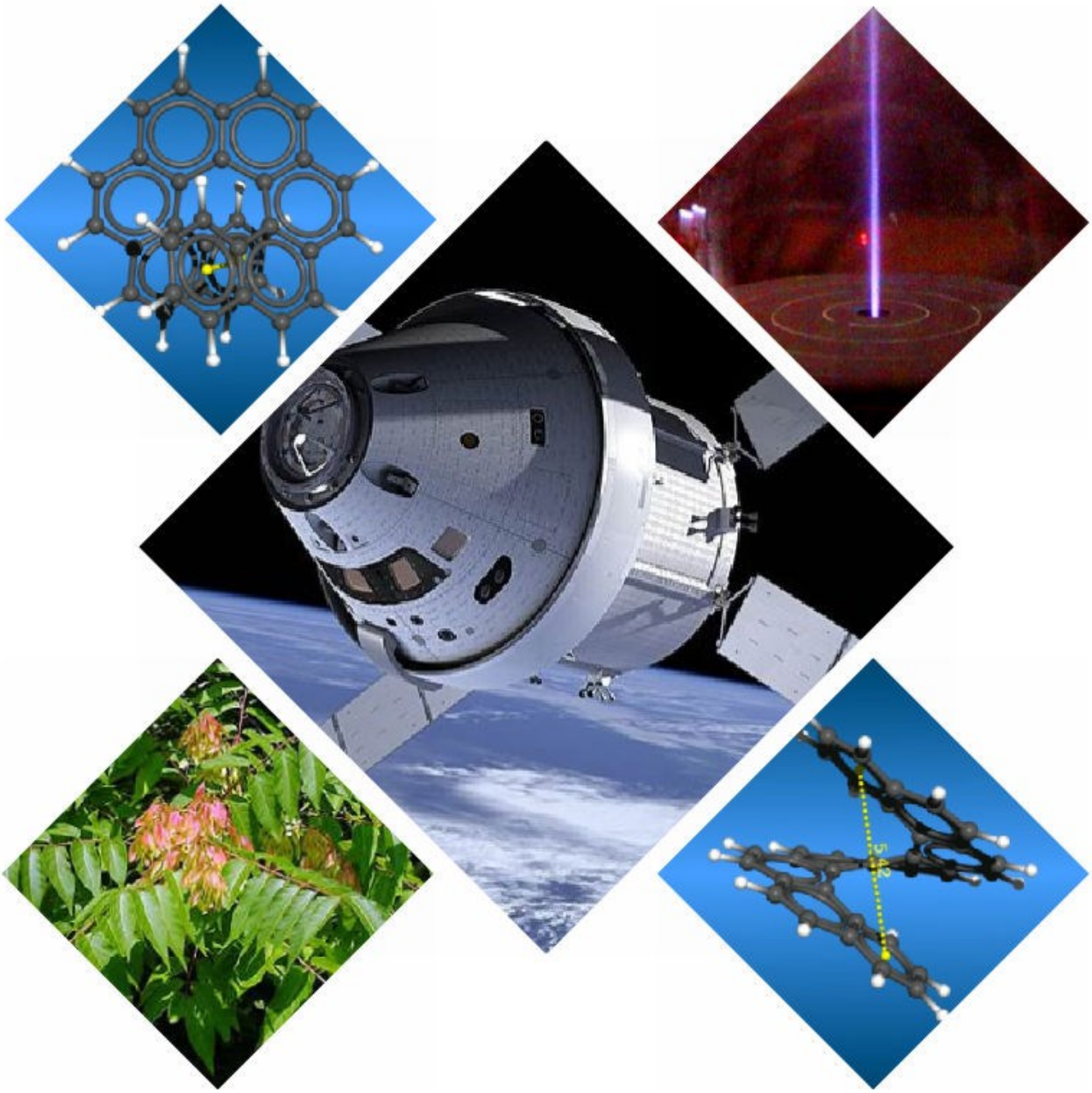
THE GOVERNOR'S SCHOOL for SCIENCE AND TECHNOLOGY



2014 Science Research Journal

Hybrid Wing Body Model Aircraft: An Aerodynamic Model and Desktop Simulation

Grant Gibson
Bethel High School
Hampton City Public Schools

Abstract

The Hybrid Wing Body (HWB) concept is a modern, unorthodox design developed to combat some of the problems of commercial airliners, decreasing the amount of noise and air pollution and increasing their overall efficiency. The HWB-N2A, the newest prototype from NASA, was developed based on previous designs and research. A virtual aerodynamic model of the HWB-N2A was created based on wind tunnel measurements. This aerodynamic model was developed using a combination of Excel® and MATLAB®/ Simulink® programming environments. The aerodynamic model provides an operational analysis of aerodynamic tendencies and characteristics and uses them to simulate flight. Pilots will be able to practice the operation of the HWB model using the created desktop simulation, as well as become familiar with the unique capabilities of the HWB-N2A.

"I am so thankful for the opportunity to work alongside aeronautical engineer, Dan Vicroy, for the past eleven months. Gaining access to wind tunnel tests, experimental helicopter drops, and the work of top-rated engineers was an unbelievable experience. My mentorship has greatly expanded my knowledge of the different aspects of engineering. While working at the NASA Langley Research Center, I learned valuable programming and simulation techniques that will undoubtedly continue to be of benefit to me throughout my education and career. Because of my mentorship, I have been greatly influenced to pursue mechanical engineering and possibly venture into aeronautical engineering as I move forward. I am deeply grateful to my mentor, who taught and assisted me throughout the entire mentorship, and to the Governor's School that gave me the opportunity to have this experience."

