NJIT
New Jersey Institute of Technology

Summer Research Program

URI Summer Research & Innovation Symposium

Ronald E. McNair Postbaccalaureate Achievement Program

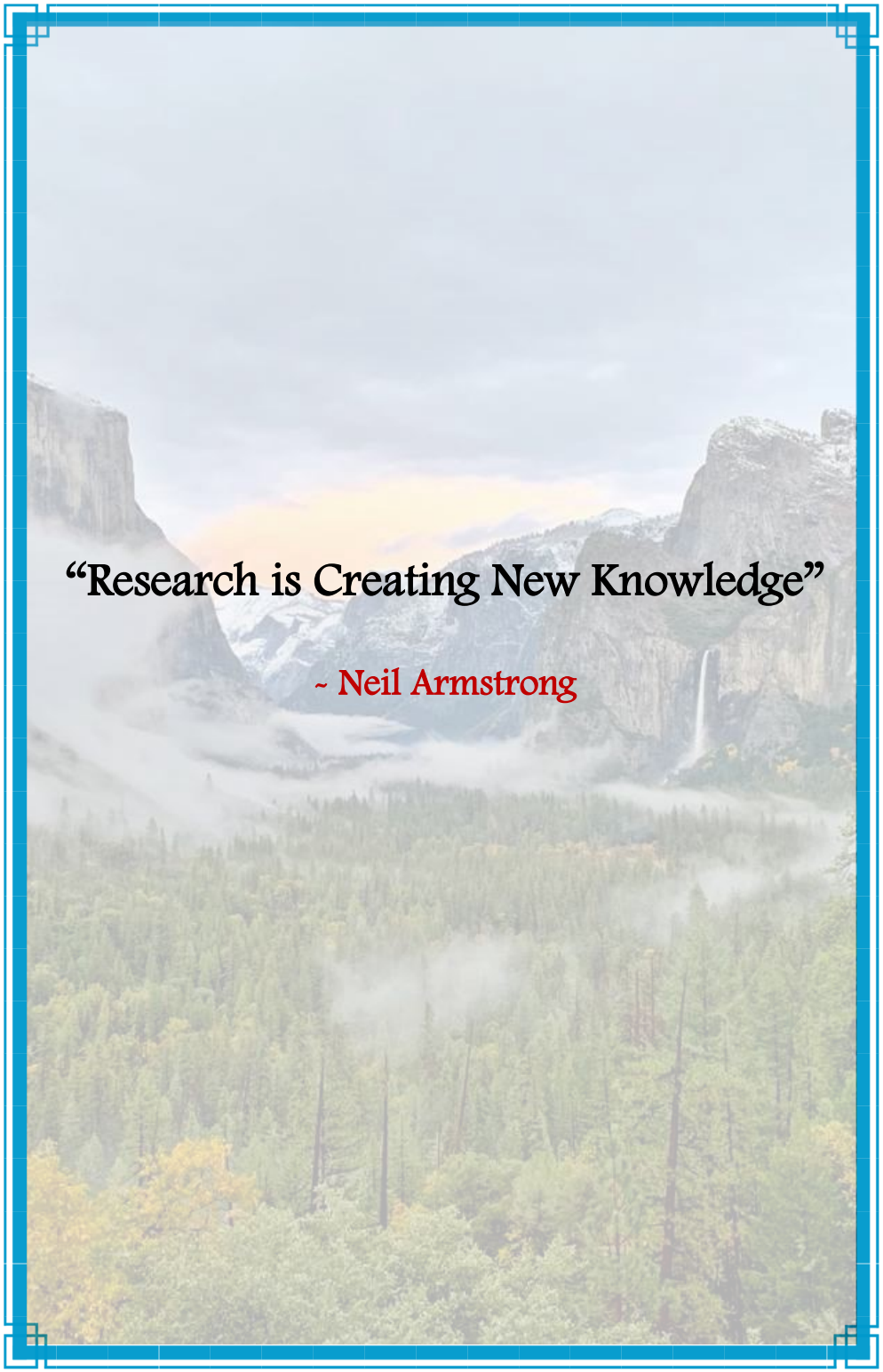
Heritage Institute of Technology

SUMMER 2024

July 24 — 25, 2024

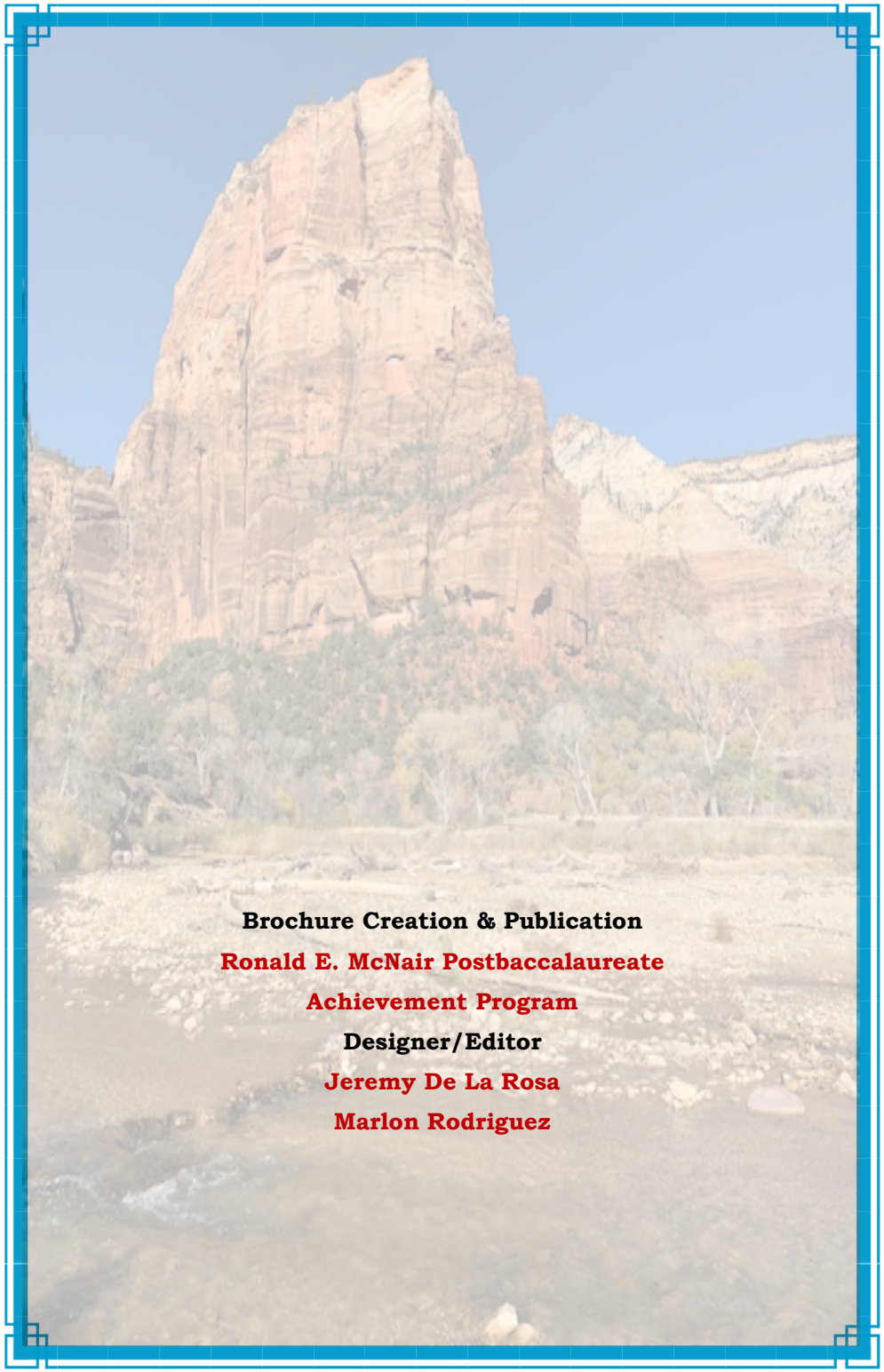
8:30 A.M. to 4:00 P.M.

Campus Center · Ballroom A & Atrium



"Research is Creating New Knowledge"

~ Neil Armstrong



Brochure Creation & Publication

Ronald E. McNair Postbaccalaureate

Achievement Program

Designer/Editor

Jeremy De La Rosa

Marlon Rodriguez

Acknowledgements

On behalf of all the participating Summer Research Programs, McNair, and Heritage Institute of Technology Research Programs we are extremely appreciative of your support and efforts in making this summer program successful. We would like to give special thanks to the following individuals: Marieta Chemishanova, Luis A. Guillen, Mike Dabrowski, Sanjeannetta Worley, Archana Srivastava, Lisa Easton, John Gruppo, Sandra Masibayi, Monica O'donnell, Lea Ronchi, Nikki Bosca, Eugene Snyder, Djadji Sylla-Samassa, Tulika Das, Deepak Vungarala, Dimana Kornegay, Stephen Eck, Nellone Reid, Grisele Gonzalez-Ledezma, Shivon Boodhoo, Darnell Simon, Brenda Gracia, Brain Hart, Zoe Mooneyhan and Jill Lagerstrom. In addition, we are deeply indebted to the faculty mentors, who have such an important role in our students 'academic, research and social development. Lastly, we must acknowledge our gratitude to the students for their hard work and perseverance. We encourage you to continue on your path of scholarly inquiry. As you have accomplished a great deal in such a short time with us, we know that you will be successful in your future academic and research endeavors.

NJIT New Jersey's Science & Technology University

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Ronald E. McNair
Postbaccalaureate Achievement Program

July 25, 2024

