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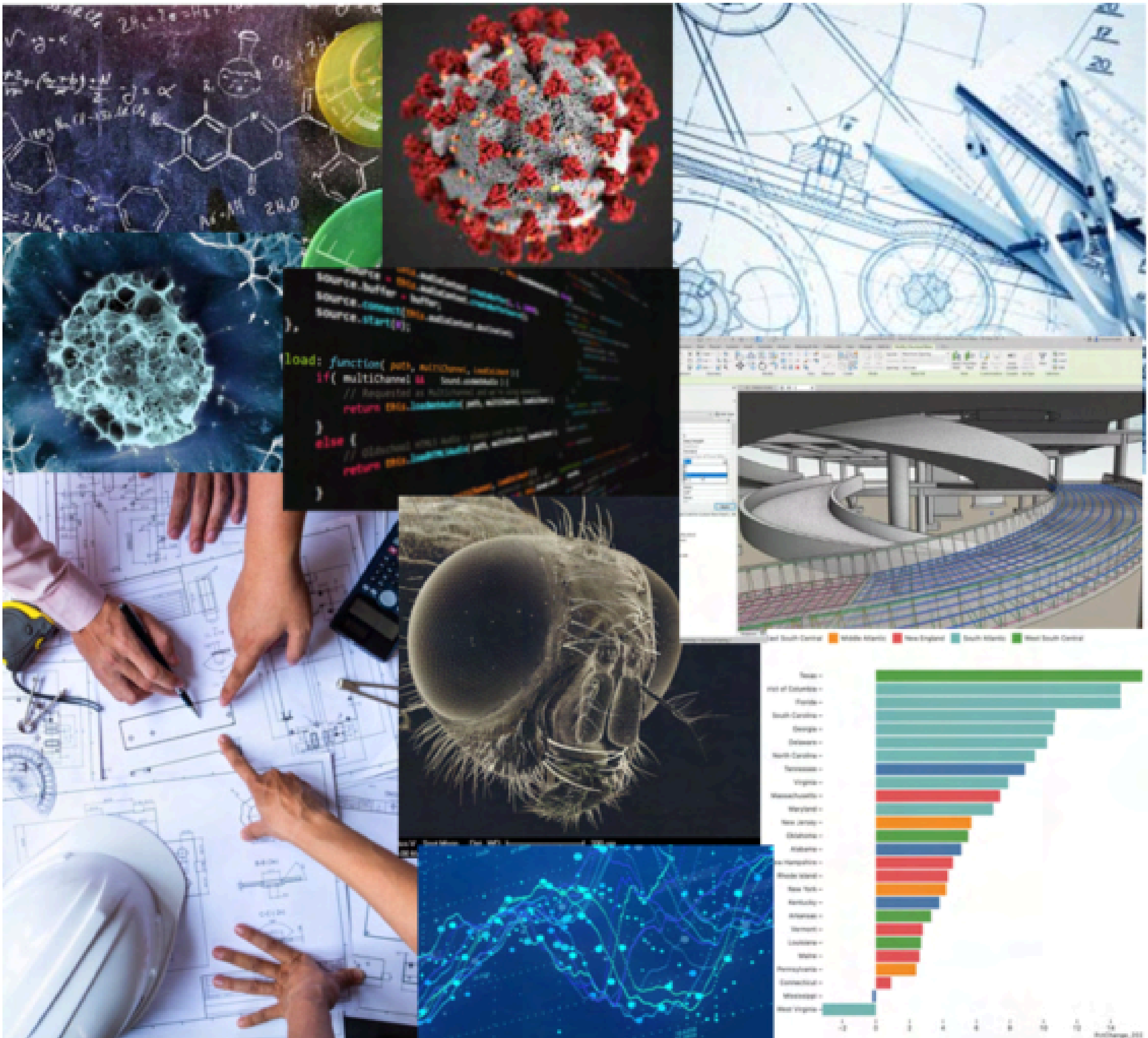


2025 Science Research Journal

Examining Thermal Tolerance of Antarctic Freshwater Algae in a Warming World

"By understanding the temperature ranges that promote or inhibit algal growth, we can better predict future changes in algal populations and their potential ecological consequences due to climate change."

Jayden Cobb
York High School
York County School Division

Abstract

Climate change poses significant threats to ecosystems worldwide, with polar regions particularly vulnerable due to their sensitivity to environmental changes and warming trends. Areas with large quantities of ice experience melting and land loss (Zhang et al., 2020). This research investigates the effects of varying temperatures on the growth of Antarctic freshwater algae, which play a crucial role in nutrient and food cycling.

Samples of algae were collected from Spinach and Alien Ponds in Antarctica in 2009, providing two ecosystems with distinct species compositions. The samples were cultivated in controlled laboratory settings at four temperatures: 5°C, 15°C, 25°C, and 35°C. Each sample was grown in 1.5 mL of media, with 100 microliters of culture, and incubated on a shaker at 50 rpm. Sixteen samples were prepared, with four from Spinach Pond incubated at each temperature, and four from Alien Pond treated similarly.

