized to adjust motor behavior.

Towards addressing this gap, we analyzed changes in walking kinematics and force production of fruit flies, Drosophila melanogaster, as they moved over networks composed of precisely deposited nanofibers. These fibers were manufactured using the spinneret-based tunable non-electrospinning parameters (STEP) platform, and enable us to precisely control mechanical properties of the walking stage by adjusting the spacing or diameter of the nanofiber networks. Previous research examined the role of proprioceptive feedback only in animals locomoting on flat, rigid ground, whereas with this method we can create more complex environments that vary in their stiffness and spacing. We used crosshatch fiber networks with spacings ranging from 0.25 mm to 1.5 mm to simulate stable and unstable walking environments.

Our results demonstrate that flies adjust their walking gait in response to changes in the fiber spacing. As the spacing of fiber networks increases, joint angles and the variability of inter-leg coordination patterns (ICPs) increase during movement. Conversely, we find a decrease in average velocity as these fiber spacings increase. We also find that when we genetically inactivate proprioceptive feedback, the fly exhibits more drastic changes in motion than wild type flies. Further understanding of proprioceptive influence in motion lays the groundwork for discovering the specialized pathways responsible for helping us successfully navigate our world. This brings forth a new perspective on diseases related to motor control that may hold the key to future treatments.

Mentor(s): Sweta Agrawal (School of Neuroscience) Virginia Tech
Amrinder Nain (Department of Mechanical Engineering) Virginia Tech

Colton Fox
Virginia Tech/Computer Engineering

A Web-Based Tool for Real-Time Analysis of SuperDARN Space Weather Radar Data

Space weather involves dynamic changes in Earth's magnetosphere and ionosphere caused by solar activity. These changes can disrupt satellite communications, GPS, and power grids, making real-time monitoring essential for both scientific research and mitigation efforts. The Super Dual Auroral Radar Network (SuperDARN) is an international network of high-frequency (HF) radars designed to study space weather by tracking the motion of plasma irregularities in the upper atmosphere/ionosphere. While SuperDARN produces valuable data and offers tools for historical analysis, there are few tools currently available for real-time monitoring. This project introduces a real-time software system for visualizing and tracking SuperDARN radar data through a custom-built web application. The system ingests live radar data and distributes it via a Python-based WebSocket server, which is then rendered in the browser using Plotly.js for geographic field-of-view (FOV) plots. These FOV plots display key radar measurements—velocity, elevation, spectral width, and signal-to-noise ratio—in real time. The backend is implemented with Flask and integrates with SuperDARN's existing global infrastructure to provide seamless updates. These visualizations offer insight into ongoing space weather conditions and serve as a compelling public showcase of SuperDARN's capabilities. In addition to serving as a public outreach tool, this system supports continuous space weather monitoring for events such as solar flares and geomagnetic storms that threaten communication systems. It also opens the door for non-scientific use cases, such as real-time auroral visibility tracking for tourism.

Mentor(s): Joseph Baker (ECE) Virginia Tech
Dr. Bharat Kunduri (ECE) Virginia Tech
Kevin Sterne (ECE) Virginia Tech
Dr. Mike Ruohoniemi (ECE) Virginia Tech

Rielly Fralin
Virginia Tech/Microbiology

Post-transcriptional gene regulation by small RNAs in Brucella abortus

Brucella is one of the leading infectious zoonotic bacteria in the world, infecting millions of livestock annually. Treating Brucellosis, the bacterial disease caused by Brucella, is limited to certain antibiotics and has around a 30% relapse rate in humans. Likewise, the current vaccines for preventative treatment of livestock have great room for improvement. A vaccine for humans could be possible utilizing tools such as small RNAs (sRNA's), but furthering the current preventative and treatment options could prove just as important. While post-transcriptional regulation by sRNAs is an understudied subject, the goal is to characterize the role of the sRNA Bmsr9 region. If the gene is deleted from the B. abortus genome, then various changes could be observed, because the region is uncharacterized and has an unknown influence. This method utilized cloning as a tool to delete the Bmsr9 region out of the genome. Beginning with amplifying the area around the gene of interest with specific complementary primers, then utilizing restriction enzymes to cut the ends, the strand absent of Bmsr9 was then ligated into our plasmid. Afterwards, Escherichia coli was used to amplify the plasmid containing our strand and then transformed into B. abortus. Resulting from this, the region was deleted, and the strand was successfully input into our plasmid and transformed into E. coli. This being confirmed with blue-white screening, followed by further sequencing. This study is ongoing and can further our understanding of post-transcriptional regulation carried out by sRNAs in Brucella and improve Brucella prevention and treatment approaches.

Mentor(s): Clayton Caswell (Biomedical Sciences and Pathobiology) Virginia Tech

Cassie Freedlander
Virginia Tech/Mechanical Engineering

Using Synthetic Trees for Underground Water Harvesting and Enhanced Condensation

Natural trees pump water from the soil to their leaves in a process called transpiration, where negative pressure in the leaves' nanopores suctions water upward. Synthetic trees function under the same phenomenon, with partially-submerged glass tubes attached below a nanoporous ceramic disk. Two projects have been devised to investigate the uses of synthetic trees. The first project mimics how a natural tree draws water from soil by partially burying the synthetic tree's tubes in soil of varying saturation. In fully-saturated soil, the tree successfully used transpiration to pump water. However, reducing soil saturation introduced air bubbles, clogging the tubes. To mitigate this, we are testing an adapter with connecting tubes to divert water around blockages based on the xylem cells of natural trees. Multiple models were designed, 3D-printed, and attached to the tree's tubes. The tree-adapter configurations were placed upright in partially-saturated soil and observed during transpiration. The process is ongoing and will be considered a preliminary success if transpiration occurs despite the presence of air bubbles. The second project hypothesizes that synthetic trees can make condensation more efficient because the tree's suction will reduce the thermal resistance of a condensed surface by thinning its film of condensation. To test this, a chilled plate and a synthetic tree will be placed in the same layer of water on a mass balance. If the total amount of water collected with the tree over a set time exceeds that of the plate alone, the results may have exciting implications for condensation efficiency.

Mentor(s): Jonathan Boreyko (Mechanical Engineering) Virginia Tech

Ariana Garrastegui Segarra
Virginia Tech/Animal and Poultry Science

Reducing K63 polyubiquitination in the hippocampus increases food intake and weight gain during the development of obesity

Currently more than 40% of adults in the U.S. suffer from obesity, which is a significant risk factor for many diseases and one of the leading causes of preventable death. Interestingly, numerous studies have demonstrated that obesity is associated with memory impairments and is a significant risk factor for the development of age-related cognitive disorders, including Alzheimer's disease. One of the primary regions involved in memory formation in the brain is the hippocampus, which has been shown to be sensitive to exposure to obesogenic diets. However, the underlying molecular changes which occur in the hippocampus following exposure to obesogenic diets leading to memory impairments remain largely unknown. Our lab has previously shown that K63 polyubiquitination, a major form of protein ubiquitination that does not lead to degradation by the proteasome, in the hippocampus limits memory formation during young adulthood. However, it is currently unknown if obesogenic diets alter K63 polyubiquitination in the hippocampus to cause memory impairments. Here, we found that 13-week exposure to a high fat diet increased K63 polyubiquitination levels in the hippocampus of male rats. Surprisingly, CRISPR-dCas13-mediated knockdown of K63 polyubiquitination in the hippocampus caused animals to eat more food and gain weight faster than controls, but only when exposed to high fat obesogenic diets. While this unexpected result precluded our ability to assess if K63 knockdown could improve memory during obesity development, these data suggest that increased K63 polyubiquitination in the hippocampus may be directly involved in obesity development. Current studies are using viral-mediated retrograde labeling techniques to test if the diet-induced increases in K63 polyubiquitination are occurring on presynaptic inputs into the amygdala, a brain region involved in regulating the rewarding properties of food.

Mentor(s): Timothy Jarome (Animal Science) Virginia Tech

Allison Gibson
Truman State University/Chemistry

Tuning molecular ionic composite electrolytes for use in solid-state lithium batteries

The development of high-performance solid-state electrolytes is critical for the advancement of lithium batteries with higher energy and power densities. Traditional lithium batteries also pose safety risks due to the flammable liquid electrolytes and lithium dendrite growth, which can lead to combustion. Polymer-based solid-state electrolytes offer a safer alternative. Among these are molecular ionic composite (MIC) films, which are ion conductive, nonflammable, and lithium dendrite suppressant. MICs can be made from rigid ionic polymers, polar molecules, and salts. We will present thin MIC films developed using lithium salt, poly(ethylene glycol) (PEG), and poly(2,2-disulfonyl-4,4-benzadine terephthalamide) (PBDT). We employ PBDT for its rigid double helical nature, giving the film strong mechanical properties. The PEG component disperses between the double helix of the PBDT and improves film flexibility and ionic conductivity. By varying the ratios of these components, we are studying the mechanical and thermal properties of the films to improve the strength and flexibility of the films. We use dynamic mechanical analysis (DMA) and uniaxial tension testing to study the thermomechanical behavior of the MIC films. We further test the thermal stability of the films through thermogravimetric analysis (TGA) to determine the temperatures at which different components of the films start to decompose. By thus tuning the strength, flexibility, and thermal decomposition of the films, we can enhance electrolyte performance in battery applications.

Mentor(s): Louis Madsen (Department of Chemistry and Macromolecules Innovation Institute) Virginia Tech

Elise Grieme
Virginia Tech/Biomedical Science

Quantifying the Presence and Types of Microplastics in Soil Amendments and Assessing Their Toxicological Impact on Aquatic Organisms

Microplastics enter the environment from various sources (ex: compost) before accessing plants and water bodies, leading to environmental disruption through presence and leaching out hazardous chemicals. This presents opportunities to evaluate the occurrence of microplastics in soil amendments as well as assess the effect of their subsequent leachates on sensitive aquatic taxa. This study's first aim is to determine the presence of microplastics in fertilizers and characterize microplastics found. The second aim involved assessing toxicity levels of tire leachates and chemical tire component 6PPDQ in Daphnia magna, used as the model organism to observe oxidative stress because of its sensitive response capability as biomarkers for various exposures to substances. During the compost study, microplastics were extracted using zinc chloride, centrifugation, and hydrogen peroxide before stereomicroscopy analysis. For the second part of the study, daphnia were exposed to particles from five tire brands and 6PPDQ at concentrations of 25ug/L and 50ug/L, and the toxicological impact was assessed at these sublethal conditions by targeting glutathione (GSH) and catalase activity (CAT), both part of the antioxidant defense system in daphnia. GSH results showed that levels did not differ across treatments while CAT did, suggesting cells had better resistance to reactive oxygen species in exposure to the tire leachates. The compost study results demonstrated the amount and types of microplastics in soil, which enables the agricultural community to focus on minimally polluting soils. Future studies will further analyze the soils while daphnia will be analyzed for superoxide dismutase, another component to the antioxidant response.

Mentor(s): Austin Gray (Biological Science) Virginia Tech

Arden Grim
Smith College/Neuroscience

Analysis of the Impact of Dosage and Gender on Goal Achievement by I-ACQUIRE Clinical Trial Participants

Pediatric stroke patients often experience lifelong neuromotor impairments. Constraint-Induced Movement Therapy (CIMT) has demonstrated positive outcomes across many clinical trials, but many aspects of the treatment processes are still undefined. CIMT is an intensive treatment in which the dominant arm is casted while participants receive daily therapy sessions throughout a one-month period. I-ACQUIRE is a Phase III clinical trial investigating the efficacy of two CIMT dosages for infants and toddlers with a history of stroke and hemiparesis. The objective of this project was to determine whether goals met during CIMT differed by dosage. Data was obtained from 66 I-ACQUIRE participants (33 female) with a mean age of 19.89 (s.d=8.35). Participants received either a high dosage (6 hours/day, five days/week, 4 weeks) or moderate dosage (3 hours/day, five days/week, 4 weeks) of CIMT. Each child's therapist created a list of individualized treatment goals and reported post-treatment accomplishments. Univariate Analysis of Variance (ANOVA) indicated significant differences in percentage of goals met ($f=9.10$, $p>0.01$) and percentage of goals not met ($f=9.10$, $p>0.01$) based on gender. Additionally, a dosage by gender interaction occurred for number of goals not met ($f=5.81$, $p=0.02$). These findings are suggestive. However, further research is needed to determine if these findings reflect differences in the application of CIMT or in treatment responsiveness to CIMT based on gender. Therapists may have set differing types of goals or differed in therapeutic practices when delivering CIMT to boys versus girls.

Mentor(s): Stephanie DeLuca (Neuromotor Research Clinic/School of Neuroscience, Virginia Tech)

Sanjana Gummalla
Virginia Tech/Computer Science

HAVEN: Hierarchical Attention for Viral protEin-based host iNference for Coronaviridae Sequences

Accurately predicting the hosts of viruses is critical for pandemic prediction and prevention. HAVEN is a transformer-based machine learning model that uses hierarchical self-attention to predict the host of a virus given only its protein sequence. Initially pre-trained on over 1.2 million protein sequences from the UniRef90 dataset, which comprises protein sequences that are 90% similar to one another, HAVEN has demonstrated strong performance on both common and rare host prediction tasks. In this project, we pre-train and fine-tune HAVEN on a more challenging domain: host prediction for coronavirus protein sequences– a small subset of the UniRef50 dataset. Coronaviruses are uniquely important due to their crown-shaped proteins, which play a key role in determining which host is infected. Because HAVEN's complexity requires a substantial amount of data to be used to its full potential, the limited size of the Coronaviridae dataset (only 0.2% of UniRef50) poses a challenge. We compare HAVEN's performance to three traditional machine learning models (Random Forest, Support Vector Machines, and Logistic Regression) to further evaluate and compare its performance. Such models thrive on the size of the dataset we are using for this project due to their architectures. We found that HAVEN performs comparably across most evaluation metrics. On the coronavirus dataset, HAVEN achieves an average AUPRC of around 0.75. While HAVEN shows high potential and accurate predictions for larger datasets, such as the entirety of Uniref90 or Uniref50, the small 1,122 Coronaviridae dataset imposes limitations from the small-scale fine-tuning used.

Mentor(s): T.M. Murali (Computer Science) Virginia Tech

Su Gursoy
Hollins University/Biochemistry

Antimicrobial Potential of Bucida buceras (Black Olive) Fruit and Seeds: Bioprospecting for Novel Antibacterial Agents

Polyphenols are a category of compounds that are naturally found in plant foods, can act as antioxidants, and can naturalize harmful free radicals that would otherwise cause damage in the body (Petre, 2023). Phytochemicals found in natural substances are important for the healthy microbiome of the body because of their antioxidant properties involving different mechanism of action against diverse pathogenic bacteria (Suriyaprom, et al., 2022). Black olives are rich in bioactive compounds, especially polyphenols. The specific phenolic compounds were determined in both fruit and seeds using High Performance Liquid Chromatography (HPLC). The antibacterial resistance of black olive seed and fruit extracts as well as found phenols and antibiotics that were known to have effects were tested against two specific ESKAPE pathogens: Acinetobacter baumannii and Staphylococcus aureus. ESKAPE pathogens are a group of antibiotic-resistant bacteria that represent a global threat to human health due to its antibacterial resistant genes which reduce the treatment options for serious infections and diseases (Oliveria, et al., 2020). It was hypothesized that the black olive seed will contain more phenols compared to the fruit part and those determined phenols will show antimicrobial effects against the A. baumannii and S. aureus. The results indicated that part of the experimental hypothesis that stated seeds will contain more phenols than the fruit was accepted. However, neither seed nor the fruit extract, as well as the standard extracts made for specific phenols found showed any antibacterial effect against the A. baumannii and S. aureus. Therefore, the second part of the experimental hypothesis was rejected.

Mentor(s): Mary Jane Carmichael (Biology Department) Hollins University
Daniel Derringer (Department of Chemistry) Hollins University
Molly Lynch (Department of Mathmatics) Hollins University

Su Gursoy
Hollins University /Biochemistry
Emily Bryant
Hollins University/Chemistry

Investigating the Synthesis and Characterization of Heteroleptic Silver(I) and Copper (I) Complexes on Fluorinated Diphosphine and Bipyridine Ligands

The overarching research question that this study investigates is: “Could earth-abundant Copper(I) or Silver (I) be an efficient alternative to Iridium (III) in organic light-emitting diode devices?” The primary approach involved modifying Copper(I) and Silver(I) complexes and electronically tuning them by using sterically bulky electron-withdrawing and electron-donating ligands, thereby altering the energetics of Copper(I) and Silver(I) complexes. All reactions were performed under Nitrogen using the Schlenk Technique. The steps to synthesize the compounds began by conducting the reactions under Nitrogen, followed by stirring the reactions overnight, pipette filtering, and allowing the filtrates to crystallize inside a scintillation vial with a septum and exit needle for two to four days. The Copper reactions and the Silver reactions involving AgBF4 did not crystallize as expected; instead, the reactions either formed films or powders at the bottom of the vial. Slow evaporation of Dichloromethane (DCM) or vapor diffusion with Ether was used to facilitate crystallization in those cases. Using Ultraviolet-Visible Spectroscopy, Fluorimeter, and LC-MS, the crystals and mother liquor of the end products of reactions, along with the used ligands, were analyzed, and some of the end products of the reactions were confirmed while others are still in progress. Additionally, crystal samples were sent to the Virginia Tech Crystallography Lab for determination and characterization of the end products of the reactions. Heteroleptic structures for several crystals have been confirmed with X-Ray analysis, and others are still in progress.

Mentor(s): Brian Reeves (Chemistry) Hollins University

Camryn Hardin
Virginia Tech/Biochemistry

Molecular characterization of the lactic acid bacteria from three distinct sourdough starters

The rise of sourdough consumption increased steadily over the past five years and is projected to increase the next coming years. Heterofermentative lactic acid bacteria (LAB) is one of the most abundant microbial groups found in sourdough, which play a crucial role in the fermentation process. LAB is a group of Gram-positive, catalase negative, non-spore forming and aerotolerant. Typically, they coexist with yeast and significantly contribute to the acidification, flavor fermentation, and leavening of the dough. Previous studies have characterized a wide range of LAB in sourdough with the most common strain being Lactobacillus sanfranciscensis. This research aimed to characterize LAB isolated from three distinct sourdough starters: all purpose, rye and whole wheat. To achieve this, bacterial colonies were isolated and stored at -80°C for further analysis. Isolates were tested for catalase activity and Gramstained for morphology confirmation. Finally, the 16S rRNA gene was amplified and sequenced to identify LAB communities across the three starters. A total of 129 cultures were isolated from the starters.
Of these, 114 were tested for catalase, and 23% (30/114) tested positive. For the remaining isolates, 66% (85/129) were catalase-negative and presumed to be LAB and were subjected to polymerase chain reaction (PCR) amplification of 16S and subsequent Sanger sequencing. Among 25 isolates were characterized with Sanger sequencing, Enterococcus faecium (60% of sequenced) was the predominant bacteria isolated, with additional LAB and Kosakonia spp. found across all starters. These findings highlight the dominance of Enterococcus faecium in sourdough starters which may guide future starter optimization.

Mentor(s): Rachel Cheng (Food Science and Technology) Virginia Tech

Merridith Harrison
Virginia Tech/Environmental Science
Landen Higgins
Virginia Tech/Chemical Engineering

Independent

Mycoremediation in Treatment Wetlands: Enhancing Pathogen Removal Using Pleurotus ostreatus Mycelia in Dynamic Hydraulic Systems

Wastewater treatment wetlands (WWTWs) are utilized for wastewater treatment but often fall short of eliminating pathogenic and antibiotic-resistant bacteria (ARB), posing serious environmental and public health concerns in receiving waters. This study explores the use of fungal mycelia—specifically Pleurotus ostreatus (White Oyster Mushrooms)—to enhance pathogen removal efficiency in WWTWs through a novel myco-augmented strategy. Expanding upon previous batch-mesocosm research demonstrating that active mycelial mats reduced Escherichia coli (E. coli) concentrations by up to 85.0%, meeting US EPA recreational water standards within 3.33 days, this study addresses limitations in static systems by configurating flow-through columns that more accurately represents wetland hydraulics and redox conditions. Columns of 5.08cm diameter, 50cm length, and 1L volume were filled with actively colonized or autoclaved mycelial substrates and compared against control columns devoid of fungal material. Non-pathogenic E. coli K12 (ATCC) was used as the pathogenic bacteria indicator, and effluent concentrations were monitored as water passed through each treatment. Data collection is ongoing. The flow-through approach mitigates stagnation and variability observed in previous systems by enhancing contact between fungal mycelia and target bacteria. It promotes improved and more consistent microbial removal under dynamic hydraulic conditions, with a Hydraulic Retention Time (HRT) of 6 hours, a more scalable and operationally viable enhancement to conventional WWTWs. This eco-friendly, myco-augmented method presents a promising, low-energy, resilient solution for improving pathogen removal in wastewater treatment wetlands. Future studies will investigate underlying removal mechanisms using flow cytometry, fluorescence microscopy, and biochemical compound analysis to further elucidate the mycoremediation process.

Mentor(s): Natasha Bell (Biological Systems Engineering) Virginia Tech
Brian Badgley (School of Plant and Environmental Science) Virginia Tech

Wynn Haslam
Virginia Tech/Fish Conservation

Connecting Morphological, Behavioral, and Genetic Variation in Erimystax Chubs

This study aims to investigate how morphological differences are connected to genetic and behavioral phenomena amongst Erimystax chubs. Intraspecific (within species) morphological variation has been identified amongst members of this genus in the Clinch and Powell rivers of Virginia and Tennessee. The goal of this project will be to identify 1: if the morphological variation seen is related to genetic variation, 2: if there is any interspecific (between species) hybridization, and 3: if reproductive behavior differs between Blotched Chub and Streamline Chub, especially those with varying morphologies. Snorkel surveys and sampling will identify individuals with varying morphologies; genetic information from these individuals will be collected through fin-clips; and comparisons of reproductive behaviors between the species will be observed directly and with underwater videos. Small portions of the individual's caudal fin will be removed to provide DNA samples. Mitochondrial and microsatellite DNA will be analyzed to detect hybridization in the genomic data if it exists. Field data will be assessed to determine if morphologies of individuals are related to patterns of behavior occurring during reproduction. A report will be created to describe the morphological, behavioral, and genetic patterns seen in the study. This report, along with a literature review that is being currently conducted on hybridization in North American Leuciscids, will provide information on how we can inform conservation of the populations of Erimystax, and possibly other species.

Mentor(s): Emmanuel Frimpong (Fish and Wildlife Conservation) Virginia Tech
Paul Angermeier (Department of Fish and Wildlife) Virginia Tech
Kyle Grundy (Department of Fish and Wildlife) Virginia Tech
David Haak (School of Plant and Environmental Sciences) Virginia Te

Jacob Hayes
Virginia Tech/Mechanical Engineering

Spatial Variability of Monoterpenes in a Tropical Ecosystem in Ecuador

Monoterpenes are compounds released by plants in response to various stimuli, including fruit ripening, stress responses, immune responses, and plant growth. This study focuses on fruit ripening as the stimulus of interest. The objective of this study is to quantify the number of monoterpenes emitted from plants and determine whether the distance between locations with varying levels of fruiting results in noticeable differences in monoterpene concentrations. The samples for this study were collected from Fundación para la Conservación de los Andes Tropicales (FCAT, Ecuador) using sampling boxes to collect samples on sorbent tubes. These sorbent tubes were analyzed using thermal desorption gas chromatography-mass spectrometry (TD-GC-MS). The data from the TD-GC-MS were processed and used to identify and quantify the concentration of individual compounds in the samples. After identification and quantification, the individual compounds from each site were compared to one another to determine a correlation between sites. The correlations between the sites are used to determine whether differing locations within a region yield a significant difference in monoterpene concentrations and examine the impact distance has on similarity of monoterpene profiles. This study may also detect changes in monoterpene profiles depending on the degree of fruiting in the study area.