"*model provides an operational analysis of aerodynamic tendencies and characteristics*"

Grant will be attending the University of Virginia in the fall as a University Achievement recipient and Rodman Scholar and plans to major in mechanical engineering with an engineering business minor.

Economic and Environmental Value of Glyphosate as a Commercial Herbicide in Eastern Virginia

> *"society needs smarter and more environmental-friendly herbicides, and glyphosate is a strong candidate."*

Patricia Shorter
Gloucester High School
Gloucester County Schools

Abstract

Glyphosate is an herbicide well known for its effectiveness on woody and herbaceous growth, while having little impact on nearby ecosystems. To determine its effectiveness at various concentrations, a study was conducted in New Kent, Virginia. Three plots representing successional hardwood and herbaceous cover growth were marked and inventoried as thousandth-acre subplots, before being sprayed using sanitized backpack sprayers containing 0.5, 1.0, or 2.0 percent glyphosate. The surrounding area served as a negative control. Photographs were taken, recording the degree of herbicide success by leaf wilt, necrosis, and leaf drop. Using market prices for December 2013, 1.0 percent backpack application was deemed most cost effective when compared to other concentrations and applications, including Imazapyr, a highly-regulated competitor. A more cost-effective and environmentally-friendly herbicide is crucial to investor-owned utility companies, as well as other large organizations, as they work to protect ecosystems while addressing the need for plant control.

"This year, I have had the pleasure of working with Brian Daliege, head of Ecosystem Solutions in Toano, VA. On the first day, Brian told me that even though the study was a contract with a set problem in mind, it was my project, and I should not be afraid to make changes as I saw fit. The freedom was inspiring, but I learned a lot about how difficult being the person in charge really is. My mentor taught me about trees and chemicals, while also giving me a list of things to research on my own. Although environmental science is not my career focus, the skills I have developed in time management, field work, and scientific method will certainly help me in the years ahead."

Patricia will be attending Virginia Tech this fall in pursuit of a degree in microbiology and immunology.

Data Format Description Language Learning Resources

Avery Bibeau
Grafton High School
York County School Division

"tutorials provide a resource center for DFDL users"

Abstract

Parsing is the process of analyzing the validity of a data stream, converting the data stream into a desired, organized structure, and then performing actions based on this structure. Parsers are primarily used to interpret data files and convert them to a standardized format that can be used by other programs. Data Format Description Language (DFDL) is a modeling language developed by the Open Grid Forum used for describing the structure of text and binary data files. There are currently limited tutorial resources for DFDL. Detailed training materials are necessary as more features are implemented with DFDL parsers such as Daffodil, IBM Integration Toolkit, and FlowerVase. Toward this end, a series of tutorials dedicated to the implementation of DFDL features was produced and then submitted to the Open Grid Forum for publication. The tutorials cover a range of advanced DFDL features and their application. Tutorial subjects include default properties, default values, fixed values, trimming, escape blocks, and escape characters. Each tutorial was developed through a process of researching the feature, creating a sample data set for testing, developing and testing the schema, and then writing the tutorial. Each tutorial includes an Explanation of the feature and its purpose, a Problem that demonstrates a need for the feature, a Solution to the problem and what DFDL properties are needed, and an attached Schema that parses the sample data. The only feature not supported by all three DFDL parsers is the default values settings. All other schemas successfully demonstrate their use with the sample data. Although each tutorial only covers a specific feature and its use on simple data structures, the features can be combined to describe more advanced data formats. The tutorials for DFDL will provide professionals interested in using DFDL for their projects or services a resource center for feature specific lessons.

"I worked with James Garriss from the MITRE Coporation on creating tutorials for the emerging language DFDL. I spent the year learning the process of parsing data files into logical structures and creating materials that will be used by new users to DFDL. My mentor allowed me to interface with the language's publisher, the Open Grid Forum, and get feedback from the tutorials I developed throughout the year. Not only was I able to learn about an entirely foreign field of computer science, but I also learned a new programming language and will have my work published on the Open Grid Forum's hub for DFDL tutorials."

Avery will attend the University of Washington in the fall to pursue a major in computer science.

Beam Transport Monitor Design, Fabrication and Testing

Abstract

The Thomas Jefferson National Accelerator Facility (Jefferson Lab) Continuous Electron Beam Accelerator Facility (CEBAF) accelerator is currently undergoing a major energy upgrade. Multiple safety systems are currently used to minimize risk and protect staff and equipment. All safety systems were upgraded as part of the 12 GeV beam upgrade, and new systems added, for protection of people and equipment in the new experimental Hall D. Hall D has unique requirements to ensure the primary electron beam cannot be transported to the photon experimental area. A Beam Transport Monitor (BTM) was designed and installed in the Tagger area of Hall D as one method to fulfill this requirement. This safety system measures the energy setpoints of the magnets steering the beam into the Tagger area and the magnets directing the beam into a high power beam dump. If the magnet energies differ by more than one percent, the BTM automatically shuts off the electron beam in less than a half second. Current transducers were used to measure magnet current, and safety programmable logic controllers (PLC) were used to compare the measurements and calculated energies. The system was deemed successful because the BTM automatically shuts off the electron beam in less than 0.5 seconds if the calculated energy of the magnet steering the beam into the Tagger facility differs by more than one percent from the calculated energy of the magnet steering the beam into the high power beam dump. This program can be used as a model for other systems in which selected values must be averaged in safety logic, or two independent tools must continually perform identically.

