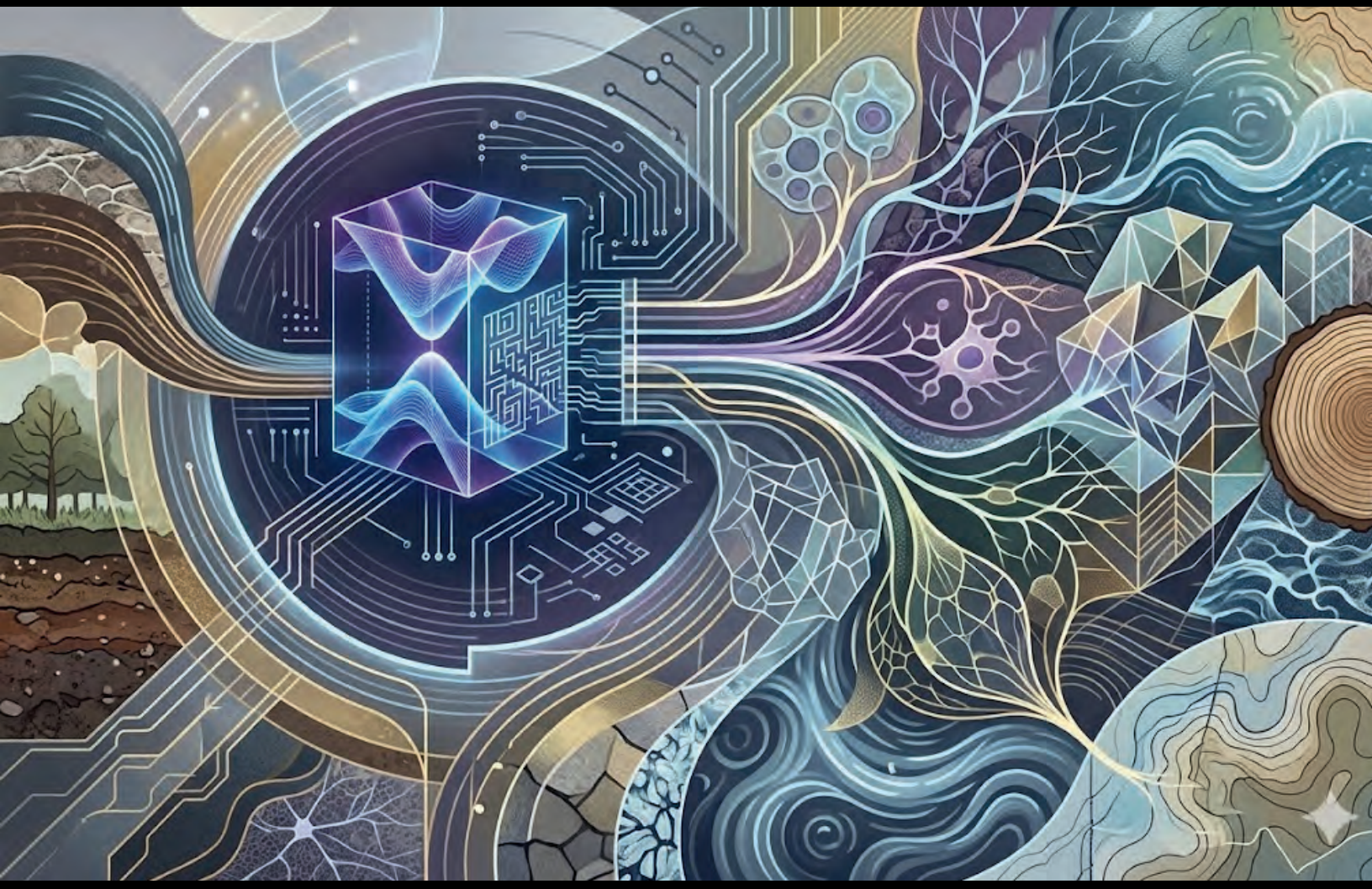
Friends Academy Journal of Science



A collection of original
science research summaries
from Friends Academy students
striving to make the world a better place

20 MAY 2026 A MOMENT OF SCIENCE VOL. 1

LETTER FROM THE EDITOR

Welcome to the First Annual Friends Academy Science Journal! Within these pages, you will find the original research of our Independent Research students, who have worked passionately over the last year to complete an independent research investigation of their choosing. They presented at several competitions, winning many prestigious awards. This inaugural year has been remarkable, and the momentum is only building. Looking ahead, our research community will triple, opening a new chapter of scientific inquiry at Friends. All DNA Barcoding students participated in the Barcode Long Island project and will present their findings at a research symposium in June at the Cold Spring Harbor Laboratory.

In our rapidly evolving, digital-first landscape, the definition of "skill" is shifting. For all students, the valuable skills learned through their education are moving towards the development of tangible, real-world expertise and away from simple information acquisition. Post-AI skills lie in the ability to interact directly with the physical world, master tangible tools, manage complex systems, and apply high-level critical judgment. Science research at Friends is uniquely positioned to cultivate these essential competencies, providing an environment where students build deep resilience and grit. It is not just about learning scientific concepts; it is about reclaiming the tactile. By embracing discovery's messy, hands-on, and unpredictable nature, this program keeps the next generation grounded in authentic, lived experience.

Ultimately, this rigorous scientific journey does more than build capable minds; it actively supports our students in living the Quaker testimonies of integrity, stewardship, community, and continuing revelation. It provides opportunities for students to ask big questions, build confidence, collaborate, and develop a sense of purpose. Our investment in this program and our research students is an investment in our future, as they remain curious and passionate, opening pathways to discoveries that can change the world.

With Gratitude,
Rebecca Glavan
Friends Academy
8-12 Independent Science Research Teacher

This issue's cover art is a custom-designed research mosaic celebrating the diverse, physical, and theoretical research undertaken by the students of the Friends Academy Science Research program. Cover concept and visual compilation generated in collaboration with Gemini AI (2026).

IT TAKES A VILLAGE

Independent Research Class Partners

Dr. Joeli Marrero-Zoulias
Dr. Cristina Fernandez-Marco
Cold Spring Harbor Laboratory DNA Learning Center

Kyle Schlecht
Uplands Farm

Dr. Marc Fuchs, Professor
School of Integrative Plant Science, Plant Pathology and Plant-Microbe Biology Section, Cornell AgriTech

Dr. Raza Zaidi, Surgical Oncologist, P '27
Long Island Jewish Hospital

Dr. Nitin Mariwalla, MD, Neurosurgeon, '98
P '29, '30, '32
New York Brain, Spine & Joint

Chris Penn, P '29

Dr. Mark Bridgen, Professor
School of Integrative Plant Science
Cornell University
Long Island Horticultural Research & Extension Center

DNA Barcoding Research Class Partners

Dr. Cristina Fernandez-Marco
Jeffrey Petracca
Cold Spring Harbor Laboratory DNA Learning Center

Tim and Remsen Dooley, '02
P '32, '34
Youngs Farm

Michael Maron
Bailey Arboretum

Dr. Russell Burke, Professor
Department of Biology, Hofstra University

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The Regeneron Science Talent Search (STS) is the nation's oldest and most prestigious science and math competition for high school seniors. The competition focuses on identifying the most promising young scientists in the United States who are developing ideas that could solve the world's most urgent challenges. The Top 300 Scholars: From nearly 2,000 entrants annually, 300 students are named "Scholars." Each scholar and their school receive a $2,000 award to support STEM education. From the pool of scholars, 40 finalists are selected to attend the Finals Week in Washington, D.C. Here, they undergo rigorous judging, display their work to the public, and meet with notable scientists. Awards: The top prize is $250,000, with a total of over $3 million in awards distributed throughout the competition.

Long Island Science and Engineering Fair (LISEF) is a prestigious competition that showcases high-caliber STEM research from students across Nassau and Suffolk Counties. It serves as a regional gateway to the International Science and Engineering Fair (ISEF), where top students compete on a global stage. (11-12). JV LISEF students (9-12) in this division do not advance to ISEF, however, they receive valuable feedback from professional judges and win awards, setting the stage for future research at the Varsity level.

South Asian American Women's Association (**SAAWA)**: While its mission focuses on empowering women, SAAWA hosts regional science fairs that are open to all students (regardless of gender) to foster a community of young researchers. It provides a platform for students to present original research to professional judges, with cash awards for top projects in categories like Biology, Physical Science, and Environmental Science.

Full Research Paper Scan here

Investigating Plant–Pathogen Interactions in *Nicotiana benthamiana* to Uncover Novel Mechanisms of Tumor Suppression

Hayden Penn, Gracian Mariwalla, and Graham Davis, Grade 9, LISEF, SAAWA

INTRODUCTION

Cancer is characterized by unregulated cell division and disruption of normal growth-control pathways. The plant pathogen Agrobacterium tumefaciens which naturally causes crown gall disease is a well-established biological model for studying tumor formation. Tumors are induced by wild-type strains through the transfer of oncogenic T-DNA into host plant cells, leading to an overproduction of auxins, cytokinins, and the consequent unregulated cellular proliferation. The mutant strain GV3101 can still infect plant tissue however it is non-tumorigenic because this strain lacks genes necessary for tumor induction via T-DNA. Since this system mimics the abnormal growth signaling, it can provide an observable and controlled model for tumorigenesis, biological competition, and tumor suppression mechanisms in a living system.

