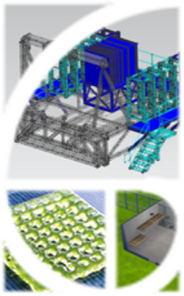
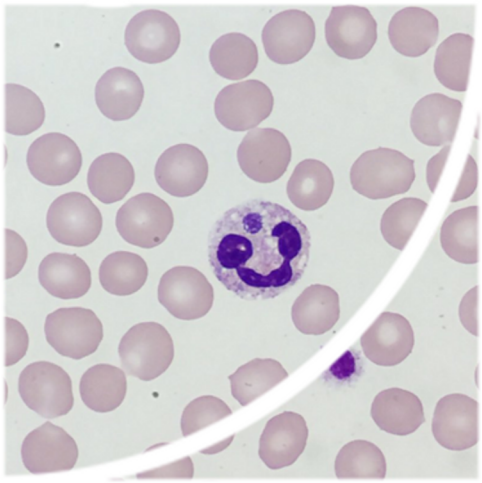
The Governor's School for Science and Technology

2019 Research Journal





Research

A 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 or engineering design 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, local engineering firms, hospitals, and numerous medical and professional specialists.

Development of a System to Calculate Safe Distances from Electromagnetic Interference Sources for Drone Flight

Abstract

Today, drones are becoming increasingly prevalent in society and their usefulness is continuing to increase. While drones have many exciting features and possibilities, electromagnetic interference is an obstacle that must be overcome. Electromagnetic interference is an external source that generates a disturbance in an electrical circuit, which can cause a drone to malfunction and endanger the drone or surrounding people and buildings. In order to safely and successfully use drones, a plan is necessary to avoid sources of electromagnetic interference to ensure the drone will not malfunction.

A program was developed to calculate the distance a drone must stay away from electromagnetic interference sources to safely fly and operate (operate meaning complete any tasks such as deliveries) in a given area. The program first found all sources of electromagnetic interference in a flight area. Specific information about each electromagnetic interference source including: latitude and longitude, power, and whether a tower operates on AM or FM frequencies were retrieved. The program then parsed out needed information to calculate a safe distance the drone must stay away from EMI sources assuming perfect free-space loss. The program was tested multiple times throughout the development process. The program was able to calculate the distance of avoidance needed by a drone given the frequency and power of the signal source. This calculated distance is used for the drone to maintain a safe distance from the electromagnetic interference source. The program was successful and the relationship between power levels of the signal source and the susceptibility of the drone, the frequencies of the signal, and the distance of avoidance calculated was graphed to display the importance of shielding and avoidance.

Nathanial Doggett | Poquoson High School

"I was able to discover the real-world research field and enhance my skills in programming and computer science in general. I know that the skills and ideas that I attained throughout my mentorship will serve me well later."

Mentor: Mr. Patrick Quach, NASA Langley Research Center
Will attend: Virginia Tech

A Bobcat Habitat to be Added to Bluebird Gap Farm: A Proposal to Hampton City Council

Abstract

Bluebird Gap Farm in Hampton, Virginia acts as a location both for animal conservation and for family recreation. The addition of a new animal habitat would further attract visitors to the farm, as well as provide a beneficial environment to an animal in need of human care. Information about a potential bobcat habitat for Bluebird Gap Farm was researched, including general information, habitat specifications, animal dietary requirements, ideal location for new habitat on the farm, determining what could be accomplished by farm staff without contractors, and a cost analysis of the proposed habitat. In addition to online research, the Virginia Living Museum was visited in order to gain a better perspective and understanding of existing bobcat and other animal habitats from both a visitor and staff standpoint. Following the compilation of research information on animal and habitat requirements, an appropriate location on the farm was selected, and the habitat was designed. However, the habitat design can be used to house many different animals with minor or no adjustments, so it would be well-suited to house almost any animal found in Virginia in need of human care. Following the design of the habitat, a cost analysis was conducted on the estimated cost of materials. The habitat includes a sturdy concrete block shelter building, an isolation yard, a double fence, and numerous other features. The approximate cost of construction is $17,700 and can be broken down into phases to effectively manage the costs. A survey was also designed to poll public opinion, which has been strongly in favor of the addition of a new habitat, indicating that the new habitat would increase visitation to the park and increase the influence of the benefits of the farm within the community.