Welcome to New Jersey Institute of Technology's 2024 International URI Undergraduate Summer Research and Innovation Symposium. It is an honor and privilege to be part of this year's Symposium. Ten participants of Ronald E. McNair Postbaccalaureate Achievement Program started their summer research program from May 20, 2024. Seven students from Heritage Institute of Technology (HIT), India started their research from June 17, 2024. The students worked very hard to carry out their research projects with literature review, data analysis and simulation in addition to lab experiments.

The successful student exchange program during summer for research between NJIT and HIT has entered the 17th year this year. The purpose of this exchange is to promote international understanding, scholarly collaboration, cultural interaction, and friendship by supporting educational professional and cultural activities among faculty and students of the two institutions.

This year's success comes because of Ms. Zara Williams, Assistant Director, Prof. Ashish Borgaonkar, the Faculty Coordinator of the Ronald E. McNair Program for their efforts in coordinating the overall program. Staff members of Research Office, Admissions, Office of Global Initiative, Budget Office, Housing, Facility Systems, Photo ID & Parking Services, and ECE Department contributed significantly to the success of the Symposium. Efforts of Mr. Marlon Rodriguez and Jeremy De La Rosa of the Ronald E. McNair Program is recognized for the valuable input in producing this program's brochure.

The students in the Ronald E. McNair Program and HIT Program have the opportunity for presentation of their research accomplishments that was completed under the supervision of dedicated NJIT faculty. Without the time and effort of NJIT faculty and graduate student mentors the outstanding achievement of the students would not have been possible.

We are extremely proud of the research efforts of all the students, the quality of the research presentations and grateful for the support of the NJIT administration, faculty, and staff in contributing to the success of the symposium.

