



THE GOVERNOR'S SCHOOL for SCIENCE AND TECHNOLOGY

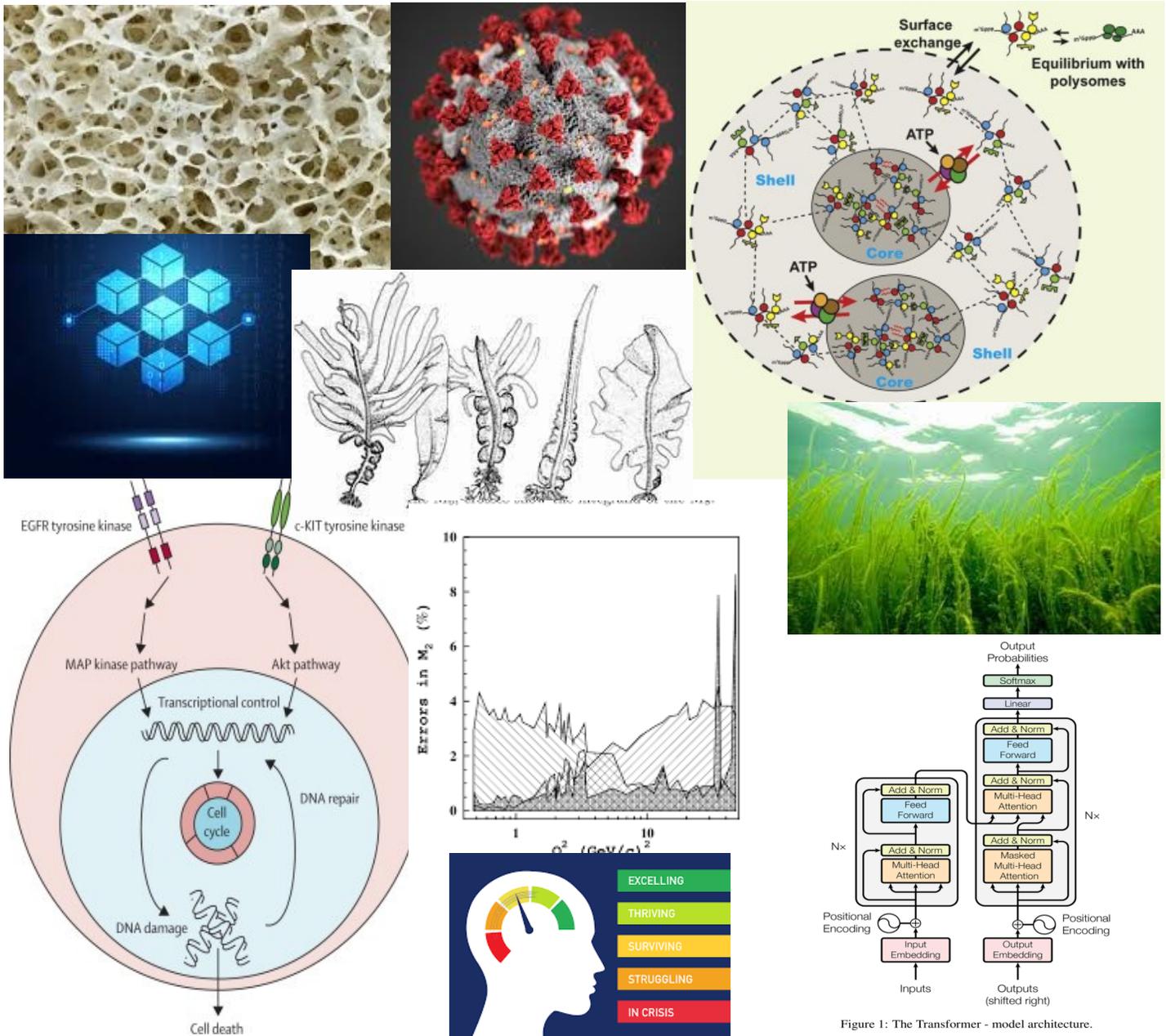


Figure 1: The Transformer - model architecture.