Mentor(s): Gabriel Isaacman-VanWertz (Civil & Environmental Engineering)

Hannah Hill
Virginia Tech/Clinical Neuroscience

Perceptions of the Headspace Mental Health App Design in Rural Appalachian Adults

Mental health disparities in Appalachia are well-documented, yet while mobile health apps offer increased accessibility, few studies have explored their reception in rural cultural contexts. Appalachian residents often face geographic isolation, provider shortages, and stigma surrounding mental health care, making them less likely to seek traditional services (Ziller et al., 2010; Behringer & Friedell, 2006). At the same time, research suggests that digital tools must be tailored to users' cultural norms and communication styles to be effective (Torous et al., 2018). This project investigates how rural Appalachian adults perceive the Headspace mental health app, with a focus on its emotional tone, cultural relevance, and compassionate design. The goal is to assess whether digital mental health tools align with the values and needs of individuals in underserved rural communities. This project asks the following research questions: (1) How do rural Appalachian adults interpret the design and emotional tone of the Headspace mental health app? (2) How do these interpretations explore narratives of compassion, care, and cultural relevance in digital mental health technologies?
Participants from Southwest Virginia will engage in a guided 10-minute Headspace session, followed by a semi-structured interview. Interview questions are designed to elicit emotional reactions, cultural resonance, and user-centered feedback. Thematic analysis will be used to identify patterns in perceptions and suggestions for more culturally sensitive app design. Anticipated results include a range of responses, from appreciation of the app's calming tone to critiques regarding language, spiritual assumptions, or perceived relevance.

Mentor(s): Qin Zhu (Department of Engineering Education) Virginia Tech

Sarah Hoekema
Oregon State University/Biological Data Sciences

Developing a Pipeline to Improve Pathogen Identification in Metagenomes

Developing a Pipeline to Improve Pathogen Identification in Metagenomes
Hoekema, S., Pierce-Ward, N.T., Kaur, S., Vinatzer, B.A.

Metagenomics is the study of the collective genetic material of a microbial community in an environment, such as the microbes, including pathogens, present in a diseased plant. Classification tools are often used to assign the obtained sequences to species to determine the microbial diversity in the community, possibly including the pathogen that caused the disease. Sometimes certain species have little to no sequencing reads within the sample, resulting in no classification of the species, leading to the question of how can one classify a species when there is low abundance of the species in the sample to avoid false negatives. Previous research has shown that using a custom genome database targeting the expected species in the sample may provide more reliable results of metagenomics classification software. My research expands on this approach by not only using a custom database of many species to improve metagenomic classification, but also mapping reads to a reference genome of a single target species and using BLAST against a target species for gene identification for additional verification. So far, using a custom database with the classification tool Sourmash has improved metagenomics classification within metagenomes containing the pathogen Ralstonia solanacearum. Overall, improvement of metagenomics classification would allow for easier and quicker identification of pathogens, allowing for quicker response to appropriately manage the disease and prevent further spread of the pathogen.

Mentor(s): Boris Vinatzer (School of Plant and Environmental Sciences) Virginia Tech
Lina Rodriguez Salamanca (Plant Disease Clinic) Virginia Tech

Ny'Ree Holland
Hollins University/Biology
Karli Craighead
Hollins University/Environmental Science

Fortifying Armor: An Investigation into Fly Cuticle Strengthening Against Parasitoid Wasp Attacks

The correct recognition and response to environmental threats is critical for organismal survival. In nature, parasitoid wasps pose a significant threat to fruit flies (Drosophila spp.). Female wasps inject their eggs into fly hosts, and once the egg hatches, the developing wasp eventually consumes the fly from the inside out. Flies have evolved numerous behavioral and immunological defensive mechanisms to protect themselves, but investigation into their physiological defenses have remained largely unexplored. In this study, we examined whether flies strengthen their protective cuticle after exposure to wasps. In a laboratory environment, flies were reared and exposed to female wasps (Leptopillina heterotoma) for 24 hours or remained alone without wasp exposure, and then continued their development until the pupal stage. A low-cost penetrometer assay was developed to determine the force required to pierce the cuticle with a fine metal pin. First, we tested wild-type Drosophila melanogaster flies for their ability to alter cuticle stiffness. Additionally, anosmic flies were tested to determine the role of olfaction in detecting the wasps' presence. Secondly, we tested whether the altered cuticle would protect flies by reducing parasitism rates. Finally, we assessed different wild-caught Drosophila species to test whether the enhanced cuticle response is conserved in nature. This work opens the possibility of a third defensive mechanism flies use to protect themselves, particularly at a vulnerable stage in their life cycle.

Mentor(s): Shaun Davis (Biology Department) Virginia Tech

Collin Holt
University of Richmond /Business Administration
Aziza Altyyeva
Berea College /Mathematics & Economics

Do Utility-Scale Solar Facilities Affect the Value of (Farm)Land?

As the development of utility-scale solar facilities (USSFs) continues to expand rapidly across Virginia, their economic impact on the surrounding landscape has become a crucial area of focus. This paper examines the effects of USSFs on land values in the state of Virginia, which may help inform landowners, policymakers, and solar developers about the financial viability and consequences of utility-scale solar development. Our aim is to contribute to a developing understanding by measuring the facilities' effects at both the county and the more granular parcel level. In order to isolate the causal impact of USSFs on land prices, this study uses a difference-in-differences (DiD) model at the parcel and county level, controlling a range of agricultural and socioeconomic factors. The results indicate no statistically significant average effect on local land prices at either the county or parcel level. However, a more granular continuous DiD analysis at the parcel level reveals a key indirect effect: following the construction of a USSF, proximity to existing electrical grid infrastructure becomes a more valuable land attribute, suggesting a market response to an area's heightened potential for future energy development.

Mentor(s): Michael Cary (Department of Agricultural and Applied Economics) Virginia Tech

Oluwatoni Ikhile
Virginia Tech /Psychology

The Role of Psychopathology and it's Subfactors in Age of ADHD Diagnosis

ADHD is a neurodevelopmental disorder occurring during childhood (Demma et al., 2020). Diagnostic overshadowing leads to later ADHD diagnosis, particularly for girls (Martin, 2024), who tend to be diagnosed at lower rates and older ages than boys (Martin, 2020). The general psychopathology "p-factor" captures covariation among mental disorders, accounting for their comorbidity and severity (Caspi et al., 2014). This study aims to determine whether higher levels of the p-factor relate to the age of ADHD diagnosis in boys and girls.

To do this, we used clinical data from the Adolescent Brain Cognitive Development study of 11,875 pre-adolescents. We split this sample into 3 groups based on diagnosis: healthy (n=3228), persistent ADHD diagnosis (n=135), and later-diagnosed ADHD (n=510). One-way ANOVA was used to test differences in p-factor scores across groups. Linear mixed-effects models were used to determine whether p-factor scores predict age of diagnosis, and whether gender moderates that relationship.

There were significant differences in p-factor scores across groups ($F(2,3855)=481$, $p<.001$). Tukey's HSD test showed that p-factor scores were significantly higher in the ADHD groups than the healthy group ($ps<.001$), and the persistent ADHD group had significantly higher p-factor scores than the later-diagnosed group ($p<.001$). Regression results indicated that p-factor scores were unrelated to diagnosis age (beta=-0.19, $p=.659$) and were not moderated by gender.

Overall, our results contradict our hypothesis that greater comorbidity leads to delayed ADHD diagnosis, particularly in girls. In the future, researchers should investigate other factors that may lead to delayed ADHD diagnosis, particularly in girls.

Mentor(s): Adrienne Romer (Psychology) Virginia Tech

Maryam Imran
Virginia Tech/Clinical Neuroscience

Independent

The Lung Microbiome's Role in Lupus Pathogenesis

Systemic lupus erythematosus (SLE) is a chronic autoimmune disease with unclear triggers. Despite this, recent evidence suggests that the microbiota may play a role in the progression of the disease. The gut microbiome has been studied extensively in this regard, but the lung microbiome has not. We hypothesized that destabilization of the lung microbiome exacerbates lupus and intensifies symptoms.

This study investigated the lung microbiome's role as a driving factor in lupus using MRL/lpr mice. We administered intranasal antibiotics to these mice from 4-8 weeks of age, comparing them to mice that received PBS dosages. We found that at 15 weeks of age, mice treated with antibiotics exhibited visible changes in the lung microbiome, increased lymph node size, and increased inflammatory cells in their lymph nodes. We also discovered that the mice treated with PBS exhibited higher urinary protein levels compared to their ABX-treated counterparts. We later found that these proteinuria levels shared a correlation with the abundance of certain bacteria in the lungs and feces of these mice. Collectively, these findings suggest that the relationship between the lung microbiome and lupus severity is complex and warrants further exploration.

Our data demonstrates that altering the lung microbiome impacts systemic immunity and affects lupus presentation in MRL/lpr mice. This presents the mucosal surface of the lung as a potential site of intervention in the alleviation of systemic symptoms. Future studies will aim to determine whether bolstering protective bacterial communities in the lung can mitigate the severity of lupus.

Mentor(s): Xin Luo (Department of Biomedical Sciences and Pathobiology) VA-MD College of Veterinary Medicine

Norman Jackson
Virginia State University/Computer Engineering

Quantum Sensing of Magnetic Fields

Quantum Sensing of Magnetic Fields
Research Question: What are the possible capabilities of Quantum Sensing?
Quantum sensing is an emerging field that leverages the principles of quantum mechanics to achieve highly sensitive measurements of physical quantities, such as magnetic fields. This project focuses on one powerful quantum sensing technique known as Optically Detected Magnetic Resonance (ODMR), which utilizes Nitrogen Vacancy (NV) centers in diamond crystals to detect magnetic field variations with remarkable precision. NV centers are defects in the diamond lattice that fluoresce when excited by a green laser. When a microwave signal is swept across a range of frequencies near the energy gap between the NV center's quantum states, a measurable decrease in red fluorescence intensity occurs due to Zeeman splitting, which corresponds to changes in the local magnetic field.
The goal of this project is to understand both the theoretical foundation and practical implementation of ODMR for magnetic field detection. Using the qutools quantum sensor, we perform experiments to set up and conduct ODMR measurements, observe how vector magnetic fields influence the photoluminescence signal, and estimate magnetic field strength under various conditions. Key experimental steps include aligning the laser excitation, optimizing the microwave frequency sweep, and collecting photodiode photon count data. Through this process, we gain hands-on experience with cutting-edge quantum technology and develop a deeper appreciation for how fundamental physics can be translated into real-world sensing applications.
Potential applications of this research include biomedical imaging, navigation without GPS, andspace exploration, where precise magnetic field mapping is essential.

Mentor(s): Wayne Scales (Quantum Engineering) Virginia Tech

AJ Jackson
Virginia Tech/Aerospace Engineering

Predicting Atmospheric Density Conditions During Geomagnetic Storms By Modeling Joule Heating

A leading cause of satellite collisions and de-orbits is upper atmosphere density enhancement, which causes unpredictable satellite drag effects and telemetry changes. A driving force for such density enhancements is Joule heating, which is caused in the Earth's upper atmosphere when electric currents pass through a layer of ionized gas. This layer, known as the ionosphere, acts as a conductor for the electromagnetic energy to dissipate as heat energy to the surrounding atmosphere. During geomagnetic storm events, deposited amounts of electromagnetic energy increase, and the Joule heating response becomes less predictable. Using a simplified equation, Joule heating was estimated by relating Pedersen conductance and electric field magnitude. Electric field data was obtained using the Super Dual Auroral Radar Network (SuperDARN) while Pedersen conductance values were obtained using the Ovation-Prime model coupled with solar input data from the NASA OMNI data set. These data sets were analyzed within a Python environment, and the Joule heating distribution for the northern hemisphere was mapped using polar projection plots. These plots were then compared with neutral density data from the European Space Agency (ESA) Swarm satellite constellation. This study serves as a demonstration of Joule heating modeling as a potential atmospheric density enhancement forecasting tool by comparing modeled Joule heating distributions with measured density enhancements. In the future, the analysis framework created could be expanded to use more robust models and equations for more accurate modeling of Joule heating effects during geomagnetic storm events.

Mentor(s): Joseph Baker (Electrical and Computer Engineering) Virginia Tech
J. Michael Ruohoniemi (Electrical and Computer Engineering) Virginia Tech
Bharat Kunduri (Electrical and Computer Engineering) Virginia Tech

Anushka Jadhav
Virginia Tech/Biochemistry

Building a microbial database of natural drinking water sources in Southwest Virginia via MALDI-TOF Mass Spectrometry

Many who live in rural southwest Virginia rely on wells and roadside springs as their main source of drinking water. Often, many do not have access to cost-effective and reliable methods to test it for potability. Knowing the quality of this water is imperative, as fecal matter, heavy metals, and/or harmful or pathogenic bacteria could easily contaminate the water source. MALDI-TOF mass spectrometry (MS) has been used in the medical field to identify microbes by their protein signatures, eliminating the need to culture them; this technique can be harnessed to determine what microbes are living in freshwater sources, including viable but nonculturable microbes (VBNCs). As MALDI-TOF MS has not yet been used extensively for environmental applications, a database of the common existing microbes in current water sources must be created. This project describes the start of database creation. Samples from several drinking water sources were collected, either cultured or filtered, and spotted onto a MALDI target plate and analyzed. The same samples were also imaged under a microscope. Additionally, fatty acid methyl ester (FAME) analysis and gas chromatography identification can be used to supplement the database, as microbial fatty acids are highly conserved and stable. The combined mass- and image-based features as well as FAME data provide the foundation of the developing database.

Mentor(s): Rich Helm (Biochemistry) Virginia Tech
Dr. Brown (Biochemistry) Virginia Tech

Ian Jeong
Virginia Polytechnic Institute and State University/Nanomedicine

Assessment of Pre-Focal Cavitation-Associated Risks in Ex Vivo Histotripsy of Extremity Tumor Models

Histotripsy is a noninvasive tumor ablation method that uses focused ultrasound to generate acoustic cavitation that mechanically ablates targeted tissue. Efficient and safe ablation depends on precisely generating cavitation solely at the focus, keeping mechanical damage localized at target tissue. However, cavitation can be observed forming pre-focally along the beam path on real-time ultrasound, within 1 centimeter above the surface of the limb, between the transducer and the skin. This study investigates whether pre-focal cavitation leads to off-target skin ablation and thermal injury through elevated skin surface temperatures. Samples included 12 amputated osteosarcoma (OS)-bearing canine limbs, 24 amputated canine limbs with other pathologies that led to amputation, and 18 healthy porcine limbs. Limbs with OS were treated at the tumor center, while limbs without tumors were treated in healthy regions of the radius in forelimbs or the tibia in hindlimbs. All limbs had a 3 x 3 x 3 cm (14.14 cm3) volume treated with histotripsy using a 500 kHz transducer at one of three levels (500, 1500, 2500 Hz) of pulse repetition frequency (PRF). On the pre- and post-focal skin surfaces, three temperature probes were placed subcutaneously 1 centimeter apart from each other on both the proximal and distal sides and recorded temperatures continuously throughout all treatments. Intensity of pre-focal cavitation was subjectively scored on a scale of 0-5 at five time points corresponding to 1%, 25%, 50%, 75%, and 99% of treatment completion via ultrasound video observation. Pearson correlation testing revealed a significant association between pre-focal cavitation score and maximum pre-focal temperature ($r = 0.65$, $R2 = 0.42$, $p = 0.0038$) and with change in pre-focal temperature ($r = 0.66$, $R2 = 0.44$, $p = 0.0027$) in porcine limbs. In contrast, no tested variables demonstrated significant correlations with pre-focal cavitation score in canine limbs. Of the 18 porcine samples, a total of 9 limbs reached cutaneous-damaging levels of temperature (44-55°C), but no mechanical or thermal damage was observed on the skin of any samples—canine or porcine—after treatment. This may be attributed to the lack of blood flow and viable tissue in amputated limbs. A Tukey's multiple comparisons test for porcine samples showed that pre-focal cavitation score significantly increased with each successive level of PRF, while the canine samples only showed such a correlation between 500 and 1500 Hz. This correlation indicates that using a lower PRF may contribute to a more successful and safe treatment by reducing pre-focal cavitation, allowing for more precise ablation and less off-target cavitation and its associated effects. This study provides information on the correlation between pre-focal cavitation and superficial temperature changes that should serve as precedent for further studies into the safety and clinical feasibility of histotripsy.
Keywords: Histotripsy, pre-focal cavitation, temperature, skin, canine, porcine

Mentor(s): Joanne Tuohy (Small Animal Clinical Sciences) Virginia-Maryland College of Veterinary Medicine
Alayna Hay (Small Animal Clinical Sciences) Virginia-Maryland College of Veterinary Medicine

Jeremy John
Virginia Tech/Mechanical Engineering

Design Optimization of Ocean Vehicles Using Large-Scale Multidisciplinary Design, Analysis, and Optimization (MDAO) Methods

This project develops a computational framework for the Multidisciplinary Design, Analysis, and Optimization (MDAO) of ships, with the objective of minimizing delivered power while ensuring satisfactory maneuvering performance. MDAO is particularly well-suited for early-stage design, where a large number of design variables, tightly coupled disciplines, and multiple interacting constraints make traditional methods inefficient or intractable. By leveraging modern techniques—such as automatic differentiation, adjoint-based sensitivity analysis, and parallel acceleration on high-performance computing platforms—MDAO enables efficient gradient-based optimization of large-scale, complex engineering problems.

In this work, we apply MDAO to ship design, beginning with principal hull parameters and systematically modeling resistance, propulsion, hull-propeller interaction, and maneuvering behavior. The methodology integrates the Holtrop-Mennen method for resistance prediction, Wageningen B-series polynomials for open-water propeller characteristics, and empirical models for hull-propeller interaction. Maneuvering behavior is captured using an MMG-style model, with hydrodynamic derivatives and rudder parameters estimated to compute non-dimensional indices such as advance, transfer, and tactical diameter.

Preliminary results show that this framework can optimize hull form coefficients and propeller geometry to significantly reduce delivered power while meeting IMO maneuvering standards. The anticipated outcome is a modular, extensible platform that supports state-of-the-art gradient-based MDO for ship design, providing marine engineers with a powerful tool to achieve efficient, well-balanced vessel configurations.

Mentor(s): Darshan Sarojini (Aerospace and Ocean Engineering) Virginia Tech

Luthien Jones
Liberty University/Chemistry

A Novel Snake Antivenom Using Zinc Chelation

Approximately 100,000 people die each year from venomous snakebites. Victims are often unable to obtain antivenom immediately, leading to disfigurement or death. Current antivenoms for rattlesnake and pit viper venoms are only available in locations in which they can be kept at low temperatures, as they will denature at above 10 degrees C. Therefore, adequate methods do not exist for countering snake bites received in locations that lack immediate access to medical aid. The goal of this project is to create a thermally stable and easily portable antivenom for hemotoxic snake venoms that is not immunogenic and can be delivered intramuscularly at the point of envenomation. This will be achieved using N-Bis-pyridin-2-ylmethylethane-1,2-diamine, which is an effective chelator for zinc. The proteins in rattlesnake and pit viper venom responsible for its damaging effects are zinc-based and N-Bis-pyridin-2-ylmethylethane-1,2-diamine demonstrates a very high binding affinity for zinc, -35 kJ/mol, enabling it to denature the proteins in the venom and slow its effects significantly. Importantly, this chelator has a high specificity for zinc over calcium: a unique quality, as most zinc chelators prefer calcium to zinc. Future synthesis will involve adding the functional group to dextran and performing further characterization.

Mentor(s): Michael Schulz (Department of Chemistry) Virginia Tech

Wykendrick Jones
Tougaloo College /Biology

Isolation of HRV3C protease for tag removal in recombinant protein technology

Recombinant protein technology often relies on affinity tags such as glutathione S-transferase (GST) to facilitate purification. However, efficient removal of these tags is essential for downstream applications. The human rhinovirus 3C (HRV3C) protease is a highly specific enzyme used to cleave fusion tags, offering minimal off-target effects. Here, we describe the overexpression, purification, and functional validation of recombinant GST-HRV3C protease. The GST-HRV3C protease was overexpressed in Escherichia coli (Rosetta) cells induced with IPTG for 4 h at 25°C. Following cell lysis by sonication, the lysate was subjected to affinity purification using glutathione-Sepharose beads. The GST-HRV3C protease was eluted using reduced glutathione and further purified by Superdex 200 size-exclusion chromatography. Purified GST-HRV3C was obtained in a highly pure state as confirmed by SDS-PAGE. The protease was tested on various GST-fusion proteins to evaluate its cleavage efficiency. HRV3C successfully cleaved the fusion targets, whereas the GST-HRV3C itself remained bound to the glutathione beads. This feature eliminates the need for additional removal steps, making the procedure more efficient than traditional cleavage reactions. The GST-tagged HRV3C protease provides a robust and selective system for tag removal. Its ability to remain immobilized on glutathione beads offers a practical advantage, simplifying purification workflows in recombinant protein production.

Mentor(s): Daniel Capelluto (Department of Biological Sciences & Fralin Life Sciences Institute) Virginia Tech

Khadeejah Jones
University of Maryland Eastern Shore/Urban Forestry

Impact of Antibiotics, Air Temperature, and Other Stresses on Microbial and Plant Growth

A gram of soil contains up to 10 billion microorganisms, including bacteria and fungi. Microbes produce antibiotics to stop the growth of other microorganisms and access limited resources. Most of the antibiotics used in medicine come from soil microorganisms and antibiotic resistance is an issue. Understanding how antibiotics impact microbes is important for ecology and public health. This study employed microbes isolated from serpentine or non-serpentine soils and antibiotics at different concentrations: tetracycline (ppm: 2.5, 5, 10, 20), spectinomycin (ppm: 60, 100, 800, 1600), and kanamycin (ppm: 5, 10, 20, 50). Spectinomycin was the most effective against all microbes. Antibiotics are stressful and understanding how much stress a microbe can tolerate is important even if it is not antibiotics. This study used MgSO4 (1% and 5%), and NaCl (1%, 2.5%, 5%, and 20%). Jensen's media was also used to test whether there were any nitrogen fixers. All of the microbes were nitrogen fixers and the 20% NaCl solution inhibited growth.. This tells us the limits of microbial growth in increasingly stressful environments. The limits of plant growth were also explored. Lettuce (Lactuca sativa) is widely grown in greenhouses and air temperature in greenhouses is controlled, but research suggests there is variation. In this study, 14 varieties of red leaf lettuce were placed in a hydroponic system to test the impact of uneven air temperatures on lettuce cultivars. The results of this study are forthcoming but important for understanding how differences in temperatures influences plant development.

Mentor(s): Allie Igwe (Biological Science)
Eric Stallknecht (VT AREC) Virginia Tech

Carolyn Jones
Virginia Tech/Cognitive & Behavioral Neuroscience

Lighting the Way to Sustainable Biofuel Production: Optogenetic Control in Yarrowia lipolytica

Optogenetic tools rely on light-inducible transcription factors to turn the expression of target genes on and off using different wavelengths of light, facilitating control over cells' behavior with lower cost and toxicity risks than chemical methods of gene expression induction. However, the applications of these switches in industrially useful organisms, such as Yarrowia lipolytica, remain understudied. As an oleaginous yeast, Yarrowia produces high levels of energy-dense lipids that can be converted into fuel; therefore, tools to easily control their metabolism would be valuable to sustainable energy-production efforts. Here, we used the Golden Gate cloning method to construct two DNA plasmids with optogenetic switches—blue-responsive EL222 and green-responsive CarH/CarO—along with genes for antibiotic resistance and a fluorescent reporter protein whose expression is driven by the light-activated transcription factor. The constructs were transformed into Yarrowia, which were screened for successful integration via growth on antibiotic plates and PCR. Positive colonies were then grown under light containing blue and green wavelengths with controls grown in the dark, and the activity of the optogenetic switches were measured with the reporter fluorescent protein. After six hours, light-incubated yeast containing EL222 exhibited around 70 times more fluorescence intensity than the controls. Fluorescence in CarH/CarO-containing yeast tended to peak at the two-hour reading, with the light-incubated yeast displaying around 1.5 times greater fluorescence than the controls after six hours. Future work based upon these results will focus on optimizing and multiplexing these switches to exert control over expression of target areas in the yeast genome.

Mentor(s): Clay Wright (Biological Systems Engineering) Virginia Tech

Jessica Kang
Virginia Tech/Cybersecurity Management & Analytics

Understanding the Emotional and Behavioral Impact of Cyber attacks on Users

Cyberattacks have become increasingly widespread in today's digital world, targeting individuals across various backgrounds and levels of technical knowledge. While the technical impacts of these incidents such as data breaches, identity theft, and financial loss are well documented, the emotional and psychological effects receive less attention. Victims frequently experience stress, fear, anxiety, confusion, and shame following a cyberattack. These emotional responses can lead to lasting behavioral changes, including hesitation to engage with digital platforms or complete loss of trust in technology. This research aims to explore how everyday users emotionally respond to cybersecurity threats, focusing on phishing scams and online attacks. The goal is to raise awareness about the human side of cybercrime and advocate for more empathetic cybersecurity education and practices. This study fits into a growing area of research that seeks to understand the broader impacts of digital threats beyond their technical consequences. A mixed methods approach was used to collect both qualitative and quantitative data. In-depth interviews were conducted with nontechnical users who have experienced a cyberattack firsthand, allowing for a comprehensive understanding of emotional and behavioral responses. The anticipated outcome of this project is a clearer understanding of how users emotionally react to cyberattacks. The research expects to identify common emotional patterns and behavioral changes, which can inform cybersecurity training and outreach efforts that prioritize both emotional and technical support for users.