Elizabeth Hinton | York High School

"I would like to pursue research opportunities in college and beyond dealing with animal conservation, and I feel that my mentorship experience has truly prepared me for that and may even give me an advantage in competitive application pools."

Mentor: Mr. Adam Newland, Bluebird Gap Farm
Will attend: University of Virginia

Knockdown of Alpha-synuclein Prevents Tau Toxicity

Abstract

Aggregation of protein tau into neurofibrillary tangles and α-synuclein into Lewy bodies are hallmarks of Alzheimer's and Parkinson's disease, respectively. These proteins are known to form pre-fibrillar aggregates called oligomers (multiples of monomeric protein), which are considered the toxic entity of the diseases. The coexistence of both tau and α-synuclein is associated with worse disease progression, which suggests a synergistic relationship between these proteins. Although the interaction between α-synuclein and tau oligomers has been demonstrated in Parkinson's and Dementia with Lewy body (DLB) cases, the mechanism of toxicity remains unclear. To probe this synergistic mechanism, a stable cell line was created with expression of full length human α-synuclein in SH-SY5Y neuroblastoma cells. siRNA was used to knockdown the expression of α-synuclein in SH-SY5Y cells prior to toxicity assay. The stable cell line and SH-SY5Y cells were exposed to recombinant oligomeric species of tau or vehicle (PBS) for 8-24 hours. Immunostaining and MTT assay were used to assess cell viability. RT-PCR was used to compare mRNA expression of tau, α-synuclein, and GSK3β following the toxicity assay. Results depict that the knockdown of α-synuclein prevents tau oligomer toxicity in vitro. Furthermore, the coexistence of both proteins enhances the neurotoxicity of the tau oligomers. These findings strongly suggest that a synergistic mechanism among tau and α-synuclein potentiates toxicity. Elucidating the mechanisms of neurodegeneration could reveal novel protein targets of disease progression.

Katelynne Berland | Grafton High School

"This experience gave me the opportunity to present my research at several conferences and science fairs and taught me multidisciplinary laboratory skills that I will utilize throughout my career."

Mentor: Dr. Diana Castillo-Carranza, Hampton University
Will attend: Georgia Tech

Relationship Between Forest Fragmentation and Reported Cases of Human MonocyticEhrlichiosis in Virginia

Abstract

Human monocytic ehrlichiosis (HME) is a disease caused by the bacteria *Ehrlichia chaffeensis*. HME is commonly found in the Southeastern United States but is spreading across the country. Many questions related to what affects the likelihood that humans will become infected with HME have not been answered. *E. chaffeensisis* typically carried from infected hosts, such as deer, rabbits, and squirrels, to humans through ticks that feed on the small mammals and bite humans. The tick bite allows for *E. chaffeensisis* to directly enter the human bloodstream and cause HME. Landscape fragmentation, by natural or human barriers, reduces the number of deer that are able to live in an area. A relationship between forest edge length in Virginia counties and the number of reported cases of HME in each county was defined using data from the CDC and GIS.

Data were compiled into a spread sheet, and using ArcGIS, a map of Virginia was created to display the forest edge length and HME cases reported in each county. The number of reported cases of HME was not an exact value, but rather a value assigned in relation to the binned maps from the CDC. Neither mixed nor coniferous forest proportion had a strong correlation with the sum of the values for reported cases of HME.

Sofia Mendez | Lafayette High School

"My mentorship experience helped me to understand how important it is to be well versed in various studies. My mentorship also helped me to become more excited about my future studies in biology and helped me to determine which type of biology I prefer."