> *"BMT automatically shuts off the electron beam in less than a half second"*

Bethany Wissmann
Warwick High School
Newport News Public Schools

"I learned a lot from my mentorship experience this year. I was introduced to safety systems and programming and also was able to learn more about Jefferson Lab and the work done there. It was great to learn how physics and math are applied in engineering, and then to get to work to apply them myself. Though my project was not strictly research for the sake of science, I feel I learned a lot about how research is conducted and also about life skills. I learned about scheduling and meeting deadlines, both for Jefferson Lab and for the research class. It was also really exciting to see something I helped build be used at Jefferson Lab to keep others safe. My mentorship has helped me to be more confident in my pursuit of an engineering degree."

Bethany will attend University of Virginia and plans to earn a degree in biomedical engineering.

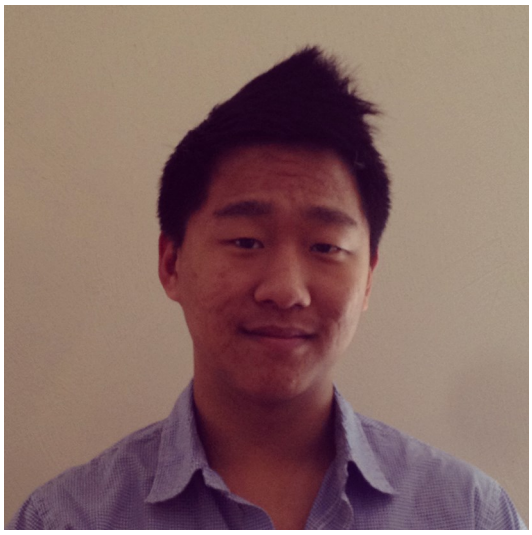
Role of Poly Thymine Promoter Tract in the Expression of Outer Membrane Protein 2 (OMP2) in Helicobacter pylori

Abstract

The bacterium *Helicobacter pylori* is a Gram-negative gastric pathogen that causes chronic gastritis, gastric ulcers, and the development of gastric cancer. Pathogenesis requires *H. pylori* to detect and respond to environmental signals, perhaps through the action of outer membrane protein 2 (OMP2). The hypothesis was that the transcription of OMP2, a porin, involves a transcription factor protein that binds upstream of a Poly Thymine (PolyT) tract associated with an OMP2 promoter. Mutation of this PolyT tract could potentially alter the expression of OMP2; however, the process to genetically mutate it, by increasing or decreasing the tract length, had yet to be accomplished. A plasmid was generated to deliver a mutant PolyT tract to *H. pylori* strain J99. A novel *Bam*H1 restriction endonuclease site (GGATCC) was successfully inserted into the plasmid upstream of the OMP2 PolyT tract, along with an antibiotic resistance gene to allow selection of transformed bacteria. Verification of OMP2 mutation will be via quantitative real-time PCR (qPCR). Mutants expressing defective OMP2 will be further studied to determine if OMP2 function is regulated by natural alterations in this gene sequence.

> *"mutation of the PolyT tract could potentially alter the expression"*

"I had the great privilege of working with Dr. Mark Forsyth at the College of William & Mary to learn more about the expressions of outer membrane proteins as a result of genetic mutations of a homopolymeric promoter tract. Throughout the year, I was able to learn how to do restriction enzyme digestions, recombine plasmids, and do genetic mutations to create a plasmid to make bacteria work in a way determined by humans. My mentor was of great help during the course time and was always available with information and guidance. Not only was I able to work alongside graduate students and my mentor, but I was also able to gain a great deal of knowledge and understanding within a field about which I originally knew very little. I wish to continue my research for as long as possible, but will have it continued by Dr. Forsyth and his graduate students if I am no longer able to continue it myself."



Edward Choi
Jamestown High School
Williamsburg James City County Schools

Edward will attend Virginia Tech in the fall where he will be majoring in biology.

Effect of Decreasing Vacuum-bag Pressure Below 30” on the Quality and Strength of the Newport Carbon Plain Weave Fabric

Sarah Selim
Menchville High School
Newport News Public Schools

Abstract

Composites, often used in aerospace, automotive, marine and recreational industries, are materials made of two or more constituents. Because each constituent retains its own physical properties, its optimum characteristics play an integral role in the formation of the composite. The effect of decreasing vacuum-bag pressure below 30” Hg on the quality and strength of the Newport Carbon Plain Weave Fabric 3K70P / NB321 composite were evaluated. Six composite panels were fabricated by stacking nine plies of this material. Each panel was placed in an individual vacuum bag and pressurized to the respective values of 30, 27.5, 25, 22.5, 20, and 16.5 “Hg for twenty-four-hours. Then the vacuum bags containing the six panels were placed in the autoclave to be cured. Visual analysis showed that the panels cured in the lower vacuum levels exhibited more surface porosity, leading to weaker physical properties. Future testing of the panels will include short beam strength, photo microscopy, and an acid digestion test. The data retrieved from these fabricated panels will be crucial in gaining a better understanding of the sensitivity of the material to variations in the vacuum level. Understanding the impacts of changes in the vacuum bagging procedures may result in lowering the required vacuum pressure for processing large pieces of hardware, such as the diaphragm of the NASA Orion, which could lead to cost and time schedule savings.