The findings from this research provide valuable insights into the resilience and adaptability of Antarctic algae to climate variability (Jackson et al., 2021). By understanding the temperature ranges that promote or inhibit algal growth, we can better predict future changes in algal populations and their potential ecological consequences due to climate change (Marie Bolander Jensen et al., 2023). This study contributes to the broader field of climate change research by enhancing our understanding of how temperature fluctuations affect algal growth. The knowledge gained will aid in predicting the resilience of these ecosystems and developing adaptive practices to preserve their integrity in the face of climate change.

“This mentorship helped me realize the struggles of lab work. I was surprised at how informative lab work can be, and am excited to conduct more lab work in the future.”

Jayden will be attending the College of William and Mary

Salinity Tolerance of Artemia: Simulating the Great Salt Lake Salinification

"These results support the hypothesis that salinification of the Great Salt Lake negatively impacts the Artemia population."

Jace Oliver
York High School
York County School Division

Abstract

Artemia are a keystone species of the Great Salt Lake in Utah, known for their high salinity tolerance. Despite this level of hardiness, their populations are decreasing, and researchers predict this decline is caused by the increasing salinity of their habitat, a result of water being drained due to human activity. The goal of this project was to determine whether the drop in population is truly due to salinification.

To test this, three Artemia colonies were raised in containers with different salinity levels: 35 ppt, 50 ppt, and 65 ppt. All colonies were kept under identical conditions aside from salinity. One-milliliter samples of water were removed from each container and analyzed under a light microscope to count the Artemia. These counts were then used to estimate the total population in each container based on the water-to-Artemia ratio.

Over several weeks of testing, the 65 ppt container consistently showed the lowest Artemia population growth, while the 50 ppt container had the highest, with the 35 ppt group in between. These results support the hypothesis that salinification of the Great Salt Lake negatively impacts the Artemia population. This study adds further evidence that the drainage of the lake should be slowed or stopped to protect the ecosystem.

"My mentorship at The Virginia Tech Agricultural Center taught me about important sustainability research happening right here in Hampton Roads."

Jayden will be attending the University of Virginia

Ground Wind Loads on NASA SLS Model Launch Vehicle

"Research conducted at NASA's TDT and CDT has advanced understanding of wind-induced forces on launch vehicles, providing critical insights that support the development of more robust and reliable spacecraft."

Caleb Sava
Poquoson High School
Poquoson City Public Schools

Abstract

Ground wind loads can be the difference between a launch vehicle successfully reaching orbit or not. This is because they have a significant impact on the aeroelastic loads affecting launch vehicles, particularly NASA's Space Launch System (SLS), the subject of this study.

This study investigated the relationship between ground wind loads and the performance of the SLS during ground-level wind exposure. Conducted at the Concept Development Tunnel (CDT), the project aimed to understand the aeroelastic dynamic loads influencing the SLS and its structural response to varying wind speeds. Building on prior research at NASA's Transonic Dynamic Tunnel (TDT), the study employed both experimental and analytical methods to examine wind-induced forces such as vortex shedding and resonant frequencies that could impact vehicle stability.

The model, designed using CAD software and 3D printed for precision, was tested at different wind speeds and orientations to collect data on pressure distribution, displacement, and acceleration. Advanced data acquisition tools, including accelerometers and laser displacement sensors, captured detailed measurements, which were analyzed using MATLAB-based software. Analysis of the data revealed significant frequency peaks, identifying distinct bending modes and vortex shedding—key elements in aeroelasticity research.

Research conducted at NASA's TDT and CDT has advanced understanding of wind-induced forces on launch vehicles, providing critical insights that support the development of more robust and reliable spacecraft.

"This mentorship helped me realize my passion for aerospace engineering. I found it especially rewarding to apply engineering tools like 3D modeling, data acquisition, and data analysis in a real-world NASA research setting."

Caleb will be attending Liberty University

Structural and Functional Analysis of Mycobacterium Leprae Inorganic Pyrophosphatase

"The MlPPase structure is 90.12% aligned with MtbPPase, suggesting that treatments for tuberculosis may also be effective against leprosy."

Unkarabile Nare
Smith Field High School
Isle of Wight County Schools

Abstract

Inorganic pyrophosphatases (PPase) are enzymes that perform vital biosynthetic reactions within cells, playing a crucial role in sustaining life. These enzymes are also responsible for maintaining Mycobacterium leprae (M. leprae), the bacterium that causes leprosy. Alarmingly, there has been a rise in leprosy cases as current anti-leprosy treatments are becoming less effective. Therefore, extensive research on M. leprae pyrophosphatase (MlPPase)—its structure and functional role—is needed to combat drug resistance.

This project aimed to identify, analyze, and assess the structure of MlPPase in order to address drug resistance in existing treatments. To determine the structure of M. leprae PPase, multiple bioinformatics tools—including Clustal Omega, PyMOL, and the Protein Data Bank (PDB)—were used to compare the enzyme with PPase from M. tuberculosis (MtbPPase) and human PPase 1 and 2 (HsPPase 1 & 2). Molecular weight separation (SDS-PAGE) and light absorption analysis (circular dichroism spectroscopy) provided a chemical understanding of the secondary structure of MlPPase and its behavior under different denaturant concentrations.