Mentor(s): Michelle Ausman (Engineering Education) Virginia Tech
Qin Zhu (Department of Engineering Education) Virginia Tech

Sophia Kelly
Virginia Tech/Cognitive and Behavioral Neuroscience

Transcranial Magnetic Stimulation for the Treatment of PTSD Symptoms

Post-Traumatic Stress Disorder (PTSD) is a heterogeneous psychiatric condition that affects millions of Americans, yet the underlying neurobehavioral processes of PTSD are incompletely understood. While trauma-focused behavioral therapy can be effective interventions, they often have high drop-out rates. Alternative interventions based on noninvasive neuromodulation devices, such as transcranial magnetic stimulation (TMS), have been investigated as methods for altering neural circuit activity responsible for PTSD symptoms. Here, as part of an ongoing double blind, randomized phase II clinical trial, 14 participants with PTSD underwent functional and structural brain scanning prior to and after receiving an experimental TMS treatment or sham control. Participants completed the PCL-5 PTSD symptom checklist before and after the intervention. We observed a distribution of changes in PTSD symptom scores following the TMS intervention, with some participants' total scores decreasing substantially. Furthermore, we compared these changes in total scores to changes in known subsets of symptom clusters for each participant. As the TMS intervention was applied in the alpha frequency band (8-12 Hz), we explored the relation between changes in participants' PTSD symptoms and alpha band activity recorded using OPM-MEG. We hypothesize that the change in alpha band power following TMS intervention correlates with changes in symptom intensity. Together, these experiments address how TMS as an intervention for PTSD alters neural activity underlying disease pathology, providing an alternative approach to treating PTSD symptoms that augment traditional behavioral interventions.

Mentor(s): Read Montague (Neuroscience) Virginia Tech
Paul Sands (Neuroscience) Virginia Tech

Nikhitha Khasnavis
Virginia Tech/Computer Science

HAVEN: Hierarchical Attention for Viral protEin-based host iNference - Finetuning on Uniref50 dataset

Accurate prediction of viral hosts is critical for understanding and mitigating the spread of zoonotic diseases. Many viruses that infect humans originate in animals, yet it remains infeasible to experimentally determine the host range for the vast number of known and unknown viruses. Existing models struggle to generalize across highly diverse protein sequences and often fail when encountering previously unseen hosts or viruses. HAVEN is a hierarchical transformer based protein language model that learns rich representations of viral protein sequences using a two level architecture that combines segment level encoding with sequence level hierarchical self-attention to capture patterns in variable length inputs.
HAVEN: Hierarchical Attention for Viral protEin-based host iNference - Finetuning on Uniref50 dataset
While previous work on HAVEN used the UniRef90 dataset, this project evaluates the model on UniRef50, which contains protein clusters with no more than 50% sequence identity - providing a more diverse and challenging input space. Each cluster in UniRef50 is represented by a single, non redundant sequence. We curated a fine tuning dataset by filtering for vertebrates infecting non-immunodeficiency viral protein sequences and selecting the seven most common host species based on prevalence. This resulted in a multi-class classification setup with 6,396 sequences and seven host labels. We then applied unsupervised pretraining followed by supervised fine tuning of HAVEN and compared it to standard baseline classifiers, including logistic regression, random forest, and support vector machines. Results show that HAVEN consistently outperforms these baselines in macro AUPRC and generalizes well across both common and rare host classes.

Mentor(s): Murali TM (Computer Science) Virginia Tech

Muhammad Khurram
Virginia Tech/Computer Engineering

16-Channel Flexible Fiber-Based Neuro-Probes

Most existing brain probes are constructed from rigid materials such as silicon or metal wires, which can cause significant tissue damage and typically fail within 18 months due to micromotion and chemical degradation during use. Their fabrication is also costly, often requiring cleanroom facilities. To address these limitations, we developed a scalable method for producing flexible fiber-based neuro-probes using a thermal drawing process. This technique eliminates the need for cleanroom fabrication and allows batch production of devices composed of polycarbonate and tungsten, materials selected for their flexibility and improved biocompatibility. One of the biggest obstacles in neural probe development is the trade-off between minimizing device size to reduce tissue disruption and maintaining a form factor that supports reliable electrical interfacing. Our approach resolves this by incorporating a tapering process, giving the probe a narrow, flexible tip that minimizes tissue damage in vivo and a larger backend that facilitates integration with external electronics for data analysis. The tapering process also allows for high-channel-count recordings. We developed probes that have 16 channels, all fitted with electrodes to record data. The channels are modular, allowing for the electrodes to be replaced with optical waveguides or drug-delivery channels to stimulate the brain. These probes can be mass-produced, enabling a wide range of channel configurations to suit different experimental needs. Through these improved manufacturing processes, difficulty in analyzing brain activity could greatly be reduced due to the increased reliability of the probes.

Mentor(s): Xiaoting Jia (Bradley Department of Electrical and Computer Engineering) Virginia Tech

Ben Kim
Virginia Tech/Biochemistry

Independent

Uncovering Direct Targets of Protein Kinase G Using Engineered Kinase Biochemistry

Protein Kinase G Iα (PKG Iα) is a key regulator in cardiovascular physiology, yet the full spectrum of its direct phosphorylation targets remains unclear. Identifying these direct targets is crucial for understanding how PKG modulates signaling pathways, especially in the context of heart failure. To uncover novel PKG substrates, we adapted an orthogonal kinase engineering strategy originally developed for Protein Kinase A: combining modified ATP-binding pocket mutants with bio-orthogonal substrate tagging. We introduced and validated a methionine-to-glycine substitution at position 438 (M438G) in the ATP-binding pocket of PKG Iα, creating a kinase that preferentially accepts bulky ATP analogues. This gatekeeper residue mutation replaces the native methionine, a large hydrophobic amino acid containing sulfur, with glycine, the smallest amino acid with only a hydrogen side chain. The M438G substitution creates additional space in the ATP-binding pocket, enabling selective recognition of bulky nucleotide analogs while maintaining catalytic activity. When paired with orthogonal nucleotide cofactors and detected via specialized affinity capture methods, this approach enables selective tagging of PKG Iα substrates in vitro and in cell-based systems. Our data confirms that transfection of PKG Iα-knockout cells with either wild-type or M438G constructs effectively reconstitutes PKG Iα expression. Both wild-type and M438G PKG Iα retain catalytic activity, as demonstrated by robust phosphorylation of VASP, a canonical PKG Iα target, validating the experimental platform. This orthogonal kinase system lays the groundwork for systematically mapping the direct substrate landscape of PKG Iα in cardiovascular models. Ongoing studies will exploit this platform to identify novel PKG-regulated targets in lipid metabolism and cardiovascular disease, providing new insights into cardioprotective mechanisms and therapeutic opportunities.

Mentor(s): Sumita Mishra (Fralin Biomedical Research Institute at VTC, Center for Exercise Medicine Research) Virginia Tech

Anastazja Kiselka
Virginia Tech/Biochemistry

Investigating the Structural Differences Between the Peptidyl Transferase Centers of the Mammalian and Bacterial Ribosomes

With the rise of antimicrobial resistance (AMR) for existing antibiotics, the need for novel therapeutics with increased potency and selectivity is becoming more prominent. Promising antibiotic derivatives must not only exhibit high affinity for the bacterial peptidyl transferase center (PTC) but also minimize off-target interactions with the mammalian ribosome. Currently, there is a limited understanding of the structural differences between bacterial and mammalian ribosomes. Addressing this gap would provide critical information to optimize antibiotic derivatives, specifically targeting bacterial ribosomes. This study investigates the similarities of the PTCs from the bacterial 50S ribosomal subunit (Deinococcus radiodurans) and the mammalian 60S subunit from the European rabbit (Oryctolagus cuniculus) via structural analysis and molecular docking. Antibiotic derivatives known to successfully bind to the bacterial ribosome were docked into the mammalian ribosome to assess differences in binding potential. The binding cavities were compared by their key interacting residues and the variation in the structure and shape of the binding cavity. While conserved structural features exist between species, our results reveal that the significant variation in cavity geometry and residue composition contribute to reducing binding affinity of the antibiotics in the mammalian ribosomes. These findings facilitate the computer-aided drug design of next-generation antibiotics with minimized off-target interaction with the mammalian ribosome, thus decreasing cytotoxicity.

Mentor(s): Anne Brown (Biochemistry/University Libraries) Virginia Tech

Amelia Kurowska
Virginia Tech/Chemistry

Degradable thermoplastic nanocomposites using mushroom-derived nanochitin

Polycaprolactone (PCL) is regarded as a ductile, degradable plastic but it is relatively soft and its environmental degradation is sluggish. This project aims to synthesize high-performance nanocomposites that display enhanced degradability via melt extrusion of PCL as the matrix and mushroom-derived nanochitin as the filler. This work addresses the urgent need to reduce plastic waste by creating more degradable materials that incorporate biomass without compromising mechanical performance. The biomass filler content (5-20%) as well as extrusion parameters (rpm, mixing time, screw choice) were optimized to enhance material thermomechanical properties. Results show a significant increase in Young's modulus with increased nanochitin content, indicating improved stiffness compared to PCL. Degradation tests also revealed that the nanocomposite materials displayed enhanced hydrolytic degradability under alkaline conditions with increasing nanochitin content. This work highlights the potential of using plant-derived nanochitin as a more renewable filler material to create robust nanocomposites with thermoplastics.

Mentor(s): Josh Worch (Chemistry) Virginia Tech

Julia Lane
Virginia Tech/Biochemistry

Linking Lakes: Hydrological Connectivity and Ice-Nucleating Bacteria in the Bodensee Alpine Lake System in Austria

Microorganisms are widely distributed in aquatic environments, but ecological factors influencing functional traits, such as ice-nucleating activity (INA), remain underexplored in connected freshwater systems. INA refers to the ability of microorganisms to facilitate the freezing of water at relatively warmer temperatures, typically above –8 °C. These traits have implications for cloud formation, frost damage, and freezing of large water bodies. In this study, we investigated growth patterns and INA in Pseudomonas-related bacteria across the Bodensee alpine lake system in Gössenberg, Austria. The system consists of three alpine lakes linked by streams, ponds, and waterfalls. This network defines the region's hydrological connectivity, the physical ways in which water connects from one lake to another. Water and air samples were collected in June and July 2025, along with measurements of water temperature and elevation. Samples were filtered, plated onto agar media, and resulting colonies were screened for INA. Preliminary analyses focused on concentrations of bacteria and percentages of INA across the connected lakes, with particular attention to elevation and meteorological conditions at the sampling locations. Early patterns suggest that hydrological connectivity may influence microbial distribution and INA across alpine water bodies and smaller intermediate systems. Future research can integrate improved sampling methods to capture dynamic terrains, along with flow rate measurements at regular intervals. Additionally, studying seasonal and geological shifts may reveal broader impacts of terrain and climate on microbial patterns and INA. This work contributes to a growing understanding of ice-nucleating bacteria in alpine freshwater systems and highlights the importance of landscape connectivity.

Mentor(s): David Schmale (School of Plant and Environmental Sciences) Virginia Tech
Regina Hanlon (School of Plant and Environmental Sciences) Virginia Tech

Adam Lanning
Virginia Tech/BSE
Merridith Harrison
Virginia Tech/Environmental Science

Enhancing Engineering Education through Integrated Chatbot Development and System Optimization at the LEWAS Lab

Adam Lanning
Virginia Tech/Biosystems Engineering
Merridith Harrison
Virginia Tech/Environmental Science

The LEWAS (Learning Enhanced Watershed Assessment System) lab is focused on integrating AI-based learning into the classroom, advancing Virginia Tech's educational mission by optimizing its real-time environmental monitoring tools. Our interdisciplinary team addresses critical gaps in data validation and system functionality through two key initiatives: (1) The development of a local rating curve and cross section, and 2) Upgrading the lab's data collection through the addition of a newer multiparameter water quality sonde model (YSI/Xylem). The local rating curve and cross section offer improved accuracy of the hydrological data collected by the lab. This addresses the fundamental need for reliable streamflow measurements and allows us to validate the information that real-time data collection provides. Efforts will continue in the future by providing reference documents on development of the rating curve and cross section for the LEWAS chatbot, further expanding its knowledge base and improving the abilities of the chatbot. The addition of a modern sonde contributes to these efforts, enabling more robust real-time data acquisition and improving the system's reliability and user access to environmental data. Integration of a modern sonde allows more parameters to be continuously monitored, including nitrate concentrations, in the water. To ensure that data is reliable, regular maintenance is conducted at the collection site at least once a week and after significant storms. These technical advancements result in measurable improvements in data reliability, modernizing the LEWAS Lab's technical ecosystem, and strengthening its role as an open-access educational resource.
Mentor(s)/Co-author(s): Dr. Natasha Bell P.E. (Biological Systems Engineering), Dr. Vinod Lohani (Engineering Education), Mohammad Yunus Naseri, (Civil & Environmental Engineering), Jeremy Smith (Mechanical Engineering) , Dr. John Hoben (School of Plant and Environmental Sciences)

Mentor(s): Natasha Bell, Virginia Tech
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Colin Larkin
Virginia Tech/BioChemistry

Yeast-Based Functional Characterization and Evolutionary Engineering of Arabidopsis AAP Transporters

Amino acid transporters play a central role in plant nitrogen distribution by mediating amino acid uptake and allocation during growth, development, and stress responses. This project investigates the function and regulation of Arabidopsis thaliana AAP transporters using Saccharomyces cerevisiae as a heterologous expression platform. Two independent strategies were pursued: a directed evolution approach using the OrthoRep system, and a functional complementation-based strategy to measure the activity of AAPs expressed under the control of promoter of different strengths.

The goal the directed evolution was to evolve AAP1 and select sequence variants with improved or altered amino acid transport. This requires transfer of the OrthoRep mutagenesis plasmids into our yeast strain, which depends on generating viable protoplasts. To improve protoplast formation and recovery, I have optimized several steps in the protocol: improve resuspension by using more adequate tubes, scaling resuspension volumes based on OD, adjusting zymolyase digestion time, and fine-tuning shaker speed and temperature. These changes have increased protoplast viability, but I am still working on the regeneration of actively dividing yeast cells from protoplasts.

The functional complementation approach consists in the characterization of the transport efficiency and substrate specificity of all eight AAP family members (AAP1–AAP8). To identify the relationships between AAP expression and yeast growth rate, I cloned a four yeast promoters using the Golden Gate system, and created the corresponding expression plasmids. The next step is to insert each AAP coding sequence in these plasmids and introduce into yeast. Once complete, this system will allow expression-level-dependent characterization of the activity of each AAP family members using growth-based assays on individual amino acid substrates.

Together, these two approaches, random mutagenesis of AAP1 and comparative activity of AAP1–AAP8, will shed light on the structural and regulatory determinants of amino acid transport in plants, with potential applications in engineering crops for improved nitrogen use efficiency.

Mentor(s): Guillaume Pilot (School of Plant and Environmental Sciences) Virginia Tech

Jordan Lavey
Virginia Tech/Geosciences

Influence of Seasonal Shifts and Glacial Meltwater on Spatial Dynamics of Ice-Nucleating Bacteria in Austrian Alpine Lakes

Geological processes mold and change landscapes, and have the ability to alter the distribution of microorganisms. As glaciers retreat, they erode terrain and leave behind bowl-like structures (cirques), forming nutrient-rich lakes which act as an ideal setting for bacteria growth. High in the Alps within the Schladming-Dachstein region of Austria, field campaigns were conducted in June and July (2025) to study the effect of seasonal changes throughout cirque lake systems on ice nucleating bacteria, including Pseudomonas syringae and close relatives. P. syringae is found throughout the water cycle, facilitating the freezing of water at high temperatures (at or above -8°C). Campaigns focused on two lake systems comprised of three lakes each: Bodensee and Gosausee. During the seasonal shift from June to July, an increase in glacial melt and rain accumulation occurs, creating a flow-thru system where lakes involved are categorized as source, flow-thru, or sink. The source lake is connected to the system's water source; sources being either glacial melt or rainwater. Water passes through the "flow-thru" lake and accumulates in the "sink" lake. Water samples were collected and bacteria were cultured and tested for INA in droplet freezing assays, colonies that exhibited freezing at or above -8°C were accredited to P. syringae. Data analyzed suggests a change in Pseudomonas-type bacteria presence between the three lake types of each system over different collection dates. Future work aims to develop a connection between change in time and change in bacteria concentration in relation to spatial location within flow-thru glacial lake systems.

Mentor(s): David Schmale (School of Plant and Environmental Sciences) Virginia Tech
Regina Hanlon (School of Plant and Environmental Sciences) Virginia Tech

Ayanna Liburd
Oakwood University /Biochemistry

Comparing Reaction Pathways of Different Photocatalysts for Defined Block Copolymers

Photoinduced electron/energy transfer (PET), reversible addition-fragmentation chain transfer (RAFT) polymerization has previously been shown with a variety of photocatalysts. However, these photocatalysts have previously only been used in RAFT polymerizations that follow conventional blocking order. When going against a conventional blocking order, issues arise, including poor chain-end fidelity. Herein, due to the poor chain-end fidelity currently observed using Ir(ppy)3, we studied four different catalysts for the PET-RAFT chain extension of poly(methyl acrylate) with methyl methacrylate. The experiments included photocatalysts that proceed through photoinduced energy transfer, oxidative electron transfer, and reductive electron transfer pathways. The four catalysts being used are Ir(ppy)3 (energy transfer), Eosin Y (oxidative and reductive electron transfer), ZnTPP (oxidative electron transfer, and ZnPC (oxidative electron transfer). By measuring photocatalysts that proceed through different modes of activation, we expect to identify a photocatalyst yielding higher chain-end fidelity, enabling access to higher-order multiblock copolymers, yielding physical properties not available within the current diblock copolymers.

Mentor(s): Adrian Figg (Chemistry)

Hugo Liu
Virginia Polytechnic Institute and State University/Clinical Neuroscience

Modulation of Motor Corticospinal Excitability Using Low-Intensity Focused Ultrasound (LIFU)

Low-intensity focused ultrasound (LIFU) is a new, promising form of non-invasive transcranial brain stimulation offering high spatial precision combined with deep focal lengths. Despite these advantages, standardized stimulation parameters that produce reliable and robust effects are unknown. Work in other brain stimulation modalities, including deep-brain stimulation (DBS) and repetitive transcranial magnetic stimulation (rTMS), demonstrates that temporal patterning is an effective form of energy delivery. Here, we test whether different temporal patterns of LIFU affect primary motor corticospinal excitability. This is a single-blind, sham-controlled, within-subject study investigating how the coefficient of variation (CV) influences motor evoked potential (MEP) amplitude. Utilizing subject MR and CT scans, acoustic modeling was used to accurately target LIFU to the motor cortical first dorsal interosseous (FDI) representation previously identified using a finger-tapping fMRI task. Different patterns of stimuli were tested, including: 50Hz (CV=0), low (CV=0.5), low shuffle (CV=0.5), medium (CV=1.5), theta burst (CV=1.5), high (CV=2.5), and high shuffle (CV=2.5). In N=4 subjects, MEP amplitudes (mean ± SEM) normalized to baseline were 0.99±0.23 (50 Hz), 0.76±0.15 (Low CV), 0.88±0.14 (Medium CV), 0.71±0.13 (High CV), 0.82±0.07 (Low CV Shuffle), 0.63±0.13 (High CV Shuffle), 0.88±0.20 (Theta Burst), and 1.24±0.35 (Sham). Preliminary statistical analysis revealed no statistically significant differences between groups: $F(7, 21) = 2.14$, $p = 0.08$. These early results suggest, however, that High CV patterning may lead to greater MEP inhibition (70%) compared to conventional stimulation paradigms. Optimization of patterning to produce robust and reliable excitation and inhibition will help translate LIFU for clinical therapeutic use in a variety of neurological and neuropsychiatric conditions.

Mentor(s): Wynn Legon (Neuroscience) Virginia Tech

Jacob Liu
Virginia Tech/Microbiology

Tardigrade-Derived Protein Hydrogels as Genetically Programmable Platforms for Radiation-Resistant Biomaterials

This study investigates the UV-protective capabilities of tardigrade-derived proteins, including CAHS1, CAHS3 (cytoplasmic abundant heat soluble proteins), and Dsup (damage suppressor protein), which contribute to the remarkable resistance of tardigrades to radiation and desiccation. CAHS1 and CAHS3 are cytoplasmic proteins known to protect against dehydration and UV exposure, while Dsup is a nuclear protein that binds to DNA and mitigates damage from ionizing radiation. These proteins are hypothesized to form fibrous amyloid-like structures under stress, enabling their protective functions. To explore their utility in synthetic biomaterials, we genetically engineered β-solenoid nanofibers fused with CAHS and Dsup proteins. These engineered protein-based nanofibers were utilized to produce hydrogels to enhance the existing radiation shielding capabilities of non-engineered nanofiber hydrogels. The resulting hydrogels offer enhanced radiation shielding while maintaining low density and flexibility, offering a lightweight alternative to conventional heavy-metal-based shielding materials. When embedded with live bacteria, these hydrogels also exhibit self-healing properties, making them especially useful in remote or resource-limited environments such as space. To assess protective efficacy, E. coli expressing the engineered proteins were encapsulated within various hydrogel formulations, including control gels lacking fusion proteins. The hydrogels were exposed to UVC radiation, then resuspended in growth media, serially diluted, and plated. Survivability was quantified via colony-forming unit (CFU) counts, revealing the extent of protection conferred by each protein. This work highlights the potential of tardigrade-inspired biomaterials for developing next-generation, radiation-resistant living materials for medical and space applications.

Mentor(s): Anna Duraj-Thatte (Biological Systems Engineering) Virginia Tech

Nicholas Louvet
Virginia Tech/Aerospace Engineering

Evaluating Ionospheric Model Output Against Observations during a Geomagnetic Storm on February 4, 2022

The ionosphere is a layer of the Earth's upper atmosphere that contains a high concentration of ionized gases and free electrons capable of reflecting radio waves. It can be described empirically by the International Reference Ionosphere (IRI), a model widely used for ionospheric research, radar propagation studies, and communication system design. While effective under average conditions, IRI relies on statistical smoothing of electron density profiles and may lose accuracy during periods of high solar activity. To address this, physics-based models such as the Multiscale Atmosphere-Geospace Environment (MAGE) framework aim to capture geomagnetic storm-time dynamics and improve the fidelity of electron density forecasts. This study compares outputs from IRI and MAGE during a geomagnetic storm on 4 February 2022, using Global Navigation Satellite System (GNSS) total electron content (TEC) as a benchmark. Simulated TEC was calculated globally for both models across multiple time intervals and compared regionally to GNSS data. Initial results show that IRI exhibits higher root mean square error (RMSE) in the European, North American, and South American sectors, whereas MAGE displays reduced RMSE but lower spatial correlation in these same regions. This suggests MAGE has improved magnitude predictions but a potential misplacement of ionospheric features. These findings highlight key strengths and limitations of each modeling approach, informing both model development and the selection of appropriate tools for space weather analysis and operational use.

Mentor(s): Joseph Baker (Electrical and Computer Engineering) Virginia Tech
Michael Ruohoniemi (Electrical and Computer Engineering) Virginia Tech
Bharat Kunduri (Electrical and Computer Engineering) Virginia Tech

Logan Lynxwiler
Hollins University/History

Through Her Eyes: Women Portraying Women in the Eleanor D. Wilson Museum Collection

This digital exhibition began with a question: how can I use the Eleanor D. Wilson Museum's permanent collection to celebrate the voices and perspectives of women artists in a way that aligns with the missions of both the museum and Hollins University, a historically women's institution?

I began by identifying all works in the collection by women artists. My goal was to highlight women portraying women as a meaningful way to explore both self-representation and the female gaze, offering insight into how women have chosen to depict themselves and each other in a world where they have often been subjects of art but rarely its creators.

This gathering of works was shaped by a few logistical parameters: most notably, I could only include works with existing photographs uploaded to the museum's collections management system. I also excluded works featured in the permanent collection section of the museum's Bloomberg Connects guide.

From this preliminary group, I conducted research using the museum's object files, as well as books and scholarly articles. Through this research and reflection, I narrowed the selection based on how the works spoke to each other visually and thematically. Given the variation in medium, style, and approach, it became important to identify points of comparison. The most prominent connections were women's spaces, contemplation in nude portraiture, artist self-portraits, and photographic reflections of identity. I then identified artworks with similar themes from earlier time periods, demonstrating the continuity of larger narratives within the art historical canon.