> *“could lead to decreases in the estimated cost and time for fabrication of large carbon composite structures”*

“Through the Governor’s School of Science and Technology mentorship program, I was selected to become a member of a research team at NASA Langley. There, I gained experience in a real-world working environment, as well as exposure to the growing field of materials engineering. Working on a large-scale project from start to finish, through the design, fabrication, testing and analyzing stages, has been an amazing learning experience. My project has provided me with an opportunity to fabricate carbon composites with large-scale machinery such as an autoclave, and perform in-depth structural analysis of those composites.”

Sarah will attend Georgia Tech to study engineering in the fall.

HUNCH—High school students United with NASA to Create Hardware

> *"solve problems related to the absence of gravity aboard the International Space Station"*

Overview

GSST participated in the NASA HEXS (HUNCH (High school students United with NASA to Create Hardware, Extreme Science program), a national STEM education program run locally by the Engineering Directorate at NASA's Langley Research Center. The HEXS program challenges students to use advanced science and engineering skills to solve ongoing problems related to the absence of gravity aboard the International Space Station (ISS).

GSST was:

- One of only 14 schools nationwide invited to develop Extreme Science experiments.
- One of only four new schools for 2013-2014.
- The first school in the history of the program to complete an experiment in their first year.

Using a formal engineering approach, the students evaluated reported ISS problems, brainstormed solutions, and drafted proposals for experiments to run in a microgravity environment. Students constructed two experiments, each employing advanced biomimicry technology:

- artificial photosynthesis system that could help astronauts combat the localized buildup of carbon dioxide on the ISS.
- "gecko tape," robotic system to clean dust from interior surfaces of the ISS.

Four students were selected to represent GSST:

Christopher Feigh - Gloucester HS
Matthew DiMarcantonio - Lafayette HS
Bethany Wissmann - Warwick HS
William Archer - Windsor HS

They conducted the HEXS experiments in microgravity aboard Zero Gravity Corporation's G-Force One plane.

During Flight Week, students faced a lengthy engineering readiness review and received flight training in Houston, Texas, near NASA Johnson Space Center.

NASA Exploration Design Challenge

"prototype will be sent into space on the Orion space capsule"

EDC 1st Place

Christopher Dobyns - Bethel HS
Daniel McNamara - Tabb HS
Anna Montgomery - Phoebus HS
Abid Rizzvi - York HS
Sajan Sheth - Tabb HS

Abstract

Deep space is an area of great interest for mankind; however, it is inhospitable, in part due to high levels of ionizing radiation – energy emitted in the form of rays or high-speed particles and carrying enough energy to destroy bonds on the molecular level. The NASA Exploration design Challenge (EDC) offered an opportunity for high school students across the U.S. to participate in the research and design process for radiation shielding in space. For this purpose, a structure was built to strict specifications: dimensions of not more than seven inches by seven inches by seven inches, and weighing no more than seven pounds. The structure contained several dosimeters to measure radiation doses, and was evaluated for its ability to shield against different types of radiation, as well as to its ability to withstand launch conditions of high G-loads and rigorous shaking. Radiation shielding was tested using simulations and the Bethe Formula, which calculates stopping power, or the ability of a material to block fast-moving particles. Launch conditions were tested using a centrifuge to simulate heavy G-forces and a paint shaker to simulate the rigorous shaking of the launch. The validity of these tests was supported by the use of an accelerometer, which measured the acceleration of the device. The final design was submitted to the EDC for evaluation. The Governor's School for Science and Technology EDC team submitted the national winning design, whose prototype will be sent into space on the Orion space capsule late in 2014.

"Our mentorship was a little bit unusual in that we were a team with members from both the morning and afternoon Governor's School sessions, so we all had to learn to work with new people on a very long-term project. This was a valuable skill not only for this project, but will continue to be later on in both college and in industry. Our mentor, Mr. Gregory Hajos, is a retired NASA engineer who has mentored for the Governor's School for a number of years. His guidance and contacts were an invaluable resource as we moved forward through the Exploration Design Challenge. The EDC gave us some pretty amazing experiences. We got to meet the Administrator of NASA, Charles Bolden, the CEO, President, and Chairman of Lockheed Martin, Marillyn Hewson, Program Manager of Orion, Mark Geyer, astronaut Rex Walheim, and many other NASA, Lockheed Martin, and NIA officials. These people are very busy and it was very special for them all to be in one place and for us to have the opportunity of meeting them. I think the most amazing part of this project is that we got to build something that will actually be sent into space, and top that off by being present to watch the launch. As high school students, being able to put something in space is just incredible. No, its more than incredible. It's out of this world….."

Christopher and Anna and will attend Virginia Tech in the fall to pursue a major in engineering. Sajan and Danny will be attending the University of Virginia and Abid will be at the College of William & Mary for the fall semester.

Charged Particle Tracking with CUDA

Jacob Pomeranz
Poquoson High School
Poquoson Public Schools

> *integration of CUDA with existing code requires major structural changes to maximize performance*

"Taking part in the senior mentorship was a lot of work and responsibility, but it was definitely worth it. Through my mentor, I was exposed to many new tools and technologies and learned a great deal about creative problem-solving. The experience I gained will be extremely useful later on in my career, and I look forward to taking part in similar research opportunities in the future."