Mentor: Dr. Matthias Leu, The College of William and Mary
Will attend: Cornell University

Radiation Shielding Properties of Martian Regolith Simulant

Abstract

Colonization of the moon and Mars is becoming more and more possible as the information age has propelled science and engineering faster than ever. However, challenges to sustain life in these harsh environments still remain. Deadly radiation that constantly interacts with the surface of both the moon and Mars prevents life from surviving for extended periods of time. The radiation level is relatively low for a small period of time; but as a few years go by, more and more health risks become probable. One possible solution is to use radiation shielding materials from Earth, but transportation of those materials would be expensive. Another solution is to look at the radiation shielding properties of the Martian and lunar regolith on their respective celestial bodies. This idea holds potential as the regolith could be easily attainable, effective, cheap, and easy to use. To test this idea, Martian regolith simulant was encapsulated in a polyvinyl chloride (PVC) pipe at different depths with polyethylene film, held by rubber bands, at each end of the pipe. Each depth, starting at zero and moving up in 2-inch increments to 36 inches, underwent a 3-minute trial where an Americium-Beryllium source provided a constant dose of radiation and a neutron detector determined the dose that is coming through the regolith simulant. After removing the shielding effect of the PVC pipe, the trend found confirms that Martian regolith is a viable radiation shielding material. The experimental dose was greater than the dose on Mars, therefore Martian regolith is still a viable source.

Ryan Shoenburg | Menchville High School

"One of the most valuable things this mentorship has taught me is how to balance accepting failure and remaining determined in my work."

Mentor: Sheila Thibault, NASA Langley Research Center
Will attend: Georgia Tech

Evaluation of Methods for Grain Size Analysis of Equiaxed Grain Microstructure

Abstract

Material science focuses on the study of the structure, properties, and performance of materials. Microstructural analysis focuses on the structure of a material that is revealed by a microscope with a magnification greater than twenty-five. A microstructure consists of phases, the distinct chemical structures, and grains, the crystals within the phase. Grain size analysis can reveal important physical properties about a material such as resistance to plastic deformation which is an important indicator for the performance of the material. Methods for grain size analysis range from manual methods and digital methods done in image analysis software. A comprehensive search and evaluation of seven image analysis methods for grain size was conducted. The seven methods were used to evaluate twenty different images of equiaxed grain microstructure. The results from each image-method pairing were assessed on the difference from the ASTM grain size found from the control method and on the amount it time it took to complete the analysis. The optimal methods were identified as the Gwyddion Threshold method and ImageJ Bandpass Filter method based on ANOVA and Tukey test results. The Gwyddion Thresholding method had a mean time of 159.7 seconds and mean difference of 0.525 from the control ASTM grain size. The ImageJ Bandpass Filter had a mean time of 183.0 seconds and mean difference of 0.425 from the control ASTM grain size. These optimal grain size analysis methods can be used for future grain size analysis within a microstructure of a material.

Catherine Mikhailova | Bruton High School

"I ultimately learned that I could create a space from my limited knowledge where I could work and develop my project."

Mentor: Dr. Samuel Hocker, NASA Langley Research Center
Will attend: University of Virginia

Analysis of Algal Growth in Diatom-based 3D Printed Hydrogels

Abstract

Ceramics are amongst the strongest available materials; however, they are extremely brittle.For example, most man made ceramics shatter upon impact instead of absorbing the energy and denting like a metal.Naturally occurring ceramics like bone and sea shells do not have this same shattering problem due to their hierarchical structure.However, the small nanostructures found within hierarchically structured bioceramics have proven extremely challenging to replicate synthetically.To overcome this limitation, frustules, skeleton-like structures with an inherent nanostructure found in diatoms, can be used as building blocks for larger objects.To do so, two species of diatoms, *Thalassiosira pseudonana and Navicula trivialis* were integrated into a 3D bioprinting “ink” made of the hydrogel sodium alginate.In order to understand how diatoms grow on hydrogels, an initial scaffold mold for diatom-gel 3D printing was used in two separate observational experiments for T. *pseudonana* and N. *trivialis* to find how different levels of light and nutrient levels changed the density of diatom growth in gels. Testing of several different mold shapes was also initially conducted. Gels growing T. *pseudonana* exhibited increased growth when the culture medium was continuously replenished and diatom growth seemed only minimally inhibited by the confined gel structure. Gels growing N. *trivialis* showed that the diatoms moved toward the light source with the greatest algal density being on gel sides that faced the light source.