RATIONALE

The biological suppression of tumor formation has an important role that is applicable to cancer research. If a non-tumorigenic strain such as GV3101 competes with tumor-inducing wild-type strain, it may disrupt oncogenic signaling, acquiring resources or infection efficiency. Such a competitive dynamic suppresses tumorigenesis to some extent. To this end, in vitro and in vivo approaches were used. The in vitro component tested bacterial growth sophistication and nutrient rivalry under controlled laboratory conditions, while the in vivo plant model observed tumor formation, plant stress, and physiological tradeoffs more directly. The focus was towards a non-tumorigenic strain (GV3101) and whether oncogenic signaling, resource capture, or infection efficacy are affected by competitive interference when cohabitating with a tumor-inducing wild type and mixed single strains in vitro and in vivo.

RESULTS

For the in vitro assays, bacterial cultures were normalized to set turbidity values and plated out to test for colony-forming units under single and mixed conditions. However, there was bacterial contamination from the plants, making reliable quantification impossible. Background growth from plant material prevented reliable differentiation of experimental strains and assessment of competitive results. Hence, the in vitro findings failed to provide a quantitative basis for comparing bacterial viability or dominance.

Wild Type tumor growth. Photo taken by student researchers and teacher, 2026

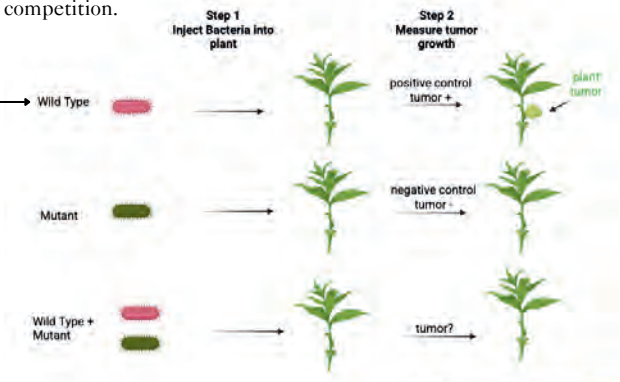
Results of the experiement: From Left to right: Control Group, GV3101/WT mixed inoculation, WT, and GV3101 single inoculations. Photo taken by student researchers and teacher, 2026 Note: Note the stunted tap, secondary and tertiary root structures on the mixed inoculation.

On the other hand, the in vivo experiment had very noticeable outcomes that could be quantified. In contrast, inoculation with wild-type consistently produced visible crown gall tumors at the infection sites. Notably, leaf denaturation was only a moderate phenotype, and the root system remained mainly intact. On the other hand, the GV3101 inoculation led to zero tumor formation and mild physiological stress, with a large number of healthy leaves and the preservation of taproots, secondary, and tertiary root systems.

The Mixed inoculations of wild-type and GV3101 gave the most dramatic results overall. Tumor formation was negligible or absent altogether compared to inoculations with only the wild-type strain, indicating that oncogenic activity was suppressed. This was characterized by high levels of necrosis, inhibited crown gall formation, and foliar symptoms typical of GV3101 infections (leaf curling and leaf size reduction). Attempts to suppress oncogenic activity resulted in physiological stress, evidenced by leaf denaturation, fewer leaves, and destroyed or missing taproots in plants exposed to the mixed treatment. There were also the most denatured leaves for this group, when analyzed quantitatively. Control plants that were inoculated with LB medium had no tumors and only displayed background stress that was likely induced by the environment.

CONCLUSION

This study shows that GV3101 can in vivo suppress tumors formed by wild-type Agrobacterium tumefaciens, which supports the hypothesis that biological competition can disrupt tumorigenic signaling pathways. The physiological stress experienced in GV3101-treated hosts was correlated with anatomical damage and hormone disruption. The impact of a biological balancing act between two or more signalling pathways manifests a cellular physiological tradeoff as competition or cooperation between the pathways. In vitro assays were compromised by contamination, but in vivo assays clearly indicated that competitive interference plays a role in tumorigenesis. Finally, this model reflects the complex dynamics of tumor suppression and the need to assess systemic health alongside tumor inhibition in studies of biological competition.



Images created in Bio Render, 2026

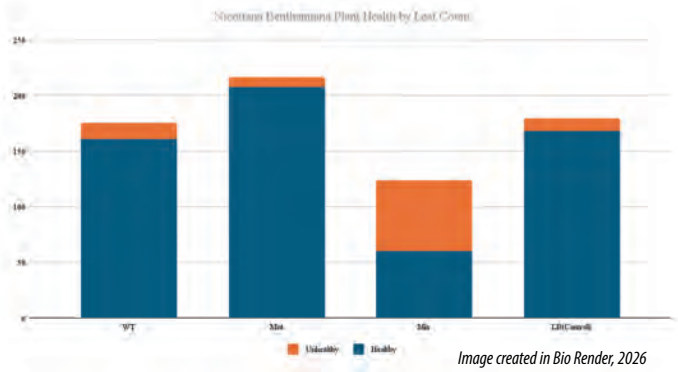


Image created in Bio Render, 2026

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Understanding Hormone Absorption in Plant Leaves in Aquatic vs Terrestrial Environments to Enhance Climate-Resilient Plant Growth

Isabella Martinez, Madelin Mott, & Rachael Pan, Grade 9, JV LISEF

INTRODUCTION

Plants are essential to ecosystems, providing oxygen and regulating environmental conditions. Their growth is controlled by hormones such as auxins, cytokinins, and gibberellins, which regulate cell elongation, division, and differentiation. This study will examine how varying concentrations of these hormones affect growth in the aquatic plant *Elodea* and terrestrial radish seeds, comparing responses across environments and nutrient absorption methods.

RATIONALE

The objective is to determine how hormone type and the environment of plants influence plant growth and oxygen output, and whether different nutrient absorption methods impact this relationship. Understanding these effects could improve the current knowledge of plant physiology and assist with ecosystem restoration strategies that rely on maximizing plant growth.

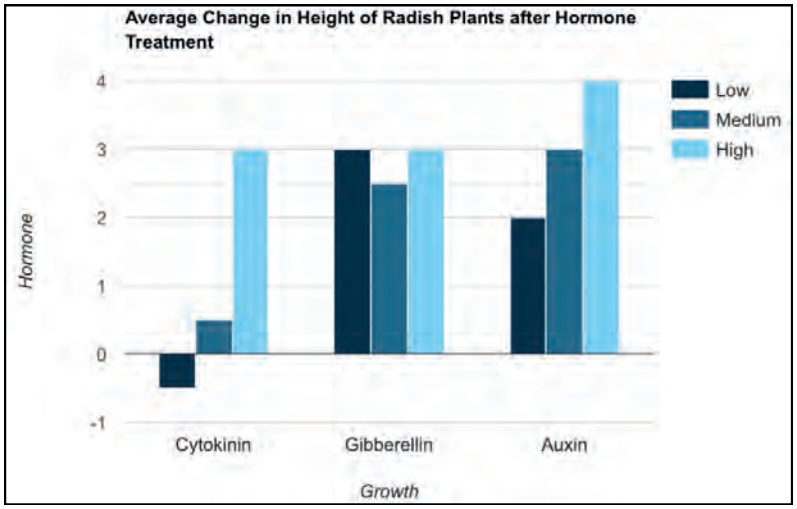
RESULTS

The aquatic plant *Elodea* had varying effects for each hormone for example for axin and giberellin we had good results with a lot of growth from both although gibberellin only had significant growth at its highest concentration. While using the hormone cytokines our plants plummeted and all died causing it to be the least effective hormone out of the three.

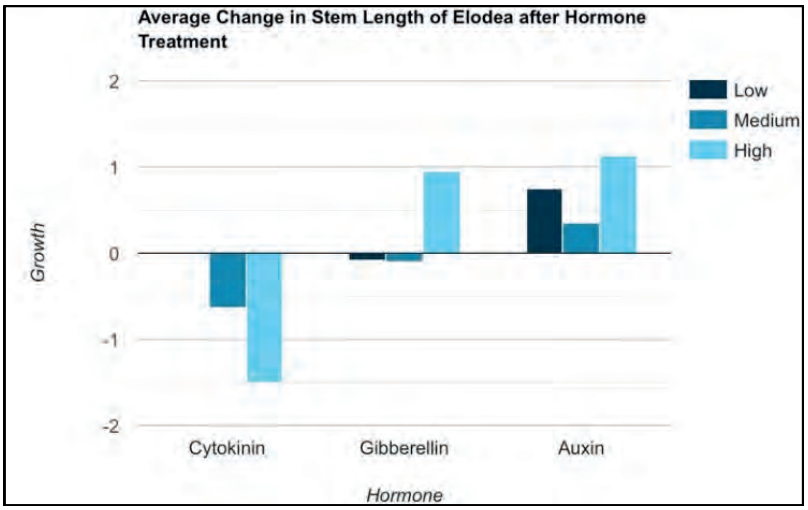
The terrestrial plants were measured every other day over the course of 2 weeks. After tracking all the data our group noticed, the terrestrial plants performed well with the high concentrations of each hormone. The high concentrations provided consistent high growth among all the plants. However, our team observed that Auxin helped the plants grow the best. Cytokinin grew more horizontally and bushy, which led to small growth.

CONCLUSION

The results of this study show that auxin and gibberellin promoted cell elongation in both aquatic and terrestrial systems. Cytokinin was shown to be effective only at high concentrations in radish plants, but toxic to *Elodea* in all tested concentrations. This difference in results is likely due to differences in absorption methods. Spraying leaves limited absorption in radish plants, while full submersion allowed for continuous absorption in *Elodea*. These findings highlight the importance of considering hormone type, concentration, exposure method, and plant species when applying plant hormones in ecological or agricultural contexts.