Abstract

In weight-critical applications such as airplanes, honeycomb sandwich structure made of composite materials has been suggested as an effective alternative to heavier metals due its lower density and thus lighter weight but retained transverse stiffness. However, transverse loading on the honeycomb structure can cause a buckled core, resulting in greatly reduced resistance to further loading, but a possibly unnoticeable dent in the outside facesheet. Thus, predicting the damage caused by transverse loading becomes important, in order to decide if the core is sufficient. The confinement mechanism of quantum chromodynamics (QCD) has yet to be fully explained. Lattice QCD calculations support the existence of exotic hybrid mesons that are not predicted by the quark model. The GlueX experiment at Thomas Jefferson National Laboratory will search for the existence of mesons in excited gluonic states. Because GPUs offer a low-cost method of performing many floating-point calculations, and the fact that Jefferson Lab has a lattice QCD farm of GPUs available for research, a program was created using Compute Unified Device Architecture (CUDA) and C++ to reconstruct the tracks of charged particles in the GlueX experiment. The program was designed to use location and time data from the GlueX detector to simultaneously fit multiple tracks with multiple mass hypotheses to each particle, using Nvidia GPUs. The track fitting uses the least squares method of curve fitting. Particles are identified by comparing the chi-squared per degree of freedom of the fit for each particle type. The program was compared to the existing CPU-based Kalman Filter code at Jefferson Lab with 830 single-track events generated by a particle gun simulation to determine whether parallel processing on GPU cores offers a faster running time, while maintaining the same momentum resolution and efficiency. The GPU program reconstructed tracks at 32.5 events per second, while the CPU program ran at 80.0 events per second, indicating that the GPU program is not a viable alternative in its current state. Development of the GPU program revealed that the integration of CUDA with existing code requires major structural changes to maximize performance. While optimization and refactoring of the CUDA code could potentially improve performance, the GPU program will not be used in the GlueX project due to limitations on the time available for development.

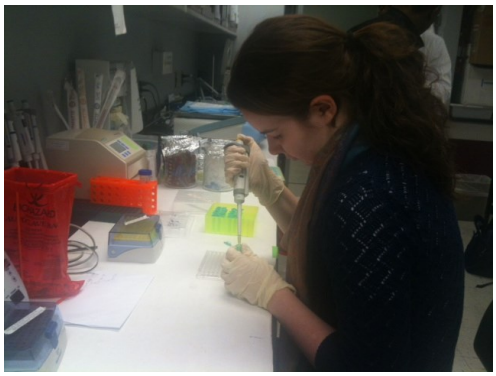
Jake will attend the University of Virginia in the fall of 2014 and plans to earn a degree in computer engineering.

Characterization of DNA Release from Thin Film Layer-by-Layer Drug Delivery Systems

"LbL self-assembly uses electrostatic interaction between polymers to build nanoscale delivery systems"

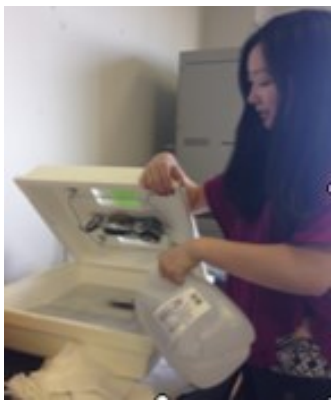
Abstract

Layer-by-Layer (LbL) self-assembly uses the electrostatic interaction between positively and negatively charged polymers to build alternating nanoscale layers of polymers and DNA. Certain factors can be tuned to achieve a desired kinetic profile. In this experiment, the number of layers (*n*) and method of assembly, dipping or spraying, were modified in order to analyze the resulting DNA release kinetics. DNA release of LbL thin films has so far only been characterized in phosphate buffered saline (PBS), a water-based salt solution. To understand the release of DNA in a human body, it is important to characterize the films in a protein solution such as bovine serum albumin (BSA). Thin films were constructed onto silicon slides by dipping the slides or spraying them with alternating solutions. DNA on the slides was then released into PBS or BSA over a period of 80 hours. The DNA released into the solutions was measured using a NanoDrop spectrophotometer, and release curves for the PBS and BSA were drawn. The DNA release rates and total amount of DNA release of the dipped PEM films varied from those of the sprayed PEM films due to factors that included electrostatic and molecular interactions, as well as the differences in time taken to form the dipped and sprayed films. For *n* = 10 baselayers, DNA released significantly more slowly in BSA than in PBS due to the interaction between the particles in the BSA solution and the proteins in the layers.



Kathleen Jordan
Menchville High School,
Newport News City Schools

Lucy Jin
Tabb High School
York County Public Schools



"We were mentored by Dr. Raymond Samuel at Hampton University's Engineering Department. We had a wonderful experience working in a college lab and becoming familiar with all the different lab procedures. We also learned a great deal about the scientific process and understanding that events do not always go as planned. Overall, the whole experience was rewarding, and we will certainly carry the lessons we learned with us into our college careers."

Katie will be attending Georgia Tech in the fall where she will major in Biomedical Engineering.

Lucy is an Echols Scholar at the University of Virginia; her major is currently not decided.