The analysis revealed that the MlPPase structure is 90.12% aligned with MtbPPase, but shares only 27.21% and 24.49% similarity with HsPPase 1 and 2, respectively. This suggests that drugs developed to target M. tuberculosis PPase may also be effective against M. leprae. Future research should continue comparing MlPPase with human enzymes to identify drugs that are both effective and selective, minimizing the risk of harmful side effects.

"This mentorship opened my eyes to the possibilities within the drug development field. I truly enjoyed exploring how computer modeling and lab techniques intersect in the medical research process."

Unkarabile will be attending the Georgia Institute of Technology

Rotator Cuff Tears: Evaluating Conservative vs. Surgical treatment for Pain Relief and Range of Motion Improvement

"This study found no significant difference in recovery between conservative and combined treatments for rotator cuff tears, offering patients greater flexibility in treatment choices.c

Thatcher Faciszewski
Poquoson High School
Poquoson City Public Schools

Abstract

A rotator cuff tear (RCT) occurs when one or more of the four tendons in the rotator cuff are torn. These tears can result from falling on an outstretched arm, a sudden force pulling the arm into an unnatural position, or gradual degeneration over time. This study aimed to analyze various treatment methods for RCTs and compare their effectiveness based on recovery time and improvements in range of motion (ROM).

Three treatment methods were evaluated: conservative therapy, surgical intervention, and a combination of both. Forward flexion and abduction ROM measurements were taken at both the initial and final patient visits. Pain scores, duration of treatment, and patient age were also recorded. Data were compiled into graphs using Google Sheets, and statistical significance was evaluated using ANOVA and two-sample t-tests. Two-sample t-tests were used due to a noticeable difference between the surgical group and the other treatment groups.

The results showed a significant difference in ROM improvements across all groups for both forward flexion and abduction. However, no statistically significant difference was found between the conservative and combination groups. These findings can assist individuals with an RCT in choosing the most appropriate treatment option for their needs. Understanding the expected recovery process is essential for patients and their families when planning for physical and emotional support throughout rehabilitation.

“This mentorship gave me insight into the daily life of a sports medicine physician. Knowledge I gained through all those at my mentorship will greatly assist in my journey to work in the medical field.”

Thatcher will be attending Virginia Tech

Electromagnetic Interference Shielding and Antifungal Laminates: An approach based on polymer/nanomaterial composites

"This study developed graphene-infused polymers with promising EMI shielding and antifungal properties, offering potential solutions for aerospace and wearable technologies."

Abstract

This research focuses on developing a polymer-based material for electromagnetic interference (EMI) shielding that is flexible, antifungal, and cost-effective, with potential applications in aerospace, technology, and wearable textiles. The study combines polycaprolactone (PCL) and polymethyl methacrylate (PMMA) with nanomaterials such as multi-walled carbon nanotubes (MWCNT) and graphene to form thin film laminates that block EMI and resist fungal growth.

Polymer-nanoparticle solutions were created and applied using spray and hand-coating techniques. For the antifungal component, Green-Silver (G/S) nanoparticles were synthesized with PMMA and added to the polymer mixtures. A one-way ANOVA test demonstrated that increasing the weight percentage of nanoparticles led to higher solution viscosity. The antifungal properties of G/S nanoparticles were preliminarily tested by placing bread—chosen for its convenience—between two laminates to observe mold growth, though other perishable foods could also be applicable in future testing.

The laminates and G/S nanoparticles were successfully synthesized. Although PMMA initially failed to form fibers, PCL was used effectively. Results indicated that a 10 wt% blend of graphene and related materials provided the greatest resistance to electromagnetic waves. While the project is ongoing, future analysis of the G/S nanoparticles will further clarify their antifungal effectiveness. These findings contribute to the development of efficient, affordable, and multifunctional EMI shielding materials, addressing a current gap in the literature.

Aliahana-Ophelia Araneta
Smithfield High School
Isle of Wight County Schools

"This mentorship exposed me to the expansive world that is in chemical engineering, as I never thought to have any interests. It was intriguing to learn about what polymers are, and the many possibilities they hold."

Aliahana-Ophelia will be attending the University of Virginia

Structural Analysis and Drug Design: Targeting M. Leprae Pyrophosphatase

"This study used computer-aided drug design to identify promising compounds that could serve as new treatments for leprosy by targeting a key bacterial protein."

Gabrielle Johns
Smithfield High School
Isle of Wight County Schools

Abstract

Leprosy continues to affect hundreds of thousands of people worldwide, yet as a Neglected Tropical Disease (NTD), it remains underserved in drug development. This study aimed to address growing drug resistance by identifying alternative treatments targeting Mycobacterium leprae inorganic pyrophosphatase (MlPPase), a protein essential to the bacterium's survival. Using computer-aided drug design (CADD), the study focused on developing competitive inhibitors derived from known iPPase substrates.

By analyzing prior research on MlPPase and related mycobacterial diseases, potential drug candidates were designed and evaluated through molecular docking simulations and density functional theory (DFT) calculations. These analyses identified several promising compounds with strong binding affinities and high specificity to M. leprae, offering a strong foundation for future drug synthesis.