Graphs generated in Rapid tables by student researchers, 2026



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Improving Enteral Tube Care: Testing Methods to Clear Nutritional Formula Blockages Against a Novel Approach

Anthony Yu & Aleena Zaidi, Grade 11, LISEF Honorable Mention

INTRODUCTION

J-tubes are enteral feeding tubes that are placed in a patient who is unable to orally ingest nutrients. These specific tubes are inserted into the jejunum, which is a part of the small intestine. This project will investigate the implementation and effectiveness of several outpatient techniques including enzymatic methods and a novel pressure-based method that will focus on being accessible and cost-effective.

RATIONALE

A common problem patients receiving nutrition through jejunostomy enteral feeding tubes, or J-tubes, face is the occlusion of their tubes due to a buildup of feeding formula and crushed medication. As a result, many tubes that get occluded by medications and feed are unable to administer nutrition properly and require interventional radiology to clear these occlusions. This project will investigate the implementation and effectiveness of several outpatient techniques including enzymatic methods and a novel pressure-based method that will focus on being accessible and cost-effective. It is also important to note that patients may also face the additional challenge of being on a fluid restricted diet if they face diseases such as chronic kidney disease (CKD). A common issue with the use of these enteral feeding tubes is their tendency to clog if not flushed properly with water after every feeding. It is found that approximately between 12.5-40% of feeding tubes can get clogged over their lifespans

A 30ml clogging slurry consisting of tube feed; the contents of one capsule of omeprazole, crushed to a fine powder; and 1.5g of potassium chloride were placed into a 12 french size j tube. This was left to dry in an incubator. Five methods were tested. Warm water flushing, carbonated water, meat tenderizer, our novel pressure method and Clog Zapper were used, the later being a commercially available enzymatic solution. To determine the effectiveness of each method the flow rate was measured to see the rate at which 200 mL of water flowed out though the treated unclogged tube into a collection beaker. Our novel method consisted of a triple luer lock stop cock with two female ends and one male end was used to attach the components of the device with a 10 mL syringe attached to one female luer side. A vessel dilator of size 8 Fr was used to maintain a secured fit into the opening of the clogged J-tube, attached to the other female luer side. An aneroid manometer attached to the luer lock through the insertion of a luer barb between the male luer side of the triple luer lock stop cockand the aneroid manometer.

CONCLUSION

The findings from this experiment can lead to the emergence of a widely used method of unclogging J-tubes for both outpatient and inpatient situations, ultimately improving enteral tube patient care. The other conventional methods of unclogging did not have as successful of a flow rate at the Novel Pressure Method's flow rate, which was most similar to the flow rate of the control tube.

RESULTS

Out of all the unclogging methods, the warm water, seltzer flushing, and meat tenderizer did not unclog any tubes in their respected group. Though Clog Zapper was limited to 2 tubes per trial instead of the usual 4, the clog zapper provided a 50% chance of unclogging with each one in each trial providing a flow rate of 0.77 mL/sec and .38 mL/sec respectively. For the novel pressure method, out of all 8 tubes, all 8 unclogged and they provided the highest flow rates. To measure whether differences in unclogged flow rate are due to the treatment used, the trial in which the test was run, or a combination of both, a two way Analysis of Variance (ANOVA) test was run. We found that the novel pressure method restored flow to a level comparable to the untreated baseline. The effectiveness of our method can be attributed to Bernoulli's principle from the snug fit ensured from the vessel dilator, and the high pressure generated by the small syringe.

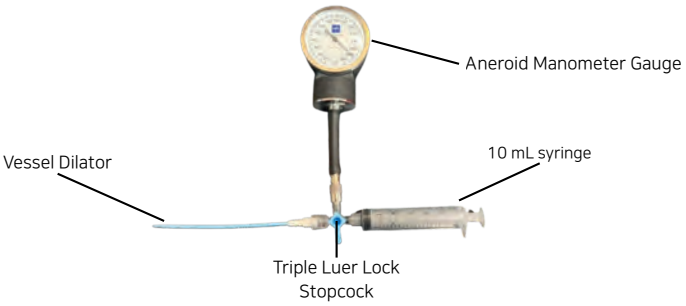

Figure 3: The setup of the triple luer lock stop cock pressure system. Photo taken by student researcher, 2026.

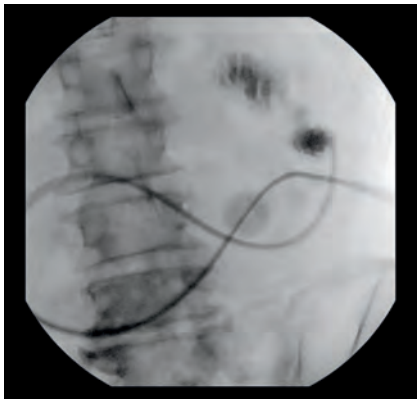

Figure 1: Procedural insertion and replacement of a J-tube placed into patient's abdomen, attached to his jejunum.
Image provided by Dr. Putterman, Northwell Health 2026.

Figure 2: The clogged J tubes placed in the incubator, vertically oriented. Photo taken by student researcher, 2026

Full Research Paper Scan here

Comparison of Fascicular Network Topology in Paired Human Cervical and Thoracic Vagus Nerves via Morphometric Micro-CT Analysis

Sarah Khan, Grade 10, JV LISEF Third Place, SAAWA

INTRODUCTION

Vagus nerve stimulation (VNS) is an established neuromodulation therapy used to treat disorders such as epilepsy, depression, and inflammatory conditions. However, treatment outcomes and side effects vary because the human vagus nerve contains a complex and non-uniform internal fascicular structure. Fascicles are bundles of axons that carry signals between the brain and major organs such as the heart, lungs, and digestive tract. Since electrode performance depends on the anatomy surrounding the nerve, understanding regional and left-right structural variation is important for improving stimulation selectivity and reducing off-target effects.

RATIONALE

Most current VNS devices stimulate the cervical vagus nerve without accounting for differences in fascicle arrangement along the nerve or between the left and right sides. This study aimed to quantify regional (Regions 1–4) and lateral (Left vs Right) differences in paired human vagus nerves using micro-CT reconstructions and a standardized computational analysis pipeline. Metrics analyzed included fascicle count (fc), total fascicular area (TFA, mm²), and equivalent nerve diameter (END, µm). By identifying where structural differences are greatest, this research can help guide anatomy-aware electrode placement and future selective VNS device design.

Figure 1. Micro-CT scan of a human vagus nerve sample showing internal fascicular structures. Cadaver B822 C2L-C7L in 3D slicer

RESULTS

The analyzable dataset included 18 donors with complete matched nerve reconstructions and centerline files. Results showed clear longitudinal variation across Regions 1–4. Region 4 was the most structurally distinct, demonstrating lower fascicle count, reduced total fascicular area, and smaller nerve caliber compared with Regions 1–3. Equivalent nerve diameter steadily decreased across regions on both sides, indicating strong region dependence of nerve size.

Laterality differences were region-specific rather than global. Region 4 showed the strongest asymmetry, where the right vagus nerve had significantly greater fascicle count and larger nerve diameter than the left. Mean fascicle count in Region 4 was 11.28 on the left vs 16.10 on the right (paired $p = 0.0097$, Bonferroni $p = 0.0389$). Mean equivalent nerve diameter was 2544 µm on the left vs 2803 µm on the right (paired $p = 0.0016$, Bonferroni $p = 0.0064$). Total fascicular area in Region 4 was also lower on the left (1.44 mm²) compared with the right (2.07 mm²). Regions 1–3 did not show significant left-right differences after correction.

CONCLUSION

This study demonstrated that human vagus nerve morphology varies significantly by longitudinal region and, in some areas, between left and right sides. Region 4 showed the greatest structural differences, suggesting that vagus nerve asymmetry is localized rather than uniform throughout the nerve. These findings are important because electrode placement and stimulation parameters may behave differently depending on anatomical location, which can contribute to variability in clinical outcomes. Understanding fascicular organization provides a foundation for developing more precise, anatomy-guided VNS therapies that can better target specific neural pathways while minimizing unintended side effects. In the future, integrating morphometric data with computational modeling of electrical stimulation and expanding the dataset to include more donors could further improve the accuracy and clinical relevance of these findings.

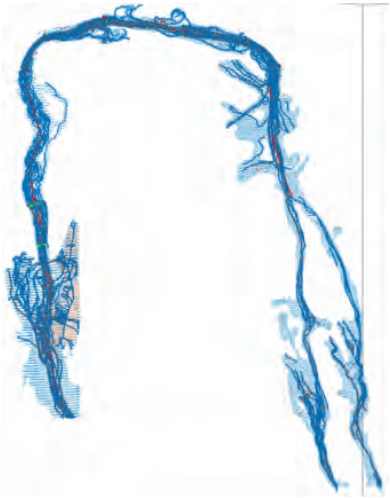

Figure 2. Image showcasing xml file of the entire cervical and thoracic portion of one side of a nerve

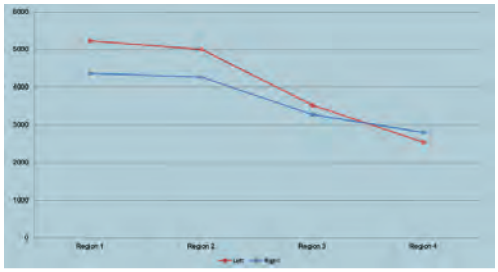

Figure 4. Distribution of fascicle diameter and cross-sectional area obtained from morphometric analysis. Equivalent nerve diameter (END, µm) by region for left and right sides.