Sincerely,

Durgamahab Misra, PhD
Symposium Co-Chair, McNair Program Director, HIT Program Coordinator
Professor and Chair, Department of Electrical and Computer Engineering

Ronald E McNair Postbaccalaureate Achievement Program

Making Engaging and Effective Presentations Seminar

Introduction Statistics for STEM Research Seminar

Electromagnetic Field Effects on T47D (Breast Cancer) and MCF-10A(Healthy) Cells

Mina Abdelmalak, Advisor: Dr. Nellone Reid

Breast cancer is the second leading cause of death for women in the U.S., with 43,250 reported fatalities in 2022. Conventional treatments, such as chemotherapy, radiotherapy, and surgery, have severe side effects impacting both the physical and emotional well-being of patients. Electromagnetic fields (EMFs) offer a potential non-invasive treatment option that could effectively treat breast cancer while reducing the negative impact on patients. However, it is crucial to ensure minimal to no harm to healthy cells to avoid severe long-term side effects. This research project aims to design an EMF device that negatively affects breast cancer cells while keeping healthy cells safe. Therefore, a Helmholtz coil (as illustrated in Figure 1) was designed with air cooling running through the coils to prevent temperature rise and ensure stable current flow, mitigating heat-induced effects. Air cooling also allows precise temperature control, maintaining conditions at, below and above body temperature. Past experiments show a noticeable decline in cell life for T47D cells. However, following experimentation at body temperature (37˚C) using three distinct intensities (0.14A, 0.7A, and 1.45A), no decline in T47D cell viability was observed through imaging and cell count analysis. This shows that past experiments were conducted at temperatures different from body temperature, which can be a potential reason for T47D cell deaths. Nevertheless, this does not eliminate the fact that a stable temperature can be achieved that can eliminate T47D cells while still keeping healthy cells safe. Future experiments will be conducted in a microfluidic setup to provide cells with a more controlled thermal environment, aiming to eliminate T47D cells while preserving healthy ones. Furthermore, anticipated outcomes include measuring the metabolic rate of the cells while in the field to better understand the mechanisms at play.

Computer-Aided Ligand Design for the Sigma-2 Receptor to Increase Anti-Neuropathic Pain Activity

Hatice Aygun, Advisor: Dr. Nellone Reid, Dr. Vivek Kumar,
Mentor: Joseph Dodd-o, PhD Student

Neuropathic pain has a massive impact on a patient's quality of life, typically occurring in the aftermath of diabetes, chemotherapy, aging, or obesity. Despite currently affecting between 7-10% of the U.S. population, established treatments directed towards neuropathic pain are limited. The treatments currently in use for neuropathic pain are tricyclic antidepressants or non-steroidal anti-inflammatory drugs (NSAIDs). These medications are not made to address the biological mechanisms of neuropathic pain, instead focusing on mitigating its symptoms. Therefore, it is crucial that a safe and effective therapy to address neuropathic chronic pain is developed. The sigma-2 receptor (S2R) is abundant among the peripheral nervous system (PNS) and has a proven capacity to produce anti-allodynic effects. This study will utilize computational methods to treat S2R as a target for peptide-based therapies with the intention of alleviating neuropathic pain. Using the Rosetta suite of macromolecular modeling functions parsed with RosettaScripts, five thousand randomized amino acid sequences were generated alongside their binding energy scores. The top ten sequences with the lowest binding energies were tested further using conformer RMSD analysis. The ligands will be then synthesized via solid-phase peptide synthesis and tested to verify that their identity, characterization, and binding matches the computational models. Subsequent in vivo studies will assess the anti-neuropathic pain effects of the ligands generated.

Nanoplastic Exposure May Contribute to Abnormal Placenta Development in Mice

Christopher De Oliveira-Cordova , Advisor: Genoa Warner

The amount of plastic waste has dramatically increased in the past hundred years and is now present in every area of the planet. Microplastics (MP) and nanoplastics (NP) derived from plastic waste degradation are capable of entering the human body, potentially leading to significant negative health effects. MPs have been detected in the human placenta, but their effects are not fully understood. Placenta Accreta Spectrum (PAS) disorder is characterized by abnormal placen-tal growth into surrounding tissue, which can lead to life-threatening blood loss during childbirth. Several biological processes are implicated in PAS disorder, including abnormal cell growth, adhesion, and migration. The effects of MP and NP exposure on the developing placenta are unknown. We hypothesize NP expo-sure during pregnancy will affect biological processes in the placenta which may contribute to PAS disorder. To test this, pregnant adult CD-1 mice were exposed to either water, 5 mg/kg of 50 nm polystyrene NP, or 5 mg/kg of 200 nm polysty-rene NP beginning on the 8th day of pregnancy for one week. Afterwards, the mice were euthanized, and placenta samples collected for gene expression anal-ysis using real time quantitative reverse transcription polymerase chain reaction (qRT-PCR). We found that expression of genes relevant to cell growth, adhesion and migration processes were considerably altered after exposure to polystyrene NP, suggesting that exposure to NPs may lead to abnormal placental implantation and growth. In addition, the sex of the fetus may mediate the extent of changes in gene expression in the placenta after NP exposure. Our results indicate that plastic exposure may affect crucial processes for the development of PAS disorder.