The findings highlight new pathways for therapeutic development, particularly for patients who do not respond to current treatments. Moreover, this research demonstrates the potential of CADD to accelerate drug discovery for leprosy and other neglected tropical diseases, with the broader goal of improving global health outcomes.

"My mentorship was a great experience that brought to my attention the flexibility within the field of biochemistry, particularly its intersection with computerized design and modeling. Working both outside and in the lab granted me invaluable skills in research methods and critical thinking. The most valuable takeaway from this opportunity was the confidence my mentor affirmed regarding my abilities to research, a skill I will take with me as I continue on in my academic pursuits."

Gabrielle will be attending the University of Virginia

Dual-Bell Nozzle Optimization through Computational Modeling to Maximize Thrust and Efficiency during Flight

"This mentorship gave me firsthand experience applying computational modeling to real-world aerospace challenges. I learned how simple tools can lead to powerful innovations in rocket design."

Evan Richards
Grafton High School
York County School Division

Abstract

Dual-bell nozzles improve rocket engine efficiency by adapting to changing atmospheric pressure during ascent, but traditional modeling methods rely heavily on computational fluid dynamics (CFD), which are time- and resource-intensive. This study developed a lightweight, Python-based simulation tool that models and optimizes dual-bell nozzle geometries without the need for CFD, allowing for rapid feasibility testing and performance evaluation.

The model was created in three phases. First, a single-bell nozzle was developed and validated across a simulated atmospheric profile. Second, the dual-bell geometry was constructed by combining two single-bell models. Third, an optimization algorithm was introduced to iterate through nozzle designs and identify the most efficient geometry. The resulting tool demonstrated under 5% error in specific impulse (Isp) compared to real engine data.

Efficiency tests on legacy engines showed substantial gains: 29.91% for the F-1 engine (Saturn V), 10.50% for Vulcain 2.1 (Ariane VI), and 7.78% for the RS-25 (SLS and Space Shuttle). Minimal improvements were found in the Merlin 1D (Falcon 9) due to geometric constraints. Contour plots of efficiency versus nozzle diameter were generated to guide realistic design within structural limits.

By accurately simulating performance from sea level to vacuum with minimal computational demand, this tool offers aerospace engineers a practical, early-stage method to assess dual-bell nozzle feasibility. Its simplicity, speed, and accuracy support sustainable and cost-effective space exploration through improved propulsion technologies.

"This mentorship allowed me to better understand the programs and processes used in real life engineering projects. It deepened my interest in studying engineering and broadened my skill sets to be better prepared for the workforce.”

Evan will be attending Purdue University

Title: Contraceptive Use Across Age, Marital Status, and BMI: A Demographic Analysis

"These findings underscore the importance of age and marital status in shaping contraceptive decisions."

Lillian Maynor
Warhill High School
Williamsburg-James City County Public Schools

Abstract

This study examines how demographic factors—specifically age, marital status, and body mass index (BMI)—influence contraceptive choices among women of reproductive age (18–49) in the Hampton Roads area. The aim is to understand how life stage and personal circumstances shape contraceptive decision-making.

A retrospective, systematic chart review was conducted using patient records from EPIC Systems at Riverside Partners in Women's Health. Chi-square tests of independence were used to assess relationships between variables, and results were visualized through bar charts created in Excel.

Statistically significant associations were identified between both age group and contraceptive method and marital status and contraceptive method. Women aged 18–25 most commonly used long-acting reversible contraceptives (LARCs) (39.1%), while those aged 42–49 more often chose permanent sterilization (41.7%). Marital status also played a role: single women most frequently selected LARCs (24.4%), partnered women preferred short-acting reversible contraceptives (SARCs) (43.8%), and married women most often opted for permanent sterilization (38.9%). In contrast, no statistically significant association was found between BMI and contraceptive method.

These findings underscore the importance of age and marital status in shaping contraceptive decisions. The results offer valuable evidence to inform patient counseling, reduce provider bias, and improve reproductive health education efforts in the Hampton Roads region.

"Shadowing Dr. Cole has been an unforgettable experience—not only in the clinic, but also in the operating room, where I observed procedures such as cesarean sections, hysterectomies, and bilateral tubal ligations. This mentorship deepened my interest in women's health and provided me with invaluable hands-on exposure to the field."

Lillian will be attending the University of Virginia

Target Absorber Cooling for the KLONG Experiment

"Extensive simulation testing and heat transfer analysis suggest the system will keep absorber temperatures below the critical 250°C threshold."

Isabel Dreyer
Menchville High School
Newport News Public Schools

Abstract

Developing an effective cooling system for the tungsten absorber in Jefferson Lab's Hall D KLONG experiment's Kaon Production Target (KPT) is essential to prevent overheating, which could compromise both performance and longevity. The system must balance three core design constraints: maintaining absorber temperatures below 250°C, minimizing maintenance, and integrating with existing infrastructure. To meet these goals, a fluid-based convection system with conductive copper plates was selected for its high thermal conductivity and proven performance. Copper piping and plates were chosen to optimize heat transfer, and lead-free solder will be used to ensure durable, leak-resistant joints. Water, selected as the cooling fluid, offers both thermal efficiency and ease of waste management.