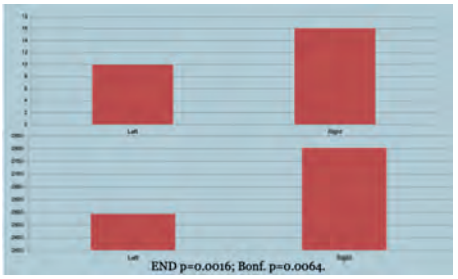

Figure 5. Comparison of morphometric measurements between left and right vagus nerves.

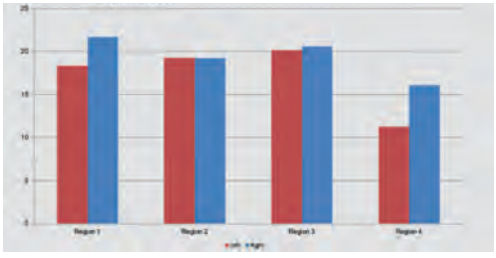

Figure 6. Mean fascicle count (fc) by region for left and right vagus nerves.

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Inverse Designed Metaresonators with Localized Fields for Mid-Wave Infrared Spatial Light Modulators

Julang Wang, Grade 12, Regeneron Science Talent Search Top 300 Scholar, LISEF

INTRODUCTION

Spatial light modulators (SLMs) are essential tools for controlling light in applications such as LiDAR, holography, and biomedical imaging. However, current phase-only transmissive SLMs are largely limited to visible and near-infrared wavelengths because commonly used liquid crystal materials exhibit high absorption in the mid-wave infrared (MWIR) range. Additionally, traditional designs require thick material layers, which lead to pixel crosstalk and reduced spatial resolution. To address these challenges, this study explores metasurface-based SLMs using phase-change materials, specifically Sb_2Se_3, to enable efficient and compact MWIR light modulation.

RATIONALE

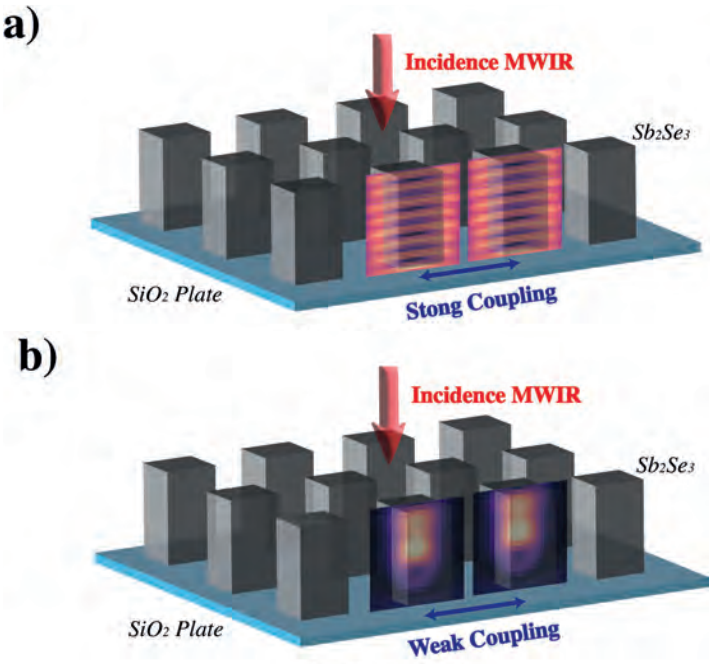
Despite the importance of MWIR in imaging and sensing applications, existing SLM technologies are ineffective due to optical loss and limited resolution. There is a need for a low-loss material platform that can achieve strong phase modulation while minimizing pixel interference. This research addresses that gap by using Sb_2Se_3, a low-loss phase-change material, and by applying inverse design techniques to create metasurfaces with highly localized optical fields. By reducing mode area and crosstalk, this work aims to improve the performance and scalability of MWIR SLMs.

RESULTS

The study first demonstrated a resonant metasurface using Sb_2Se_3 on a silica substrate, showing high transmission and tunable resonance in the MWIR range. Experimental measurements confirmed resonance behavior with a quality factor of approximately 50. However, the initial design exhibited extended optical modes and limited phase shift (~π), leading to strong coupling between adjacent pixels. To overcome this, inverse design optimization was applied, producing a metasurface with a significantly reduced effective mode area (~0.128 μm², about 1/50 of the wavelength squared) and minimal edge intensity (<5% of total). These results indicate improved localization of the optical field and reduced crosstalk.

CONCLUSION

This research demonstrates a viable approach to developing high-performance MWIR spatial light modulators using Sb_2Se_3 metasurfaces. By combining low-loss materials with inverse design techniques, the study achieves compact devices with enhanced spatial resolution and reduced pixel interference. The findings represent an important step toward practical phase-only transmissive MWIR SLMs, with potential applications in biomedical sensing, imaging, and compressive sensing technologies.



*figures not drawn to scale

Schematic drawings for a regular metasurface and an improved metasurface design with localized optical modes. a) a regular metasurface. b) designed metasurface hosting a localized resonance with only weak coupling effects. © Graph created by the student researcher using Adobe Illustrator, 2025.

Optical microscope images of fabricated metasurfaces with a size reference scare of 50 microns. © Graph created by the student researcher using Adobe Illustrator, 2025. Image collected using optical microscopes and SEMs in MIT. Nano.

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Quantum Algorithms for Band Structure Calculations of Quantum Materials

Weining Wang, Grade 11, LISEF

INTRODUCTION

In quantum systems, physical quantities such as energy levels are described by a Hamiltonian in matrix form. However, the size of Hamiltonians grows exponentially with the number of particles or orbitals, making classical calculation methods expensive. Quantum computing offers a powerful tool for solving complex problems that classical computers struggle with. Quantum Phase Estimation (QPE) is a quantum algorithm that can determine the eigenvalues of a unitary matrix, which enables efficient calculation of Hamiltonians in complex quantum systems. In this project, based on the IBM quantum computing platform Qiskit, we investigate the QPE algorithm as a method for solving energy eigenvalues of Hamiltonians in solid state materials.

RATIONALE

Graphene, a two-dimensional honeycomb lattice of carbon atoms, serves as the ideal benchmark object. Its unique electronic properties can be described elegantly by a tight-binding model, which facilitates a direct mapping onto a unitary transform in the QPE circuit. Furthermore, graphene serves as the "mother of all graphitic materials," a fundamental building block that can be extended to multiple dimensions, including zero-dimensional buckyballs and three-dimensional multi-layer graphene. Finally, the existence of an exact analytical solution and direct measurement by angle-resolved photoemission spectroscopy (ARPES) provides rigorous cross-validation to quantify the fidelity and noise-constraints of current quantum hardware.

RESULTS

Simulations executed on the IBM quantum processor ibm_fez suggest that increasing the counting qubits is the primary driver for reducing simulation error. The Root Mean Square Error (RMSE) drops from approximately 0.8208 eV at 3 qubits to 0.0781 eV at 8 qubits under 2 Trotter steps. However, a fundamental trade-off exists where the accumulation of noise-induced errors eventually outweighs theoretical precision gains. For example, at 10 qubits, increasing Trotter steps from 2 to 10 leads to a sharp rise in RMSE from 0.0849 eV to 0.5789 eV. The optimized simulation achieved a Mean Absolute Error (MAE) of 0.02731 eV, which represents approximately 63% of the conventional chemical accuracy threshold (1 kcal/mol ≈ 0.043 eV).

CONCLUSION

This research successfully demonstrates the implementation of the QPE algorithm to resolve the electronic band structure of solid-state materials. Our optimized simulation achieved results within the standard threshold of chemical accuracy and exhibited strong consistency with both analytical models and experimental ARPES results. These findings validate the feasibility of employing NISQ-era hardware for high-fidelity material simulation. Future exploration includes scaling to multilayer systems and the investigation of magic-angle twisted bilayer graphene (TBG), where high-resolution phase estimation could provide critical insights into unique flat-band physics and emergent topological properties.