Optimizing Hydrogen Transportation

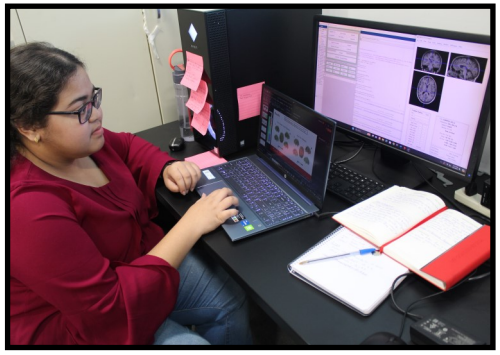
Adrien Durasno, Advisor: Dr. Philip Pong

Hydrogen production is becoming increasingly vital in the search for sustainable energy sources. Utilizing hydrogen instead of gasoline benefits the environment, especially as climate change remains a growing concern. One key method of producing hydrogen is through the electrolysis of water, which splits water into hydrogen and oxygen. Once produced, the next challenge is determining the optimal method for transporting hydrogen. Our research evaluates various transportation methods, including trucks, pipelines, and ships, to identify the most efficient and cost-effective option. The findings suggest assessing the efficiency of each transportation method by considering the distance covered and the volume of hydrogen transported. The study indicates that shipping is the most advanta-geous method for hydrogen transportation, particularly because offshore power stations can more efficiently transfer hydrogen onshore. The costs of transporting hydrogen are influenced by safety procedures to prevent explosions of hydrogen liquid or gas, as well as factors such as the ship's distance, capacity, and contain-er. The energy contained in the hydrogen also affects the price of containment due to its volume. Our research concludes that shipping hydrogen in large con-tainers is the most cost-efficient method due to the significant amount of energy it can transport daily. Consequently, we recommend using ships to transport hydro-gen energy over long distances to maximize efficiency and minimize costs. To explore this further, we are conceptualizing an imaginary ship designed specifical-ly for hydrogen transport. Our main focus is to determine the cost of this ship along with the amount of energy it can transport, providing a better alternative for the transportation of liquid hydrogen.

Funding Graduate School Seminar

How to Make Effective Poster and Oral Presentations Seminar

Akash Raj
Computer Science and Engineering



Dipanjali Ray
Biotechnology

Riddhiman Santra
Civil Engineering

Viajinee
Electrical Engineering

How does extinction affect and shape lineages in ant species over time?

Andrea Gomez, Mentor: Geanpero Fiorentino, Advisor: Phillip Barden

Extinction has shaped ecosystems throughout Earth's history, influencing species' evolution and distribution. The extinction of species through dispersion events creates vacuums in ecosystems, which can lead to significant changes in composition, food webs, and ecological functions. Removing a species can alter the dynamics of predation, competition, and nutrient availability, leading to surviving species adapting to altered environments. Integrating fossil records with observations of contemporary ecosystems provides valuable insights into the patterns and processes of extinction. The Dominican Republic, home to ancient amber deposits and diverse living ant species, offers a unique opportunity to study these dynamics. The genus Pseudomyrmex, currently present on the island, is also well represented in the amber fossil record with four species existing today and ten identified from fossils. By comparing the morphology of living and fossil species of Pseudomyrmex with data collecting methods and data analysis using programming tools such as R and Rstudio, this study aims to identify evolutionary change and the impacts of extinction on ant morphology and diversity. Namely, I will assess whether there was greater morphological diversity in the past than in the present. The results will explain how past extinction events have influenced current ant species' morphology and inform our understanding of biodiversity and extinction resilience.

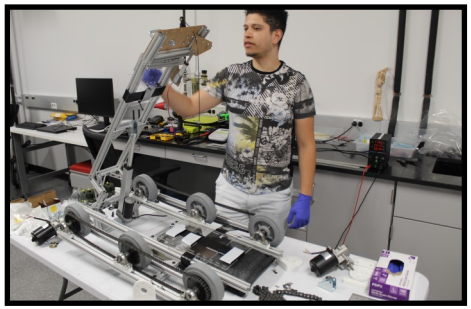
McNair Orientation

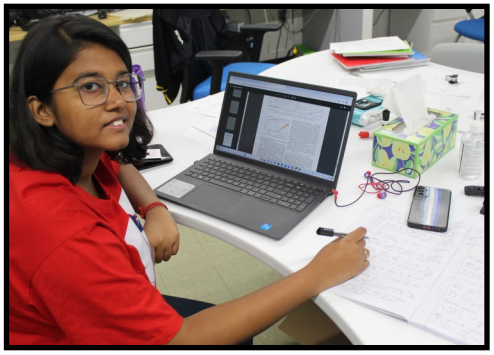
All That Remains. Assessment of Human Identification in Forensic Scenarios

Maya Hassan, Advisor: Dr. Sara Casado Zapico,
Mentor: Maria Castagnola, PhD Student

The identification of human remains is critical in criminal investigations, mass disasters, and humanitarian settings. However, obtaining DNA for identification from these remains is challenging due to exposure to different insults: fire, chemicals, and environmental factors. Additionally, estimating the postmortem interval (PMI) – the time since an individual's death – could also be important to pursue the investigation. New approaches in forensic biology and anthropology introduce next-generation sequencing technologies, transcriptomics, and proteomics as more accurate methods for determining PMI, particularly in human remains. The goal of this study is to assess the feasibility of extracting DNA, RNA, and protein from human remains exposed to fire and chemical treatments, aiming to facilitate identification and PMI estimation. To do so, sample extraction was performed using Quick-DNA/RNA Microprep Plus Kit (Zymo) on samples from 18 whole human teeth (18 dentin and 12 pulp) subjected to hydrochloric acid (HCl) and sodium hydroxide (NaOH) treatments, alongside respective controls. Additionally, 24 samples of powdered human bones underwent treatments including exposure to fire, HCl, and NaOH, compared to control powdered bones. Quantification of DNA/RNA/proteins was performed using spectrophotometric and fluorescence methods. Human DNA profiles were generated using the Promega® Fusion 6C System. In both whole teeth and bone powder samples, DNA, RNA, and proteins were successfully extracted in the majority of cases. In whole teeth, higher yields of DNA, RNA, and proteins were found in control samples compared to chemically treated ones. Specifically, DNA concentration was consistently higher in pulp than in dentin across all groups. Significant yields were also obtained for RNA and proteins, with variability depending on the treatments. Particularly, the HCl treatment yielded the highest levels of DNA, RNA, and proteins for teeth. Conversely, in bone powder samples, NaOH treatment yielded higher amounts of DNA and RNA than the HCl treatment, contrasting with teeth samples. Successful extraction of DNA, RNA, and proteins was achieved from burned bone powder, with DNA showing the highest yield. The successful extraction of DNA from human bone remains exposed to fire aligns with findings from a previous study conducted by Zapico et al. 2016. The extraction of DNA is fundamental for generating profiles for individual identification. Additionally, RNA and protein yields obtained from this work hold promise for estimating the postmortem interval (PMI). To the best of our knowledge, this is the first extensive study assessing the simultaneous extraction of DNA/RNA/proteins from human remains exposed to different insults. In most cases, DNA/RNA/protein material from fully fleshed corpses could be better preserved within the human body than in the analyzed bone remains that were completely exposed. The findings of this research studying the worst-case scenario could significantly aid in identifying human remains in challenging cases like mass disasters.