2022 Science Research Journal

Tracking African and Asian Dust to North America using NASA's CALIPSO Satellite

“...Around the world dust is picked up from deserts and follows well-known wind patterns spreading disease along its route.”



Ahmed Ali
Tabb High School
York County School Division

Abstract

Every year millions around the world contract influenza and asperigil dowii ravages our coral reefs. What's the cause for these two events? Dust! Dust has millions of micro imperfections on its surface that give microorganisms such as bacteria and viruses a safe protected place to live. As well as an abode to these disease-causing culprits, dust is a great mode of transportation for these diseases to extend its grabs on the farthest stretches of the world. Around the world dust is picked up from deserts and follows well-known wind patterns spreading disease along its route. These particulate matter in the air are then inhaled by individuals who then become infected with the dust's respective pathogen. One of the most famous routes dust follows is the transatlantic dust airway. This route carries pathogens from deep within the Saharan desert toward the Mexican Yucatan and southern tips of Northern America. Aerosol-dust transmission is a huge part of seasonal influenza and asperigil dowii transmissions, however this mode of transmission has been widely neglected by epidemiologists. The objective of this experiment is to utilize the advanced LiDAR systems aboard the CALIP-SO satellite to map the movement of dust across the Atlantic and into the western hemisphere to correlate the heavy migration of dust to increases in influenza and asperigil dowii cases with CDC data. It is expected that with increases of dust density and migration the number of infections of influenza and asperigil dowii will increase. This will demonstrate the truth that airborne dust matter does contribute to the yearly rise in influenza and asperigil dowii.

“At NASA, Dr. Ali Omar and I scanned dust particle movements using LiDAR scanners on the CALIP-SO satellite to investigate the epidemiology of dust transmitted diseases across the Atlantic.”

Ahmed will be attending University of Southern California

The Effectiveness of Macroalgae on Denitrification and Oyster Growth and Viability in a R.A.S.

Abstract

The aim of this study was to determine the optimal ratio of macroalgae to oysters for water denitrification and oyster viability and growth. This project used three separate recirculating aquaculture systems kept at similar water volumes, salinity, and temperatures. The first system had a ratio of 45 g of ulva macroalgae to 15 oysters, the second system had a ratio of 15 g of ulva to 15 oysters, and the third system acted as the control group with a ratio 0 g of ulva to 15 oysters. Nitrogen levels were measured using a LaMotte SpinTouch Lab spectrophotometer. Nitrite, Nitrate, and Ammonia concentrations were measured and recorded once a week for all three systems. The trial ran for 28 days, water salinity and temperature were measured twice a week. Water additions and exchanges were administered to keep the salinity of the three systems consistent. The expected results of this study were that the system with the higher ulva to oyster ratio would have lower nitrogen levels and higher oyster viability and growth compared to the two other systems. However, at the conclusion of the trial it was found that the system with a lower ratio of ulva to oysters had the lowest levels of nitrogen and the control system had the highest oyster growth and viability.

“The aim of this study was to determine the optimal ratio of macroalgae to oysters for water denitrification and oyster viability and growth”



“This project provided us with an introduction to scientific research and lab work. We were guided by our mentor but we were also given the freedom needed to learn how to work well on our own.”

Emily Bradley
Poquoson High School
Eleanor Patterson
Poquoson High School

Emily & Eleanor will be attending Washington and Lee University

Implementing Pet Detection on the NVIDIA Jetson Nano

Abstract

“We found that animal detection and identification is very much achievable on the NVIDIA Jetson with a satisfactory frame rate...”

Embedded computing devices have emerged as a cost-effective way of implementing machine learning on a mobile platform for use in everyday life. This research compares multiple implementations of convolutional neural networks on the Nvidia Jetson Nano for the purpose of animal recognition. We ultimately compare the use of a YOLOv4-tiny algorithm with optimized Tensorflow implementations to both demonstrate the capability of this technology for this application as well as determine which of the two prominent approaches would work better in this scenario. Both algorithms are evaluated on a set of incoming still images for metrics as well as tested with real-time footage to determine successful recognition ability. We found that animal detection and identification is very much achievable on the NVIDIA Jetson with a satisfactory frame rate, supporting our hypothesis that there are affordable computing solutions in this domain. Though both algorithms produced viable results, we found that certain constraints change which algorithm would be desired in this context.