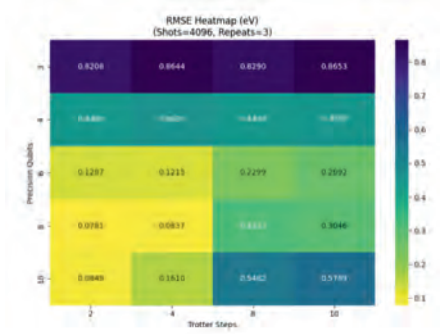

FIG 1: RMSE heatmap over different parameters

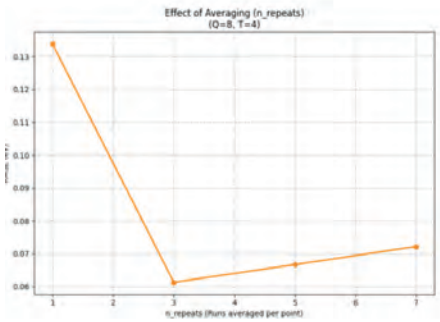

FIG 3: Effect of experimental iterations

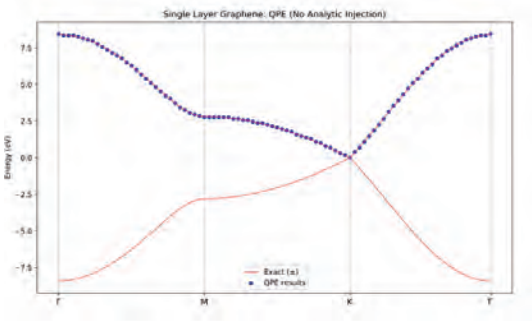

FIG 4: QPE-calculated energy band of monolayer graphene

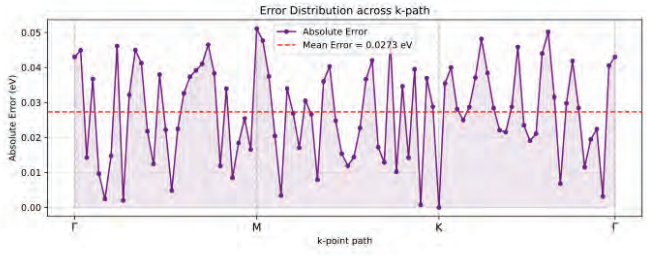

FIG 2: Simulation Slope against ARPES Data Achieved a Mean Absolute Error of 0.0273 eV, significantly surpassing the 0.043 eV threshold required for chemical accuracy

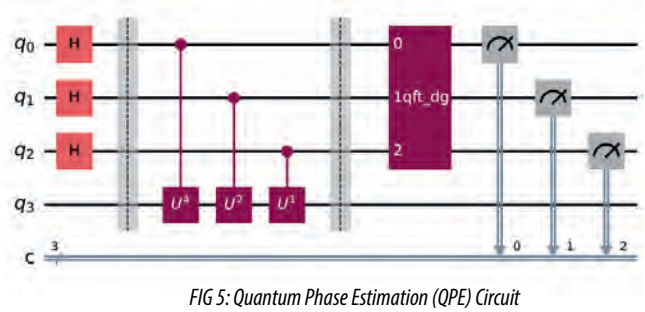

FIG 5: Quantum Phase Estimation (QPE) Circuit

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Assessing Maintenance Impacts on Urban Water Reservoirs by Comparing Bacterial Composition

Lisali Peiris, Grade 11, JV LISEF

INTRODUCTION

As collection water bodies for landscaping, urban and suburban reservoirs are an interface between human activity and the natural environment. Microbial communities including viruses, prokaryotes (bacteria and archaea) and microeukaryotes (protists, micro-animals) establish complex relationships. These interdependencies influence water quality, disease dynamics and biogeochemical cycles, providing stability to such environments.

RATIONALE

The goal of this study was to study prokaryote community composition in two suburban reservoirs, TP and SG. We predicted that TP would have a higher prokaryotic abundance than SG, because SG is periodically cleaned and would have interrupted growth cycles. We also predicted that TP would have a higher prokaryote diversity than SG, due to a larger diversity in macro species (turtles and fish) in TP than in SG, indicating that TP is a more complex ecosystem. This study will ultimately provide crucial information as to how human intervention through maintenance practices can alter the bacterial communities of urban reservoirs.

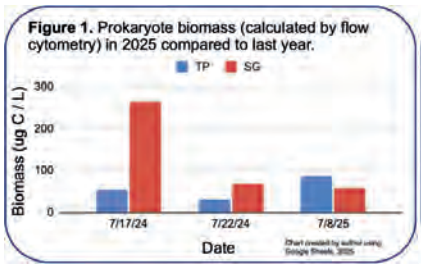
RESULTS

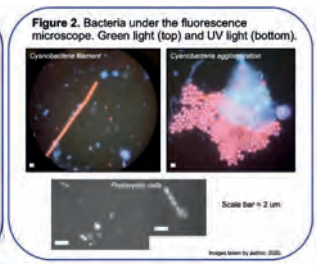
Hypothesis 1 was supported by higher biomass values in TP than SG in 2025 (Fig. 1). The lower values for 2024 samples suggest that SG may have been cleaned between sampling dates.

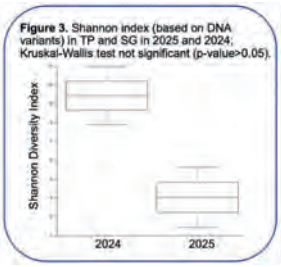
The much higher values in SG during one 2024 date may be due to a lack of recent cleaning at the time of sampling. Biomass in 2025 included both cyanobacteria, which are photosynthetic, and heterotrophic prokaryotes (Fig. 2). Hypothesis 2 was partially supported by higher Shannon Diversity Index values in TP (4.35) than SG (3.76) in 2024, but not in 2025 (Fig. 3). This year, TP (1.48) had a significantly lower value than SG (4.85). The prokaryote community composition differed between reservoirs, and especially versus the estuary, in part due to the much lower salinity values in freshwater versus brackish waters (Fig. 4). SG had a very similar prokaryote composition in 2022 and 2025 (Fig. 5), suggesting that the two samples were taken a similar amount of time after clean up (secondary succession). The increased cyanobacteria composition in TP-2025 may indicate an environmental shift that benefits cyanobacterial growth such as increased nutrient availability (Fig. 5).

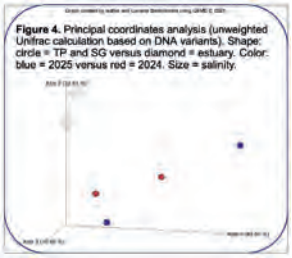
CONCLUSION

The final data provides insight into how maintenance practices can alter microbial community structure in urban water systems. Understanding these impacts can inform improved pond management strategies and contribute to broader efforts to assess ecosystem health using microbial indicators.









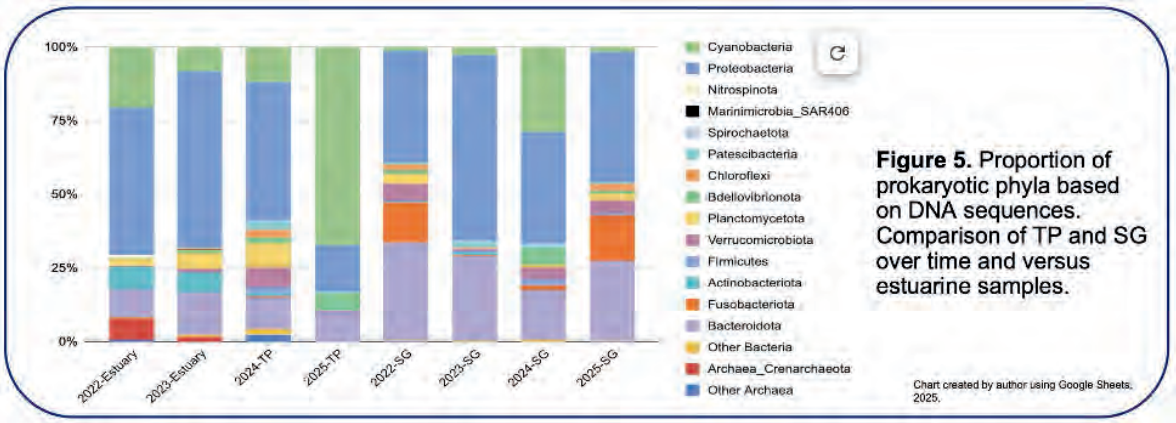


Figure 5. Proportion of prokaryotic phyla based on DNA sequences. Comparison of TP and SG over time and versus estuarine samples.

Full Research Paper Scan here

Determining Quantities of Microplastics in 22 Home Tap Water Samples Throughout Long Island and New York City

Christina Yin, Jaya Gambhir, & Olivia Hang, Grade 9, JV LISEF Honorable Mention

INTRODUCTION

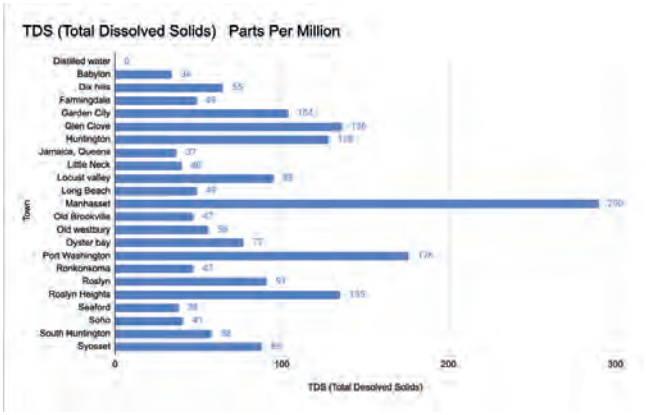
Microplastics, which are synthetic polymers measuring less than 5mm in diameter, are increasingly being found in the drinking water supplies of countries around the world. This has raised significant and pressing concerns with regards to the long-term effects of microplastic ingestion on the stability of the environment and the health of the world's population. Unlike organic materials, microplastics are not biodegradable and thus cannot break down into smaller particles. Instead, they degrade into nanoplastics and enter the bloodstream of the human body and even the blood-brain barrier. This study aims to determine the level of microplastic contamination in the drinking water of 20 towns on Long Island and 2 towns in New York City. This study aims to determine the level of contamination in the drinking water of various towns and thus establish the level of influence of infrastructure on the quality of drinking water.