Extensive simulation testing and heat transfer analysis suggest the system will keep absorber temperatures below the critical 250°C threshold. This prediction will be validated through steady-state thermal simulations using FLUKA power absorption data, which will model heat transfer from the tungsten to the copper plates and subsequently from the copper to the water within the cooling tubes. By addressing a key thermal management challenge in high-energy physics, this research supports the long-term reliability of the KPT and offers a model for similar beamline cooling applications across particle physics and other experimental domains.

"This mentorship provided me with exciting opportunity to explore engineering principles at a higher level than ever before. This experience was definitely one of the highlights in my time at the Governor's School."

Isabel will be attending Randolph-Macon College

Strain-Dependent Structural Transformations in Latrodectus Silk Using Raman Spectroscopy

"Preliminary data indicate significant molecular transformation beginning at as little as 15% extension, involving several amino acid structures."

John Steiner
Warwick High School
Newport News Public Schools

Abstract

Spider silk has long been recognized for its exceptional strength and ductility, making it a valuable model for biomaterial applications. This study aims to investigate the structural and mechanical properties of spider silk to inform the design of more efficient synthetic materials. While protein transformation during silk spinning has been previously documented, a detailed understanding of which molecular structures in Latrodectus silk undergo stress-induced transformation remains incomplete.

In this study, single-strand silk samples were extracted from southern black widow spiders (Latrodectus mactans) and secured with epoxy to a custom device designed to apply controlled strain. Samples were scanned under various levels of strain using a Raman spectrometer, and changes in the position and width of characteristic spectral peaks were analyzed. Preliminary data indicate significant molecular transformation beginning at as little as 15% extension, involving several amino acid structures. Notably, prominent shifts were observed in the β-sheet structures within the Amide III band.

These findings enhance our understanding of spider silk's mechanical behavior and lay the groundwork for developing synthetic materials that are stronger and lighter than those currently available. Furthermore, insights into molecular structural transformations will support the engineering of biocompatible materials with biomedical applications, such as sutures, tissue scaffolds, and drug delivery systems.

“Working in the William and Mary Biomaterials Lab has been an extremely enriching experience that has prepped me for pursuing lab opportunities in college and beyond."

John will be attending Johns Hopkins University

Determining the Accuracy of Proton-Electron Reconstructive Analysis Methods

"These findings suggest that the choice of reconstruction technique should be guided by the specific characteristics of each event and the quality of the detector data."

Razvan Verde
Warwick High School
Newport News Public Schools

Abstract

Understanding the internal structure of protons remains a central challenge in high-energy physics. This study compares two kinematic reconstruction methods for proton–electron collisions: one based on measurements of scattered electrons and the other using information from the hadronic final state, known as the Jacquet-Blondel method. Monte Carlo simulations, processed with the upROOT framework, were used to analyze collision events across three beam configurations: 5×41, 10×100, and 18×275 GeV.

Each method was evaluated under varying detection conditions. When the scattered electron was accurately measured, the electron-based reconstruction produced smooth and reliable determinations of momentum transfer. However, in events where the electron signal was incomplete or compromised, the hadronic method offered better coverage—especially in the higher momentum transfer range. Statistical analyses confirmed that the electron method is optimal when full electron data is available, while the hadronic method is more robust in scenarios with limited electron detection.

These findings suggest that the choice of reconstruction technique should be guided by the specific characteristics of each event and the quality of the detector data. This insight has significant implications for future experiments at high-luminosity facilities such as the Electron-Ion Collider, where precise kinematic reconstruction is essential for probing quark-gluon dynamics and deepening our understanding of proton structure.

"This mentorship introduced me to computationally advanced research methods, preparing me to work on complex scientific problems with greater analytical precision and confidence in the future."

Razvan will be attending Princeton University

The Effect of Glucose Concentration on Cell Growth, Post Etoposide-Induced Senescence

"These results suggest that senescent cancer cells may require more targeted approaches for effective elimination."

Abstract

Cancer relapse remains a major challenge, often due to senescent cancer cells that go undetected during treatment. These cells stop dividing but release inflammatory signals (SASPs) that promote tumor growth and spread. Hyperglycemia, or high blood glucose levels, is common in diabetic patients and is known to increase senescence, but its role in senescent cells escaping growth arrest has not been studied.

This project tested whether hyperglycemia promotes senescent escape in H460 lung cancer cells. Senescence was induced using Etoposide, and cells were then exposed to glucose concentrations of 2.5 mM, 5 mM, and 30 mM. No significant increase in cell growth was observed at higher glucose levels, suggesting hyperglycemia does not lead to senescent escape. However, cells exposed to the lowest glucose concentration showed a marked decrease in viability.

A follow-up experiment using the glucose transport inhibitor WZB117 also showed no change in senescent cell viability, indicating resistance to this treatment. These results suggest that senescent cancer cells may require more targeted approaches for effective elimination.

"Being a part of this project has given me valuable lab experience and reinforced my interest in biomedicine. It was very fulfilling knowing I've contributed to such a critical field."