School Parking Lot Congestion: Modeling Time Inefficiencies

Avery Bibeau and **Sam Kim**
Grafton High School
York County Schools

> *simple changes to a system can lead to big results over time*

Abstract

Due to inefficiencies in traffic flow, many students experience major delays when exiting from the New Horizons Regional Education Center (NHREC) parking lot. Poor driver reaction times and parking lot structure lead to delays of up to half an hour, as buses from high schools (9 in the morning and 10 in the afternoon) attempt to leave the campus. Because of this, students often find themselves late to after-school activities and mentorships. A widely-applicable model of driver behavior capable of simulating changes in traffic systems was developed. The driver behavior model utilizes general information such as reaction and decision times, acceleration, and responsiveness to road information to simulate individual entities. Since each entity is influenced by the progress of those further ahead, this reactive system leads to slight delays between the actions of each successive entity. The expectation was that because of the individual influence of each entity on surrounding cars, minor tweaks to variables for each entity would lead to reduction in total time wasted. The simulation also employs basic traffic components such as yield signs, stop signs, and lanes to represent parking lot systems, allowing the NHREC parking lot itself to be studied using the driver behavior model. By observing actual driver behavior at the school, through security camera video footage, a range of driver reaction times was generated. Results of the study indicated that interchanging stop and yield signs at the two specified intersections may lead to as much as a 23% decrease in time experienced within the traffic system.

"Our project simulated parking lot congestion at New Horizons Regional Education Center, using an originally-developed simple traffic flow model. We learned about the process of analyzing a complex phenomenon and simulating it using an algorithm that includes the most influential factors of the event. After the simulation was completed, we had an opportunity to share our work with experts in the field from around the world at the 2013 Interservice/Industry Training, Simulation, and Education Conference. Lessons that we have gained from the research experience will prepare us for college and future endeavors."

Sam will be attending Virginia Tech in the fall where he will be majoring in finance.

Avery will be attending the University of Washington where he will be majoring in computer science.

Abdominal Surgery Fast-tracking

> *"Fast-Tracking expedites RRMC colorectal surgery patient recovery without compromising patient comfort or safety"*

Abstract

The Riverside Regional Medical Center (RRMC) anesthesia section recently began Fast-Tracking colorectal surgery patients. Efficacy, comfort, and safety of Fast-Tracking in expediting colorectal surgery patient recovery at RRMC were examined. Patient data for 80 conventional perioperative care and 80 Fast-Tracked RRMC abdominal surgery patients were retrospectively compared. Patient length of stay (LOS) was significantly shorter for Fast-Track patients (median LOS 3 days) than for conventional care patients (median LOS 6 days). Pain levels did not significantly differ between treatment groups. For both groups, pain scores decreased significantly as age increased. Postoperative serum creatinine change, an indicator of renal function, did not significantly differ between treatment groups. Forty-five percent of Fast-Track patients were readmitted and 47.5% of conventional care patients were readmitted. Differences in readmission percentages were not statistically significant. Given the factors considered, Fast-Tracking expedites RRMC colorectal surgery patient recovery without compromising patient comfort or safety.

Kayla Holston
Bethel High School
Hampton City Schools

"Doing research at Riverside Regional Medical Center has been an amazing experience. I have been given the opportunity to observe various types of surgeries—from outpatient orthopedic surgeries to inpatient neurosurgeries—and learn from conversations with countless physicians. Anesthesiologists at Riverside have explained to me the importance of various narcotics, protocols, and techniques they use. Neurosurgeons, colorectal surgeons, and orthopedic surgeons often shared their knowledge as well, teaching me about common diagnoses and surgical procedures in their areas of expertise. With so many experts willing to share their knowledge, the year seemed as if I had fifteen different mentors to teach me about controlling patient respiration during colorectal surgery, pumping blood out of the body and back in during cardiac surgery, and more. I have thoroughly enjoyed the learning experience I was afforded at Riverside, and I plan to continue researching there after graduating from high school."

Kayla will be attending to University of Virginia to study biomedical engineering. After undergraduate studies, she hopes to attend medical school to pursue a career as an anesthesiologist. Kayla plans to continue analyzing additional data from Riverside and to pursue publication of her findings.

Health Insurance Status and Severity of Illness of Emergency Department Patients

Abstract

A big problem currently impacting American hospital emergency departments is overcrowding, resulting in decreased physician access, resources, and patient safety. The growing number of uninsured patients is thought to contribute to this overcrowding, since they tend to use the emergency department for primary care, preventative treatment, and rapid access to medical resources. Since this seems to be the case, the hypothesis was that uninsured patients would tend to have less severe symptoms than the fully insured patient population seeking care in the Sentara Careplex Emergency Department.

In order to make sure that the critically ill receive priority in receiving treatment, a rating system, the Emergency Severity Index, has been implemented to prioritize patients based on symptom severity. Data from this system, along with patient age and insurance status, were collected and analyzed. Data were collected at different times and days of the week in order to reduce the effect of regular data patterns of any particular day or time. Results supported the hypothesis that uninsured patients tended to come to the emergency department with less severe symptoms than fully insured patients, indicating that health insurance is a major factor in determining a reason to visit the emergency department.

Tyler Sanders
Tabb High School
York County Public Schools

> *"health insurance is a major factor in determining a reason to visit the emergency department"*

"I had the privilege to work with Dr. Garrison in the Sentara Careplex Emergency Department. Mentorship in the Emergency Department has given me the opportunity to explore the medical career field. I saw the interactions between doctors and patients, medical problems of various subfields including cardiology and the digestive system, and unique treatments and procedures only found in the emergency department. Through mentorship, I was studied the relationship between health insurance status and severity of illness of the emergency department patients. The findings showed the fully insured patients were sicker and the uninsured were healthier. My mentorship has not only been a wonderful learning experience but also has affirmed my interest in medical career. "

Tyler will attend the University of Virginia in the fall where he is planning to major in biology.