Anna Song | Jamestown High School

"The GSST Mentorship program gave me the hands on experience in material science that I otherwise couldn’t have had before college."

Mentor: Hannes Schniepp, the College of William and Mary
Will attend: Duke University

Designing an Extension for the Forward Calorimeter Platform to Hold Instrumentation for the Charged Pion Polarizability Experiment at Thomas Jefferson National Accelerator Facility

Abstract

Thomas Jefferson National Accelerator Facility uses a particle accelerator to study nuclear physics. Many studies focus on discovering interactions between protons, neutrons, and quarks. Currently scientists are developing the Charged Pion Polarizability (CPP) experiment, to study hybrid mesons. To conduct the experiment, components of the experiment must be placed on a platform in a location where there are currently several racks of instrumentation. An extension was designed and fabricated to hold the instrumentation racks. The platform meets requirements set by Thomas Jefferson National Accelerator Facility. The requirements include that the extension must hold 50 pounds per square foot, allow the instrumentation racks to be accessed by employees, and not exceed the budget of $10,000. Several design solutions were brainstormed. These solutions were analyzed using standard engineering analysis techniques. Additionally, the researcher created technical drawings of the final design using a CAD (Computer-Aided Design) program. The final design was tested in a simulation using the computer software ANSYS. Based on computer simulation data, the platform will not be deformed over one inch. Such a small deformation will not affect the performance of the platform. The results of the computer simulation support the conclusion that the platform will perform successfully under a force of 50 pounds per square foot. Additionally, the technical drawings show that there is enough room to allow employees to access the instrumentation racks. Lastly, the calculated budget will not exceed $10,000. In conclusion, the platform will be successful as it upholds all requirements set by Thomas Jefferson National Accelerator Facility.

Erin Cox | Tabb High School

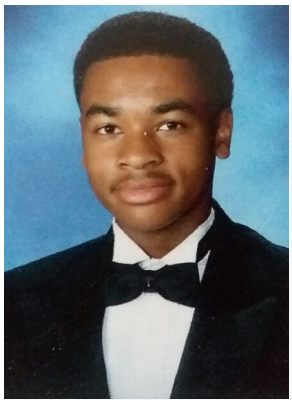
"I got real-world experience learning about how engineers work with other disciplines at Thomas Jefferson National Accelerator Facility through my mentorship."

Mentor: Tim Whitlatch, Thomas Jefferson National Accelerator Facility
Will attend: Virginia Tech

Developing a Safe-by-Design Unmanned Aircraft System

Abstract

The designing, building, and testing of a safer unmanned aircraft system (UAS) is important, because of the long history of neglect of safety shown by companies that produce UASs. The growing field of commercially available UASs causes more of them to fall into the hands of inexperienced pilots who may lose control of the UAS and put people or property in danger. A safer UAS was conceptualized which included features such as a soft polyurethane foam airframe that prevents things from reaching the propellers and a parachute system which is able to be deployed with the push of a button. A vertical takeoff and landing (VTOL) quadcopter was chosen as the layout of the UAS. A two-thirds scale prototype was made for proof of concept and flight testing. A Cooper Harper UAS flight assessment was used to evaluate flight performance of the prototype. This was done for both the hover orientation and transition into forward flight. This safer UAS can prove helpful to the expansion of UAS roles and presence in the future by being the base that other safe UAS designs can build upon.



Joshua Lewis | Smithfield High School

"Mentorship has allowed me to obtain a unique learning experience from a professional. This helped advance my knowledge in the field that I want to pursue."