Isabella Gaston
Grafton High School
York County School Division

Isabella will be attending the College of William and Mary

Determining the Accuracy of Proton-Electron Reconstructive Analysis Methods

"This AI assistant has the potential to transform how nuclear physicists access and apply knowledge, paving the way for more efficient and innovative research."

Lauren Peabody
Lafayette High School
Williamsburg-James City County Public Schools

Abstract

Nuclear physics presents distinct challenges, including the need for complex simulations and the interpretation of dense experimental data—tasks that traditional methods struggle to handle efficiently. While fields like biology and cosmology benefit from domain-specific AI models, nuclear physics currently lacks a tailored solution. This project addresses that gap by fine-tuning a large language model (LLM) specifically for nuclear physics applications.

To build the system, research papers were extracted in PDF format, preprocessed, and embedded using BERT, then stored in a FAISS vector database for fast and relevant text retrieval. The Llama 2-7B model was fine-tuned on these embeddings to create a responsive AI assistant capable of answering nuclear physics queries. Preliminary results show an average precision of 56% and recall of 40%, suggesting that the model can provide contextually accurate and relevant responses.

Although challenges remain—such as interpreting LaTeX equations and expanding the document base—this AI system has the potential to transform how researchers access knowledge, automate routine tasks, and generate insights more efficiently. Ultimately, it represents a promising step toward innovation and collaboration in the field of nuclear physics.

"This mentorship allowed me to expand my knowledge of machine learning and learn how to apply it in real-life research. I appreciated the ability to develop a large project over time with the guidance of a mentor to advise me on the steps and possibilities that came up throughout the program for the uses of AI in science."

Lauren will be attending the University of California, San Diego

Investigating the Implementations of Vertical Care in a Community Hospital

"These findings suggest that while vertical care may offer benefits in theory, its effectiveness in small-scale hospitals may be limited compared to larger institutions."

Isabella Mendez
Bethel High School
Hampton City Schools

Abstract

Overcrowding in community hospitals has become a growing concern since the COVID-19 pandemic, prompting the exploration of new emergency department (ED) care models. This project investigates the effectiveness of a vertical care model—a system designed to treat more patients without increasing the number of beds—compared to the traditional Emergency Severity Index (ESI) triage method. The analysis focused on three key areas: cost efficiency, changes in patient throughput times, and staff/patient satisfaction.

Using queuing theory and hospital data from Tableau, expected wait times and costs were calculated and compared to actual outcomes. A student t-test was used to determine statistical significance. Survey results showed improved staff and patient satisfaction with the new model; however, the transition period led to reduced ED efficiency and increased costs.

These findings suggest that while vertical care may offer benefits in theory, its effectiveness in small-scale hospitals may be limited compared to larger institutions.

“This mentorship allowed me to gain experience working with the staff that are in charge of ensuring patient safety and satisfaction. This mentorship and research project made me realize the importance of public health leaders in the emergency room.”

Isabella will be attending the University of Virginia

Diatoms: Investigating their Potential for Chemically Etching Nanoporous Designs

"Diatoms may serve as a scalable, eco-friendly platform for advancing nanotechnology, with potential applications in medicine, material science, and disease diagnostics."

Teagan Ketterman
Jamestown High School
Williamsburg-James City County Public Schools

Abstract

This project investigates the feasibility of using diatoms—microscopic algae known for their intricate silica cell walls—as a sustainable method for transferring nanoporous patterns onto silicon wafers. Diatoms offer a biologically derived alternative to conventional nanoscale etching processes, which often require expensive and hazardous chemicals. The research explores whether the natural structures of diatoms can be leveraged to create precise nanoimprints, potentially reducing both the environmental and financial cost of nanofabrication.

Using chemical vapor deposition followed by chemical etching, the study attempted to achieve a uniform nanoporous pattern on the silicon substrate. Potassium hydroxide (KOH) was tested as a less hazardous etchant, but preliminary observations revealed surface irregularities and possible undercutting—indicating limitations in diatom adhesion or etch resistance. To address these challenges, the procedure is being refined by incorporating a spin-coated polymer mask to improve selectivity and definition in the pattern transfer.

This approach holds potential applications in medicine, material science, and photonics. Specifically, diatom-derived nanopatterns could enhance light-based sensors used in DNA sequencing, protein analysis, and biomarker detection—tools critical in early disease diagnosis and precision medicine. Ultimately, this research supports the idea that diatoms may serve as a scalable, eco-friendly platform for advancing nanotechnology.

"On top of learning about the fascinating biology of diatoms, this mentorship gave me valuable insight about what research and development looks like in practice: embracing, learning, and reinventing each and every failure as they come. In science and the world in general, we have to be persistent, resilient, and maybe just a little bit stubborn to achieve our highest goals!"

Teagan will be attending the University of Virginia

Model Planetary Rover Utilizing a ClearPath Husky A200

"This prototype demonstrates a scalable and adaptable robotic system capable of autonomous navigation and sample retrieval, addressing key challenges for future planetary exploration missions."