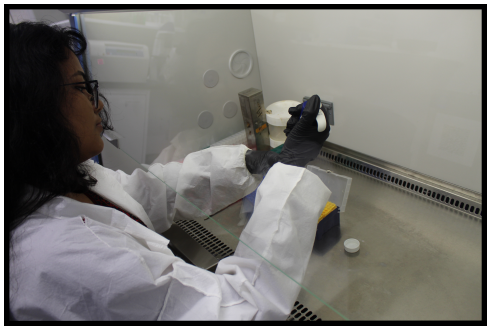
Oscar Zamora
Mechanical Engineering





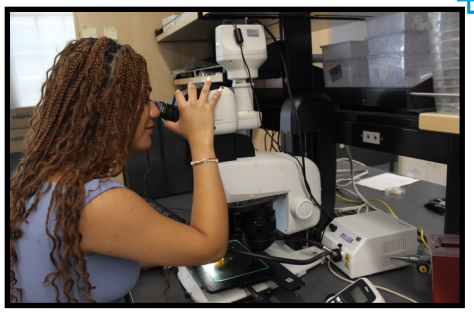
Koushiki Das
Computer Science and Engineering

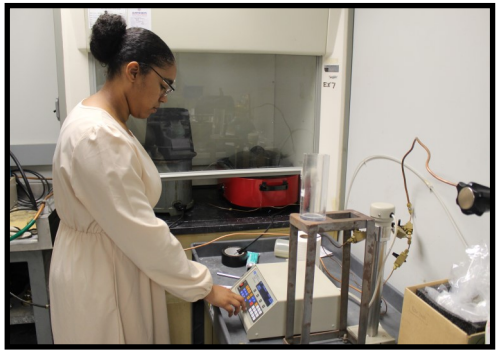
Kaivya Dey
Biotechnology



Kankana Karmakar
Biotechnology

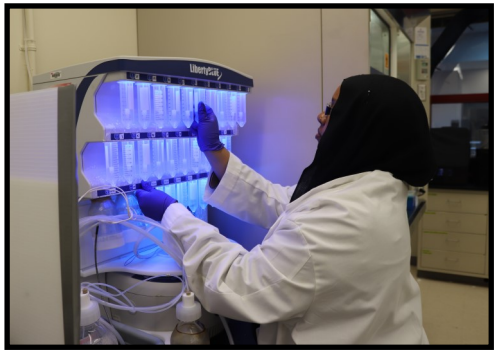
Andrea Gomez
Biology





Yorquiria Maldonado
Chemical Engineering

Nada Mohamed
Chemical Engineering



Shyamkumar Rana
Electrical and
Computer Engineering
Technology

Characterization of Softening of Shale due to Storage of Green Hydrogen

Yorquiria Maldonado Mejia, Advisors: Dr. Jay Meegoda & David Washington

Fossil fuels are the primary contributors to climate change, prompting countries to shift towards renewable energy sources. Hydrogen produced from renewable sources presents an efficient solution. However, hydrogen generated in remote locations requires storage for subsequent transport to urban areas. Underground Hydrogen Storage (UHS) is emerging as a technique for storing and utilizing hydrogen, offering stored renewable energy and reducing carbon footprint by preventing additional greenhouse gas emissions. Nevertheless, further research is essential to understand the interaction between hydrogen and rock formations. In this project, shale samples were exposed to simulated underground conditions of 2000 PSI and 170°C for 3 days. It is hypothesized that under these simulated conditions, hydrogen interaction with rock formations causes softening of the rock. Therefore, comprehensive analyses including X-ray diffraction (XRD) and Brunauer-Emmett-Teller (BET) pore size distribution will be performed to assess the characteristics of hydrogen exposure to rock formations. These analyses provided insights into micro/nano structural changes in shale before and after hydrogen treatment, focusing specifically on potential softening effects. This study can be used to determine if hydrogen can be safely stored in the depleted reservoirs.

Designing a Peptide Ligand for a Novel Cancer Therapeutic

Nada Mohamed, Advisors: Dr. Nellone Reid, Dr. Vivek Kumar, Mentor: Joseph Dodd-o, PhD Student

Globally, 500,000 women die annually from breast cancer, of which 150,000 cases are estimated to be of the Triple Negative Breast Cancer (TNBC) staging subtype. TNBC is an aggressive type of breast cancer that lacks the Estrogen (ER), Progesterone (PR), and Human Epidermal Growth Factor (HER2) receptors. There is a lack of targeted therapies available for TNBC, as current endocrine and drug therapies that target ER, PR, or HER2 are ineffective. Sigma 2 receptors are overexpressed in proliferative cells and tumors, especially breast cancer cells. The aim of this study is to computationally randomize amino acid sequences that bind to the sigma 2 receptor to make a cytotoxic drug. By utilizing the Rosetta Scripts software, an XML-like language used for parsing functions within the Rosetta suite, 4,000 different amino acid sequences that bind to this receptor were generated. The top ten unique sequences with the lowest binding energy were then used for further analysis. Using the FlexPepDock docking protocol, PackRotamersMover, and relaxation algorithms, one thousand different amino acid sequences were generated. The top 10 most energetically favorable structures were further analyzed by their Root Mean Square Deviation (RMSD) relative to the top-scoring pose to evaluate the potential entropic penalty of adopting the energetically favorable pose. By analyzing the RMSD values and corresponding energy scores, the top three peptides were then chosen to synthesize and characterize to further test for cytotoxicity and affinity.