William Chestnut

Bruton High School
Williamsburg—James City County Schools

Jason Cox

Smithfield High School
Isle of Wight County

“We learned specific skills such as how to use Ubuntu, program a KNN algorithm from scratch, design code for small devices such as the NVIDIA Jetson, etc. to more general skills such as understanding how machine learning algorithms and metrics .”work, gaining experience in the customer design process, and learning to program in a more collaborative and professional setting.”

Brandon will be attending Virginia Tech

Jason will be attending

Using ColdFusion for More Efficient Data Organization in Jefferson Lab's Pansophy System

Abstract

The focus of this project is to find an alternative method for fixing bone defects and replacing bone in an animal's skeletal system. The current method used worldwide is the implementation of metal plates into the skeletal system. With heavy research, it was determined that this method was obsolete. A better way is to implement a bone composite material that can mimic bone and is biodegradable. This experiment uses a polymer that is then mixed with bone and then 3D-printed to substitute the metal plates. Testing the mechanical properties of stress and strain on each of the five combinations of bone particles and polycaprolactone (PCL) showed how well the bone composite would exist in the body. The best combination was a composite composed of 40% PCL and 60% bone. This combination was determined to be the best due the fact that it had the most desirable mechanical properties out of all five combinations.

“Testing the mechanical properties of stress and strain on each of the five combinations of bone particles and polycaprolactone (PCL) showed how well the bone composite would exist in the body.”



Yunseo Chung

Grafton High School
York County School Division

“The mentorship experience was a valuable insight into how the things I learned at the Governor’s School could be applied in the real world.”

Yunseo will be attending Columbia University

Tracking African and Asian Dust to North America using NASA's CALIPSO Satellite

Abstract

“The current warm dewar magnetic flux measuring system uses expensive magnetometers which is not feasible for the division. Therefore a new measuring system is proposed...”



Justin Dean
Hampton High School
Hampton City Schools

Thomas Jefferson National Accelerator Facility uses the Continuous Electron Beam Accelerator Facility (CEBAF) to study the subatomic structure of an atom's nucleus. An integral component of the accelerator is a superconducting radiofrequency (SRF) technology known as cavities, which generate electromagnetic fields to accelerate particles. The conventional material used in SRF cavities is the element Niobium which becomes superconducting at a temperature of 2° Kelvin. At this temperature, the Niobium cavity expels magnetic flux that can become trapped in the cavity. Magnetic Flux can be detrimental to the quality factor of the cavity thus decreasing the efficiency of the accelerator. The SRF Division at TJNAF tests cavities inside dewars to measure the magnetic flux expelled from the cavities. The current warm dewar magnetic flux measuring system uses expensive magnetometers which is not feasible for the division. Therefore a new measuring system is proposed that can be built within a budget of \$1000. The requirements include a resolution of at least 100 nT, wireless communication between the readback unit and the tester's computer, operational in a range of 300° - 307° Kelvin, and the ability to move vertically inside the dewar. If development is successful the SRF Division can improve the efficiency of their cavity tests and the accelerator.

“My mentorship experience taught me that with enough effort and patience, failure can turn to prosperity.”

Justin will be attending Virginia Tech

The Smith Point Traffic Separation Scheme (TSS)

Abstract

A Traffic Separation Scheme (TSS), is a traffic management route system ruled by the International Maritime Organization (IMO). An Automatic Identification System (AIS), tracks every ship's position, heading, and ground track. Using the AIS, a problem presented itself with the TSS. The problem with the TSS is ships that enter from upbound or downbound are cutting into the other lane and maneuvering in the opposite flow of traffic. Using the data from the AIS, one can track ships and gather their longitude and latitude points at which they enter, travel, and exit the TSS. Due to the magnitude of data points gathered from the AIS, one would have to organize the data. Python is used to iterate through the data of all the points and delete irregular or unwanted data. After the data has been collected and cleaned, the behaviors of the ships can be classified. After defining the behaviors of the ships, the TSS can be reviewed to see if it needs to be modified to match the behaviors of the ships. If it is found that not enough traffic is using the TSS, removing the TSS would be a consideration.