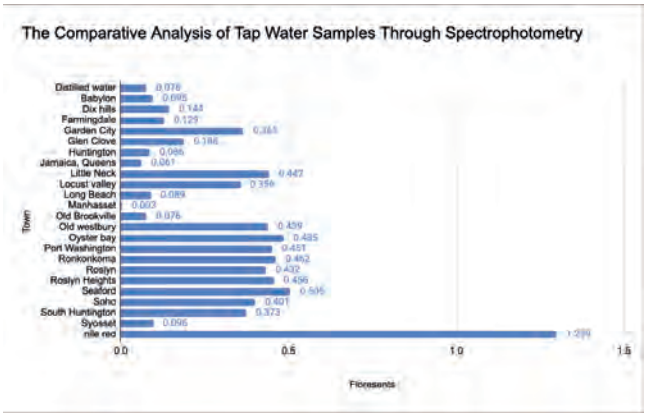
RATIONALE

The purpose of the research was to determine the level of risk of microplastic ingestion in the drinking water of the New York metropolitan area. This study hypothesizes that microplastics are present in the drinking water of every town on Long Island and in New York City but at different levels depending on the infrastructure and level of maintenance of the infrastructure of the town. This study provides the necessary statistics to advocate for the development of improved water treatment systems and the development of future systems designed to prevent the accumulation of microplastics in the human body.

RESULTS

The morphometric and quantitative analysis carried out on 22 water samples revealed a universal presence of microplastics, along with a certain degree of structural heterogeneity among them, depending on the town from which they were collected. The results were obtained through three different types of analysis:

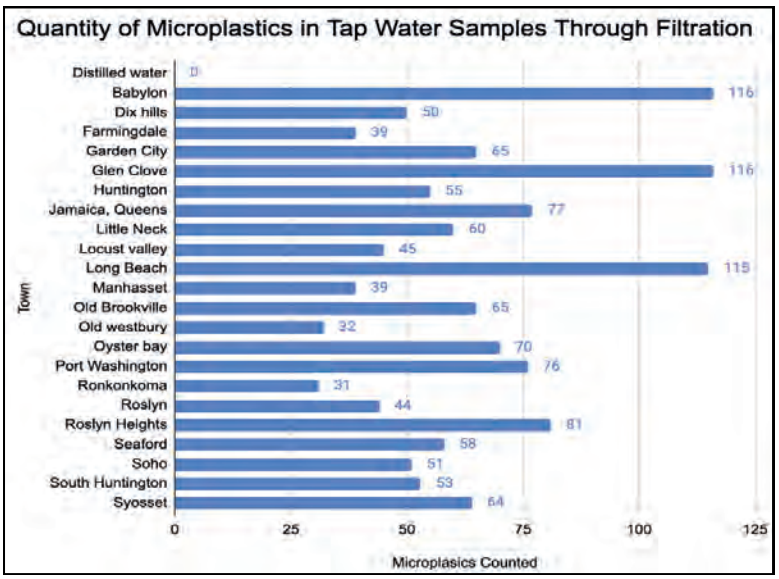




Visual Quantification (Filtration): The samples were first stained with Nile Red, filtered through fine paper, and then manually counted under UV light to detect the glowing microplastic particles. The results revealed a large degree of contamination, with Babylon and Glen Cove showing a maximum count of 115 particles per sample, while Ronkonkoma had the minimum count, i.e., 31 particles per sample. Similarly, Farmingdale and Garden City also showed a maximum count, i.e., 98 and 93 particles, respectively.
Total Dissolved Solids (TDS) Analysis: This analysis was carried out by measuring TDS in parts per million (ppm), representing a quantitative value for the overall concentration present in the water samples. Manhasset recorded a maximum TDS, i.e., 350 ppm, while Jamaica, Queens, had a minimum TDS, i.e., less than 50 ppm, compared to other Long Island towns, most of which fell under the 100-250 ppm bracket.
Spectrophotometer Comparative Analysis: This technical analysis compared the intensity of fluorescence among different samples, obtained after staining them with Nile Red and measuring them through different wavelengths. This analysis revealed a maximum intensity of fluorescence, i.e., a higher concentration of synthetic polymers, in Long Beach, followed by Syosset, while Oyster Bay and Seaford also recorded a higher concentration, compared to other Long Island towns, with Little Neck recording a minimum intensity.

CONCLUSION

This study offers an exhaustive characterization of the occurrence of microplastics in local tap water, indicating that the problem is endemic in the Long Island and NYC regions. The results show that the geographic location and local water system have a significant effect on the amount of synthetic material being ingested by the local populace. The results show that the local town's morphology is an important factor in the purity of the water, indicating that the current standards are inadequate and need to be re-evaluated. The results can be used to create high-precision methods to filter the water, effectively removing the microplastics while minimizing the health hazards associated with the ingestion of the material.



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Early Failure Prediction in Hydraulic Systems using Long-Short Term Memory networks and Multisensor Time-Series Data

Aidan Lee, Grade 11, JV LISEF Third Place

INTRODUCTION

Hydraulic piston pumps are critical for maintaining system pressure in industrial and mobile machinery. Failures in these pumps can lead to severe operational disruptions, increased maintenance costs, and even safety hazards in high-pressure applications. Cavitation-induced valve plate failures can develop gradually, reducing efficiency and causing costly downtime or safety risks. Early detection of these faults is therefore crucial for proactive maintenance. Modern hydraulic systems generate rich sensor data, including leak-line pressure, output flow, and oil temperature, but the relationships between these signals and early cavitation damage are complex and often nonlinear. Traditional threshold-based monitoring methods often fail to detect subtle precursor patterns before significant damage occurs. Machine learning provides a way to identify subtle patterns and distinguish between normal operation and emerging faults. This study builds on the experimental dataset from Rojek et al., containing sensor measurements from a piston pump under healthy and cavitation-damaged conditions. We compare non-sequential models with engineered lagged features to sequence-based models that explicitly capture temporal dependencies, evaluating performance on validation and unseen failure test sets. By incorporating interpretable methods such as SHAP for feature attribution, this work also emphasizes actionable insights for engineers, bridging the gap between predictive accuracy and practical utility. Feature attribution and statistical testing are used to ensure interpretability and robustness, aiming to support early fault detection and predictive maintenance in hydraulic systems.

RATIONALE

This study aims to improve early fault detection in hydraulic piston pumps by leveraging machine learning techniques capable of analyzing complex, nonlinear relationships in multisensor time-series data. Traditional monitoring approaches often rely on fixed thresholds and may fail to detect subtle early-stage cavitation patterns. By comparing non-sequential models with sequence-based approaches, particularly Long Short-Term Memory (LSTM) networks, this research investigates whether explicitly modeling temporal dependencies can enhance predictive performance. Additionally, interpretability methods such as SHAP are used to ensure that model predictions align with known physical behavior, supporting practical implementation in engineering systems.

(a) HPU model with tested pump

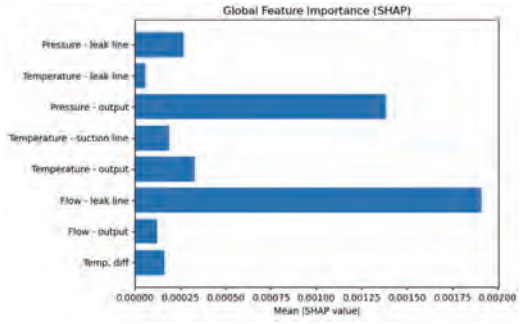
(b) Hydraulic motor and electric motor - adjustable load for the tested pump

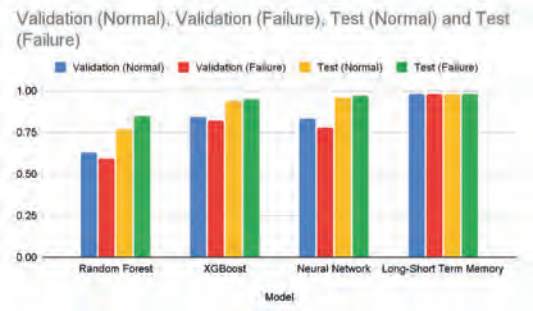
RESULTS

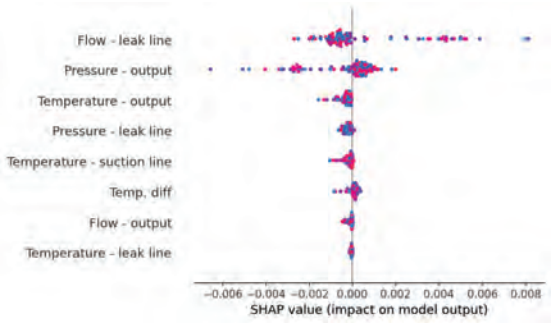
The results show that sequence-based models significantly outperform traditional machine learning approaches in detecting cavitation-related failures. While models such as Random Forest and XGBoost demonstrated signs of overfitting and limited generalization, the neural network and LSTM models achieved stronger performance on unseen test data. The LSTM model performed best overall, achieving near-perfect classification accuracy and consistently high F1-scores across both validation and test sets. These findings highlight the importance of capturing temporal dependencies in time-series sensor data for accurate fault detection.

CONCLUSION

This study demonstrates that sequence-based machine learning models, particularly LSTM networks, are highly effective for early detection of cavitation-induced failures in hydraulic piston pumps. By leveraging time-series sensor data, the model can identify failure patterns before severe damage occurs. With further validation on real-world systems, this approach could support predictive maintenance strategies, helping engineers reduce downtime, improve system reliability, and optimize monitoring of critical hydraulic components.