Mentor: David North, NASA Langley Research Center
Will attend: Virginia Tech

Airfoil Design to Improve Aerodynamic Efficiency and Balance Pitching Moment

Abstract

The Aeronautic Systems Analysis Branch at NASA Langley Research Center is focused on creating advanced technologies and concepts to improve connectivity and save valuable resources. One of the projects of ASAB is PEGASUS, which is an acronym for Parallel Electric-Gas Architecture with Synergistic Utilization Scheme. In simpler terms, it is a novel hybrid electric regional passenger aircraft. The current wing design of PEGASUS does not produce enough lift for the aircraft to remain aloft. This study produced a model that under normal cruise conditions, produced a large enough lift coefficient to remain aloft while the tail balanced the pitching moment. The model was designed through several steps. First, an airfoil was selected using XFOIL. Then the tail geometry was produced by programming the static moment equation into Matlab. Finally, a three dimensional model was tested in OpenVSP. The results indicate that a thinner airfoil positioned at a lower angle of attack reduces the amount of induced drag. Also, a tail that produces a pitching moment of zero makes the aircraft stable. Improved efficiency will be beneficial to commercial industries because less fuel is needed for PEGASUS to complete routes and that reduces the total cost.

Payton Hancock | Smithfield High School

"My mentorship allowed me to combine my interests of aerospace engineering and physics. Through mentorship, I have solidified my choice to pursue an engineering degree so one day I can have a career in aerospace."

Mentor: Mr. Nathaniel Blaesser, NASA Langley Research Center
Will attend: Virginia Tech

Ultra-Light Weight Structures for Mars Flight Vehicle Technologies

Abstract

Throughout the years, space exploration has rapidly increased. With new technology, man knows more about the solar system than ever before. Mars is one of the more current topics of interest. In the past 50 years, rovers have been sent to Mars, returning valuable data about its environment. Although these rovers are useful, flight vehicles may be able to return new Mars data at a faster rate. Vertical take-off and landing (VTOL) vehicles can reach spots that rovers cannot drive to. Flight vehicles can be used in conjunction with rovers, leading them to desired locations, or on their own. On the next NASA mission in 2020, the first flight vehicle, Scout, will be sent to Mars. The Scout helicopter weighs four pounds and has a body the size of a softball. This mission will allow insight onto new ways to explore the Red Planet.

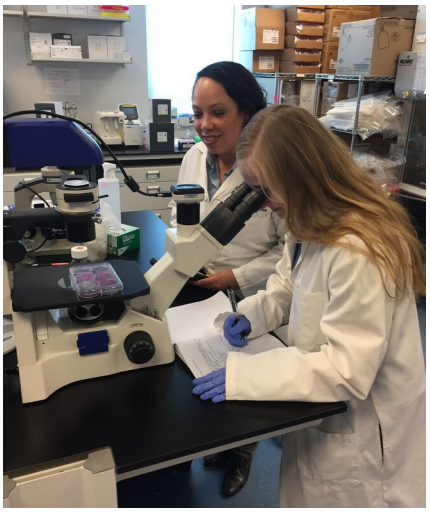
Designing Mars flight vehicles comes with a greater challenge than rovers: overcoming thin Martian atmosphere. Due to the extremely thin atmosphere on Mars, flight vehicles must be extremely light weight. The use of different materials such as inflatables, foams, woods, and carbon fiber were tested and applied to aircraft designs. These lightweight materials help figure out ways to overcome the challenge of the atmosphere of Mars. After design and experimentation, two models were finalized; the first was dominantly created with foam and wood, reaching 1.39 oz/ft2. The other model was made with carbon fiber and a monokote covering, but due to less surface area, it was 3.65 oz/ft2. The two vehicles were tested on different criteria where they flew both vertically and horizontally to ensure they met the goals for Mars VTOL flight.

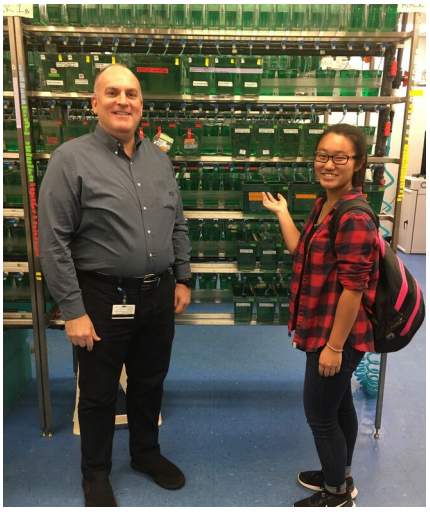
Sierra Carne | Lafayette High School

"Being able to work at NASA performing hands on research was an amazing opportunity where I gained experience that will be valuable in both college and my career."