Abstract

As planetary science advances, the return of extraterrestrial samples has become a primary objective for space exploration missions. NASA's Mars Sample Return (MSR) mission has successfully completed its initial stage of sample collection and caching on the Martian surface. However, the critical challenge of retrieving these samples and safely returning them to Earth remains unresolved. This research develops and tests a terrestrial prototype designed to simulate the sample retrieval phase of the MSR mission.

The prototype rover combines four essential components: the ClearPath Robotics Husky A200 mobility base, a GearWurx ARM 3.0 manipulator for physical sample collection, an Intel RealSense D435 camera for vision and depth sensing, and an NVIDIA Jetson TX2 onboard processing unit. These components are integrated within the Robot Operating System (ROS), enabling semi-autonomous navigation, object detection, and manipulation capabilities.

Prior to physical trials, simulations were conducted using MathWorks software to validate the rover's key behaviors, including obstacle avoidance, environmental scanning, and target acquisition. The prototype was then tested in a controlled laboratory environment to assess its ability to autonomously navigate, identify, and retrieve target objects. The project aimed for a target success rate of 85% in these tasks. This research contributes to the development of scalable, adaptable robotic systems for future autonomous planetary missions, offering valuable insights into the engineering challenges of extraterrestrial sample retrieval.

Zainedine Moussa
Tabb High School
York County School Division

"I enjoyed working at my mentorship, where I gained valuable first-hand experience and insight into the engineering field. I also appreciated the opportunity to collaborate and problem solving with my fellow Governor's School students."

Zainedine will be attending the Virginia Polytechnic Institute and State University

Analysis of Illumination Conditions on the Lunar South Pole

"The Connecting Ridge near Shackleton Crater emerges as the most promising site for a lunar base, offering over 90% illumination and strategic advantages for sustained exploration at the Lunar South Pole."

Abstract

For decades, humanity has aspired to explore and eventually colonize extraterrestrial bodies, with the Moon being a primary focus. NASA's Artemis program aims to explore and establish a sustainable human presence specifically at the Lunar South Pole. Numerous landing sites within this region have been evaluated by various organizations to determine the most suitable location for a permanent lunar base. This research consolidates data from 160 unique sources into a comprehensive database, compiling key information relevant to potential base sites on the Lunar South Pole.

Analysis of the database suggests that the Connecting Ridge near Shackleton Crater offers the most favorable conditions for a lunar base. This site benefits from over 90% illumination throughout the lunar day, providing ample solar energy, and its proximity to Shackleton Crater offers logistical advantages for exploration and resource utilization. However, these findings are somewhat limited by the fact that the majority of the data was collected using a single instrument—NASA's Lunar Orbiter Laser Altimeter—potentially introducing bias.

Despite this limitation, the database serves as a valuable resource for future, more detailed investigations into the optimal location for a lunar base, helping to guide mission planning and site selection for sustained lunar exploration.

Musie Yehdego
Phoebus High School
Hampton City Schools

"The mentorship allowed me to attain valuable research experience among a veteran at NASA. It allowed me to see how the research process works in a professional environment."

Musie will be attending Virginia Commonwealth University

Real-Time Prediction and Monitoring of Risks in Commercial Aviation Using Machine Learning

"Random forest machine learning models can accurately predict pilot stress and fatigue in real time, offering a promising tool to enhance aviation safety."

Jacob Hower
Warhill High School
Williamsburg-James City County Public Schools

Abstract

Machine learning (ML) is increasingly being explored across many fields to improve safety and efficiency. In commercial aviation, pilots face high workloads and irregular schedules, which can increase the risk of human error. This study aims to develop a machine learning model that analyzes real-time physiological data—such as heart rate variability (HRV), electrocardiogram (EKG), electroencephalogram (EEG), and respiration rate—to assess pilot stress and fatigue during and after simulated flight events. Several ML models were tested, including decision trees, random forest, logistic regression, and linear regression. Among these, the random forest model demonstrated the highest accuracy at 95.14%, while decision trees provided the fastest processing time of 35 seconds. The linear regression model was found to be unreliable for this application.

These results highlight the potential of machine learning to monitor pilot conditions in real time, thereby reducing aviation risks. Integrating ML into flight systems could enhance both safety and operational efficiency. Future research will focus on expanding datasets, improving model accuracy, and exploring advanced ML techniques to further enhance predictive capabilities in aviation.

“This mentorship has helped me confirm my passion in biomedical engineering while exposing me to the potential machine learning has in the future of healthcare. I enjoyed the chance to expand my knowledge from the classroom and solve a real-world problem with lasting impacts.”

Jacob will be attending the Virginia Polytechnic Institute and State University

Impact of Socioeconomic Status on Healthcare Accessibility: Physiological and Systemic Considerations

"Health insurance coverage remains the most significant barrier to healthcare access for low socioeconomic populations, underscoring the need for policy reform."

Justin Doan
Warwick High School
Newport News Public Schools

Abstract

This study investigates how socioeconomic status (SES) affects access to healthcare and identifies key systemic and financial barriers influencing patient outcomes. With health disparities growing in the United States, especially among low-income populations, understanding the link between SES and healthcare accessibility is crucial for creating fair healthcare policies.