Fate and Transport: Microplastics in Stormwater

Shyamkumar Rana, Advisors: Dr. Michel Boufadel & Dr. Ashish Borgaonkar, Mentor: Dr. Viravid Na Nagra

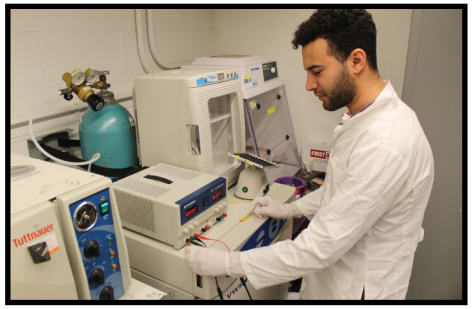
Microplastics (MPs), are tiny plastic particles, found pervasively in the environment, causing various adverse effects on the environment and human health. Stormwater runoff is one of the major sources of MP contamination in the environment. Green infrastructures, nature-based stormwater control measures, are increasingly implemented in urban areas to address flooding and stormwater pollutants, including MPs. Therefore, understanding the fate and transport of MPs in green infrastructures is crucial. The overarching objective is to optimize the design of green infrastructure and to devise appropriate maintenance approaches to prevent MPs from accumulating in the subsurface and contaminating groundwater. In this study, column experiments were conducted to mimic soil behavior, employing wet-packed quartz sand as the porous medium. Polyethylene (PE) with varying particle sizes were employed to serve as microplastic (MP) representatives. MP concentrations in the effluent and porous media samples were measured using the Aqualog Horiba. The findings from this study will inform porous media effectiveness based on particle sizes and replacement intervals which will help improve green infrastructure.

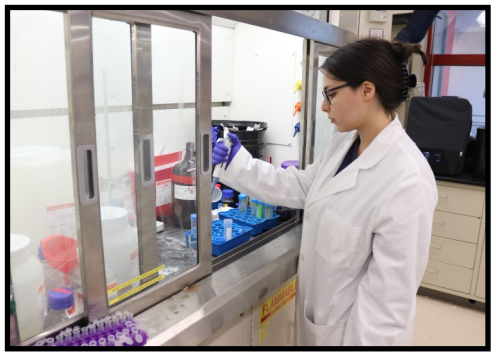
Self-Assembly of Transport Tile Robotic System for Flood Response

Oscar Zamora, Advisor: Dr. Petras Swissler, Mentor: Roberto Torres

Self-assembling swarm robotics allow a network of robots to tackle environmental challenges such as transportation in rough terrain or going through obstacles. However, most successful systems are done at a much smaller scale. Transport Tiles are built for jobs that require carrying large and heavy objects.The tiles are meant to work in unison in order to carry palettes loaded with heavy objects such as bricks. This type of system provides a safer alternative for transporting building materials and equipment through terrain that would be otherwise dangerous for humans to go through. These Transport Tiles must be able to hold their own weight so that they can assemble themselves. The linear actuator powering the rotating arm must be able to lift the robot's weight. A conveyor belt is made up of six wheels powered by a motor whose motion is transmitted through a roller chain. These wheels have to move other robots, heavy materials, and other equipment without any strain on the wheels, chain, or motor. The whole top frame of the robot must be able to rotate a full 360 degrees. The six faces of the robot must be able to dock onto another face, to establish a secure connection within the system. From experiments conducted in the lab, we found that the robot succeeds in all its functions. The linear actuator that powers the arm does not struggle supporting the weight of another robot. The conveyor belt handles the weight of the palette and moves it as it is meant to. The docking mechanism on each face of the robot works properly with other robots. The robots are able to lift their own weight and assemble themselves. All the physical mechanisms work as intended, with little to no stress on any moving component. We conclude that self-assembly is possible with this robot system and we can move forward with the programming to make these robots autonomous. That way the swarm of robots can assemble themselves without any human help.

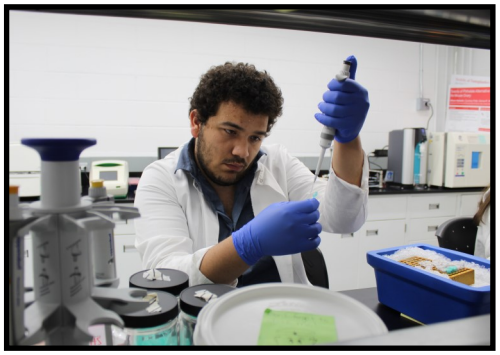
Mina Abdelmalak
Chemical Engineering





Hatice Aygun
Chemical Engineering

Christopher De Oliveira-Cordova
Biology



Adrien Durasno
Electrical Engineering

"Research is formalized curiosity. It is poking and prying with a purpose. It is a seeking that he who wishes may know the cosmic secrets of the world and they that dwell therein."