Mentor(s): Jess Ambler (Eleanor D. Wilson Museum) Hollins University

Markel Manson
Virginia Tech/Computer Science

Modeling Intent-to-Interact in Augmented Reality

Machine-learning (ML) models are able to predict users' intent to select objects in Virtual Reality (VR). However, while VR offers a fully immersive experience, Augmented Reality (AR) overlays virtual objects onto the real world, resulting in a mix of interactions between real and virtual content. These differences in real-virtual interactions lead to distinct gaze and interaction behaviors across platforms. In this study, we extend gaze-based modeling of intent to AR to investigate behavioral and gaze-pattern differences between VR and AR environments. A user study was conducted with three distinct AR selection tasks to train ML models that predict the moment of user interaction. The study included conditions that varied the presence of headset straps and sensor calibration to evaluate model robustness across both ideal and more realistic usage scenarios. Models trained on all data as well as specific levels of data quality were then evaluated. Early observations suggest that robust intent prediction models can be trained without calibration of the eye-tracker, but over time are affected by drift when a headstrap is not used. This study provides two key insights: Gaze-based intent models from VR are effective in AR settings, and data obtained under more ideal conditions are more accurate in predictions than data collected in more "realistic" usage scenarios. Future research would involve implementing solutions to counterbalance the inaccuracy of "realistic" usage scenarios. This study contributes to the development of new ML models that predict user intent in AR interactions.

Mentor(s): Brendan David-John (Computer Science) Virginia Tech

Mia Mataczynski
Virginia Tech/Mechanical Engineering

SuperDARN Space Weather Radar Observations of Traveling Ionospheric Disturbances Excited by Gravity Waves from Hurricane Helene

Between September 25 and 28, 2024, Hurricane Helene intensified to Category 4 and traveled across the Gulf of Mexico into the southeastern and midwestern United States, causing an estimated $78.7 billion in damages. Upon landfall, Helene generated strong atmospheric gravity waves through convection mechanisms, which were observed in the mesosphere by satellite measurements. This study examines the coupling of these buoyancy waves into the ionized portion of the upper atmosphere and their role in generating Traveling Ionospheric Disturbances (TIDs), which are wave-like fluctuations in ionospheric plasma density. Although it is well established that meteorological events can excite gravity waves capable of inducing TIDs, limited work has been done to investigate hurricane-driven TIDs using Super Dual Auroral Radar Network (SuperDARN) observations. This study presents evidence of TIDs associated with primary and secondary gravity waves observed in SuperDARN data, characterized by periods ranging from 15-76 minutes, phase speeds of 92–578 m/s, and wavelengths of 175-861 km.
These results are consistent with a previous study which examined waves induced from Hurricane Matthew in 2016 using Total Electron Content (TEC) from GPS receivers. These findings contribute to our understanding of troposphere-ionosphere coupling during extreme weather events, and expands upon the capabilities of SuperDARN radars.

Mentor(s): Joseph Baker (Electrical and Computer Engineering) Virginia Tech
J. Michael Ruohoniemi (Electrical and Computer Engineering) Virginia Tech
Bharat Kunduri (Electrical and Computer Engineering) Virginia Tech

Savannah McCoy
Berea College/Psychology

Independent

Early brain connectivity and cognitive flexibility as interacting predictors of social responsiveness in childhood

The frontoparietal network (FPN) undergoes significant development in childhood (Bell & Cuevas, 2016) and is fundamental to executive functions (EF) and adaptive behavior (Kelsey et al., 2025). Dysfunctions in the FPN are implicated in EF impairments associated with neurodevelopmental conditions, such as autism spectrum disorders (ASD; Clarke et al., 2021; Yang et al., 2022), suggesting that the FPN may also be linked to social impairment.

This project involved 120 children and aimed to investigate how FPN functioning—measured as EEG coherence (in left and right hemispheres during resting state) at age 4—and cognitive flexibility (a key EF component) at age 6 predict social outcomes at age 9, as measured by the parent-reported Social Responsiveness Scale (SRS). A four-step hierarchical regression, controlling for verbal IQ and maternal education, was used to examine the associations.

Results indicate FPN coherence and cognitive flexibility significantly predicted most SRS domains (Communication, Cognition, Motivation, Mannerisms, Total Score), with R2 values ranging from .137 to .352. Crucially, interaction terms between brain measures and cognitive flexibility revealed complex effects: positive interactions with left hemisphere FPN and negative interactions with right hemisphere FPN. Adding these interaction terms during step 4 of the regression analysis significantly improved prediction for these domains (all F-change $p < .05$). Social Awareness, however, was not significantly predicted ($R2 = .043$, F-change $p = .218$).

Collectively, these findings highlight FPN's nuanced contributions to social responsiveness, suggesting specific brain-behavior pathways influencing developmental outcomes and providing crucial insights for understanding typical and atypical social development.

Mentor(s): Martha Ann Bell (Psychology) Virginia Tech
Graduate student mentor: Doug Harrison (Psychology) Virginia Tech

Kyle McKay
Virginia Tech/Biomedical Engineering

Minimizing Delamination and Contamination: Mechanical and Procedural Advances in Microfluidic Chip Bonding

This project focused on improving the bonding reliability of PDMS-based microfluidic chips used for cell trapping and sorting at CytoRecovery, Inc. Inconsistent bonding between the channel and membrane-bonded electrode layers has previously led to high defect rates, including delamination, structural failure, and loss of chip function. The goal was to create a more consistent and reproducible bonding method to increase chip yield and performance.

A revised bonding tool was developed and tested, incorporating features to regulate pressure application and reduce contamination during fabrication. Prototype chips were evaluated using a standardized multi-stage flow test to simulate operational conditions and identify structural failures. Bonding outcomes were compared against earlier chip iterations to assess improvements in defect reduction and structural integrity.

Chips bonded with the new tool showed improved consistency, fewer visual defects, and higher pass rates in flow testing. These results indicate meaningful progress toward a repeatable and scalable fabrication process suitable for producing microfluidic chips for use in downstream biological applications. The findings support continued refinement of the bonding system to meet production-level standards for reliability and throughput.

Mentor(s): Keri Swaby (Office of Undergraduate Research) Virginia Tech

Gabrael McKnight
Virginia Tech/Microbiology
Ankita Kamath
Virginia Tech/Biomedical Engineering

Exploration of New Avenues of B Vitamin Production; Hyper thermophilic Methanogens; Methanotrophic Bacteria Fed with Methane from Food Waste Digester

The B-vitamins are essential for cellular function, including energy production and cell biosynthesis in organisms of every domain of life. While many organisms can synthesize these on their own, other rely on dietary supplementation or alternative sources. Deficiency of these vitamins in humans or animals' diets can cause many different ailments. Companies around the globe have taken this concern of deficiency and designed processes to mass produce these vitamins using naturally occurring or genetically engineered strains of bacteria and fungi, or chemically. However, only a limited number of these microbes have been explored for this biotechnological point of view. To fill this gap, we are examining organisms known as Hyperthermophilic Methanogenic Archaea and Methanotrophic Bacteria. These fast-growing organisms use simple growth substrates, carbon dioxide/hydrogen and methane/oxygen, respectively, for energy production. Methanotrophic Bacteria could be grown on methane produced from food waste. For these properties, the potential use of these organisms in vitamin production is compelling.

Mentor(s): Biswarup Mukhopadhyay (Biochemistry) Virginia Tech

Lea Mills
Virginia Tech/Microbiology

Cancer Killer: Exploring the Oncolytic Properties of Attenuated Venezuelan Equine Encephalitis Virus

Glioblastoma is a common, aggressive, and fast-growing type of brain tumor. Currently, there is no cure for glioblastoma, although treatment options include surgery, radiotherapy, and chemotherapy. Even with treatment, the median survival rate for glioblastoma is only 14.6–21.1 months, and the five-year survival rate is around 5%. As such, new treatment options are being explored, including the use of oncolytic viruses. Oncolytic viruses preferentially target cancer cells. One promising class of oncolytic viruses are alphaviruses. Alphaviruses can both induce cell death and activate immune cells, which makes them particularly suitable as oncolytic agents. This study focuses on one particular alphavirus: the highly attenuated vaccine strain of Venezuelan Equine Encephalitis virus (VEEV), called TC-83. The main purpose of the study was to determine the cytotoxicity of VEEV against GL-261 mouse glioma cells. To address this question, we used several complementary techniques aimed at measuring the viability of the GL-261 cells. Firstly, an MTS assay was used to measure metabolic activity after exposure to the virus. Then, an eATP assay was performed to measure immunogenic cell death after exposure. Finally, live/dead staining was analyzed via flow cytometry. We found that, compared to a positive control, VEEV produces limited eATP activity. However, we expect that cells infected with VEEV show both low levels of metabolic activity and low levels of cell viability when compared to a positive control.

Mentor(s): James Weger (Biomedical Science) Virginia Tech

Lance Mitchell
Virginia Tech/Microbiology

Revealing the Receivers: Structural Insights Into the Receiver Domains of GacS and RetS in Pseudomonas aeruginosa

Pseudomonas aeruginosa is a pathogenic bacterium that causes various acute and chronic infections in humans, especially in individuals with compromised immune systems. The switch between the motile acute and sessile chronic lifestyles is primarily regulated by the sensor histidine kinase protein GacS and its interactions with other histidine kinase proteins, such as RetS. Active GacS signaling promotes a sessile lifestyle characterized by robust antibiotic-resistant biofilms. Inhibition of GacS by RetS shifts the bacterium toward a more virulent, acute infection state. Both GacS and RetS propagate signals to downstream effector molecules that modify bacterial behavior. However, the precise structures of the receiver domains, where these signals originate, remain experimentally unresolved. This project aims to elucidate the structures of these receiver domains. To achieve this, we will clone the receiver domain genes via Gibson Assembly. Then, we will express and purify the first receiver domain of GacS and RetS, as well as the first and second receiver domains of GacS and RetS, for subsequent X-ray crystallography studies. In parallel, we will perform in-silico molecular docking analyses using AutoDock Vina with an AlphaFold-predicted model of the RetS receiver one domain to identify a potential ligand-binding pocket that could impact signal transduction. A binding pocket in a similar histidine kinase, ShkA, in Caulobacter crescentus helped us determine the potential location of the binding pocket in RetS. By understanding the structure of these signaling regions, we can identify ways to block signals and halt the infection process, leading to the development of novel treatments.

Mentor(s): Florian Schubot (Department of Biological Sciences) Virginia Tech

Feda Mohammadi
Berea College/Economics
Julia Vecharello
Virginia Tech/International Trade and Development

Virginia Cost of Living Dashboard

Abstract
The cost of living varies significantly across regions, yet few tools exist to help families, policymakers, and researchers understand these differences in a user-friendly, interactive way. In Virginia, where economic and geographic diversity is huge, understanding local living costs is important for informed decision-making.

The purpose of this project is to develop a publicly accessible, interactive dashboard that visualizes the minimum and average monthly cost of living across all 133 counties and independent cities in Virginia. The dashboard breaks down costs into key categories such as housing, food, transportation, healthcare, childcare, taxes, elder care, and technology. Users can explore costs based on different family structures and even manually adjust cost inputs to reflect custom scenarios.

We gather data from trusted sources like the U.S. Census Bureau, U.S. Department of Housing and Urban Development, Kaiser Family Foundation, American Automobile Association, and local transit agencies. Where local data was missing, we used proxy estimation techniques, for instance, adjusting healthcare costs based on income levels. We calculated costs using consistent formulas and created clean county-level datasets for each cost category. We built the dashboard using R and Shiny, which enables dynamic user interaction and real-time updates.

Our results show large variations in the cost of living across Virginia, especially in housing and transportation. Counties in Northern Virginia tend to have higher overall costs due to their proximity to major urban centers like Washington, D.C., while other counties may have lower costs but also reduced access to services.

Our dashboard helps make local cost data more transparent and useful. It can inform state policy, community planning, and individual decisions about where to live, work, or allocate resources.

Mentor(s): Michael Cary (Department of Agriculture and Applied Economics) Virginia Tech
Dr. Le Wang (Department of Agriculture and Applied Economics) Virginia Tech

Charlotte Monck
Virginia Tech/Neuroscience

Eliminating Background Mutations to Characterize GR28B.D Receptor Mediated Rapid Warmth Avoidance in Drosophila

Innocuous thermoreceptors are important for insects seeking their optimal temperatures. In Drosophila melanogaster, one of these receptors, GR28B.D, is responsible for rapid warmth avoidance behavior in temperatures greater than 25°C.

To investigate the functional relevance of amino acid variants in GR28B.D, we analyzed Gr28b.d sequences from 173 wild-caught fly lines in the Drosophila Genetic Reference Panel (DGRP). Based on the missense variants, we grouped these 173 lines and selected 23 fly lines. Using a thermotactic positional preference assay, we identified 11 DGRP lines that lacked normal warmth avoidance behavior, showing decreased or no preference between 25°C and 31°C similar to the loss-of-function mutant line, Gr28bMB.

To determine whether these behavioral deficits were due to mutations in Gr28b.d rather than unrelated background mutations, we backcrossed these 11 DGRP lines with Gr28bMB. While five lines retained the defective behavior, six recovered normal warmth avoidance.

In the future, to determine whether the missense variants in Gr28b.d contribute to defects in rapid warmth avoidance, we will create transgenic fly lines containing the corresponding point mutations in these five DGPR lines and express the mutant receptors broadly in adult flies to evaluate whether these altered amino acids are necessary for thermosensitivity using the warmth-triggered knockdown experiments.

Mentor(s): Lina Ni (School of Neuroscience) Virginia Tech

Alyssa Morrison
Virginia Tech/Biological Systems Engineering

Chronic Effects of Trimethylamine N-Oxide on Mouse Hearts

Trimethylamine N-oxide (TMAO) is a gut microbiota-dependent metabolite derived from trimethylamine containing nutrient precursors that are rich in meat and dairy products. An increasing number of animal and clinical studies has confirmed a strong association between the elevated plasma level of TMAO and cardiovascular diseases. Although it is well established that TMAO promotes vasculopathy (i.e., atherosclerosis), little is known regarding its direct effects on the heart and cardiomyocytes. This study aims to investigate how TMAO modulates cardiac structure and function using a mouse model. Briefly, C57BL6J/wild type (WT) and organic cation transporter-3 knockout (OCT3-KO) mice with the same genetic background were treated with TMAO drinking water for 13 weeks, while the control mice were supplied with regular drinking water without TMAO. At the end of the treatments, echocardiography and electrocardiograms were utilized while mice were under anesthesia to evaluate the cardiac structure and functional changes. Following opening the animal chest, the heart was enzymatically perfused to isolate single cardiomyocytes for further analysis. Our preliminary study found that long-term feeding of TMAO to WT mice induced hypertrophic cardiomyopathy and heart failure evidenced by increased wall thickness, decreased ejection fraction (EF%), and abnormal ECG compared to the control mice. Interestingly, the same TMAO treatment did not alter the above parameters in OCT3-KO mice. We conclude that chronic treatment of TMAO deteriorates cardiac structure and function eventually leading to heart failure. The ongoing experiments using isolated single cardiomyocytes may provide mechanistic insight into TMAO-induced heart failure.

Mentor(s): Jia-Qiang He (Department of Biomedical Sciences and Pathobiology) Virginia Tech

Carolina Moscote
James Madison University/Biology

Concrete vs Abstract Future Thinking: How the Concreteness of Future Thinking Influences Delay Discounting in Alcohol-Related Decisions

Individuals who misuse alcohol tend to devalue future rewards, a behavior known as delay discounting. Episodic future thinking (EFT), vividly imagining future experiences, can reduce delay discounting, yet the role of cue concreteness remains unclear. This study tested whether concrete, episodic cues more effectively reduce delay discounting among heavy drinkers than abstract cues. Participants were randomized into one of four groups combining episodic vs. abstract and future vs. recent (control) thinking, and completed a delay discounting task before and after their assigned condition. The task involved binary choices between smaller, immediate, and larger, delayed rewards at varying delays (e.g., $50 now vs. $100 in 6 months). Cue concreteness was evaluated using ratings of 40,000+ words from 1 (abstract) to 5 (concrete), confirming that episodic cues were more concrete than abstract cues. Mixed-effects modeling of Area-Under-the-Curve (AUC) revealed that future thinking reduced delay discounting from pre- to post-test, regardless of whether cues were episodic or abstract. That is, there was no significant interaction between cognitive style and time. These findings suggest that future thinking, even without detail, can reduce impulsive decision-making. Although both cue types were personalized, the absence of a concreteness effect challenges assumptions about the need for episodic detail in EFT interventions, highlighting future thinking more broadly as a promising tool for reducing delay discounting in heavy drinkers. Future research should investigate whether personalized cues are required to achieve these effects, especially in scalable EFT implementations using virtual reality or neuroimaging, where individualized prompts are less feasible.

Mentor(s): Jeff Stein (The Fralin Biomedical Research Institute Center for Health Behaviors Research) Virginia Tech

Grace Mullins
Berea College/Sociology
Joshua Yoo Yoo
College of William and Mary/Finance
Yin Kyay Wai
Berea College/Computer Science

Exploring the Impact of Childcare on Labor Force Outcomes

Childcare costs remain one of the most significant barriers for parents re-entering the workforce. When expenses consume up to 15% of a family's income, nearly equivalent to rent, it becomes difficult to justify employment if the second parent's earnings cannot cover the cost. To support lower-income families, the federal government created the Child Care Development Fund (CCDF) to provide childcare subsidies to help eligible families work. This block grant is administered by state governments and in the state of Virginia, it is the responsibility of the Virginia Department of Education (VDOE) to allocate and implement.
This study aims to better understand the impact of childcare prices on the workforce with particular attention to parent gender and locality, along with examining how eligibility expansion and policy changes impact subsidy utilization and workforce participation in Virginia. We analyze the Survey of Income and Program Participation from 2017 – 2023 and the U.S. Department of Labor's Women's Bureau National Database of Childcare Prices as well as state-level data on subsidy receipt.
Through our OLS regression model, we find that individuals who qualify for subsidies are more likely to be employed and work more hours. In our Differences in Differences model looking at the VDOE policy change in 2022, we find again that subsidy qualification has a large beneficial impact on employment outcomes.

Mentor(s): Le Wang (Applied Agriculture and Economics) Virginia Tech

Muhammad Ali Naqvi
Community College of Baltimore County/Biology

Regulation of Bone Morphogenetic Protein 3 in Pulmonary Arterial Hypertension

Background:
Despite recent advancements in PAH management, the disease remains devastating, with limited survival. Although the Bone Morphogenetic Protein (BMP) signaling pathway is known to play an important role in PAH, our understanding of this pathway remains limited.

Aims:
We hypothesize that BMP3 expression is altered in pulmonary arterial hypertension (PAH). To test that, we evaluated BMP3 expression levels in PAH-diseased lungs across mice, rats, pigs and human pulmonary vascular cells.

Methods:
BMP3 levels were assessed in lungs of PAH-diseased mice (Sugen/hypoxia model), rats (Sugen/hypoxia model), and pigs (pulmonary vein banding model). BMP3 levels were also assessed in pulmonary artery smooth muscle cells (hPASMCs) and pulmonary artery endothelial cells (hPAECs) isolated from healthy donors and from patients with idiopathic PAH.

Results:
We found BMP3 levels to be decreased in the lungs of mice, rats and pigs with pulmonary hypertension. At the cellular level, we found BMP3 to be predominantly expressed in PASMCs and its levels to be significantly downregulated in PAH.

Conclusions:
Our findings show that BMP3 expression is reduced in PAH and suggest that BMP3 might play a key role in PAH.

Mentor(s): Yassine Sassi (Assistant Professor)
Aymen Halouani (PhD)

Astin Naveen John
Vrignia Tech/Microbiology

Independent

Myeloid-specific Stat4 Deficiency Attenuates Lupus-like Disease in MRL/lpr mice

Systemic lupus erythematosus (SLE) is an autoimmune disease with no known cure. Lupus is considered to be mediated by type 1 and type 3 immune responses in human SLE and lupus-like disease in MRL/lpr mice. This study investigates how knocking out signal transducer and activator of transcription 4 (STAT4), a key signaling molecule in type 1 and 3 immunity, from myeloid cells in MRL/lpr mice disrupts lupus progression. We found that LysM Cre, STAT4 FL mice (CKO) are protected from lupus, but its underlying mechanism is unknown. We believe this is from a reduction in the responsiveness of type 1 and 3 cytokines. To examine this, we utilized procedures such as RT-qPCR of CKO vs. WT splenocytes, ELISA for IFNɣ, and immunohistochemistry, examining markers of inflammation, particularly in genes relating to type 1 and 3 inflammation. We found that knockout mice had reduced proteinuria and smaller spleens, kidneys and lymph nodes, all associated with less severe lupus. Additionally, there were lower amounts of neutrophils and increased CD8 T cells in the spleens of knockout mice indicating disrupted type 1 and 3 signalling. Lastly, INFɣ levels, the hallmark type 1 cytokine, correlated with disease parameters in WT mice, but were not predictive of disease in KO mice, suggesting a decoupling of type 1 signaling and disease severity. Therefore, knocking out STAT4 in MRL/lpr mice disrupts lupus progression. Future studies will investigate the mechanism behind this protection, as targeting STAT4 could be important in the treatment of autoimmune disease.

Mentor(s): Xin Luo (Biomedical and Veterinary Sciences) Virginia Tech

Naima Ndeh
University of Maryland, College Park/Neuroscience

Fairness First: Uncovering & Correcting Bias in AI-Driven Emergency Department Chest Pain Triage

Chest pain accounts for nearly eleven million Emergency Department (ED) visits annually. Yet research shows that women and Black patients receive less aggressive testing and face longer treatment delays than White men with similar symptoms. This research examines how these historical under-triage patterns affect the fairness of AI-powered ED triage models and identifies strategies to mitigate algorithmic bias. A systematic review of clinical studies, public health analyses, and AI bias research from PubMed, Google Scholar, and IEEE Xplore, followed by a literature-informed risk assessment of data pipelines, model training, and clinical integration was performed. Our findings demonstrate that models trained on unbalanced datasets reproduce under-triage for women and Black patients relative to their clinical acuity. To promote fair, patient-centered triage, we propose three interventions: (1) continuous bias audits comparing predicted urgency to outcomes across demographic groups; (2) equity-focused data practices, like targeted labeling and dataset rebalancing; and (3) open-science practices such as federated learning under multidisciplinary oversight. Implementing these measures can align AI recommendations with true clinical need, advancing both the speed and equity of emergency care.

Mentor(s): Arianna Schuler Scott (Pamplin College of Business) Virginia Tech

Oumar Ndiaye
Virginia Tech/Computer Science

How Political Tensions in Rural Communities Shape Environmental Information Access for Supporting Environmental Awareness

For rural community members, who often rely on the environment for their livelihoods, the effects of environmental changes like deforestation or pollution can result in life-threatening consequences. However, rural residents often have limited access to timely, relevant, and trustworthy environmental information due to factors such as digital inequality and a lack of localized information sources. To better understand how rural community members obtain and share environmental information, and what barriers affect their environmental awareness, we conducted semi-structured interviews with 14 residents from rural communities located in Southwest Virginia. These interviews were guided by a flexible protocol of open-ended questions designed to allow participants to discuss their personal experiences with accessing and interpreting environmental information. We analyzed interview transcripts using thematic analysis to identify common codes or themes. We found that rural residents have a desire to gain a better understanding of the environmental threats directly related to them, but a number of obstacles keep them from being informed, including limited awareness of information sources like local news outlets and community forums, and their politicized perception of environmentalism. Furthermore, some community members preferred not to report environmental concerns online out of fear that doing so might associate them with a particular political party, highlighting the broader impact of polarization on rural information practices. Our results contribute to an understanding of how we can effectively design technologies to promote environmental awareness in rural communities.

Mentor(s): Ihudiya Williams (Department of Computer Science) Virginia Tech

Mihir Nimkar
Rock Ridge High School

Independent

Linking Memory Performance to Task-Based fMRI for Personalized LIFU Targeting

Memory impairment affects millions worldwide and is a leading cause of disability and mortality, often resulting from traumatic brain injury or aging. Current pharmaceuticals offer limited benefit, primarily slowing decline. Neuromodulation offers a promising alternative. Low-intensity focused ultrasound (LIFU) is a non-invasive technique that uses mechanical energy to precisely modulate deep brain regions, making it well suited for targeting the medial temporal lobe (MTL), a key hub for episodic memory. However, anatomical variability across individuals poses a challenge for precise targeting, motivating the use of functional imaging to guide stimulation. This study investigated whether task-based functional magnetic resonance imaging (fMRI) contrasts could inform targeting by linking neural activation patterns to memory performance. Nineteen healthy adults completed the Face Name Associative Memory Exam (FNAME) during fMRI. Behavioral results showed that higher confidence was linearly correlated with higher accuracy (β=2.042; p=0.004), and variance in average reaction time was greater in subjects that were below the median accuracy (7.469 s ± 2.210 s) than in subjects that were above the median accuracy (6.071 s ± 0.836 s). To assess contrast utility for identifying brain targets that can be modulated to affect memory, MTL activation for the correct > incorrect encoding contrast was tested for its association with individual memory accuracy. Results revealed no strong relationship (β=-0.044; p=0.83), suggesting that the MTL may be too broad of a metric for effective LIFU targeting and underscoring the need for more refined or contrast-specific approaches.