“Using the data from the AIS, once can track ships and gather their longitude and latitude points at which they enter, travel, and exit the TSS.”



“I am appreciative of the support received from my mentor and GSST staff, as I learned valuable skills. I have been offered the opportunity to continue and broaden the scope of my research in college.”

Abdalla Elrahhah
Denbigh High School
Newport News Public Schools

Abdalla will be attending the Air Force Academy

Application of FUN3D to the MUST Environment + Development of Machine Learning Fluid Dynamics Model

“This research aims to apply NASA’s flagship CPD solver suite, FUN3D, to a modeled urban environment in the Mock Urban Settings Test in the state of Utah.”



Woody Hulse
Jamestown High School
Williamsburg—James City
County School District

Abstract

The progression of the field of computational fluid dynamics (CFD) has seen the rapid development in enterprise solutions. An ongoing trend toward maximizing the airspace potential, particularly in the world’s most traffic-heavy environments, proves to be one such challenge which the field is moving toward for commercial application. This research aims to apply NASA’s flagship CFD solver suite, FUN3D, to a modeled urban environment in the Mock Urban Settings Test in the state of Utah. Comparing experimental trial results from the site to computationally modeled and simulated data from FUN3D, the viability of this application and its accuracy can be determined and analyzed comparatively to other commercially available and cutting-edge software. The nature of FUN3D as a half-century-long pioneer in the field of CFD would suggest it provides significant improvement in this area over pre-existing simulation methods in both speed and precision.

"...not only is my research leading me toward publishing peer-reviewed research in a journal, it also provided an excellent exposé into the world of research and collaborative academic software development."

Woody will be attending Brown University

Machine Learning for the HEBI Robotic Arm

Abstract

Robot arms like the HEBI robotic arm can be used to automate certain human tasks, for example, playing a game like air hockey. The issue with using a simple algorithm is that the simplicity of movement that it supports is not enough to out play a human, requiring the use of machine learning, specifically reinforcement learning, to improve the algorithm over time. With the help of ROS (Robot Operating System), Gazebo, and RViz, a simple algorithm for returning the puck to the opposite goal will be written at first. Once an the algorithm can be used to successfully return the puck consecutively 10 times in a row, the robot arm can be tested in-game against human opponents. After 10 matches against a player, the HEBI robot arm is expected to win more than at least 50% of the 10 matches, with its success anticipated to become more consistent over time due to the feedback provided from past games that improve the algorithm. If the expected results are achieved, the HEBI robotic arm will successfully and consistently be able to beat a human player at air hockey, which means that using algorithms allows robots to outperform humans. In the future, this knowledge can provide a basis for applying machine learning to other robots to increase efficiency in various other tasks.

“Thank you to Dr. Conner for providing access to the CNU computer lab, HEBI robotic arm, and class lectures, as well as providing guidance eand help with the whole process. Thank you to Ms. Vobrak for helping me get placed in this mentorship and providing guidance through the research process, this was a great opportunity and learning experience.”

“If the expected results are achieved, the HEBI robotic arm will successfully and consistently be able to beat a human player...”



Daniel Khalil

Tabb High School
York County School Division

Daniel will be attending California Institute of Technology

AERONET and Satellite Data Analysis of Aerosol Optical Depth and SO₂ Concentration for the 2022 Hunga Tonga Eruption

Abstract

“Given the recent developments in satellite technology for remote sensing, geological events are a good indicator for evaluating atmospheric measurement performance.”



Andrew Kwong
Bethel High School
Hampton City Schools

“The atmosphere is much more than just weather.”

Aerosols have a profound effect on the atmosphere and affect human beings as a result. On January 14, 2022, Hunga Tonga, a submarine volcano located near the main island of Tonga, erupted and released a substantial amount of volcanic ash into the atmosphere. Over the next few days, this volcanic plume would travel westward, across the Australian continent and into the Indian Ocean. Various networks would measure the release of particulate matter from the eruption, tracking the movement of the plume and evaluating the changes in atmospheric composition as a result of the eruption. Given the recent developments in satellite technology for remote sensing, geological events are a good indicator for evaluating atmospheric measurement performance. My mentorship served to determine the effectiveness of satellite data in collecting aerosol data by using and evaluating measurements from the S5p satellite. This satellite data was then compared with ground-based data from AERONET, the Aerosol Robotic Network, to validate the measurements made. Both sets of data were analyzed through various other programs to provide visual and qualitative representations of the data. This process eventually led to the creation of a comprehensive timeline of the movement of volcanic ash and other aerosols, specifically SO₂, following the eruption of Hunga Tonga.