Design and Analysis of Structure to Support Proposed Muon Detector for Hall D of Thomas Jefferson National Accelerator Facility

> *"complete structural analysis of the design was conducted to confirm its structural integrity"*

Abstract

A structure was designed to support the estimated 16.5 English ton load and four cubic meter geometry of a muon detector that will be housed down beam of the main detector in Hall D at Thomas Jefferson National Accelerator Facility (TJNAF). The design attempted to safely and efficiently support the load of the detector while remaining within a reasonable budget and meeting design requirements. The generated design had to be capable of being integrated into the existing hall layout by attaching to the existing Forward Calorimeter platform (FCAL platform). The structure will attach to the truss system of the FCAL platform by adding members to the existing truss system. Additional design requirements and constraints included fitting within the limited space available on top of the FCAL platform.

Once a geometric configuration for the structure was selected, models of the design were created using Autodesk Inventor 2014. Following the completion of several iterations of 3-D CAD models, a complete structural analysis of the generated design was conducted to confirm its structural integrity. A structural analysis application available as part of the Autodesk 2014 Suite, as well as hand calculations, were used to analyze the structure. The results of the analysis confirmed that the maximum stresses throughout the structure were within industry standard safety factors, and deflections throughout the structure were less that 1/32" and therefore a non-issue. For this reason, the design was determined to be a success and can be used as a reference for TNAF employees when the muon detector structure is formally designed.

Robert Smyth
Grafton High School
York County Public Schools

Working with Mr. Whitlatch at Jefferson Labs provided me an exceptional learning opportunity. I was able to use a variety of approaches for design and structural analysis. It is gratifying to think that a structure that I worked on may contribute to the fundamental understanding of high energy physics.

Bobby will attend Virginia Tech where he plans to major in engineering.

Interactive Web Software for Presentation of Bidirectional Reflectance Distribution Function

> *"understanding energy systems is critical to dealing with climate changes and global warming"*

Sophia Lin
Grafton High School
York County Public Schools

With Dr. Szedung Sun-Mack (mentor)

Abstract

A heightened understanding of Earth's climate and energy systems is critical to dealing with Earth's constant climate changes and global warming. Satellites are commonly used to collect data on these systems, but an abundance of unmanageable data hinders scientists from effectively analyzing the data at hand. Bidirectional reflectance distribution functions (BRDFs) are critically important in reflectance models, but generate large quantities of data, due to the multiple dimensions and intervals in each function. A user-friendly and easily-accessible database is needed to efficiently analyze these vast amounts of data. A computer program in Interactive Data Language (IDL) was written to effectively process all the data generated by BRDFs, while also outputting clear and neat graphics of the corresponding data. A website was programmed using PHP, HTML, CSS and JavaScript that features easy-to-use dropdown menus and lists from which the user can choose desired options, and the website then displays the appropriate graphs. The format of the website is also in accordance with other NASA Clouds Working Group database websites. The completed website aids scientists in their research on reflectance models by allowing them to easily analyze large amounts of data at once.

Working with Dr. Mack was a challenging and rewarding experience. I was able to work in new programming areas to create an opportunity for easier access to NASA climate data. These data are critical for ongoing studies of global climate change.

Sophia will be attending the University of Illinois at Urbana-Champaign where she will major in computer science.

Effect of Conjugation Length on NLO Properties and Band Gap of D-π-A Semiconductors Containing a Thiopene Ring

Abstract

The photovoltaic effect occurs when a photon strikes an electron in a semiconductor and excites it, causing it to gain energy and move to a higher energy level. Excited electrons jump from the valence band to the conduction band. The gap in energy between the bands is known as the band gap. A low band gap is beneficial for electronic devices because electrons may more easily jump it. One type of organic semiconductor is a D-π-A molecule. *D* refers to the donor species, a group of atoms that easily loses electrons to the rest of the molecule. *A* refers to the acceptor species, a group of atoms that attracts electrons from the system. The π group refers to the rest of the structure, including a thiopene ring. NO_2 and $^{+}NH_3$ were tested as *A* species, and $N(CH_3)_2$ and $N(CH_2CH_3)_2$ were tested as *D* species. The number of vinylene bridges (alternating single and double bonds between carbons) was varied between one and ten (n = 1-10). The band gap and polarizabilities were calculated for each molecule using MOPAC 2012, a semi-empirical software package. Results showed that as n increased, the band gap generally decreased, and polarizabilities increased. Varying the *A* species between NO_2 and $^{+}NH_3$ had a larger effect on band gap than varying the *D* species in the same manner. $^{+}NH_3$ proved to be a more potent acceptor, producing lower band gaps than NO_2. The results of this study may lead to more in-depth studies and potentially to improvements in the design of photovoltaic cells and other optical devices.