Full Research Paper
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Prediction of North Atlantic Basin Tropical Cyclones using Machine Learning and Statistical Analysis

Eric Ha, Jeremy Ross, Kimi Zhang, Grade 10, JV LISEF

INTRODUCTION

The Atlantic hurricane season is a period of time from between June and November in which an average of 14 tropical cyclones are most likely to occur in the North Atlantic Ocean. Due to the threat of these storms, weather prediction and forecasting have become crucial during these summer and fall months. In the modern era, these forecasts are usually made with Numerical Weather Prediction models. However, these forecasts aren't always accurate despite technological advances in recent years. There may be alternative methods that could theoretically complement this approach, to make prediction of hurricanes more consistent. Numerical Weather Prediction (NWP) historically uses mathematical models of ongoing conditions in the atmosphere and ocean to predict the weather. Even with new technological advancements, NWPs still aren't entirely precise, having a number of errors made by models over the past few years. A National Hurricane Center report on the 2024 season notes the message "Mean official intensity errors for the Atlantic basin in 2024 were higher than the previous 5-yr means from 12 to 96 h… Decay-SHIFOR errors in 2024 were significantly higher than their 5-yr means." In recent years, multiple large and destructive category 5 hurricanes were underpredicted by NWPs.

RATIONALE

A new program based on pattern recognition could be used to complement this. Information on around 400 tropical cyclones in the past 50 years from the NHC (National Hurricane Center) databases are put into a machine learning algorithm. The algorithm known as a Logistic Regression is a part of a python program that will preprocess the data before it's fed into the machine learning algorithm. Logistic regression has advantages for interpretability and can avoid overfitting due to limited dataset size. A key part of the preprocessing is the proportional stratification of the training and testing data, which is used to prevent bias within the model. The data consists of two types of variables: independent or predictor variables and dependent or target variables. Predictor variables such as SST (average sea surface temperature), wind shear, and humidity is used to predict target variables wind speed and time at each level of intensity using the logistic regression model.

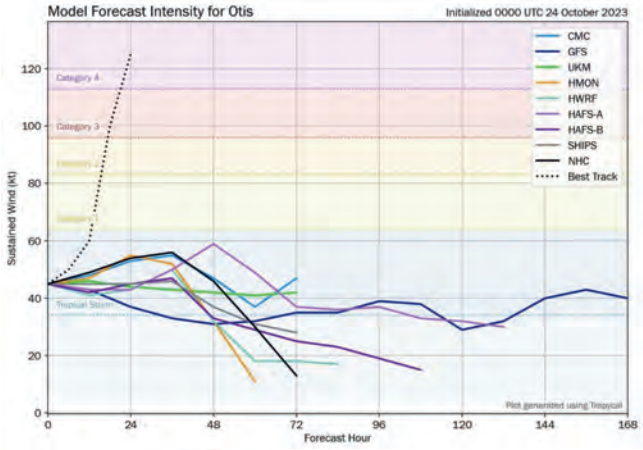
```
train_dataset = HurricaneDataset(train_texts, train_labels, tokenizer)
val_dataset = HurricaneDataset(val_texts, val_labels, tokenizer)

train_loader = DataLoader(train_dataset, batch_size=4, shuffle=True)
val_loader = DataLoader(val_dataset, batch_size=4)

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
print(f"⚡ Using device: {device}")

model = HurricaneBERT(num_labels=len(cat_encoder.classes_)).to(device)

optimizer = AdamW(model.parameters(), lr=2e-5)
num_training_steps = len(train_loader) * 15  # 15 epochs
```

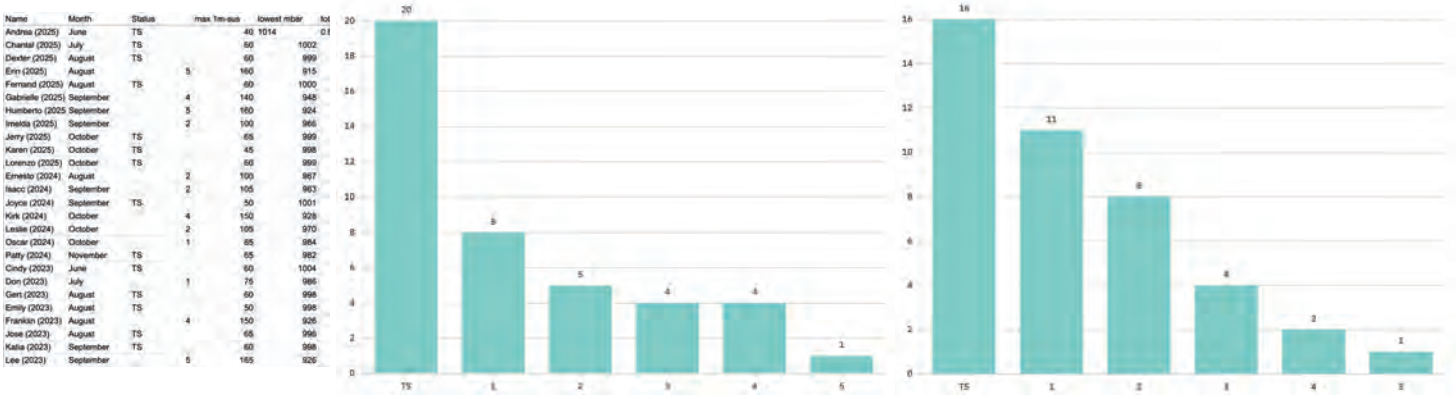
RESULTS

After testing, it was found that the model was able to accurately predict the category of the storm around 70% of the time, giving an interval of peak wind speeds as given from the Saffir-Simpson scale. Some observations made include that the model was stronger at analyzing weaker tropical storm strength cyclones, errors tended to be overestimations in strength rather than underestimations, and errors mostly differed by only one category.While differing from official model's 80% success rate, these findings still suggest that data driven approaches can forecast tropical cyclones.
While not intended to replace physics-based forecasting models, this machine learning framework shows potential as a supplementary analytical tool that may enhance forecasts made by NWPs.

CONCLUSION

This study examined whether a machine-learning model trained on North Atlantic storm data could generate reliable peak intensity classifications and provide complementary insight to numerical weather prediction (NWP) systems. The model achieved a 70% overall accuracy and correctly predicted all storms within one intensity category of their observed values. While differing from official model's 80% success rate, these findings still suggest that data driven approaches can forecast tropical cyclones.
While not intended to replace physics-based forecasting models, this machine learning framework shows potential as a supplementary analytical tool that may enhance forecasts made by NWPs.





Full Research Paper
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Effects of Gas Fee Shocks on User Activity for Solana, Ethereum, and Arbitrum Blockchains Over Hourly Intervals

Kyle Chen, Grade 10, JV LISEF

INTRODUCTION

Blockchains utilize transaction fees (gas) to regulate network congestion and allocate block space. Sudden spikes in these fees, known as gas fee shocks, create an unpredictable environment that can discourage participation and reduce economic activity. This study evaluates the short term elasticity of blockchain user activity in response to extreme congestion. By analyzing three structurally distinct networks (Ethereum, Arbitrum, and Solana), this research serves as a resilience test, revealing how different fee mechanisms, architectural frameworks, and user demographics maintain stability under stress.

RATIONALE

Quantifying transaction elasticity provides essential data for several stakeholders across the ecosystem. It allows blockchain engineers to design more resilient architectures, helps application developers optimize transaction scheduling algorithms during volatility, and provides investors with metrics to gauge a network's long term economic performance. Previous research primarily utilized daily data, which obscures immediate user responses to sudden congestion. To capture these abrupt behavioral changes, this study recorded hourly data over five distinct 180 day periods. Local Projection regressions were employed to calculate Impulse Response Functions (IRFs), measuring the precise impact of gas shocks on total transactions, successful transactions, and aggregate gas usage over a 1 to 24 hour horizon.

RESULTS

A consistent trend emerged across all observed networks: the impulse response for successful transactions remained consistently higher (less negative) than for total transactions. Sudden fee spikes act as an economic filter, rapidly pricing out low margin spam and failing high frequency bots, which temporarily improves the overall ratio of successful executions.

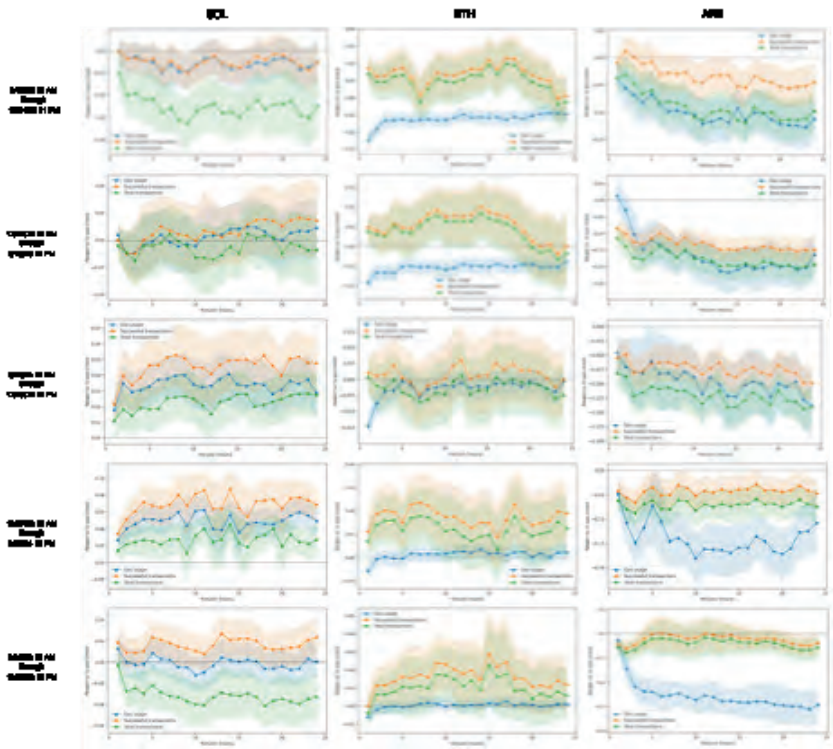
Beyond this shared baseline, user responses diverged based on network architecture. Ethereum demonstrated a unique compositional shift. Overall gas usage contracted as price sensitive users deferred complex, gas heavy smart contract executions. At the same time, successful transaction counts drifted slightly upward as participants rushed to execute simple, economically urgent asset transfers to prevent liquidations.