Andrew will be attending University of Virginia

Diatomaceous Earth as a Pozzolanic Supplement in 3D Concrete Printing

Abstract

Pozzolanic materials are a group of highly siliceous minerals that, when directly substituted for a portion of the cement used in concrete, increases the strength of the concrete and helps to reduce cement and concrete's production of CO₂, which in turn reduces global warming. Diatomaceous Earth, a mineral composed of unicellular algae characterized by a silica shell, is such a pozzolanic material, but is not widely used in the construction industry. Another method, 3D Concrete Printing, also works to curb CO₂ production and global warming by eliminating the need for molds, large manpower, and resources, while creating a cheaper, faster, more environmentally friendly final product. However, 3DCP is not widely used because of issues related to when the concrete used is fresh, when it is hard, and the geometric limitations of the machines used. This paper reviews works detailing concrete chemistry, the pozzolanic reaction, DE in concrete, the challenges of the 3DCP industry, and pozzolanic 3D Cementitious Materials to more accurately predict the propensity of DE as a novel pozzolanic 3DCM that would remove many of the barriers 3DCP faces.

“Diatomaceous Earth, ... is such a pozzolanic material, but is not widely used in the construction industry.”



"This is all so cool: wearing the lab coat and doing real science experiments. As an 8 year old you're told that scientists are very busy doing really important research, and now I'm here, in it, working to make something incredible, and it's all so exciting."

Cooper Martin
Poquoson High School
Poquoson City Public Schools

Cooper will be attending Virginia Tech

Determining the Concentration of Chloroquine to Effectively Study the Role of MK-STYX through Autophagy

Abstract

“The exact mechanism in which MK-STYX decreases stress granules is currently unknown.”



Marianne Packer

Warhill High School
Williamsburg—James City
County Schools

The pseudo-phosphatase, MK-STYX (mitogen-activated protein kinase phosphoserine/threonine/tyrosine-binding protein), has been found to regulate stress granule formation in mammalian cells. Stress granules are cytoplasmic storage units of mRNA that cells create as a protective response to harmful environments. However, excess stress granule formation can lead to uncontrolled cell division, which may result in cancer or neurodegenerative diseases. The exact mechanism in which MK-STYX decreases stress granules is currently unknown, yet it is known that the process of autophagy rids of stress granules. This commonality in clearance of stress granules could indicate an interaction between MK-STYX and the autophagy pathway. To compare the efficiency of MK-STYX in reducing stress granules in the presence and absence of the autophagy pathway, the autophagy inhibitor chloroquine will be utilized. Chloroquine inhibits autophagy by blocking the binding of auto-phagosomes to lysosomes. This study focuses on determining a concentration of chloroquine that inhibits autophagy without killing the cell. In previous Hinton Lab experiments and in the current study, higher concentrations of chloroquine were found to kill HEK-293 cells. In contrast, lower chloroquine concentrations, such as 25 μ M, allowed for HEK-293 cell survival. Therefore, this study suggests that a relatively low chloroquine concentration would be best utilized in subsequent experiments regarding a relationship between MK-STYX and the autophagy pathway.

"I am incredibly grateful for the opportunity to work with Dr. Shanta D. Hinton. I truly believe this experience will prepare me for other college

Marianne will be attending University of Richmond

Finding Biosynthetic Gene Cluster in Streptomyces Albidoflavus Strain

Abstract

The bacteria streptomyces albidoflavus strain 09MW18-IS was a bacteria found by Dr. Sharma and its genome was sequenced by her team at Hampton University. It will be tested for biosynthetic gene clusters that produce antibiotic natural products. The goal of this project is to identify if the found bacteria has antibiotic capabilities that would allow us to isolate certain genes and use them to synthesize a new medicine for public use. The main programs used consist of antiSMASH and BAGEL4, which look for bgcs by looking for rules such as the synthesis of r-groups or gene structure ("Validate User"). The found clusters will be researched using MIBig to identify similar gene clusters and Google Scholar to look up what natural products are produced and what their roles are. Four clusters were found that produced natural products that aid in the bacteria's antifungal properties. These four relate to the production of antifungal proteins that can help humans resist disease as the race against mutation continues.