~Zora Neale Hurston

Heritage Institute of Technology

Solving Fast Fair Bandit with Switching Cost Using Reinforcement Learning

Koushiki Das, Advisors: Dr. Arnob Ghosh, Dr. Shuai Zhang

The multi-armed bandit (MAB) problem where different arms correspond to different rewards (unknown) is becoming widely popular. In many applications, ranging from wireless to recommendation systems, MAB is used. In this project, we consider the traditional MAB problem with two additional challenges– i) satisfying constraints, and ii) incurring costs for switching arms. In particular, in addition to getting a reward for drawing an arm, there is a switching cost in switching arms between two-time slots; further, one needs to ensure that the fairness constraint is maintained at each time slot. Such constraints are prevalent in practice. Considering the example of a recommendation system, to maintain fairness one needs to ensure that the contents from diverse groups should appear with non-zero probability. Similarly, if one wants to change the beam directions (Arms) in mmWave communication or the contents (Arms) in the recommender system, it might incur a significant cost. Traditional MAB approaches require frequent switching of arms for efficient exploration and are not equipped to satisfy constraints. While algorithms have been proposed to solve this problem, theoretical and practical performances are sub-optimal. We thus, propose a Reinforcement-Learning (RL) based approach to solve this problem. In particular, because of the advancement of the RL in solving complex engineering problems, we, thus, envision that the RL algorithm can have a better theoretical and empirical performance. Such a development will be significant and impactful in applying ML-based tools for many applications such as edge devices, wireless communication, and recommender systems.

Design and in Vivo Analysis of Self-Assembling Peptide Hydrogels

Kaivya Dey, Advisor: Prof. Dr. Vivek A. Kumar, Mentor: Abhishek Roy

Diabetes is a chronic disease characterized by the body's inability to properly regulate blood glucose levels, resulting in hyperglycemia. The 2024 report documented by Harvard University had stated that in 2021, more than 38 million people of all ages (11.6% of the U.S. population) had diabetes, a number projected to double in the next decades and which has a global annual cost ~$250 billion. Wound healing in diabetics is impaired due to a combination of neuropathy, vasculopathy, infection, and other internal and external factors stemming from hyperglycemia and other diabetes-related pathological conditions. Current diabetic wound care involves vascular assessment, infection management, debridement, and offloading, but approximately 20% result in lower extremity amputation. Despite challenges such as immune rejection and poor gene uptake, biomaterials like self-assembling peptide hydrogels (SAPHs) offer promising alternatives to growth factor delivery for wound healing. This project focuses on two self-assembling peptides: angiogenic and antimicrobial peptides, which are synthesized by solid phase peptide synthesis in this very lab and then prepared into hydrogels. These hydrogels are injected into the subcutaneous layer of rodents. The tissue samples are observed on day 7 and 28 and then studied under the inverted microscope and stitched digitally with the help of Photo Affinity 2 software. The slides are then quantified with the help of QuPath Software. Quantification involves analyzing the tissue sections for cell density, neovasculature and the degree of infiltration. It is done to observe any changes introduced by the hydrogels in the system. This would further help in understanding the drug's effects, assessing its potency, and evaluating its other characteristics.

Flexible Solar Cell for Indoor Light Energy Recovery and Reuse

Vijainee, Advisor: Prof Wen Zhang, Mentor: Shan Xue

Energy conservation is the prudent use of resources, ensuring sustainability for future generations. In order to conserve energy, shifting to renewable sources is of utmost importance. Keeping this in mind we came up with a solution of light recovery and reuse. Due to the visible degrading and uncertain environment conditions, farmers struggle with their maximum productivity. The irregular precipitation and harsh sunlight adds up to this cause. So, more farmers are shifting to indoor cultivation which requires less space and gives more yield. For this planters provide LED or other light forms to plants for them to complete their photosynthesis process. In this process not all of the light is absorbed by the plants as the lights are prolonged on. To minimize this wastage we intend to install flexible solar panels at the walls of indoor farms which will take negligible space and the excessive light energy emitted will be absorbed by the panels leading to energy conservation. The absorbed energy can then be used to perform various other activities. For this testing and measurement we intend to use the Stellar software, intensity meter and various lights. Our objective will be to optimize the distance between the light, panel and plant to maximize the desired output. In this way the excessive light can be put into use again. This will contribute to the noble cause of sustainability.

Best Classroom Practices Seminar

Cost-effective Service considering Passenger Waiting Time

Riddhiman Santra, Advisor: Dr. Steven I-Jy Chien

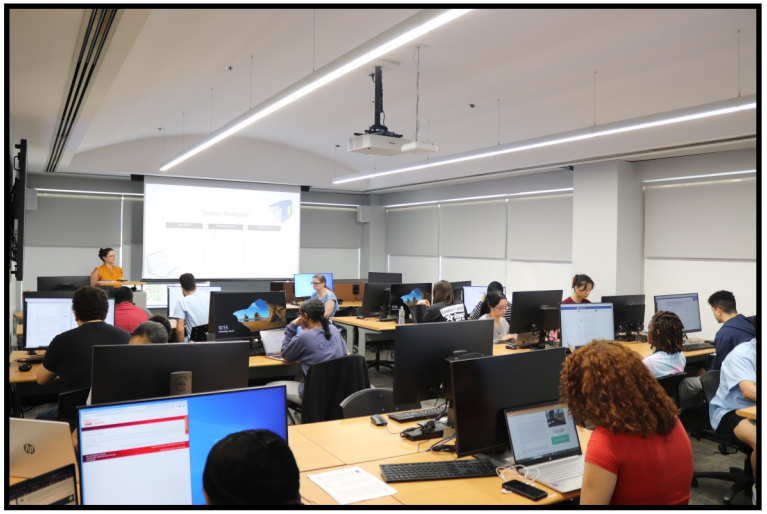
Every year, millions of passengers lose productive time waiting for buses or other forms of public transit, which is frustrating. While bus service stakeholders aim to maximize profits, potentially neglecting users' benefit such as wait time. In order to design an optimal service, this study intends to minimize total cost, consisting of supplier cost and user cost, considering realistic waiting time. A mathematical model will be formulated and a solution method will be developed to optimize bus service frequency, subject to practical constraints. A numerical analysis is conducted under various operation scenarios. The results will suggest that the optimized service may yield the best service at least cost. The sensitivity analysis is conducted, and the impacts of model parameters on decision variables to the cost of operation will be explored.