Mentor: Mr. David North, NASA Langley Research Center
Will attend: Northeastern University

Mentorship Experiences






DATAXSTREAM
Integrating the Best Run Businesses
XSTREAM CONNECTOR
SAP SERVICES
BLOG
WE LOVE SAP
OUR VISION
W&M
Computer Sience


Specialized Care
Where You Need It.
VISITOR

Tidewater Science Fair

Overall Grand Prizes

First Grand Prize Anna Vargas

Second Grand Prize Katelynne Berland

Chemistry

Honorable Mention Alexandra Neikirk

Cellular and Molecular Biology

First Katelynne Berland

Computer Sciences

First Gavin McGabe, Kai Vylet, Jacob Rice

Honorable Mention Georgia Danehy

Engineering: Electrical and Mechanical

Honorable Mention Hunter Culverhouse

Environmental Management

First Anna Vargas

Honorable Mention Caroline Way

Engineering: Materials and Bioengineering

Third Brendan Cox

Environmental Sciences

First Peneeta Wojcik

Mathematical Sciences

First Maria Stuebner

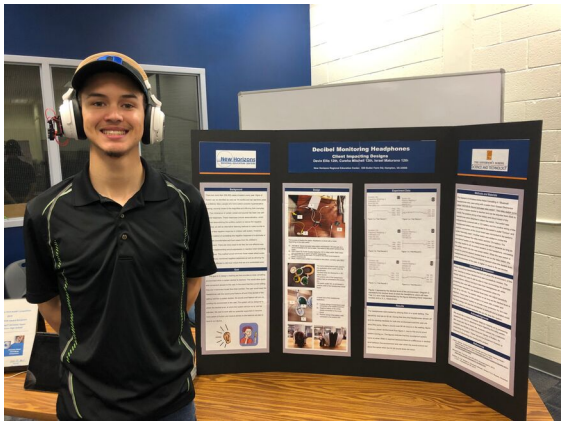
Microbiology

First Ricardo Rodriguez

Honorable Mention Anushka Acharya

Physics and Astronomy

Honorable Mention Samantha Watson



Special Awards

American Institute of Aeronautics and Astronautics
Second Hunter Culverhouse

American Society of Civil Engineers
Caroline Way

AFCEA - Hamptons Road Chapter
Second Gavin McGabe, Kai Vylet, Jacob Rice

AFCEA - Tidewater Chapter
Third Gerogia Danehy

HRSD Environmental Improvement Fund Award
Second Brendan Cox

Intel Excellence in Computer Science
Gavin McGabe, Kai Vylet, Jacob Rice

Stolkholm Junior Water Prize
First Anna Vargas
Second Ricardo Rodriguez

Vectrona
First Georgia Danehy
Second Brendan Cox

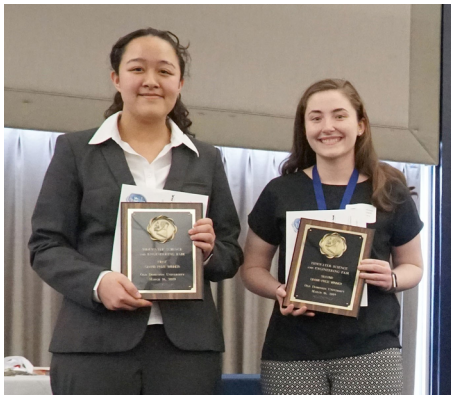
Vertical Flight Society - Hampton Roads Chapter
First Peneeta Wojcik

Virginia Dental Association
Honorable Mention Katelynne Berland

Virginia Section, American Water Works Association
First Caroline Way
Second Ricardo Rodriguez
Honorable Mention Anna Vargas

Mu Aplha Theta
First Maria Stuebner

Air Force Research Labratory STEM Initiative
First Gavin McGabe, Kai Vylet, Jacob Rice



THE GOVERNOR'S SCHOOL for SCIENCE AND TECHNOLOGY

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