"The goal of this project is to identify if the found bacteria has antibiotic capabilities that would allow us to isolate certain genes and use them to synthesize a new medicine for public use."

"Unlike teaching that most students are familiar to, you are required to conduct your own research and are responsible for keeping up with your schedule and due dates. I found myself slip in regards to keeping communication with my mentor during the hectic school year, but the information I gained from it is invaluable. I owe much gratitude to Dr. Sharma for taking the time to mentor me during this year and providing the necessary assistance and foundation needed in order to complete our study."



Won Heo

Menchville High School
Newport News Public Schools

Won will be attending University of Virginia

Small Farm Sheep Care

Abstract

“..The main focuses of the project are diet, shelter, and grooming.”

Caring for sheep is far more complicated than it seems, as is the case for most livestock. While large commercial farms have scientists and dieticians to formulate plans for them, small scale farms often lack the research necessary for proper care. A new plan for diet, habitat, and hoof care will be put together to create a manual for Bluebird Gap Farm to use when training people to care for their sheep. The current standards will be evaluated and altered based on research findings. This new plan will be implemented over the course of a few years and the effectiveness of it will be evaluated. It should create better quality of life for the sheep at Bluebird Gap Farm. The main focuses of the project are diet, shelter, and grooming.



Lauren Tyler

Grafton High School
York County School Division

“This mentorship was not only full of amazing animal encounters and in-depth research, but it also gave me a powerful insight about what I will enjoy as a career and has helped me better map a path for my future.”

Lauren Tyler will be attending Wake Forest University

Reducing Neural Biases

Abstract

“...Studies using EEG data analyzing have shown that these biases can impact various aspects of someone’s life, both personal and professional.”

Implicit racial biases impact people as young as 6 months old. Since most people are only exposed to their “in-groups”, or people of the same race; when confronted with “out-groups” or members of other races, their biases can impact the way they think and feel towards these people. This creates an Other Race Effect (ORE)- a phenomenon in where people are generally better at recognizing faces of their own race, compared to faces of different races. One way this can impact someone is how they empathize with people from an “out-group.” Studies using EEG data analyzing have shown that these biases can impact various aspects of someone’s life, both personal and professional. Our study aims to examine whether or not extended contact with outgroup members would increase empathy and subsequently decrease the ORE. In our study, we utilized a two-part method to conduct our research. The first part was an online survey and the second part was a story that was read to the participants in the EEG lab. Our expected results are that the participants with extended contact to out-group members will associate positive or neutral characteristics towards them.



Sarah Ahmad
Grafton High School
York County School Division

“I loved getting to work on this project because it combined my interests of racial justice with science and the intersections between the two were super interesting to explore. Working with Dr. Dickter has been a most pleasurable experience and has

Sarah will be attending

The Effect of Maternal Incarceration on the Behavioral and Emotional Impacts of Children

Abstract

This study has analyzed the correlations among factors regarding maternal incarceration backgrounds and their effects on the behavioral and emotional reactions of children. It is theorized that the independent variables studied promote negative impacts on behavioral and emotional outcomes of children as young adults (dependent variable). Data was derived from the National Longitudinal Study of Adolescent to Adult Health (Add Health) Wave IV Survey, which is a longitudinal study of a nationally representative sample of adolescents in grades 7-12 in the United States to examine the impact of maternal incarceration on emotional and behavioral outcomes among adolescents. Survey responses from 210 respondents were used to assess and analyze the independent variables and their effects on children's behavioral and emotional outcomes. Results from the surveys were formatted into frequency tables to analyze and make direct correlations. Results demonstrated that having a mother incarcerated indicated a varied response in behavioral and emotional outcomes of children. Additionally, numerous factors regarding the maternal incarceration and family backgrounds of the mothers surveyed influenced the reactions of the children. Implications for possible interventions and suggestions for future research are addressed.