Mentor(s): Dr. Wynn Legon (FBRI Center for Health Behaviors Research and School of Neuroscience) Virginia Tech

Ayra Ayaan Nirar
Virginia Tech/Industrial and Systems Engineering

Cybersecurity in Formula 1 Telemetry: Safeguarding Engineering Workflows and Data Integrity

Formula 1 (F1) relies extensively on real-time telemetry data transmission to support engineering pursuits and race strategy. This infrastructure encompasses onboard sensors, Electronic Control Units (ECUs), Controller Area Networks (CANs), the Advanced Telemetry Linked Acquisition System (ATLAS), and analysts. This study investigates how cybersecurity is integrated into F1's telemetry systems and how secure digital environments enable engineering workflows in this competitive sport. Due to the limited public disclosure of internal team-specific cybersecurity protocols, the research navigates the topic through a literature review on credible sources, a risk assessment to identify potential telemetry anomalies, and an interview with an industry professional into cybersecurity processes between F1 teams and third-party partnerships. These approaches reveal how security is embedded within the sport's operational infrastructure. Findings indicate that cybersecurity measures are implemented at critical system endpoints and through internal protocols addressing both hardware and software vulnerabilities. This study concludes three key security ideas in F1: maintaining detailed documentation, actively implementing defined security procedures, and adhering to frameworks enforced by the Fédération Internationale de l'Automobile (FIA) and F1 Management.

Mentor(s): Arianna Schuler Scott (Pamplin ISERC) Virginia Tech

Mark O'Horo
Virginia Tech/Biological Systems Engineering

FTW Aquaculture

Floating Treatment Wetlands in Aquaculture
By Mark O'Horo and Kimiya Yousefi
Floating Treatment Wetlands (FTWs) are a best management practice used for water quality improvement in stormwater and agricultural systems; however, their effectiveness in outdoor aquaculture systems has not been investigated. The aim of this study is to evaluate how FTWs perform to reduce nutrient (specifically nitrogen and phosphorous) and total suspended solids concentrations, as well as the occurrence of algal blooms, within outdoor catfish ponds. The research is being conducted at Virginia State University, where six catfish ponds—historically impacted by nutrient and algal blooms, which have required frequent chemical treatment—serve as the testbed.
For this research, a polyculture FTW will be used. The native plant species Canna flaccida and Juncus effusus were planted in alternating rows and placed in FTWs within three of six catfish ponds with 10% surface area coverage. The remaining ponds serve as controls and do not contain FTWs. Two EXO2 multiparameter water quality sondes were deployed in one of the FTW ponds and one in a control pond to compare water quality parameters including pH, turbidity, dissolved oxygen, total algae, oxygen-reduction potential, conductivity and temperature (collected every half hour). Sondes are being calibrated on a bi-weekly basis. With this experiment still in the beginning stages, the next step in our research process is gathering stored sonde data and continuing to monitor the ponds and collect water samples every two weeks until the end of October 2025.

Mentor(s): Natasha Bell, Virginia Tech

Lauren Oliva
Virginia Tech/Clinical Neuroscience

How Dopamine Innervation Levels and Oxidative Stress Differ in Brain Regions Affected by Parkinson's Disease

While movement deficits are the hallmark of Parkinson's Disease (PD), cognitive impairments are also common and less understood. Dopamine (DA) dysfunction contributes to both, but the role of DA innervation in motor vs cognitive symptom onset remains unclear. DA neurotransmission induces oxidative stress: an imbalance in reactive oxygen species (ROS) that can damage or kill DA target neurons. This is particularly relevant in 22q11.2 Deletion Syndrome (22q11DS), a chromosomal deletion that removes genes involved in ROS regulation, increasing vulnerability to oxidative damage. Individuals with 22q11DS have a 5-to-6-fold increased risk for early-onset PD, making the 22q11DS mouse (LD) a promising model for PD. I developed two approaches to investigate whether differences in DA innervation density in the striatum (motor function) vs. neocortex (cognition) influence oxidative stress and neuronal vulnerability. First, I performed immunolabeling for Darpp-32, a DA target neuron marker, tyrosine hydroxylase (TH), marking DA axons, and NeuN, a pan-neuronal marker, to measure innervation around striatal and cortical Darpp-32+ vs. NeuN+/Darpp-32- neurons. As a higher-resolution alternative, I used Darpp-32Cre: Ai9 td-Tomato reporter mice to visualize DA target neurons in both regions alongside TH and NeuN. In parallel, I developed analytic software to quantify DA innervation relative to distance from target neurons. Preliminary findings suggest that the Darpp-32 reporter enhances resolution and that DA innervation is denser in the striatum than cortex in both LD and wild-type mice. This work aims to clarify whether elevated DA levels in 22q11DS+PD reflect increased innervation or impaired ROS defense due to the deletion.

Mentor(s): Anthony LaMantia (Fralin Biomedical Research Institute) Virginia Tech

Natalie Owens
Hollins University/Physics

Recovering

Many educational institutions store equipment and materials purchased by and left behind by previous faculty. In the case of the physics department at Hollins University, several appliances in storage date back to the 1920s. While some of the equipment holds little value, there still exists a reasonable amount that can be applied to modern-day courses. The goal of this five-week project was to gather, research, renovate, and exhibit interesting objects to demonstrate that older equipment can still hold educational value. Our main strategies involved creating a quick list of the items found in storage, writing short overviews of the items using information found online, and then deciding whether we could bring value to the objects by determining their applications in physics. Limited information existed for several of the items, posing a unique challenge. Regardless, we found that many of the devices could be used in labs, as lecture demos, and as examples from the history of physics education. The result is a digital catalogue exhibiting our findings as well as the addition of new equipment to physics courses offered at Hollins. In our poster presentation, we will display some of the recovered equipment as well as information about the equipment, offering a view into educational physics. We will describe how we assessed each object and procured data when no sources were readily available.

Mentor(s): Artur Tsobanjan (Physics Department) Hollins University

Rayn Owens
Virginia State University /Computer Engineering

Investigating persona-based prompting and the impact of different identities on the output of generative AI in software development contexts

Effective prompt design is increasingly important in leveraging AI tools for prompt engineering, especially among Research Software Engineers. This study investigates the effectiveness and usability of PromptRSE. This is an AI-assisted tool designed to help Research Software Engineers (RSEs) improve the quality of prompts used in prompt engineering. The objective of the project is to evaluate whether PromptRSE enhances prompt clarity, structure, and overall usefulness in real-world software development settings. PromptRSE offers automated feedback, optimized prompt suggestions, and detailed explanations based on criteria such as context, persona, disambiguation, reasoning, and keyword usage. To assess the tool's impact, we conducted a user study by designing and distributing a survey to a targeted group of RSEs. Around 25 Participants were asked to use PromptRSE, compare original and optimized prompt outputs, and provide both quantitative ratings and qualitative feedback. The survey focused on identifying user preferences, perceived value, and areas where the tool could be improved. Preliminary findings suggest that a majority of users preferred the optimized prompts generated by the tool and found the feedback useful for improving their requirements engineering communication. However, responses also highlighted areas for future enhancement, such as improving explanation clarity and supporting a broader range of software project types. The study concludes that PromptRSE is a promising tool for supporting prompt development in requirements engineering, particularly among RSEs. The results provide valuable insights into how AI can assist in technical communication tasks. Future research will explore how the tool performs across different roles in software development and whether its benefits extend to other professionals involved in the requirements engineering process.

Mentor(s): Chris Brown (Department of Computer Science)

Janet Park
University of Maryland/Mechanical Engineering

Mitigating Dynamic Range Limitations in CHANDLER Using Extrapolation

The CHANDLER (Carbon Hydrogen Anti-Neutrino Detector with a Lithium Enhanced Raghavan optical lattice) detector is designed to measure neutrino signals, which vary based on a reactor's power and fuel composition. However, its data acquisition system has a limitation due to the dynamic range of the analog-to digital-converter (ADC), making it susceptible to saturation. Large signals can cause waveform flatlining, resulting in incomplete data. To address this, a system of photomultiplier tubes (PMT) was studied–one with full and one with partial exposure–using an LED flasher with varying DC voltages. A consistent ratio was found between the responses of the two PMTs within the unsaturated voltage range, which was used to scale the ADC counts within the dynamic range, resulting in expected values at the saturated voltage range. Using the saturated waveforms, the ends could be curvefitted and used to extrapolate backwards to recover the max ADC count for any saturated event. Comparing the extrapolated values to the expected, this method for recovering data from saturated waveforms was found to work most accurately at lower saturation inducing LED intensities, but diverge from the expected at higher intensities. This study contributes to a better understanding of the detector's dynamic range and offers a method to recover information lost to ADC saturation.

Mentor(s): Jonathan Link (Physics)

Gabriel Patch
Virginia Tech/Clinical Neuroscience

Using Machine Learning to Assist in Mice Behavioral Observations After Double Hit Stress

Over the past decade, depression prevalence has increased by nearly 60% according to the CDC. Stressful experiences often precede the development of mental health disorders such as depression. In particular, the number of early life adverse events are thought to interact with individual differences contributing to the development of mood disorders in men. Females are suggested to experience increased risk of depressive symptoms due to early life insults. Although the biological influences are less known that contribute to individual differences. We tested a two-hit hypothesis on behavior in male and female offspring, looking at how the early experience with nursing mothers (PND 9-15) undergoing variable maternal stress can affect the stress experience during early life. When the pups reached puberty, a time when most people experience their first episode of depression, half were exposed to variable stress and evaluated using a behavioral test battery that included social interaction. We tested the ability of a machine learning algorithm to measure behavioral data in an efficient and adaptable manner compared to manual analysis. Social interaction (SI), video data was analyzed using DeepLabCut (DLC), a pre-trained network capable of tracking animal movements with relatively little training. Using the software, large-scale behavioral analysis could be performed, important when testing additional layers of differences, like male vs. female mice's behavioral stress susceptibility. Future use of machine learning in behavioral research could not only assist in future studies, but utilization of previously acquired data.

Mentor(s): Georgia Hodes (School of Neuroscience)

Purva Patel
Virginia Tech/Computer Science

Compassionate design of virtual reality for mental health therapy

Virtual reality therapy for mental health is an emerging technology that uses virtual worlds as a therapeutic tool. Prior research shows that while individuals can benefit from virtual reality therapy for mental health, because of a controlled environment, other studies show uncertainty about consent, overstimulation, and accessibility. Limited information exists on how this type of therapy affects individuals with mental health disorders who experience sensation, spatial awareness, emotions, and stimuli differently from other individuals. The purpose of this study aims to use qualitative data to understand and help make the processes of accessing mental health therapy with virtual reality to be more respectful, caring, and compassionate. The research questions for this study are as follows: 1. How can patient experience be compassionately designed to ensure that their voices are centered in mental health therapy? 2. How can patient experience be used to reimagine the design of virtual reality therapy providing platforms? Semi-structured interviews, with individuals who have received or are receiving virtual reality therapy for mental health disorders, aim to understand their experiences using virtual reality therapy for mental health treatments. These interviews will help identify common concerns, patterns, and suggestions from patients to guide engineers and therapists cater to the needs of patients.

Mentor(s): Qin Zhu (Department of Engineering Education) Virginia Tech

Casie Peng
Virginia Tech/Computer Science

Auditing and Increasing the Interpretability of Privacy Policies for Virtual Reality Sensors

The Meta Quest Pro is a Virtual Reality (VR) device that offers immersive experiences using sensors like eye-tracking to monitor users' gaze. Although processed locally on the headset, Meta does not regulate third-party gaze data use, raising privacy concerns. Privacy policies aim to clarify sensor-related practices but are often difficult for users to locate and understand.
This study has two aims: (1) to assess whether VR apps notify users about eye-tracking, and (2) to explore whether Generative AI can better interpret privacy policies concerning sensor usage. We scraped free VR apps from the Meta Quest Store, selecting samples by permission count, sensor count, ratings, user ratings count, and genre. We used Google Gemini 2.5 Flash, a large language model (LLM), to analyze VR app privacy policies for sensor details using targeted prompts.
Results showed 62.9% of 35 free eye-tracking apps lacked consent prompts. Apps with fewer than four sensors had prompts 28.6% of the time, versus 50% with more sensors. One of the most popular VR genres, entertainment, had consent prompts only 25% of the time. Preliminary results revealed LLM summaries sometimes missed sensor details due to implied mentions (e.g., voice recording implying microphone use). Many free eye-tracking apps lack consent prompts, disregarding the permission, or possibly accessing data differently, leaving users unaware their gaze data is collected. Future work includes expanding the sample, testing more LLMs, refining prompts for improved summaries, and using metrics such as ROUGE, BLEU, and human feedback to evaluate responses.

Mentor(s): Brendan David-John (Computer Science) Virginia Tech

Presley Pickeral
St. Mary's College of Maryland /Neuroscience

Active synapses are necessary for competitive synapse formation and neural survival in the developing cerebellum

The brain makes many more synapses and neurons than are ultimately used in adult circuits. This selective pruning is essential for proper brain function. In the cerebellum, multiple climbing fibers connect to each developing Purkinje cell, but only one winning climbing fiber remains in adulthood. We previously found that climbing fibers are more likely to lose this competition when we eliminate their glutamatergic neurotransmission. However, it remains unknown what happens to the neurons of the losing climbing fibers in the inferior olive, a brainstem nucleus where the climbing fiber originates. We hypothesized that losing climbing fibers' neurons are also less likely to survive. To test this, we collected brains at postnatal day 24, after synaptic pruning of olivo-cerebellar synapses had occurred, and quantified the number of surviving neurons in the inferior olive. We found fewer winning climbing fibers when we eliminated their glutamatergic neurotransmission, and that their inferior olive neurons were also less likely to survive. These findings confirm that the survival of inferior olive neurons depends on synaptic competition in the cerebellar cortex. In conclusion, the cerebellum refines its circuits through a neurotransmission-dependent mechanism, and neurons making unused synapses are eliminated.

Mentor(s): Meike van der Heijden (School of Neuroscience)

Hannah Poole
Virginia Tech/Microbiology

Independent

The Role of Bacteriophage in Mediating Vitamin B12 Cross-Feeding in Bacterial Communities

Bacterial cross-feeding is a trophic interaction in which one bacterium produces a metabolite that, once released into the environment, supports the growth of another. While this phenomenon is well documented, the underlying mechanisms by which metabolites are released from bacteria are still unclear.
We hypothesize that one significant mechanism by which bacterial contents are released to the environment is bacteriophage-induced lysis. Bacteriophages (phages) are viruses of bacteria that hijack the host machinery to reproduce, then lyse the host to release their progeny phage, along with the intracellular contents of the host.
The goal of this work is to determine the extent to which bacteriophage-induced lysis contributes to interspecies cross-feeding of B12 and methionine between two bacterial species, Salmonella enterica and Escherichia coli. The analysis was performed using knockout mutants from the E.coli Keio collection and a double-mutant, created using phage-transduction. Each strain had distinct metabolic requirements, which enabled independent evaluation of B12 and methionine uptake.
Our results showed significant interspecies cross-feeding of B12 between S.enterica and E.coli in the presence of phage. In contrast, methionine cross-feeding was minimal, suggesting that nutrient-specific factors, such as uptake or metabolic efficiency, may influence the extent of exchange. Overall, this work demonstrates that phage-induced lysis can mediate interspecies cross-feeding of B12, suggesting the potential role of phage activity in shaping microbial community interactions through nutrient exchange.

Mentor(s): Bryan Hsu (Biological Sciences)

Artha Pradipta
Virginia Tech/Biological Sciences

Optimizing Phage-Driven Niacin Release from E. Coli in Modulating Gut Immune Response

Inflammatory bowel disease (IBD) is an illness used to describe chronic conditions that cause inflammation in the digestive tract. This inflammation is caused by various defects in the gut epithelium, microbiome composition, and other defenses which disrupt the gut barrier and activate the immune system. Phages are abundant in the gut and continuously lyse bacteria, releasing microbial products that may influence the immune response. Studies suggest that niacin (vitamin B3), a compound known to influence the mucosal immune response, is also produced by phage-infected bacteria before lysis. This research aims to investigate how phages may influence IBD through the release of niacin. To examine this question, we attempt to quantify and optimize the release of niacin from E. coli by T4 phage. Bacteria were infected by phage in minimal niacin-free media (M9 media) using varying infection conditions. We manipulated the multiplicity of infection (MOI), bacterial optical densities (O.D) and time of infection to observe and control their effects on niacin release and lysate production. To analyze the niacin release, we used a Lactobacillus growth assay to form a standard curve using standardized niacin solutions and interpolated niacin produced from different phage lysate samples. By optimizing niacin release from phages, we can generate phage lysate that can be used in downstream tests with immune cell cultures to evaluate the impact of phages on the immune system. These results could give insight into how bacteriophages shape gut immune responses and lead to further research on possible phage therapy for IBD.

Mentor(s): Bryan Hsu (Department of Biological Sciences) Virginia Tech
Joshua Heuler (Department of Biological Sciences) Virginia Tech

Laura Prince
Virginia Polytechnic Institute and State University/Chemistry

Incorporation of Proton Transport Pathways in Ru-UiO-67 for Improved Water Oxidation Application.

In the search for renewable sources of energy, hydrogen is a promising energy carrier due to its high energy density and identity as a clean-burning fuel. Hydrogen can be produced by splitting water, with a key step in that process being water oxidation. Water oxidation has a high kinetic energy barrier, and the use of ruthenium-based water oxidation catalysts has been shown to be effective in decreasing overpotential. The catalysts can be further stabilized when they are incorporated into metal-organic frameworks (MOFs, porous structures containing metal nodes connected by organic linkers). MOFs are highly stable and tunable, giving them the potential to mimic the environment of enzymes that use secondary transport chains to manage protons. In this study, we synthesized linkers with bipyridine, bipyrimidine, amino, and imidazole groups that act as proton acceptors. We combine the proton transport function with the known ruthenium catalyst [Ru(tpy)(dcbpy)OH2]2+(where tpy = 2,2′;6′,2′′-terpyridine and dcbpy = 2,2′-bipyridine-5,5′-dicarboxylic acid) through a multi-variate(MTV) or mixed linker approach. These specialized linkers were added using post-synthetic modification and multivariate approaches. PXRD and SEM were used to confirm MOF structure and morphology. Cyclic voltammetry and chronoamperometry were used to measure the catalytic response of the proton transfer mediator modified films. When compared to the native MOF in the absence of proton management, there is a marked increase in catalytic response through a decrease in the overpotential for water oxidation.

Mentor(s): Amanda Morris (Chemistry) Virginia Tech

Kayla Pugliese
Duquesne University/Chemistry

Developing Manganese Carbonyl Catalysts for Electrochemical Hydrogenations

Metal-hydride species play a crucial role in renewable energy applications, including hydrogenation reactions, carbon capture and conversion, and energy storage. While thermal hydrogenation using H2 is well understood, electrocatalytic hydrogenation (ECH), which replaces H2 with protons and electrons from another species, remains underexplored. A key challenge in electrocatalytic hydrogenation is controlling competing side reactions such as radical coupling and hydrogen evolution, both of which impact efficiency and selectivity. Specifically, heterogeneous ECH often leads to both side reactions occurring, while homogeneous ECH eliminates the radical coupling reaction by forming a Metal-Hydride intermediate. Using homogeneous ECH, our research focuses on utilizing an aminophenol ligand to facilitate a proton-coupled electron transfer, enabling the generation of a Metal-Hydride species at lower cathodic potentials. By examining the reactivity and reduction-oxidation ability, we aim to generate a Metal-Hydride species that selectively favors ECH over hydrogen evolution, allowing hydrogenation at lower overpotentials.

Mentor(s): Caroline Saouma (Chemistry)

Sarayu Pulipati
Virginia Tech/Computational Modeling & Data Analytics

Evaluating Hierarchical Attention for Viral protEin-based host iNference (HAVEN) on UniRef90 Representative Protein Sequences from Unseen Hosts

Virus-host prediction, inferring a virus's host organism from its protein sequence, is essential for monitoring viral evolution, identifying disease threats, accelerating outbreak response, and mitigating transmission. While there are several computational models developed for this task, challenges remain in generalizing across diverse and underrepresented host types.

HAVEN, a transformer-encoder, trained on viral protein sequences clustered at 90% similarity (UniRef90) leverages hierarchical self-attention to handle sequences of varying lengths and attains a median macro-AUPRC of 0.67. It is fine-tuned on five common hosts of vertebrate-infecting viruses: Human, Capybara, Red junglefowl, Himalayan marmot, and Pig.

A central question of this study: What does the predicted probability distribution over these common hosts look like when the input sequences do not come from vertebrate-infecting viruses? We investigate this by testing the model on major unseen reservoirs, including invertebrate animals, plants, and microbes (fungi, protozoa, archaea, bacteria). This work involved developing filters to isolate sequences infecting the hosts of interest and running HAVEN on these curated datasets. We analyzed the resulting probabilities and embeddings using dimension reduction, graphical analysis, and statistical tests to visualize trends and assess significance.

Overall, the median for four out of five hosts is close to that of a random predictor, suggesting HAVEN points to a true host not among the five and hints towards an "others" class. In contrast, median values are higher for Human, likely due to 90.79% class prevalence in the training set. To extend this project, a future step is to fine-tune on these sequences.

Mentor(s): T. M. Murali (Department of Computer Science) Virginia Tech

Lilyanne Rascher
Purdue University/Biomedical Engineering

Focused Ultrasound Enhanced Regional Drug Delivery to Glioblastoma Cells

Glioblastoma is an aggressive form of brain cancer due to its invasive nature, which is difficult to treat because of the protective blood-brain barrier (BBB). The BBB restricts drug delivery to lipophilic, small molecules. Focused ultrasound (FUS) can be used to open the BBB and deliver drugs to invading cells in regions of high outward interstitial fluid flow [1]. Directing FUS to areas of high outward flow adjacent to the tumor will improve drug delivery. Seven mice were implanted with fluorescent glioma cells during surgery. Magnetic resonance imaging (MRI) with dynamic contrast-enhanced (DCE) imaging was used to identify regions of high outward flow 12 days after implantation using gadolinium. A dextran solution with molecular weights of 3 kDa, 10 kDa, and 70 kDa was injected to visualize drug delivery. A single region was targeted with FUS and nanobubbles in four mice, followed by MRI-DCE imaging. Analysis was conducted on pre- and post-DCE imaging and stained tissue to identify alterations in outward flow and colocalization of dextran with invading tumor cells. FUS increased outward interstitial fluid flow in the targeted location and disrupted the BBB. Further analysis is expected to demonstrate a higher concentration of dextran in the invading tumor regions, indicating that FUS can be used to deliver drugs across the BBB and directly target invading cells. Drugs with a molecular weight up to 70 kDa can be delivered through the BBB to invading cells using FUS to target locations of high interstitial fluid flow.

[1] Munson JM, Bellamkonda R, Swartz M. Interstitial flow in a 3D microenvironment increases glioma invasion by a CXCR4-dependent mechanism. Cancer Research. 2013;73:1536-1546

Mentor(s): Jennifer Munson (Biomedical Engineering and Mechanics)

Kane Reczek
University of Virginia/Mechanical Engineering
Mae Hajjaj
Virginia Tech/Microbiology

Transforming Arabidopsis to Overexpress Vital Defense Genes Silenced by Parasitic Plants

Parasitic plants are a unique group of angiosperms that have evolved to survive by siphoning resources from a host plant's vascular system through a specialized organ known as the haustorium. In addition to water, nutrients, and metabolites, the parasites Cuscuta (dodder) and Phelipanche (broomrape) exchange various macromolecules with their hosts, trafficking a multitude of RNAs and proteins that may affect gene expression. These plants parasitize a wide range of commonly consumed crops worldwide, threatening the food security of millions. Improving innate crop immunity through genetic modification is an emerging possibility to combat these parasites, circumventing costly or labor-intensive control methods. Our goal was to transform Arabidopsis thaliana to overexpress defense genes typically downregulated during Phelipanche parasitism, likely from RNA interference. Various genes involved in a wide range of defense pathways were selected for cloning. Each was synthesized as one construct with MSIP-01, a synthetic promoter induced in tissues around the haustorium by Cuscuta or Phelipanche parasitism. Using In-Fusion cloning, we have successfully cloned genes ERF2, WRKY29, PDLP5, TIFY6A, and PEP6 into pCambia3300 vector containing previously cloned OCS terminator, with Arabidopsis currently undergoing Agrobacterium-mediated transformation. Effects on Cuscuta and Phelipanche parasitism will be evaluated using homozygous transgenic lines. A parasite-resistant strain of Arabidopsis would serve as a proof-of-concept for this novel control method, demonstrating that evading parasitic silencing may be invaluable to defending agricultural prospects from these devastating plants.