Arbitrum displayed high price elasticity. Over the observed timeframes, sudden fee spikes caused its user base to delay successful on chain execution entirely, driving down both transaction counts and aggregate computational demand. This severe contraction indicates that users operating on Layer 2 scaling solutions remain highly price sensitive to sudden shifts in execution costs.

Solana's fee elasticity proved to be state dependent. Under normal market conditions, shocks caused total attempts to plummet as algorithmic trading bots halted operations, while successful volume remained uninterrupted. During periods of extreme retail meme coin speculation, speculative demand temporarily overrode normal price sensitivity, causing aggregate gas usage and transaction volume to increase simultaneously despite the fee premiums.

CONCLUSION

A blockchain's underlying architecture, baseline transaction costs, and resulting user demographic fundamentally dictate its economic elasticity during a gas fee shock. A global settlement layer like Ethereum filters out complex computations but sustains urgent asset transfers. Layer 2 scaling solutions like Arbitrum remain highly susceptible to delayed execution from price sensitive users. High throughput alternative chains like Solana exhibit dynamic elasticity heavily influenced by speculative market cycles and algorithmic bots. These findings emphasize that there is no universal user response to network congestion; a blockchain's resilience is strictly tied to the structural tradeoffs chosen by its architects.



DNA Barcoding Research Summary Introductions

Biology & Ecology

Full Research Paper
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DNA Barcoding Research is a course taught in partnership with the Cold Spring Harbor Laboratory DNA Learning Center. A DNA barcode is a unique pattern generated by a DNA sequence that can potentially identify species from diverse populations and habitats. In this yearlong, half-time course, teams collect organisms from local aquatic and forest habitats based on a research question they develop. They utilize DNA barcoding technology, including DNA extraction from collected specimens, PCR, gel electrophoresis, and bioinformatics data science to identify their specimens. The genetic sequences of their collected specimens are recorded under their names in GenBank, the National Institutes of Health (NIH) genetic sequence database of publicly available DNA sequences. Students in Advanced Barcoding use the more sophisticated tool of Metabarcoding. Metabarcoding is a process used to identify multiple species within a single sample such as soil, water or feces, and allows for more complex research questions than typical Barcoding analysis. All students participate in the Barcode Long Island project, and present their findings at a research symposium in June at the Cold Spring Harbor Laboratory. Given the timeline of the research as facilitated by the DNA Learning Center, students in the course could not have their full research summaries ready for the printing deadline for this Research Journal. However, each group's Introduction sections are printed below, their final research posters are on display this evening, and the completed research summaries can be viewed by scanning the QR code above.

The Biodiversity of Invertebrates in the Beach Wrack of Oyster Bay and the Long Island Sound Beaches

Emma Slonim, Bridget Coviello, Sofia Polauf

Beach wrack is an important part of the ecosystem because it provides food and shelter for animals, helps beach plants grow, and builds natural barriers that protect the coast from storms and erosion. It's usually found along the high tide line on sandy or rocky beaches. Even though cleaning up pollution is important, removing beach wrack can actually harm the environment. In our project, we are studying beach wrack in two local areas: Oyster Bay and the Long Island Sound. Oyster Bay is smaller and more protected, with a mix of saltwater and freshwater that creates nutrient-rich habitats for many types of organisms. The Long Island Sound is bigger, deeper, and connected to the Atlantic Ocean, with stronger tides and currents that support different types of invertebrates. The salinity in the eastern Long Island Sound is about 35 parts per thousand, while Oyster Bay's salinity is lower, between 19.8 and 26.1 PSU. These differences in water movement, salt levels, and nutrients affect which insect species live in each area. By studying local beach wrack insect populations, we can learn more about their roles in the ecosystem and why it's important to protect biodiversity.

Using DNA Barcoding to Compare the Biodiversity of Flying vs. Ground-dwelling Insects at Bailey Arboretum, Youngs Farm, and Friends Academy's Forest School

Shane Morris, Ryan Kapoor, Andy Lu

Insects are crucial to the ecosystem; they act as pollinators, decomposers, and predators. Depending on how they interact with their environment, some insects stay on the ground longer, while others take off flying and move to different places. The latter are less limited in their distribution and may occur in many areas, whereas the former are more associated with the particular soil and plants of their habitat. The examination of both groups provides the necessary understanding of how movement and habitat determine the diversity of insects.

Due to the large number of insect species sharing similar visual traits, it is challenging to perform a reliable identification based solely on sight. One of the methods used for species identification is DNA barcoding, which is based on a short stretch of the genetic code known as the COI gene. In the present study, the comparison of airborne and ground insects on Long Island will be performed using the DNA barcoding technique in order to assess the differences in diversity and distribution of the two groups.

The Best Methods for Collecting a Biodiverse Range of Insects on Long Island.

Samuel Shorr, Zain Alkurdi, Edward Chen

Insects are by far the most populated branch of the animal kingdom on planet Earth; many studies estimate that there are around 10 quintillion insects alive at any given time (Smithsonian). Scientists have identified around 1 million species of insects, but it's estimated that the total number of insect species may be anywhere between 5.5 to 30 million. New York state has over 1,360 species of insects, a number which the Long Island area has certainly contributed a lot of species to (Insect Identification). In our project, we aim to identify the best method for catching and preserving insect specimens in the wild; once caught, we want to sequence their DNA to find out how effective different traps were at catching a diverse selection of insect species. It is important to note, however, that insects in this area get harder and harder to catch as the year progresses and temperatures get colder (University of Arizona). In addition, it's hard to catch a huge amount of different species of insects with just a few traps; many of them have different habitats, diets, activity patterns, and, most importantly, lifestyles; while at some cycle of their lives, most insects will develop and use wings, not all of them will, meaning our suspended jug traps will already have a bias towards winged insects. Upon completion, we will hopefully know which method of insect-trapping was the most effective at catching a wide, diverse range of insect species.

Determining Food Sources for Long Island Coyotes through Metabarcoding of Scat

Meiqi Ma, Bella Panossian, Stefan Pappas, Taylor Price

Foxes and coyotes both belong to the family Canidae. While red and gray foxes are native to the Long Island area, coyotes are newly introduced to the area as they migrated southeastward from the north. Coyotes take an arduous journey to reach Long Island, as they travel through New York City to the island by swimming through bays or crossing bridges. Some coyotes also swim from Fishing Island, Connecticut. They search for living space and new habitats as their original locations were densely populated, and newer generations of coyotes are easily outcompeted by more experienced coyotes. Despite their move, coyotes are still outcompeted by foxes on Long Island, as there are significantly fewer coyotes in Long Island than foxes. This study will compare the diets of coyotes and foxes on Long Island in order to determine whether there is significant overlap between the two, which might lead to coyotes being outcompeted. (R. Burke, pers. Comm. 2025).

Both coyotes and foxes eat a variety of foods. A diet rich in natural protein is essential for strong muscles, and calcium supports a strong skeletal system. Wild prey and fruits provide omega-3 fatty acids, which contribute to skin health. In general, coyotes eat small animals like mice, rabbits, and chipmunks, while in arid regions, they eat desert rodents, cacti, mesquite beans, and reptiles, larger prey in more temperate areas with longer winters, and human-related products in urban areas(e.g., human food waste, leftover meat, or garbage). Foxes, on the other hand, primarily eat kangaroos, rodents, and insects in arid zones; mice, voles, and rabbits in temperate regions; and also eat a significant amount of human-related products. We are using metabarcoding techniques and nanopore sequencing to determine the main food items in coyote and fox scats collected around Long Island, as despite what is known about coyote and fox diets, their exact diet varies as they expand into the densely populated habitats of Long Island.

Investigating the Effect of Phosphorus Levels on Ant Diversity in Diverse Locations in Locust Valley New York

Joshua Bornstein, Kyla Agulnick, Jenna Fragias

Often due to human activity, phosphorus levels can get too high resulting in ecosystems becoming unbalanced, with certain species growing more common while others decline. This can lower overall biodiversity and the stability of the ecosystem. According to a study in tropical forests, plots with experimentally raised phosphorus levels showed a correlation between the amount of ant species diversity and the amount of phosphorus (Bujan et al. 2016). Phosphorus does not usually poison ants, but when there is too much of it, it changes the soil and plants that ants depend on. This affects how many ants are present and which types of ants can survive there. Because they are a major food source of ant populations, when there is a lack of phosphorus in the soil it can limit their resources. Looking at the diversity of ant populations in areas with high and low phosphorus can give us clues about how this nutrient influences ecosystems.

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