John Michael McCormick
Phoebus High School
Hampton City Public Schools

> *"study may lead to improvements in design of photovoltaics and other optical devices"*

"My mentorship project initially resembled more of a classroom lecture than a research project, since I had a significant amount of background knowledge to acquire before I could actually move into the project. Dr. Ndip was very understanding, and worked with me from the ground up until I had sufficient understanding of what I would be doing and why it would be important. After this initial round of lessons, however, Dr. Ndip left me to relative independence with the project. He was always around to help with issues I encountered, particularly with the programs, but he generally let me figure out the process as I went. This was difficult at times, but very rewarding, as the final product is something I have developed from nearly the beginning to the culmination, a very satisfying feeling."

John Michael will be attending the College of William and Mary in the fall to study physics.

Class of 2015 Achievements

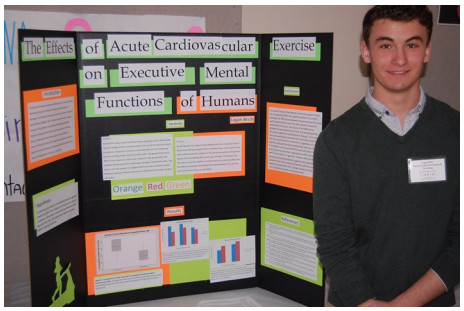
Tidewater Science & Engineering Fair (TSEF)
Old Dominion University, March 2014

Team: Nick Anselmo/Trace Goulter, Elec/Mechanical Engineering 1st
Team: Kelly Gazarik, **Courtney King**, Physics & Astronomy 1st
Austin Meier, Transportation 1st
Will Brayshaw, Elec/Mechanical Engineering 2nd
Bradley Canaday, Computer Science 2nd
Tanya Hoatson, Physics & Astronomy 2nd
Miriam Buscher, Physics & Astronomy 3rd
Sean Aminali, Behavioral Sciences, 3rd
Tuan Nguyen, Microbiology 3rd

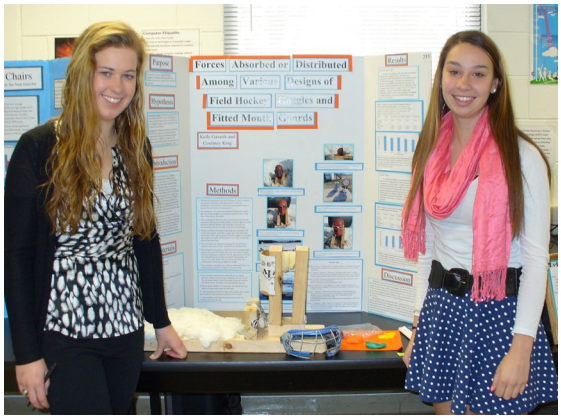
Shalni Kumar & **Christia Aspili**
Water Prize

Thomas (Trace) Goulter & **Nick Anselmo**
receiving one of many special awards

Austin Meier presents his poster



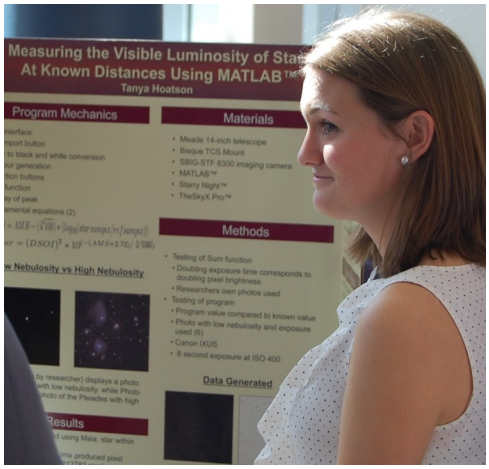
Logan Brich prepared for questions



Courtney King & **Kelly Gazarik** greet visitors at TSEF

Courtney King, **Kelly Gazarik**, **Tanya Hoatson**, **Miriam Bushcher**, **Chris Purman** "sweep" Physics & Astronomy Category

Class of 2015 Achievements



Tanya Hoatson presented at Virginia Junior Science & Humanities Symposium at James Madison University and was invited to participate at the National Junior Science & Humanities Symposium in Washington, D.C. Her project/poster presentation earned FIFTH overall in the nation!

All five first-place finishers at TSEF attended the Virginia State Science & Engineering Fair, at VMI.

Austin Meier placed 1st in the Energy & Transportation category.

Kaela Frazier
Governor McAuliffe STEM Scholarship Award—$2500

CNU Math Challenge

Shalni Kumar and **Chan Kim** take a break at the CNU Mathematics Challenge.

Shalni Kumar: Highest individual scoring junior

Honorable mention for earning one of the top 10 highest overall individual scores:
Jingwei Song
SuYoung Park
Chan Kim

Team awards in the AAA category:
First Place: **Alex Liang, SuYoung Park, Chan Kim**, and (senior) Correy Xu

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520 Butler Farm Road
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Research: Key Component of the GSST Student Experience

A primary goal of the GSST is to provide students with an opportunity to conduct serious scientific research, engineering design, or computer programming projects.

All students take a junior-year course in Research Methods and Ethics, which introduces them to research methodology, statistics, critical thinking skills, and the skills of scientific writing and presentation. In the junior year, all students prepare a science fair project for submission to the Tidewater Science Fair. Students are encourages 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 scientific 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 have included NASA Langley Research Center, Thomas Jefferson National Acceleration Facility, Virginia Institute of Marine Science, Veterans Administration Medical Center, Eastern Virginia Medical School, College of William & Mary, Hampton University, Christopher Newport University, Virginia Living Museum, local engineering firms, hospitals, and a variety of individual medical and professional firms.

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