Mentor(s): James Westwood (School of Plant and Environmental Sciences)

Tatum Register
Xavier University of Louisiana/Political Science
Jahara Lewis
Virginia Tech/Biological Systems Engineering

Advancing Engineering Education through Integrated Chatbot Development and Outreach Initiatives at the LEWAS Lab, Virginia Tech

LEWAS (Learning Enhanced Watershed Assessment System) is an integrated environmental monitoring and educational platform that incorporates real-time watershed data with AI-based learning. The LEWAS lab hosts a publicly accessible chatbot that promotes educational accessibility and generates context-aware responses based on environmental inputs from the site. This project advances the educational mission of the LEWAS Lab by developing an AI-powered chatbot that tailors responses to users with varying scientific backgrounds, while also expanding outreach strategies to enhance student engagement. Our interdisciplinary team addresses critical gaps in data accessibility, system functionality, and user engagement by refining the educational chatbot's knowledge base and user interface; expanding outreach efforts to attract undergraduate researchers; and increasing visibility of the data collection site and the LEWAS Lab as a whole. To enhance the chatbot's knowledge base, we analyzed its existing repository of documents and systematically assessed its response capabilities to diverse questions. After identifying the chatbot's limitations, we collaboratively developed and sourced the necessary documents to fill these gaps. Simultaneously, using prompt engineering, we refined the fixed prompt used by the chatbot and enabled it to better utilize its scientific knowledge to deliver precise responses tailored to different users. Concurrently, we established sustainable frameworks for future researchers (including comprehensive documentation, outreach strategies, and accessibility protocols) to support long-term usability. Results demonstrate chatbot response accuracy and educational reach through user testing and web analytics. This work modernizes LEWAS Lab's technical ecosystem and strengthens its role as an open-access educational resource for learners, researchers, and the public.

Mentor(s): Dr. Natasha Bell (Department of Biological Systems Engineering)-Virginia Tech
Dr. Vinod Lohani (Department of Engineering Education) Virginia Tech
Yunus Naseri (Department of Civil and Environmental Engineering) Virginia Tech
John Hoben (School of Plant and Environmental Sciences)Virginia Tech
Jeremy Smith (Department of Engineering Education) Virginia Tech

Maryam Rehmatulla
Virginia Tech/CMDA
Shlok Kulkarni
Virginia Tech/CMDA

Data-Science for grain marketing decision making: Planting progress and Crop Condition Interactive Dashboard

The Virginia Data Science for the Public Good (DSPG) program has developed an interactive dashboard using R Shiny to enhance data-informed decision-making in the state's corn sector. This tool displays county-level information on corn yield, planting progress, and crop condition by drawing from real-time, publicly available datasets provided by the USDA National Agricultural Statistics Service (NASS). Users can investigate both current and historical patterns, identify anomalies compared to long-term averages, and make cross-county or regional comparisons, including against national figures. The dashboard features intuitive visualizations, trend smoothing, and simple forecasting techniques to improve interpretability. In addition to traditional survey data, the platform integrates satellite-derived indicators from Google Earth Engine (GEE), such as NDVI and land surface temperature, to explore how remote sensing can complement and enhance real-time crop condition monitoring and yield prediction. By making complex agricultural data accessible and interactive, this platform equips farmers, researchers, extension specialists, and policymakers with the information needed to support effective crop management and grain marketing strategies. The broader goal is to strengthen regional resilience and economic growth by increasing transparency and access to actionable agricultural insights.

Mentor(s): Mario Ortez Amador (Agriculture and Applied Economics) Virginia Tech

Antoni Reynolds
College of Science/Neuroscience

"Conjugated Linoleic Acid Nutraceutical Modulates Gut Microbiome and Intestinal Length in HFD-fed mice"

While diets high in fat are known to induce obesity and other related physiological alterations, conjugated linoleic acid (CLA) supplementation has demonstrated anti-obesity effects. However, the mechanism(s) behind CLA's action has not yet been fully elucidated. In this study, we are testing the hypothesis that CLA exerts its effects through the modification of the gut microbiome and intestinal physiology. The genetically obese mouse model "N2KO mice", and matched wild type (WT) control mice were divided into groups based on diet (high fat diet (HFD) alone or CLA with HFD) and genotype (WT vs. N2KO). Over a 12-week study, male WT and N2KO mice on CLA diet showed lower body weight and body fat compared to mice of either genotype on HFD. EchoMRI analysis confirmed increased adiposity in HFD fed mice compared to those receiving CLA supplementation. Interestingly, our data indicated that those on CLA diet had a significantly longer intestinal length than those in the HFD group. Microbiome analysis of CLA vs. HFD indicated CLA-specific changes in "good bacteria" levels. Intestinal histology, and feces content of CLA levels are currently being examined to determine if the differences are reflected in cellular changes in the intestinal lining or metabolism of CLA. These findings suggest that CLA supplementation may influence gut morphology along with metabolic and body fat outcomes compared to the HFD, regardless of genetic background. This study provides insights into the relationship between diet, genetics, and gut health in metabolism and encourages further exploration to illuminate these complex relationships.

Mentor(s): Deborah Good (Health Sciences) Virginia Tech

Sydnee Rhodes
Virginia Tech/Cognitive and Behavioral Neuroscience

Assessing Cerebellar Purkinje Cell Density and Layer Thickness in a 3q29 Deletion Mouse Model

3q29 deletion syndrome (3q29del) is a copy number variant caused by a heterozygous deletion of a region containing 21 protein coding genes. It is associated with learning/intellectual disabilities, developmental delay, schizophrenia, and autism spectrum disorder (ASD). 3q29 deletion syndrome is known to cause cerebellar hypoplasia in both human and mouse models. However, the cellular and molecular mechanisms determining the decreased volume are unknown. This study aimed to determine whether the density of Purkinje cells or the thickness of the cerebellar layers could be the cause of the cerebellar hypoplasia. We used P12 brains from 3q29 deletion mice (n=4) and wild-type control mice (n=4). We quantified Purkinje cell density across cerebellar regions and lobes. We also measured the thickness of the internal granule cell layer, molecular layer, and external granule cell layer. We found that in the P12 brains there was no statistical significance difference between the densities of the wild-type control mice and the 3q29del mice. This suggests that Purkinje cell loss is not the primary cause of cerebellar hypoplasia at this stage. However, we found statistical differences in layer thickness of the paravermis central internal granule cell layer ($p<0.045$), the paravermis posterior molecular layer ($p<0.045$), and the hemisphere central external granule cell layer ($p<0.035$). These results suggest that disrupted development of the cerebellar layers may underlie the cerebellar hypoplasia observed in 3q29 deletion syndrome. This is potentially due to one or more of the 21-protein coding genes in the deleted region, which may alter the proliferation or development of granule cells in the cerebellum.

Mentor(s): Meike van der Heijden, Virginia Tech

Paige Roach
Virginia Tech/Biochemistry

Independent

Analyzing fluorescent peptidoglycan released from Borrelia burgdorferi to investigate the causative agent of Lyme arthritis

The spirochete Borrelia burgdorferi is the causative agent of Lyme disease. Most patients develop a mild form of the disease, but a subset experience a proinflammatory response in their joints, resulting in Lyme arthritis. While Lyme disease is the most prevalent and fastest growing vector-borne disease in the United States, the precise molecular mechanisms underlying disease pathology remain unclear. Peptidoglycan is an essential component of the bacterial cell walls and a well-known immunogen. We hypothesize that the causation of Lyme arthritis is in the molecular weight region between 1kD and 10kD of peptidoglycan, in contrast to a prevailing hypothesis that suggests it lies in the <1 kD region. To investigate this, B. burgdorferi was cultured in rabbit fetal serum, with one sample supplemented with a fluorescent alanine analogy (hydroxycoumarin carbonyl amino D-alanine, HADA), and one without. Each sample was separated first by solid phase extraction followed by molecular weight fractionation using tangential flow filtration. The resulting fractions were analyzed by both liquid chromatography coupled to mass spectrometry (LCMS) and liquid chromatography (LC) with UV and fluorescence detection, using the same chromatographic conditions. This combined approach permitted identification of HADA-labeled molecules released into the cell culture medium. Such work will help to identify potential immunogenic fragments contributing to Lyme arthritis.

Mentor(s): Richard Helm (Biochemistry) Virginia Tech

Alejandro Rodriguez-Fernandez
Virginia Tech/Biological Systems Engineering

Sustainable Wastewater Treatment Using a Hybrid Constructed Wetland System in Southwest Virginia

Many communities in Southwest Virginia struggle to implement effective wastewater treatment solutions due to limited infrastructure and financial resources. Treatment wetlands (TWs) have been proposed as a low-cost, sustainable option for supplementing or replacing traditional wastewater treatment systems. TWs offer the potential to remove contaminants through natural processes such as sedimentation, plant uptake, and microbial activity. However, their application at the municipal scale, particularly in under-resourced areas, has not been widely tested or adopted in this region. The goal of this project is to evaluate the effectiveness of a pilot-scale treatment wetland in reducing nutrient concentrations from wastewater in a resource-limited region. To achieve this, we designed and constructed a hybrid wetland system consisting of a vertical flow cell (VFC) followed by a horizontal flow cell (HFC). The VFC was layered with sand, gravel, and zeolite to promote filtration and adsorption, while the HFC included a base layer of wood chips inoculated with denitrifying bacteria and a top layer of zeolite. Both cells were planted with Juncus effusus and Carex stricta to enhance nutrient uptake. The system will use wastewater sourced from campus facilities once fully functional. Daily water samples were collected before and after each cell and analyzed for nitrate concentration to assess nutrient removal efficiency throughout the system. This system will continue to be monitored for nutrient removal performance. Once complete, the data collected will help assess the effectiveness of hybrid treatment wetlands in reducing nitrate and other common pollutants.

Mentor(s): Natasha Bell (Biological Systems Engineering)

Anandita Sahu
Virginia Tech/Chemical Engineering
Tatum Register
Xavier University of Louisiana/Political Science

Investigating Sand as a Growth Medium to Advance Sustainable Nutrient Recycling through Aquaponic Systems

This research investigates the viability of sand as a growth medium within aquaponics systems, "sandponics." Aquaponics combines aquaculture, raising fish, and hydroponics, soil-less plant cultivation, in a closed loop system that recycles water and nutrients through nitrification (ammonia excreted by the fish is transformed into nitrite and then nitrate which provides nutrients to the plants) and solids removal. This system consists of four substrates: paver sand, play sand, all purpose sand, and lightweight expanded clay aggregate (as a control) in duplicate beds planted with 12 lettuce plants per bed connected to a 1000L fish tank. The species used are Nile Tilapia (Oreochromis niloticus) and Bibb Lettuce (Lactuca sativa). Key growth metrics including fish and plant biomasses, water quality, and environmental parameters are monitored to ensure optimal conditions. Substrate properties such as particle size distribution, organic matter content, nitrogen availability, and trace metal concentrations are analyzed to assess nutrient retention and cycling. Results indicate that sand proved to effectively support nutrient recycling as it reduced ammonia concentrations while supporting plant growth. Plant yields ranged from 130g to 297g per lettuce head. The play sand medium resulted in the greatest plant growth with lettuce head weight from 207g to 297g. These findings suggest that sandponics provides a cost effective and scalable biofiltration method suitable for resource limited and water scarce environments. Future work will aim to promote improved overall fish health and explore in depth components related to substrate properties and their role in nutrient retention.

Mentor(s): Natasha Bell (Department of Biological Systems Engineering) Virginia Tech

Sarah Salama

Virginia Polytechnic Institute and State University/Biological Sciences - Biomedical

Effect of Doxorubicin on Cardiac Function and Mitochondrial Gene Expression

Doxorubicin (DOX) is a widely used chemotherapeutic agent known for its effectiveness against various types of cancer. However, its clinical use is significantly limited by cardiotoxicity, which often leads to irreversible cardiac dysfunction and mitochondrial impairment. Despite its severity and prevalence, no effective targeted therapies currently exist for managing DOX-induced cardiomyopathy. PERM1 is a striated muscle-specific regulator of mitochondrial bioenergetics. Our previous studies demonstrated that PERM1 is downregulated in failing hearts, and that genetic ablation of Perm1 leads to reduced systolic function, accompanied by global downregulation of genes involved in mitochondrial oxidative phosphorylation (OXPHOS). In this project, we aimed to determine whether PERM1 is involved in DOX-induced cardiotoxicity. To investigate this, Perm1 knockout (Perm1-KO) mice and their wild-type littermates were treated with DOX for 4 weeks, and cardiac function was evaluated by echocardiography. Additionally, the effects of DOX on OXPHOS gene expression were assessed in H9c2 cardiomyocytes by qPCR. Unexpectedly, DOX treatment did not reduce systolic function in either group. In H9c2 cells, DOX treatment significantly reduced the expression of OXPHOS genes, concurrent with downregulation of ERRα and PPARα, two key transcription factors involved in mitochondrial bioenergetics and fatty acid oxidation, respectively. In contrast, DOX-induced stress led to an upregulation of Perm1 mRNA. These results suggest that DOX impairs mitochondrial bioenergetics, likely through downregulation of ERRa and PPARa. Furthermore, our findings indicate that PERM1 is unlikely to be directly involved in DOX-induced mitochondrial impairment. Future directions include testing whether overexpression of ERRα may better preserve cardiac metabolism during DOX treatment.

Mentor(s): Junco Warren (Department of Human Nutrition, Foods, and Exercise) Virginia Tech

Renee Sarmiento
Virginia Tech/Biochemistry

Adenovirus modulates intercellular junction architecture to facilitate spread

Viral myocarditis is a leading cause of death in young adults, precipitating deadly arrythmias in acute phases of disease. Adenovirus type 5 (Ad5) is a leading etiological agent in cardiac infection yet how infection can acutely induce an arrhythmogenic substrate before significant immune responses and cardiomyopathy is unclear. Gap junctions comprising connexin43 (Cx43) facilitate action potential propagation in the heart, in addition to antiviral immune responses. We have previously reported that Ad5 infection impairs cardiac conduction velocity through targeting gap junction function. We observed that while adenoviruses may close gap junctions, they also stabilize them. Interestingly, another junctional protein also enriched in the heart is the Ad5 receptor, CAR. Based on this, we hypothesize that Ad5 promotes viral dissemination via a bystander effect rendering neighboring cells more permissive to infection through modulation of junction architecture. To investigate this mechanism, we will use super-resolution microscopy, which enables nanoscale localization of cell junction structures. We utilize infected adult mouse cardiomyocytes (ACMs) and human induced pluripotent stem cell derives cardiomyocytes (iPSC-CMs). Alterations to gap junction architecture and complexing with key scaffolding protein ZO-1 and 14-3-3 in infected cells and uninfected neighbors will be quantified together with CAR localization. We expect reduced ZO-1 complexing concomitant with increased association of Cx43 with14-3-3 in Ad5 infected cells and neighbors. We also anticipate increased CAR localization to cell junctions with infected cells. Together, this work will provide novel insight into how viral subversion of junctional protein structures facilitated spread and therefore pathogenesis and arrhythmogenesis in viral myocarditis.

Mentor(s): James Smyth (Fralin Biomedical Research Institute at VTC, Department of Biological Sciences) Virginia Tech

Harrison Scarboro
Virginia Tech/Exercise and Health Sciences

Modulation of Cardiovascular Disease through TLR9 Agonization and Concomitant Inhibition of Immune Exhaustion

Cardiovascular disease is the leading cause of death worldwide, and chronic inflammation plays a major role in its progression. Further, immune exhaustion, a complication of chronic inflammation, is increasingly appreciated to contribute to immune dysfunction. Here we describe a novel approach to reducing inflammation by targeting two parts of the immune system: toll-like receptor 9 (TLR9) and CD38, a marker of immune exhaustion. We believe that activating TLR9 with CpG-B ODNs will increase the number of regulatory B cells, which help calm inflammation by producing the cytokine IL-10. However, in exhausted B cells, this same stimulation can paradoxically lead to secretion of pro-inflammatory cytokines, such as IL-6. To prevent harmful stimulation, we use the protein inhibitor 78C to inhibit CD38, a marker of immune exhaustion, to bias B cells to be more protective when they are stimulated by CpG-B ODN treatment.

MRL/lpr mice were fed a high-fat diet and injected with an adeno-associated virus to induce atherosclerosis. Mice received one of four treatments: 1) CpG-B ODN + 78C, 2) CpG-B ODN alone, 3) 78C alone, or 4) negative control. Proteinuria was tracked as an inflammation marker. Post-takedown analyses included anti-double stranded DNA ELISA, organ weight comparison, a histology panel assessing kidney damage, and a Sudan stain performed on aortic tissue sections to assess plaque accumulation. Preliminary data suggest the combination of CpG-B ODNs and 78C works best. Mice given only CpG-B ODNs had more inflammation than those given only 78C, showing that addressing immune exhaustion is key to reducing disease.

Mentor(s): Xin Luo (Department of Biomedical Sciences and Pathobiology) Virginia Tech
Noah Oakland (Department of Biomedical Sciences and Pathobiology) Virginia Tech

John Schaefer
Virginia Tech/Biological Sciences

Uncovering DNA motifs driving rhythmicity of Long Non-coding RNAs (lncRNAs)

Circadian rhythms are 24-hour rhythms in an organism's behavior or physiology and can be seen in almost all living organisms. The mammalian circadian rhythm is regulated endogenously through an approximately 24-hour transcription-translation feedback loop generated by transcription factors called core clock genes. This circadian clock is a molecular timekeeper, and its role in driving rhythmic expression of messenger RNAs (mRNAs) has been well studied and understood. While mRNAs are used as blueprints to encode for proteins, long non-coding RNAs (lncRNAs) are regulatory RNAs that have biological functions but do not encode for a protein. Compared to the extensive research on mRNA transcription, the transcriptional regulation of lncRNAs is not well understood. Recently, the Kojima lab used machine learning models to identify 20 possible DNA motifs specific to lncRNA promoter regions that may be important for driving circadian rhythms of lncRNA transcription. To determine experimentally if these motifs within lncRNA promoters are indeed driving rhythmic expression, plasmid constructs with the predicted motif-containing lncRNA promoters driving expression of a luciferase gene were created via PCR, DNA cloning, and bacterial transformation. These constructs were transfected into NIH3T3 (mouse fibroblast) cells, and cells stably expressing the constructs were successfully isolated. In the future, these cell lines can be used to determine the rhythmicity of these lncRNA promoter motifs through multi-day bioluminescence assays. The results of these bioluminescence assays will further our understanding of how lncRNA expression is regulated independently of mRNA expression and will enable further research into DNA motifs involved in lncRNA expression.

Mentor(s): Shihoko Kojima (Biological Sciences) Virginia Tech

Maya Schulman
Brandeis University/Psychology

Artificial Intelligence Chatbots and Obsessive-Compulsive Disorder: Evaluating a New Digital Intervention for Young Adults

Abstract

Purpose: The purpose of this research is to examine the extent to which artificial intelligence chatbots could serve as a safe and effective digital intervention for young adults with obsessive-compulsive disorder (OCD) transitioning to college. Young adults with OCD are likely to struggle with this academic and social adjustment and may need more accessible support systems. Treatment accessibility issues are especially prevalent when it comes to OCD, seeing as many psychologists are not trained in exposure and response prevention—a form of therapy considered the gold standard for OCD symptom mitigation. Artificial intelligence (AI) chatbots are becoming common in various fields, including mental health care, and have the potential to bridge this treatment gap. It is essential to explore the risks and benefits of this tool and the role it should play in treating OCD.

Design/methodology/approach: Conducting a comprehensive literature review and risk assessment.
Findings: AI therapy chatbots need increased regulation to protect user privacy and safety before they can be used independently. Traditional therapy is currently more effective than chatbot-based interventions, but the potential of chatbots, when used with clinician supervision, cannot be understated.

Originality: There have been prior studies and literature reviews discussing AI chatbots used as therapeutic tools, but most focus on their use in treating depression and anxiety. There are very few papers on AI chatbots and OCD, and none that are specific to college students with OCD.

Keywords: obsessive-compulsive disorder, exposure and response prevention, exposure hierarchies, artificial intelligence, chatbots

Mentor(s): Arianna Schuler Scott (Department of Management)

Anshul Shankar
University of Arizona/Astronomy

Developments for the DarkSide-20k Project, a WIMP Dark Matter Detector

The existence of dark matter is one of the most central open questions in modern physics, to account for the discrepancy in the amount of matter we can observe in the universe and the mass we would expect to see based on gravitational effects [1]. One model explaining this is the existence of Weakly Interacting Massive Particles (WIMPs), a dark matter candidate. However, no such particle has been definitively observed yet. The DarkSide-20k experiment is a Time Projection Chamber (TPC) that proposes to use 20 tons (fiducial volume) of Liquid Argon over a ten-year detection period, expecting a "5σ discovery significance for a 1 eV/c^2 WIMP", to either prove the existence or greatly constrain the characteristics of WIMPs. At Virginia Tech, we are responsible for the construction of the wire grid, a collection of 1236 tensioned and charged wires at -5.2 kV, which will cause the drifted electrons produced from collision events (S1) to accelerate into a region of Gaseous Argon, inducing detectable electroluminescence (S2) and which provides the X and Y component for a 3D reconstruction of an event (the Z component is provided from the time difference between S1 and S2). We are also responsible for the development of the anode deflection monitoring system, which seeks to detect and allow for the correction of any deformation due to e.g. gravity of the anode housed at the top of the detector. In this paper, I present the technical developments we have made towards the wire grid; in particular, an autonomous and contact-free method of measuring the tension in the wires, and our methods to ensure the consistency of in-house manufactured springs. In addition, I discuss the prototyping process of our anode deformation monitoring system (ADMS), which is in its early stages.

Mentor(s): Bruce Vogelaar (Department of Physics)

Abhiram Sharma
Georgia Institute of Technology/Physics

Characterizing Radiation Induced Color Centers in Lithium Fluoride

Interactions between energetic particles and a crystal's lattice structure can lead to observable vacancies in the crystal. In some materials, these vacancies are optically active (aka color centers), thus allowing one to determine the type and trajectory of particles that damage the crystal by fluorescence measurements. Lithium fluoride (LiF) is a particularly good candidate as a passive particle detector due to its high selection efficiency for detection purposes and its insensitivity to gamma rays. We will further study the bulk fluorescence of LiF after irradiation by neutrons and gamma rays by characterizing the thermal and time dependence of the fluorescence. These studies will be useful in understanding how the history of LiF samples can be removed from scan data to reduce background. Additionally, using Light-Sheet Fluorescence Microscopy (LSFM), we can image single-site vacancies or damage tracks in 3D to study single particle events. Scan data from a benchtop mesoSPIM will be analyzed to identify and classify track fluorescence properties. These results could help understand how to process data from LiF to confirm the detection of neutrons, neutrinos, and dark matter, such as for the PALEOCCENE concept.

Mentor(s): Patrick Huber (Department of Physics)

Elisa Sharonov
Virginia Tech/ECE

Independent

Emulating Quantum Gates by Using Rabi Oscillations in Nitrogen Vacancy Centers in Diamonds

A quantum object only has two measurable energy states: |0⟩ and |1⟩. While there are infinitely many superpositions between those states, represented by the Bloch sphere, when measured, they just collapse into one of the aforementioned states. Thereby, they encode a certain probability distribution. However, due to quantum behavior, the object may revert to a quantum state after measurement ceases. Subsequent measurements can yield an opposite state. Furthermore, particles interacting with quantum fields may resonate, causing their state to oscillate within the field's waves. Such phenomenon is referred to as the Rabi oscillations.
Rabi oscillations enable the emulation of quantum gates, for example, the Hadamard gate that outputs an equal superposition state from a computational basis state, and the Pauli X gate which shifts the states on the Bloch sphere around the X axis by 180°, essentially swapping them. Such is achieved by finding the natural frequency of oscillation, and then inducing such a magnetic field that would force it to oscillate with a different frequency we may be interested in. This matters, because at a different frequency, the state shifts from pure |0⟩ or |1⟩ to their superposition.
Our experiments are conducted using an optical breadboard based on the principle of nitrogen vacancy centers. Our quantum phenomenon is, therefore, spin of the electrons in those centers, and its states are ms=-1 (defined as |0⟩) and ms=1 (defined as |1⟩). The optical breadboard can exert a magnetic field on it, inducing the Rabi oscillations of desired frequencies.