“Results demonstrated that having a mother incarcerated indicated a varied response in behavioral and emotional outcomes of children.”



“Even though my mentorship was completely virtual, this experience has been very valuable and has allowed me to gain important and valuable skills for my further education. Dr. McGee is a very supportive mentor who has been very helpful throughout the entire research process.”

Niya Patel
York High School
York County School Division

Niya will be attending Virginia Tech

Apparent Digestibility of North American River Otters

Abstract

“To carry out this idea a fecal sample would need to be collected and frozen after an otter has eaten their designated diet.”



Lacey Phelps

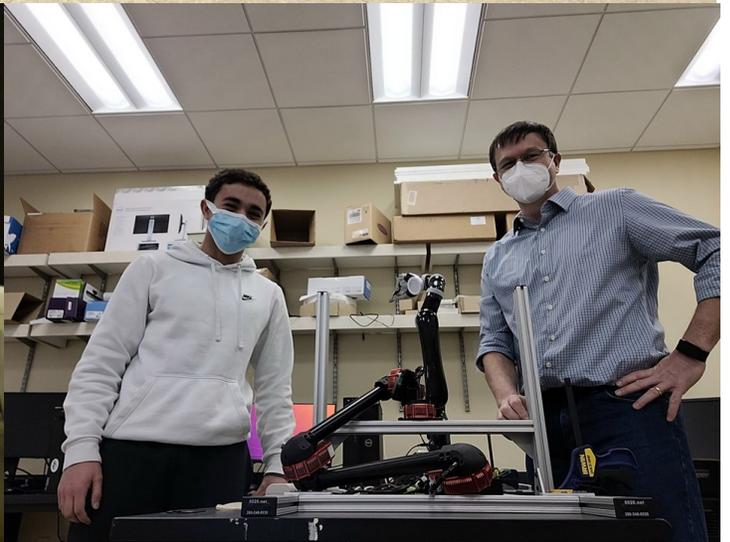
Gloucester High School
Gloucester County Public Schools

North American River Otters have increasingly become a fan favorite at many North American zoos, aquariums, and natural museums. With the increasing popularity of river otters in captive settings, it is quintessential that they have proper diet and nutrition provided to them. One way to monitor if North American River Otters are receiving proper diet and nutrition is to visually look for physical signs of health like consistent weight, good temperament, and no visible signs of discomfort. Although this method of monitoring can be effective to an extent, it is not the best option because it does not ensure that other aspects of a proper diet are maintained such as digestibility, energy consumption, and nutrient composition. Therefore, one possible solution to analyze these more focused aspects of proper diet and nutrition is to collect fecal samples from otters after they have eaten a diet that is to be tested. This idea would ensure that all aspects of diet and nutrition are analyzed for evaluation. To carry out this idea a fecal sample would need to be collected and frozen after an otter has eaten their designated diet. Frozen fecal samples could undergo Wendee Analysis, bomb calorimetry, and atomic absorption spectrophotometry. After the data is collected from these tests, it would be used to calculate apparent digestibility per day per diet, which could then be collected for a six month period and graphed as monthly averages on a line graph displaying month versus apparent digestibility. Significant data is expected to show that a preset diet at the Virginia Living Museum for their North American River Otters has an apparent digestibility of 80-95%, with overall proper weight and temperament of the animals.

“I am incredibly grateful for my mentorship experience and the connections I made throughout its duration. Working on my project has provided opportunities for me to gain essential research skills, and working with the Virginia Living Museum has provided me with knowledge I never would have gotten anywhere else!”

Lacey will be attending Virginia Tech

Mentorship



Experiences

Both students and mentors were both up to facing the challenge





THE GOVERNOR'S SCHOOL for SCIENCE AND TECHNOLOGY

The Governor's School for Science and Technology
520 Butler Farm Road
Hampton, Virginia 23666
(757) 766-1100

Website: www.nhrec.org/governorsschool
Website: www.nhrec.org/governorsschool

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.