Using a mixed-methods approach, the study surveyed and interviewed 30 participants from lower SES groups in Hampton Roads, VA. Quantitative data were analyzed through multiple linear regression and ANOVA, while qualitative data were coded for themes. Findings showed that health insurance type significantly impacts healthcare access ($p = 0.036$), while education level showed a trend toward significance ($p = 0.057$). Employment status and confidence in understanding healthcare costs did not have a significant effect. The results suggest that insurance coverage disparities are a major barrier for low SES individuals.

The study highlights the need for targeted interventions to address insurance inequities and supports further research on educational programs to improve healthcare equity in underserved communities.

“Shadowing in the emergency department opened my eyes to the field of medicine and patient care, where barriers like lack of insurance and limited health literacy delay treatment and worsen outcomes. This experience grew my commitment to helping others and passion for medicine.”

Musie will be attending Virginia Commonwealth University

The Impact of Low-Dosage Radiation Therapy on Glioblastoma Multiforme Patients

"Patients receiving reduced-dose radiation had a longer median survival and fewer side effects, suggesting a promising alternative to current treatment standards."

Nikhil Sosale
Grafton High School
York County Schools

Abstract

Glioblastoma multiforme (GBM) is one of the most aggressive types of brain cancer, with most patients surviving only 12 to 15 months after diagnosis, even with treatment. The standard therapy includes surgery, followed by 60 Gy of radiation and chemotherapy with temozolomide. However, this radiation dose can cause harmful side effects, including fatigue, memory loss, and, in some cases, damage to brain tissue. This study examines whether reducing the radiation dose to 40 Gy could still provide similar survival outcomes while lessening side effects.

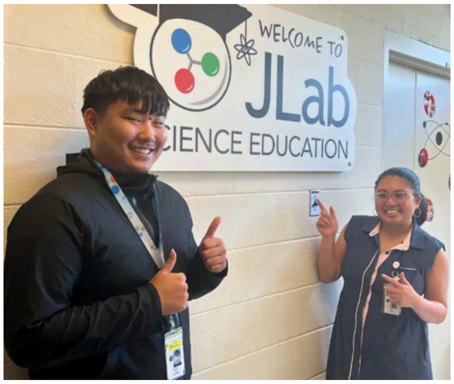
Using simulated data for 50 GBM patients based on trends in clinical research, the study compared survival rates between patients who received either low-dose (40 Gy) or standard-dose (60 Gy) radiation. Kaplan-Meier survival curves and statistical tests such as the log-rank and chi-squared analyses were used to evaluate outcomes and related factors. Results showed that patients in the low-dose group had a longer median survival (22 months) compared to those in the standard-dose group (14 months). Additionally, patient age and the extent of tumor removal were strongly linked to survival outcomes.

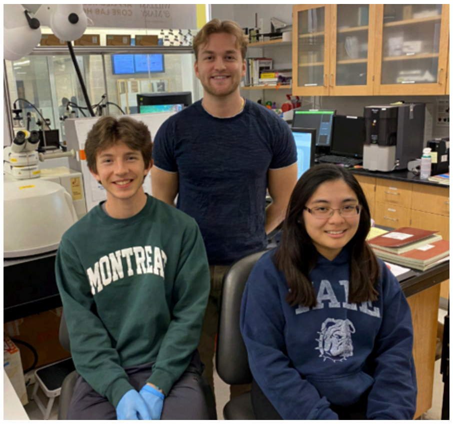
These findings suggest that lower radiation doses may be just as effective—and possibly even better—for certain patients, offering a safer alternative with fewer side effects. The study encourages further research into more personalized and less harmful treatment strategies for GBM.

“This mentorship introduced me to the world of professional medical research. I am equally thankful for the skills I learned in producing quality medical research, along with the valuable information I learned in patient-provider interactions.”

Nikhil will be attending Virginia Commonwealth University

Mentorship





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Research: Key Component of the GSST Student Experience

A primary goal of the GSST is to provide students with an opportunity to conduct serious scientific research, engineering design, or computer programming projects.
All students take a junior-year course in Research Methods and Ethics, which introduces them to research methodology, statistics, critical thinking skills, and the skills of scientific writing and presentation. In the junior year, all students prepare a science fair project for submission to the Tidewater Science Fair. Students are encouraged to take their work to additional state and national competitions.

In their senior year, students design and conduct a year-long research project under the direction of a professional in their field of interest. The field component is supported by an in-school course which guides students through the entire process, from the selection of a problem to the final presentation. Major aspects of the mentorship experience include: preparation of a formal written proposal for their project, oral presentation of the proposal and a status report at mid year to GSST faculty, a final research document, and presentation of final results to a panel of professionals in appropriate fields at the GSST Spring Symposium. In addition, many students present their findings at local, regional, and national science competitions and symposia. Exceptional work has been published in professional journals.

Research sites that have participated in the GSST Honors Research/Mentorship program included NASA Langley Research Center, Thomas Jefferson National Accelerator Facility, Virginia Institute of Marine Science, College of William & Mary, Hampton University, Christopher Newport University, Virginia Living Museum, local engineering firms, hospitals, and numerous of medical and professional specialists.