Mentor(s): Wayne Scales (ECE) Virginia Tech

Sami Sheikh
Virginia Tech/Clinical Neuroscience

Neural Sabotage: How Disrupting CO Neurons Disarms Mosquito Vectors

Mosquitoes are the most lethal animals in the world due to the diseases they transmit, including malaria, dengue fever, yellow fever, and Zika virus. This threat to human health is predicted to only worsen due to rising insecticide resistance and expansion of mosquitos' geographic distribution. Here, we aim to develop novel control strategies by studying the effectiveness of a class of insecticides, IRAC Group 9, which haven't yet been utilized to combat mosquito populations. IRAC Group 9 insecticides include compounds such as pymetrozine that target somatosensory neurons known as chordotonal organ (CO) neurons. CO neurons are found in the antennae, legs, and wings of insects and mediate sensory functions like hearing and proprioception. IRAC Group 9 insecticides activate the ion channels Nanchung (NAN) and Inactive (IAV), leading to increased intracellular calcium that silences CO neurons. We confirmed the presence of CO neurons in mosquito antennae, legs, and labellum, and hypothesize that disrupting CO function will significantly impact mosquitoes' movement and blood-feeding, leading to decreased fitness and an impaired ability to act as disease vectors. To test this, we examined how the walking or blood-feeding behavior of female Aedes aegypti mosquitoes was affected either after pymetrozine exposure or after genetically ablating CO neuron function by genetic knockout of the channel TrpVa (the mosquito homolog of IAV). We found that the insecticide and genetic knockout leads to slower, less coordinated walking. These results suggest that perturbing CO neuron function will offer a new method to control mosquito populations, thereby improving human health.

Mentor(s): Sweta Agrawal (Neuroscience) Virginia Tech

Saher Siddique
Virginia Tech/Biomedical Engineering

Melanin-Integrated, Genetically Engineered Aerogels as Lightweight Materials for Radiation Shielding in Extreme Environments

Harsh environmental conditions like high levels of radiation and extreme temperature fluctuations pose several challenges for space missions. Such missions demand materials not only lightweight but also capable of withstanding extreme conditions. While aerogels are known for their exceptional thermal insulation properties, their potential for shielding against UV radiation remains largely unexplored. This project investigates the development of melanin-integrated aerogels as multifunctional materials that combine UV resistance with thermal insulation. Melanin, a natural pigment that absorbs and protects from UV radiation is embedded into hydrogels composed of genetically programmed β-solenoid nanofibers expressed and secreted by genetically modified E.coli. These hybrid melanin hydrogels after lyophilization result in biologically derived, lightweight and highly porous aerogels, with high potential as adaptive Engineered Living Materials (ELMs). The materials are tested under UVC exposure to evaluate their protective capacity using E. coli BL21 as a model organism. Survivability is assessed via colony-forming unit (CFU) assays across melanin concentrations of 0.5 mg/mL, 1.0 mg/mL, and 2.0 mg/mL at defined exposure time points and compared to D. Radiodurans, which, upon successful experimentation, survived in 40 minutes of UV exposure. Preliminary tests using E. coli BL21 bacteria embedded in hydrogel alone yielded positive survival results, supporting the hypothesis that melanin-aerogels will further enhance protection. Developed in this work, hybrid melanin-aerogels could significantly reduce the material burden of current radiation shielding technologies, offering promising applications in spacesuit design, spacecraft instrumentation, and even extraterrestrial habitats.

Mentor(s): Anna Duraj-Thatte (Biological Systems Engineering) Virginia Tech

Jaime Simson
Virginia Tech/Biochemistry

ARF we there yet? Deducing the specificity of auxin response factors

Do specific promoter sequence features preferentially facilitate transcriptional activation by distinct Auxin Response Factors (ARFs)?

Auxin is a plant hormone that induces cell growth, elongation, and differentiation. In the auxin signaling pathway, different proteins are responsible for either repressing (Aux/IAA) or activating genes (ARF). A previous RNA sequence data set indicates that an over-expression of specific ARF's causes a significant change in regulation of 24 different Arabidopsis genes. This project aims to validate those findings by using a fluorescent reporter-gene activation system to quantify transcriptional changes induced by the individual ARF's in Arabidopsis protoplasts.

To achieve this, a co-transformation of protoplasts will be done with a green fluorescent protein (GFP) reporter plasmid and an ARF effector plasmid. The GFP plasmid was made through gateway cloning by PCR amplification of the promoter regions of the 24 genes of interest and then inserted upstream of the GFP sequence in the plasmid. The effector plasmid is used to over-express the specific ARF's in the protoplast.

If the auxin response factors bind to the promoter regions, the protoplast will express GFP and cause increased green fluorescence. The fluorescence will be measured by a flow cytometer to quantify the transcriptional changes.

By validating this data, we will have a better understanding of how ARF's regulate auxin-responsive gene expression during plant development. This will potentially allow us to manipulate plant growth to create crops that can withstand agricultural challenges such as climate change.

Mentor(s): Bastiaan Bargmann (SPES) Virginia Tech

Priya Solanki
Virginia Tech/Microbiology

Engineering Melanin-Integrated Protein Hydrogels for Radiation-Resistant Microbial Biomanufacture

Microbial biomanufacturing is an emerging solution for long-duration space missions, enabling engineered microbes to autonomously produce essential resources, including food, therapeutics, and materials. Among various platforms, autogenic Engineered Living Materials (ELMs) offer a unique approach where microbes are programmed to secrete and assemble extracellular protein nanofibers that form functional materials. In this project, ELMs are explored as radiation-resistant shield for microbes in extreme environments. We genetically engineered β-solenoid proteins to form nanofibers with a C-terminal His-tag, enabling specific binding to melanin, a natural pigment known for its radioprotective properties. These functional amyloid nanofibers were processed into hydrogels, and varying concentrations of melanin were incorporated to create hybrid melanin–protein hydrogels. Then, E. coli cells were embedded in a hybrid hydrogel and evaluated for their survival under UVC radiation at multiple time points. The results showed that the hybrid melanin hydrogels significantly improved microbial survival compared to control groups, demonstrating the potential of these materials to serve as radiation shields for living systems. The combination of genetically programmable nanofibers and melanin provides a scalable and tunable platform for developing protective biomaterials. This work establishes a new direction in the development of radiation-resistant living materials, with implications for in situ resource utilization, biomanufacturing, and synthetic biology in space exploration.

Mentor(s): Anna Duraj-Thatte (Biological Systems Engineering) Virginia Tech

Anna Starman
Hollins University/Environmental Science
Hayley Ponn
Hollins University/Environmental Science

The impacts of wing-flashing by Northern Mockingbirds on foraging, parental care, and reproductive success

Foraging efficiency may be enhanced by flashing patches of white wing and tail feathers, and has been documented in several avian species. Northern Mockingbirds (Mimus polyglottos, NOMOS) exhibit this "wing-flashing" (WF) behavior while foraging, during displays, and in response to predators. In NOMOs, WF has been hypothesized to increase foraging success, but previous findings are inconclusive. To further investigate the biological role(s) of WF behavior in NOMOs, we artificially darkened the ventral surface of white primary feathers of male NOMOs and compared the foraging and provisioning rates of these experimental males and their mates to unmanipulated (control) males and their mates. While foraging, darkened males showed a pattern of more prey strikes and more WF than their mates and control birds; however, when foraging without WF, darkened males show a similar number of successful prey strikes but a greater number of unsuccessful prey strikes. Control and experimental males provisioned nestlings less than females, and there was no clear effect of darkening on the provisioning rate of males. Body condition (mass/tarsus3) of experimental nestlings was similar to control nestlings, but experimental nestlings fledged ~2.5d later than control nestlings. While data collection for this study is ongoing, these initial findings suggest that artificial darkening of white wing patches of NOMO males does not negatively impact WF behavior but may make males work harder to find prey while foraging. Further, while darkening does not appear to negatively affect provisioning rate to nestlings or nestling body condition, it may delay fledging.

Mentor(s): Morgan Wilson (Biology Department)

Chloe Stockli
Virginia Tech/Cognitive and Behavioral Neuroscience

Independent

Maternal Intrusiveness Impacts Receptive Vocabulary: Inhibitory Control as a Moderator in Early Development

Vocabulary is crucial in the development of language and academic achievement. Receptive vocabulary is the ability to recognize words without having to generate them verbally. This early development of language can be hindered by maternal intrusiveness in which the mother interferes with their child's autonomy by being overdirective or overbearing (Ewell et al., 2024). We found that this negative impact could be lessened in children with high levels of inhibitory control (IC), which is the ability to suppress a dominant response in favor of another response that would be more appropriate (Diamond, 2014). In the current study, we examined the relationship between maternal intrusiveness and its predictive ability of receptive vocabulary and whether IC moderated this association.

There were 192 participants from a community sample. Maternal intrusiveness was behaviorally coded at 24-months using a mother-child interaction task. IC was behaviorally coded at 36-months using the Day/Night task (proportion correct). Receptive vocabulary was assessed using the Peabody Picture Vocabulary Test at 48-months.

We performed a moderation analysis. There was a relationship between maternal intrusiveness and receptive vocabulary ($b = -16.5396$, $SE = 8.1925$, $p = 0.0449$). Maternal intrusiveness at 24-months negatively predicted receptive vocabulary at 48-months in children with low and moderate levels of IC at 36-months. In children with high levels of IC at 36-months, maternal intrusiveness positively predicted receptive vocabulary at 48-months. This indicates that IC acts as a protective factor against the negative impacts of maternal intrusiveness on receptive vocabulary.

Mentor(s): Martha Ann Bell (Psychology Department) Virginia Tech
Isabela de la Rosa (Psychology) Virginia Tech

Pavithra Sundaresh
Virginia Tech/Clinical Neuroscience

Movement & Mind: Mother-Child Dance Intervention Enhances Dyadic Synchrony & Maternal Mental Health

Maternal mental health issues, which affect 1 in 5 mothers, negatively affect the mother-child relationship and a child's developmental trajectory. Pharmacological treatments are ineffective in up to 70% of cases and often cause side effects like anxiety, insomnia, or weight gain. Depression has been linked to dysregulation of neuronal biomarkers (reduced mother-child interbrain synchrony) and the immune system. Dance, a multimodal form of exercise, is a non-pharmacological alternative; it incorporates socio-emotional processes, enhances mood state, and is found to be superior to other forms of physical activity at enhancing social connection. We hypothesized that mother-child dance can alleviate maternal mental health symptoms and improve depression related biomarkers including interbrain synchrony and immune function. In this randomized controlled study, mothers with moderate-to-severe depression, anxiety, or stress and their young children (3-5 years old) participated in a 2-week mother-child dance or play program. Self-reported pre- and post-tests assessed positive and negative mood states, parental stress, and the parent-child relationship. Electroencephalography hyperscanning captured neural activity, and saliva samples were collected for immune analysis. Compared to controls, dance reduced depression ($p = 0.047$) and parental stress ($p = 0.034$), while increasing positive affect ($p = 0.026$) and the parent-child relationship ($p = 0.031$). Dance significantly increased alpha (8–12 Hz) inter-brain synchrony ($p = 0.013$), reduced IL-6 ($p = 0.06$) and TNF-α ($p = 0.07$), and increased anti-inflammatory cytokines ($p < 0.05$). This study highlights the clinical potential of mother-child dance as a non-pharmacological intervention capable of improving behavioral, brain, and immune systems.

Mentor(s): Julia Basso (Human Nutrition, Food, & Exercise at Virginia Tech)

Veronica Swartz
Pennsylvania State University/Molecular and Cellular Biology

Refining the Stress Response: Activity-Dependent Programmed Cell Death in Developing CRH Neurons

A functional stress response is crucial for survival and must be properly established during early development. Programmed cell death refines the main stress response pathway, the hypothalamic-pituitary-adrenal (HPA) axis, by selectively killing corticotropin-releasing hormone (CRH) neurons. These neurons trigger the downstream release of cortisol, initiating a physiological stress response. Dysfunction of CRH neuron activity is linked to neuropsychiatric disorders such as anxiety, depression, and PTSD. However, the relationship between CRH neuron activity and programmed cell death during HPA axis development remains unclear. To investigate this, images of CRH neurons and their calcium activity were captured in larval zebrafish at 78 and 96 hours post-fertilization using live 2-photon microscopy. CRH neuron calcium activity was analyzed retrospectively in Fiji for neurons that survived or died over the 14-hour developmental period. The level of synchronous activity was quantified among these neurons. Preliminary data suggest that a higher degree of synchronous activity is associated with increased neuronal survival during this developmental window. Ongoing analysis will assess the amplitude and frequency of neuronal activity to further predict cell death. Additionally, research into dscaml1, a novel regulator of CRH neuron development, and its role in programmed cell death is of high interest. These findings could offer new insights into how early life stress circuits are established and how their disruption might contribute to neuropsychiatric disorders.

Mentor(s): Albert Pan (Center for Neurobiology Research, Fralin Biomedical Research Institute at Virginia Tech Carilion) Virginia Tech

Elisabeth Tershak
Virginia Tech/Biomedical Engineering

Cost-Effectively Fabricating Tunable Tissue- and Vascular-Mimicking Ultrasound

Ultrasound phantoms mimic human tissue properties for training, calibration, and research in medical imaging. We aimed to improve cost-effective, in-house phantom fabrication by investigating (1) how gelatin concentration and bloom value affect speed of sound (SOS), (2) how additives (preservative and defoamer) influence SOS, and (3) methods for constructing vascular phantoms with microvasculature.

To quantify the relationship between SOS and gelatin properties, we fabricated 250-bloom ($0.01/g) and 300-bloom ($0.30/g) porcine gelatin phantoms at eight gelatin weight concentrations. Additionally, 8% 250- and 300-bloom gelatin phantoms with and without preservative were compared. A similar comparison was performed between 8% and 20% 250-bloom phantoms with and without defoamer. SOS was measured using a pulse-echo ultrasound technique, with all phantoms scanned at an average surface temperature of 22.15 ± 0.23 °C (N = 60).

There was a strong and direct correlation between gelatin concentration and SOS ($R^2 > 0.99$). ANCOVA found no significant difference between the 250- and 300-bloom gelatin linear fits, $F(2, 44) = 0.0052$, $p = 0.9430$. Two-sample t-tests revealed significant differences in SOS with preservative ($p < 10^{-12}$) and defoamer ($p < 10^{-13}$) across multiple gelatin concentrations and bloom-value.

A microvascular flow phantom was constructed by routing polyethylene tubing (280-µm-inner diameter) through a 3 × 5 grid, with water flowed through the tubing using a syringe pump. Doppler ultrasound confirmed flow, though imaging was impaired by mechanical noise from the pump.

These findings demonstrated that SOS-tunable and vascular-mimicking ultrasound phantoms can be fabricated in-house at low cost using commercially available materials.

Mentor(s): Aiguo Han (BEAM and ICTAS) Virginia Tech

Chandon Thomson
Berea College/Psychology

Independent

Examining Predictors of Variability in Inattention Among Children and Adolescents in Daily Life

Children with attention-deficit/hyperactivity disorder (ADHD) have increased intra-individual (IIV) variability in behavior in daily life and through lab-based tasks. Many other psychiatric disorders often "mimic" ADHD, with children with anxiety or depression having difficulties concentrating or completing tasks. Since inattention frequently fluctuates and may be caused by conditions other than ADHD, studies of IIV in inattention should account for anxiety and depression. This study examined predictors of IIV (age; biological sex; diagnostic status) in parent-reported inattention over 2-weeks and assessed whether differences were accounted for by IIV in anxiety and depression. Participants included 128 children and adolescents (Mage=9.95; 50.0% female; 85.9% White; 4.8% Latine). Multilevel modeling analyses were run to create the measure of IIV for inattention, depression, and anxiety; an ANCOVA was run for the main analysis.

Age and sex did not significantly predict IIV. Diagnostic status significantly predicted IIV for inattention, controlling for the effects of IIV in anxiety and depression. Post-hoc tests revealed that the ADHD only (M=.36) and the combined ADHD + Anxiety/Depression (M=.37) groups had significantly higher IIV in inattention than the Anxiety/Depression only group (M=.18). However, the No Diagnosis group did not significantly differ in IIV (M=.31) relative to either ADHD group (despite mean levels of inattention being significantly lower, M=1.63 vs. 2.08 and 2.38), and was significantly higher than the Anxiety/Depression group, suggesting that some variability in inattention is normative. Future research should explore at what level of IIV academic impairment occurs, and what other factors might predict IIV in inattention (e.g., sleep).

Mentor(s): Rosanna Breaux (Psychology) Virginia Tech

John Tinsley
Virginia Tech/Plant Science

Poison Ivy Plant Growing Experiment

Millions of people are affected each year by poison ivy rash (allergenic dermatitis). Urushiol is the chemical that causes the poison ivy rash symptoms. Despite this widespread human suffering caused by poison ivy, there is little detailed knowledge about the evolutionary ecology of urushiol production. . Evolutionary genomics is a powerful approach suitable for evaluating evolutionary pressures shaping a given plant trait, such as urushiol levels and composition in poison ivy. The main purpose of this project is to sample both the genetic and chemical (urushiol) diversity of poison ivy from three locations in Virginia. Drupes (aka seeds) collected from ten individuals each from three distant locations (Augusta County, Montgomery County, and Patrick County) provided a sample of poison ivy genetic diversity. This research project focuses on growing ten seedlings from each set of ten lianas in three locations, yielding a population of 300 individual poison ivy seedlings. My role was to initiate seedling germination using acid scarification, transfer seedlings to a magenta box for further growth in an environmentally controlled growth chamber. The seedlings were harvested at 2nd true leaf stage and frozen in liquid nitrogen and then stored at -80 C, awaiting future genetic and urushiol analyses. I hypothesize that each seedling will show different urushiol production levels and/or composition depending on certain factors such the county the drupe originated from. So far, some drupe accessions have been inviable, but there were certain counties that produced many viable drupes/seedlings.

Mentor(s): John Jelesko (School of POlant and Environmental Science) Virginia Tech

Caroline Toler
Centre College/Biochemistry and Molecular Biology

Characterizing Pannexin 1 Expression and Function in Nutrient-Stressed Vascular Cells

Coronary microvascular disease (CMD) is a dysfunction of the small blood vessels that supply oxygen to the heart. CMD causes chest pain, exercise intolerance, decreased quality of life, and increased heart failure risk. Although obesity is a major risk factor for CMD, the contributing mechanisms are not well understood, and treatment options are lacking. Pannexin 1 (Panx1) is a membrane channel protein involved in small molecule release and has been implicated in blood vessel contraction and dilation. Our preliminary data suggests that Panx1 is critical for nitric oxide production in vascular endothelial cells, which is required for blood vessel dilation and oxygen delivery to the heart. We hypothesize that obesity impairs vascular Panx1 function leading to reduced nitric oxide signaling. To test this, human umbilical vein endothelial cells (HUVEC) and coronary artery smooth muscle cells (HCASMC) were cultured in high glucose (33 mM) high palmitate (0.3 mM; HG-HP) to model nutrient stress in obesity. To assess the role of Panx1 in the nitric oxide synthesis pathway cells were treated with bradykinin, vascular endothelial growth factor, and acetylcholine. Protein expression of Panx1 and endothelial nitric oxide synthase (eNOS) were assessed by western blot. Panx1 protein expression decreased overtime in HUVECs and HCASMCs during a 5-day HG-HP treatment. Of the treatments we tested, bradykinin demonstrated the strongest induction of eNOS phosphorylation at serine 1177 and this was blunted by HG-HP treatment. Future experiments will determine whether influencing Panx1 expression alters eNOS phosphorylation in HG-HP treated vascular cells.

Mentor(s): Scott Johnstone (Biological Sciences)

Joaquin Tuckett
Virginia Tech/Computer Engineering

Smart Contract Auditing at Scale: a Comparison of Static and LLM-Based Tools

The Ethereum blockchain is a technology that lets people conduct transactions without government regulation. To ensure all involved parties uphold the transaction, smart contracts, money-transferring programs that can not be modified after use, were created. However, these contracts are often riddled with security flaws, which have resulted in millions of dollars being stolen. Researchers have recently explored using tools based on large language models (LLMs) to detect these vulnerabilities in advance. Though these systems have the potential to generalize across different contract versions, explain their findings, and provide solutions, the field currently lacks a thorough evaluation of how these technologies compare in performance to more traditional smart contract security tools. This limits our ability to properly direct future research efforts and make informed security decisions. We seek to fill this gap by evaluating both kinds of tools on contract generalization, explanation quality, and the rate of false positives and false negatives on the SmartBugs contract dataset. We found that only the LLMs could analyze the newest version of contracts, while the traditional tools crashed due to compatibility errors with these versions. However, traditional tools also run much faster than LLM-based tools, which are highly sensitive to the given contract and may produce incoherent outputs. We believe that the training scheme of LLMs needs to be reoriented around producing consistent, structured outputs, and datasets must be better curated to avoid incoherent outputs in order to maximize the potential of LLMs in smart contract analysis.

Mentor(s): Chris Brown (Department of Computer Science) Virginia Tech

Emily Urda
Virginia Maryland College of Vet Med /BSE/BIO

Independent

Exploring CX3CR1's pathway in inducing Arthritis in MRL/lpr mice

Ninety-five percent of individuals with Systemic Lupus Erythematosus, in the U.S., experience arthritis during a period of their disease. It is well researched that the CX3CR1 has a role in the pathogenesis of disease. There is a possibility that the CX3CR1 gene is linked to lupus nephritis and that the CX3CR1 pathway modulates IL-17A and IL-17F production. This leads to the possibility of arthritis and other symptoms of inflammation in lupus patients. In this project, the focus was to investigate how CX3CR1 modulates arthritis in lupus-prone mice. Cx3cr1+/+ and Cx3cr1 -/- MRL/lpr mice were used for this project. When mice were 8 weeks old, they were injected with a substance containing Complete Freund's Adjuvant (CFA) and type II collagen. CFA was created by the addition of heat killed Mycobacterium Tuberculosis. The emulsified substance was injected into the base of the tail, intradermally. The mice were given a booster shot 22 days after and culled on the 14th week, and their paws, synovial fluid, spleen, kidney, mesenteric lymph nodes, and popliteal lymph nodes were collected. The lack of CX3Cr1 showed a decrease in the expression of arthritis with clinical scores averaging less than the Cx3cr1+/+ and a decrease in the number of Cytotoxic T-cells in the Cx3cr1 -/- MRL/lpr mice. Future research will be inhibiting the CX3CR1 pathway to eliminate arthritis in SLE patients. It is also possible that using the CX3CR1 pathway may help regulate T-cell function, leading to less inflammation, and a longer life for SLE patients.

Mentor(s): Xin Luo (Immunology) Virginia Maryland College of Vet Med

Miles Veerhoff
Virginia Tech/Biological Systems Engineering

MoCloMatic: Accessible Lab Automation Protocols for Combinatorial DNA Assembly

Synthetic biology may hold the keys to solving some of the largest problems we are facing today. For example, we can modify microorganisms to break down plastics, clean our air, or convert food waste into sustainable biofuels. Within synthetic biology, Golden Gate cloning is a robust technique which allows for the construction and replication of complex DNA sequences. Standards such as Modular Cloning (MoClo) build upon the foundation of Golden Gate and can be used to join many DNA parts. These techniques have become central to the Design, Build, Test, Learn cycle of synthetic biology research. However, this framework meets difficulties when it comes to scalability and consistency. Here, we develop user friendly, open-source lab automation protocols aiming to eliminate error-prone steps. Our solution uses DNA constructs designed in Benchling, and handles reactions in the Opentrons OT-2 liquid pipetting robot. By eliminating repeated manual steps during the Build phase, we can reduce error, increase throughput, and allow the researcher to focus their efforts on design and validation. Our initial testing using MoClo toolkits with multiple DNA assemblies yielded high success rates. We are continuing development on the platform to expand scalability and functionality to perform additional tasks.