Personal Statements Seminar

Evaluation of Macrophages for Axonal Growth for Peripheral Neuropathy

Kankana Karmakar, Advisor: Prof. Dr. Jonathan M Grasman, Mentor: Jarin Tusnim

Peripheral neuropathy, a common and often debilitating condition affecting millions, is characterized by damage to peripheral nerves. Its prevalence is estimated at a staggering 2.4% globally. The current gold standard for peripheral nerve injury is autologous nerve transplantation which has got various limitations such as neuroma formation and additional injury site formation. Consequently, researchers are investigating various tissue engineering approaches to address these issues. Macrophages, immune cells crucial for wound healing and inflammation, are emerging as key regulators of axonal regeneration after peripheral nerve injury, where M1 macrophages are pro-inflammatory and involved in host defense, while M2 macrophages are anti-inflammatory and play roles in tissue repair and remodeling. This project investigates the multifaceted role of macrophages in supporting axonal growth in peripheral neuropathy. We will explore how distinct macrophage subtypes, characterized by their unique cytokine profiles, influence axonal regeneration. To investigate the role of different macrophages on axonal growth, we have utilized a 3D in vitro collagen gel model with a hollow channel where dorsal root ganglia (DRG) explants isolated from rat embryos were seeded. Culturing these DRGs under controlled conditions allows us to examine how different growth factors and simulated microenvironments influence axonal growth. This in vitro model provides a highly controlled environment to dissect the intricate interplay between macrophages (M1 and M2), and axonal regeneration. Research in this area is challenging due to the dynamic plasticity of macrophages and the difficulty of translating in vitro findings to more complex in vivo models. Despite these challenges, by elucidating the complex interplay between macrophages and cytokine signaling in peripheral nerve repair, this research aims to identify potential therapeutic targets for promoting axonal regeneration and functional recovery in peripheral neuropathy.



Library Literature Review Seminar

Prompt Optimization for Secure Generation of Functional Source Code with Large Language Models (LLMs)

Akash Raj, Advisor: Dr Hai Phan

The rapid advancement of Large Language Models (LLMs) like GPT-4 has revolutionized various domains, including code generation. However, the generated code often lacks the necessary security measures and optimization, which can lead to vulnerabilities and inefficiencies. This research addresses the critical need for a framework—PromSec—that ensures the generation of secure, functional, and optimized source code using LLMs. The significance of this research lies in mitigating the risks associated with insecure code generation. In an era where cybersecurity threats are escalating, ensuring the integrity and security of automatically generated code is paramount. The primary goal of PromSec is to enhance the prompt engineering process, leading to the creation of source code that is not only functional but also secure by design. Our research methods involve a combination of prompt optimization techniques and security validation protocols. We employ an iterative approach to refine prompts, integrating security guidelines and best practices into the prompt structures. The experimental design includes benchmarking generated code against established security standards and functional requirements. Additionally, we develop a prototype tool that automates this optimized prompt generation process. While the final results are forthcoming, we anticipate that PromSec will significantly reduce the incidence of security flaws in generated code and improve overall code quality. In conclusion, this project paves the way for safer AI-driven code generation. Future work will focus on expanding the scope of security checks and refining the prompt optimization algorithms to adapt to evolving security threats.

What is Research Seminar

Unveiling the Functional Connectivity using fMRI

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Neuropsychiatric disorders, such as Schizophrenia, Epilepsy and Attention Deficit Hyperactivity Disorder, are increasingly prevalent, affecting over 1 billion people worldwide (WHO, 2020). In the United States alone, mental health conditions account for approximately 18.3% of the total burden of disease (NIMH, 2020). The need for early diagnosis and effective treatment has never been more pressing. Functional magnetic resonance imaging (fMRI) offers a non-invasive technique to measure neuronal activity in the brain with excellent spatial and temporal resolution. By detecting changes in blood oxygenation, fMRI provides valuable insights into brain function through the Blood Oxygenation Level-Dependent (BOLD) signal. The BOLD signal serves as a proxy for neural activity, enabling the estimates of brain function and connectivity. Functional connectivity analysis using fMRI has become pivotal in understanding brain organization and dynamics. This study employs Region of Interest (ROI) calculation methods to investigate functional connectivity patterns among brain regions. Resting-state fMRI (rs-fMRI) is a type of fMRI imaging that measures brain activity when a person is not performing any specific task or function. The significance of rs-fMRI lies in its ability to- 1) Identify brain regions that are functionally connected and form networks, even when the brain is at rest, 2) provide insights into brain function, especially in regions involved in attention, memory, and default mode processing. The rs-fMRI doesn't require subjects to perform tasks, making it ideal for studying populations with cognitive or motor impairments. Functional connectivity (FC) in the brain refers to the synchronized activity between distinct brain regions, forming complex networks that underlie cognition, behaviour, and brain function. FC has emerged as a vital biomarker for early diagnosis and spatial localization of the dysfunction in the brain for neuropsychiatric disorders.

In this study, we employed fMRI to estimate FC in healthy controls (HC) and individuals with neuropsychiatric disorders. We analysed FC patterns in both groups, revealing significant differences in network organization and connectivity strength. Resting-state fMRI data from a cohort of healthy subjects were preprocessed to mitigate noise and artifacts. ROIs were defined based on anatomical landmarks or functional networks of interest. Primarily, time-series data were extracted from ROIs and correlation matrices computed to quantify interregional connectivity & then from those data the visualization of these connectivity patterns, elucidating networks implicated in various cognitive processes was facilitated. Our findings demonstrate the potential of FC estimation using fMRI and advanced analytical techniques as a biomarker for early diagnosis and localization of brain dysfunction in neuropsychiatric disorders. This work contributes to the development of novel diagnostic tools and therapeutic strategies, ultimately improving the lives of millions worldwide.