Mentor(s): R. Clay Wright (Biological Systems Engineering) Virginia Tech

Isabel Vikesland
University of Virginia/Biomedical Engineering

Design and synthesis of small molecule mitochondrial uncouplers for the treatment of obesity

Design and synthesis of small molecule mitochondrial uncouplers for the treatment of obesity Isabel Vikesland,1 Emily L. Krinos,1 Mary A. Foutz,1Ava Zhou,3 Kyle L. Hoehn,2,3,* Webster L. Santos1,*
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Obesity is a metabolic disorder driven, in part, by mitochondrial dysfunction, which leads to excessive reactive oxygen species (ROS) intracellular buildup and chronic inflammation. This cellular stress contributes to the development and progression of comorbidities, including type 2 diabetes, cardiovascular disease, and fatty liver disease. Drugs targeting mitochondrial dysfunction represent a promising therapeutic strategy. Mitochondrial uncouplers act to increase respiration and energy expenditure by dissipating the proton motive force to “uncouple” oxidative phosphorylation. Here, we report a library of small molecule mitochondrial uncoupler derivatives that are based on the mitochondrial uncoupler BAM15. Structure-activity relationship (SAR) studies revealed that this scaffold tolerates diverse substitutions and yields compounds with favorable pharmacokinetics. By utilizing an oxygen consumption assay to measure cellular respiration, lead candidate SHK1052579 was found to have an EC50 of 0.54 μM in rat L6 myoblasts. Pharmacokinetic studies determined SHK1052579 has a 6.3-hour half-life in mice with good exposure (Cmax = 12.4 nmol/mL). These findings highlight this scaffold as a new class of mitochondrial uncouplers that will be explored for the potential treatment of obesity.

Mentor(s): Webster Santos (Virginia Tech Chemistry) Virginia Tech
n/a

Annie Walls
Fralin Biomedical Research Institute/Experimental Neuroscience

Synaptic competition drives developmental pruning in the cerebellum

Children's ability to learn fine motor skills depends on the pruning of synapses in the cerebellum. Purkinje cells form hundreds of synapses with their innervating climbing fiber, making this one of the strongest connections between two neurons in adult brains. Such a strong connection must be formed precisely. The "winning" fiber that remains into adulthood is selected through competition between multiple climbing fibers that innervate each Purkinje cell initially. Still, the mechanism by which this "winner" competes remains ambiguous. We test the hypothesis that the "winning" climbing fiber is dependent on glutamatergic neurotransmission. We selectively express the fluorescent tdTomato in a subset of climbing fibers and compare their likelihood to "win" this competition during normal development to when they lack neurotransmission. After fluorescently staining Purkinje cells and climbing fibers in several sections from numerous brains per age and condition, we count whether individual Purkinje cells are innervated by tdTomato+ fibers. In control mice, natural elimination of losing fibers reduces the number of Purkinje cells innervated by tdTomato+ fibers over time. When these fibers are silenced, similar numbers of Purkinje cells are innervated by them in early development. As these mice age, though, more of the silenced fibers are eliminated. Silenced climbing fibers are more likely to lose, supporting the theory that neurotransmission drives this competition. Thus, the formation of the strongest connection in the brain is guided by competitive glutamatergic neurotransmission. The cerebellar connections most strongly reinforced in childhood learning will persist to form the lifelong circuitry supporting motor precision.

Mentor(s): Meike Van der Heijden (School of Neuroscience) Virginia Tech

Andrew Wang
University of Virginia/Biology

Spatial and Flight Dynamics of Systena frontalis On Hydrangea Blocks

Systena frontalis (Red-headed flea beetle), is known to result in significant damage in nursery plant leaves like hydrangeas and iteas. To understand their distribution and physiological flight in the landscape, an experiment was set up tracking the number of individuals caught in hydrangeas either along the edge or center of a block. Yellow sticky card traps were deployed 50 inches above the canopy to assess beetle dispersal vertically in both positions. A flight mill was used to track their flight distance based on their position. In this experiment, we observed that beetles gathered more in plants in the center while those on the edges have greater flight capability, which can explain potential density patterns. It is important to know where higher beetle densities are within nurseries to optimize insecticide application.

Being able to count live and dead spores can enhance the understanding of how treatments affect spore populations. This study compares the effectiveness for staining and counting oomycetes spores of three stains: Fluorescein Diacetate (FDA), Propidium Iodide (PI), and Trypan Blue (TB). Spores were stained and then observed under microscopes to assess dye efficacy. FDA is supposed to glow in live spores, while PI and Trypan Blue stain dead spores. The goal is to determine optimal spore viability test(s) can be determined with the most effective out of the three dyes. The results will help improve spore counting methods and guide how different treatments affect spore survival.

Mentor(s): David Haak, Virginia Tech
Alejandro (AREC Hamptom) Virginia Tech

Alex Ward
Virginia Tech/General Chemistry

Linear Free Energy Relationships in Ring Opening Metathesis Polymerization

This research project examines how different R groups on a norbornene based monomer can affect the kinetics of its ring-opening metathesis polymerization (ROMP) (Figure 1).

Figure 1. Studied Monomer Families

My first objective was to synthesize the monomers in the ar7 monomer family using the reaction in figure 2. After synthesizing the monomers, I continued to ROMP them and compare the rate constant of propagation to their sigma value (pka of R-substituted monomer vs pka-H) to construct a Hammett plot. At the time of this abstract all but the ar7-NO2 and ar7-CN have successfully polymerized, and we are looking into why these groups have not.

Figure 2. Synthesis of ar7-R (R= OCH3, CH3, H, Br, CN, NO2)

The rest of the semester has been dedicated to the reduction of ar8 into their ar11 counterparts using reaction conditions optimized from the spring semester. Using the reaction in figure 3 we were able to synthesize the ar11 family. Although we have not polymerized them at the time of this abstract, we hope to finish the Hammett plot by the poster presentation.

Figure 3. Synthesis of ar11-H

Once we have the full Hammett plots for ar7 and ar11 we will have a total of four completed monomer families. Since we have not finished the project, we are hesitant to draw any conclusions on the overall trends. However, we hope to use the information gained at the end of this project to optimize a ROMP for polymerising switch peptides, which could be used in drug delivery, tissue engineering, and bioprinting. In the following semesters we will continue this project looking at the monomers below.

Figure 4. Future Monomer Families

Mentor(s): John Matson (Department of Chemistry) Virginia Tech

Molly Westphal
Virginia Tech/Biological Science

Identifying preferred carbon sources used by Pantoea stewartii subsp. stewartii in the maize xylem environment

Pantoea stewartii subsp. stewartii (Pss) causes Stewart's wilt disease in maize. The corn flea beetle, Chaetocnema pulicaria, is the insect vector that introduces Pss into maize when fecal matter enters feeding wounds. The infection begins in the leaf apoplast where Pss initially causes leaf blight. Subsequently, the bacteria enter the xylem and generate a biofilm, preventing water transport. This results in wilting and leads to necrosis, affecting both crop yield and survival. Prior Tn-Seq experimentation identified genes essential for Pss survival in planta including lrp, which encodes the global transcription factor leucine-responsive regulatory protein (Lrp). In Pss, Lrp is known to positively control motility and biofilm production, which are important for the in planta lifestyle of Pss. Using RNA-Seq, Lrp was recently found to regulate processes relevant to metabolism. Current work is investigating the role of metabolites in Pss growth in the maize xylem environment. Targeted metabolomics analysis of extracted naïve and infected xylem fluid was performed to define the composition of maize xylem fluid. Synthetic xylem medium (SXM) was constructed using the top ~90% of sugars, organic acids, and amino acids that were identified. In vitro microplate growth assays using modified SXM with only one sole carbon source are being performed as a model system to determine the preferential nutrients utilized by Pss and to better understand its metabolic activity in planta.

Mentor(s): Ann Stevens (Biological Sciences) Virginia Tech

Nicholas Whitten
Morgan State University/Chemistry

Orthogonal Polymerization and Characterization of Nornbornene-2-methyllipoate

Traditional elastomers derived from fossil fuels have found applications in automotive, construction, medicine, 3D printing, etc, due to their elasticity, flexibility, durability, and resistance to wear and tear. However, their recycling and degradation processes are very energy-intensive and challenging, which has led to a growing need for sustainable elastomers from biogenic sources such as lipoic acid. Lipoic acid and its derivatives have been polymerized by either cationic, anionic, or radical ring-opening polymerization but not by orthogonal methods.1-3 Herein, we designed a lipoate monomer called Nornbornene-2-methylipoate that can be polymerized orthogonally by both Worch's Cationic ring-opening polymerization (CROP) and ring-opening metathesis polymerization (ROMP) using Grubb's second-generation catalyst.3 The thermomechanical properties of the resulting polymers were studied, and we discovered that the polymers exhibited tunable elastomeric behavior (soft to hard) by varying from CROP to ROMP.

Mentor(s): Josh Worch (Chemistry)

Gregory Wietrzykowski
Randolph College/Chemistry

Investigating Polymer Network Binding Site Hydrophobicity and Crosslink Density for Rare-Earth Elements Selectivity

Rare-earth elements (REEs: Y, Sc, La-Lu) are essential to modern technology and industry due to their unique properties. Current REE beneficiation and refinement methods are geographically limited, especially in the United States, and cannot respond quickly enough to meet REE demand; thereby, secondary sources of REEs are of interest. Solid-phase extraction polymer networks are a low-cost scalable solution for REE capture from unconventional sources like acid mine tailings and coal ash. However, polymer network properties influencing rare-earth element selectivity are underexplored. Ion selectivity in polymer membranes is known to be influenced by overall polymer network hydrophobicity by influencing the energy of hydration. To investigate how increasing hydrophobicity influences REE sequestration, we synthesized various crosslinked modular polymer networks (PFPA-PEGDA700), that prevent batch-to-batch variation while allowing for facile post-polymerization modification. The polymer networks were modified with increasingly hydrophobic amino acids and then evaluated using batch absorption for REE uptake. This work aims to improve engineering decisions for polymer networks used for REE capture.

Mentor(s): Chris Armstrong (Chemistry)
Tyler K. Bridges (Chemistry) Virginia Tech

Devonte Wiley
Virginia Western Community College/Microbiology

Host Range Expansion of Chi-Like Phages Against Salmonella Enterica using the Appelmans Protocol

Flagellotropic bacteriophages are viruses that specifically target bacterial flagella. Once attached, they utilize the counterclockwise movement of the flagella to reach the cell surface where they can eject their DNA into the bacterial cell to enable propagation. The bacteriophage Chi (χ) is the most extensively studied flagellotropic phage. It infects a range of Salmonella enterica serotypes, as well as some strains of Escherichia coli and Serratia marcescens. Flagellotropic phages could be an ideal candidate for treatment of bacterial infections because they present an exploitable evolutionary tradeoff, as motility is a major virulence factor for many pathogenic bacteria. As the rise in Salmonella breakouts has increased, clinical use of phage therapy could be necessary. A contributor to this problem has come from these pathogens acquiring mechanisms to colonize plants, leaving the use of external sanitizers ineffective in preventing foodborne illness. Before agricultural use of flagellotropic phages is possible, more must be understood about the most effective way to introduce phages therapeutically. Thus, we conducted the Appelmans Protocol (AP) using a phage cocktail including χ and other χlike phages. This protocol involved the coinfection 8 serotypes of S. enterica with the phage cocktail over 10 days to determine if the phages will exhibit host expansion. Through multiple trials of the AP, it was found that coinfection of multiple serotypes of S. enterica with a phage cocktail resulted in the exchange of genetic information between the phages, which resulted in an expansion of host range.

Mentor(s): Birgit Scharf (Department of Biological Sciences) Virginia Tech

Kayla Wilf
Virginia Tech/Chemistry

Enhancing solar cell efficiency through the alteration of mediator coordination geometry.

With energy concerns on the rise, research into efficient solar energy production has gained significant global attention. One facet of this research focuses on dye-sensitized solar cells, (DSSCs) which are less hazardous and more cost-effective than current solar panels. A DSSC functions as light photoexcites a chromophore adjacent to a metal oxide, subsequently forming a charge-separated state. The recombination of an excited electron to either the chromophore or oxidized mediator severely decreases the efficiency of the cell. One hypothesis suggests that severe structural reorganization of the redox mediator may reduce the recombination rate by increasing the rate of electron regeneration between the mediator and chromophore, thereby increasing the efficiency of the cell. In this project, two previously reported ligands (L1 = N,N′-dibenzyl-N,N′-bis (pyridin-2-ylmethyl)ethylenediamine; L2 = N,N′-dibenzyl-N,N′-bis(6-methyl pyridin-2-ylmethyl)ethylenediamine) were synthesized and coordinated with copper to form [CuL1] and [CuL2]. A third ligand (L3 = 3-methyl-7-tosyl-3,7-diaza-1,5(2,6)-dipyridinacyclooctaphane) is in the process of being synthesized and coordinated with palladium to form [PdL3]. Photoanodes and solar cells were fabricated using these mediators, ruthenium dye, titanium oxide and an FTO base. Severe structural reorganization was induced via incremental chlorination. The regeneration rate of the mediators was examined using transient absorption spectroscopy (TAS) and showed significant improvement with the addition of chloride. Open-circuit voltage decay (OCVD) displayed that the structural reorganization slowed the recombination rate of the DSSC. The TAS and OCVD data are consistent with the hypothesis and demonstrate the relationship between mediator coordination geometry transformation and recombination rate.

Mentor(s): Amanda Morris (Chemistry) Virginia Tech

Yavette Wilson
Virginia State University /Computer Engineering

Initializing Qubits using Rabi Oscillation

As quantum computing becomes more relevant to real-world applications, such as secure communication and drug development, the ability to accurately control and initialize qubits is essential. This research focuses on Rabi oscillations as a method for manipulating qubit states in solid-state systems, specifically nitrogen-vacancy (NV) centers in diamond. Although similar in structure to gemstone diamonds, these are specially engineered for use in quantum technologies.

Microwave pulses of varying durations were used to drive transitions between the |0⟩ and |1⟩ quantum states. These transitions were detected through changes in fluorescence using optically detected magnetic resonance (ODMR). Shorter pulses at higher power levels resulted in faster and more frequent oscillations. At 60 percent power, for example, a full Rabi cycle took about 1240 nanoseconds, while at 90 percent power, the cycle shortened to approximately 480 nanoseconds. These results show how precise control over pulse duration and power can lead to more accurate qubit initialization.

The data highlights ODMR as an effective technique for quantum state control in solid-state systems. Continued development of methods like this supports the advancement of quantum computing toward practical use in fields where classical computers fall short, including large-scale simulations, optimization problems, and real-time data analysis.

Mentor(s): Wayne Scales (Engineering) Virginia Tech

Tim Wilson
Virginia Tech/Computer Science

Benchmarking Supervised Learning Algorithms for Inferring Gene Regulatory Networks

Gene regulatory networks (GRN) are networks that connect transcription factors to genes whose expression they inhibit or promote. These networks can be reconstructed, or inferred, from single-cell RNA (scRNA-seq) expression data. However, the process of reconstructing such networks from only expression data is very difficult - many machine learning algorithms have been made for inferring GRNs over the past decade.

This proliferation of methods leads to the inevitable need to determine how successful the algorithms are at their inference task, which led to the creation of BEELINE, a comprehensive GRN inference algorithm benchmarking pipeline.

However, BEELINE only supports the benchmarking of unsupervised algorithms in its current state. We extend BEELINE to support supervised learning algorithms by enforcing data splitting paradigms to be contained within the BEELINE framework solely so that compared algorithms receive the same data splits for training and evaluation. These additions also allow for different data splits to be quickly tested between algorithms and test the extent of data leakage inflating performance.

We also add new supervised learning algorithms, namely CNNC and GENELINK, to BEELINE to provide a larger benchmark base and to test the addition of supervised support. We present results of such algorithms with respect to established higher-performance unsupervised algorithms.

Expansions to BEELINE allow researchers who approach GRN inference with a supervised model to use BEELINE. Adding new algorithms to BEELINE's pipeline also permits benchmarking against a wider selection of algorithms.

Mentor(s): T. M Murali (Computer Science) Virginia Tech

Tyler Witt
Longwood University/Chemistry

Designing Renewable Adhesive Tapes from Biodegradable Materials

The durability and strength of tapes vary depending on their functionality as they are designed based on their application or purpose. There are currently no renewable tapes on the market as most commercial tapes have a backbone made from polyethylene terephthalate (PET) and an unrenewable adhesive layer, primarily because it is very difficult to match the adhesive strength of commercial tapes using a sustainable alternative. The purpose of the study is to develop renewable tapes from cheap, biodegradable materials, lipoic acid, that have much greater adhesive strength than commercial tapes. The adhesive strength of commercial tapes have been analyzed using a peel test on both aluminum and glass surfaces with a direct comparison to synthetic biodegradable tapes. Characterization techniques such as DSC and TGA were used to analyze the thermal properties of the adhesives to understand their potential for real-world applications. The study found that a statistical copolymerization of both lipoic acid and ethyl lipoate has a much stronger adhesive strength than the commercial tapes on both surfaces whereas polyethyl lipoate demonstrated to be much stronger on glass while being slightly stronger than masking tape on the aluminum surface. PET was used as the backbone in our analysis for an accurate comparison to literature, but sodium lipoate could be analyzed as the backbone in future studies to evaluate the potential for a fully sustainable tape. The sodium lipoate backbone has the capacity to be recycled simultaneously with the adhesive, making it the ideal tape for commercial use.

Mentor(s): Josh Worch (Department of Chemistry)

Emanuel Wright-Anthony
Virginia State University/Computer Engineering

Laser-Induced Rabi Oscillations for Single-Qubit Gate Implementation in Nitrogen Vacancy Diamond Systems

As quantum technologies continue to advance, the ability to precisely control individual qubits becomes increasingly important. This study investigates how Rabi oscillations can be used to implement fundamental quantum gate operations on single qubits. The research focuses on a Nitrogen-Vacancy (NV) center in diamond, a solid-state platform known for its stability and accessibility at room temperature. Using the QuNV quantum sensing system, a laser is directed at the NV center to induce Rabi oscillations, allowing for observation and control of the qubit's state. The primary objective is to demonstrate two essential quantum gates: the X gate, which inverts the qubit state using a π-pulse, and the Hadamard gate, which uses a π2-pulse to place the qubit in a superposition state. These gates represent foundational operations for both quantum computing and quantum sensing applications. The experimental methodology involves tuning the laser parameters to achieve precise pulse durations and amplitudes. Observations of the resulting Rabi oscillations help confirm whether the target gate operations have been successfully implemented, based on the expected quantum state transitions of the qubit. Initial results show clear periodic oscillations in qubit energy levels corresponding to the applied pulse sequences. These oscillations align with theoretical expectations for both the π and π⁄2 pulse durations, suggesting accurate state control. This research contributes to a deeper understanding of single-qubit manipulation and demonstrates the potential of laser-induced Rabi oscillations as a method for executing high-fidelity gate operations in solid-state systems. The ability to reliably control quantum states at this level is a critical step toward building scalable quantum computing platforms and improving the precision of quantum sensing technologies.

Mentor(s): Wayne Scales (Computer & Electrical Engineering) Virginia Tech

Christina Yang
Blacksburg High School

Public Perceptions of the Efficiency of the Healthcare System in the United States

The United States spends18% of its gross domestic product (GDP) on healthcare, which is the highest percentage among developed countries. Despite this substantial spending, life expectancy at birth in the U.S. is lower than that of many other developed countries. This raises questions about public perceptions of the efficiency of the healthcare system. To what extent do Americans believe that the system is efficient? What factors influence their perceptions? Using recent data from the General Social Survey, this study aims to answer these questions. The results show that most Americans view the healthcare system as inefficient. Furthermore, ordinal logistic regression analyses show that factors such as socioeconomic status, health status, political ideology, and personal experiences with healthcare significantly influence perceptions of efficiency. This study improves our understanding of how Americans view the healthcare system and the reasons behind those perceptions.

Mentor(s): Haiyan Zhu (Sociology)

Nicholas Yeboah
University of North Carolina at Greensboro/Biology

Modulation of PDH phosphorylation levels by MCU Overexpression in Hippocampal Neurons

Neurons require substantial energy to maintain neurotransmission; however, it is unclear how their energy demands are regulated. Failure to meet neuronal energy demands are linked to diseases like epilepsy and Alzheimer's. Previous studies have identified regional enrichment of mitochondrial proteins in the hippocampus, the brain's memory center, that likely correlates to enhanced energy consumption. In particular, the mitochondrial calcium uniporter (MCU) is enriched in specific regions of the hippocampus and functions to bring calcium into the mitochondrial matrix that activates enzymes essential for ATP production. Thus, MCU may couple neuronal activity-driven changes in cytosolic calcium to mitochondrial ATP output through regulation of calcium-dependent energy producing enzymes.

We overexpressed MCU in the mouse hippocampus and measured the phosphorylation levels of PDH, which is negatively regulated by calcium-sensitive pyruvate dehydrogenase phosphatase. I hypothesize that MCU overexpression in the mouse hippocampus will lead to a decrease in phospho-PDH levels consistent with its negative regulation by MCU-dependent calcium uptake. Intracranial infusions were performed on mice to transduce hippocampal neurons with viral vectors encoding MCU or GFP. Brains were perfused, sectioned, immunostained, and imaged using a fluorescence microscope. Phospho-PDH intensity was quantified in multiple hippocampal subregions per condition using Fiji. While blinded analyses are ongoing, I expect significant decreases in phospho-PDH in hippocampal neurons overexpressing MCU compared to GFP controls, regardless of subregion.

Understanding how MCU mediated calcium uptake influences mitochondrial energy production in neurons provides valuable insight into how region-specific energy demands are regulated, which may be relevant for understanding neuropathologies impacting hippocampal bioenergetics.

Mentor(s): Shannon Farris (Department of Biomedical Sciences and Pathobiology)

Ian Yu
Blacksburg Virginia /General Research

A Novel Approach to Martian Obstacle Detection through Ultrasonic Transducers

Obstacle detection in a Martian environment is currently approached using cameras. Regional and global-scale dust storms occur every year on Mars, that greatly impact the rovers on the surface. The dust from these storms reduces the visibility making cameras difficult to use. This study aims to propose a novel solution through the use of ultrasonic transducers for a sonar-based approach. A key focus was to examine the performance of such systems under atmospheric conditions similar to those on the surface of Mars. Six commercially available piezoelectric ultrasonic transducers with a peak voltage between 3.3 and 5V and a frequency of 40khz were tested in a simulated Martian environment with temperatures between 296.15K to 253.15K and pressures from 5,000 to 9,000 mTorr. The transducers included three bimorphs, one monostatic, 1 one bimorph hydrophone, and 1 monostatic hydrophone. A microprocessor controlled communication and displayed the results which were complied and filtered using a Kalman algorithm to reduce noise and outliers. Results compiled from the transducers suggest under Martian atmospheric conditions, an error of 2.5% at worst and 7.6% at best can be observed. This indicates that with the usage of piezoelectric transducers, it is possible to detect obstacles in a Martian environment and judge their distance. While this research has the potential to be expanded under more accurate conditions by including variables such as dust or using more specialized transducers, the applicability of ultrasonic transducers in the Martian environment remains positive.

Mentor(s): Scott England (Aerospace and Ocean Engineering)

Hannah Ziehl
Virginia Tech/Microbiology

Training of Flagellotropic Agrobacterium Phages

Flagellotropic phages are a specialized class of bacteriophages that infect a host bacterium possessing a rotational flagellar system. Host flagella and lipopolysaccharides are primary and secondary receptors for phage infection. The high specificity of these interactions results in phages exhibiting a narrow host range. Host-range expansion is crucial to increase phage infectivity, sensitivity, and potency. Therefore, the liquid infectivity of three phages, Milano, 7-7-1, and OLIVR4, against their host Agrobacterium strains (C58, H13-3, and ST15) was tested in test tubes, flasks, and 48-well plates. Phage training was performed in 48-well plates based on successful lysis and ease of handling, following the Appelmans protocol with modifications. Phages were mixed at equal titers, serially diluted, and applied to three hosts and two non-hosts, namely A. tumefaciens 5A and A. rhizogenes, starting with a phage-to-bacteria ratio of 1:10, and then decreasing further. After 20 hours of incubation, the fully lysed and the following non-lysed samples were pooled. The highest phage concentration samples of the resistant strains were also pooled. The pooled sample was chloroform-treated, centrifuged, and the resulting phage suspension was used in successive rounds until round 10. Complete lysis was observed for C58, H13-3, and ST15 from round 1, and 5A by round 5, yet A. rhizogenes remained resistant throughout. Phages from randomly selected plaques are being screened for their host range, and the genome sequences are being compared with parent phages. Expanding a single phage's host range to target multiple bacteria species is a promising approach for plant disease control.

Mentor(s): Birgit Scharf (Biological Sciences) Virginia Tech
Dr. Nisha Dhiman (Biological Sciences) Virginia Tech