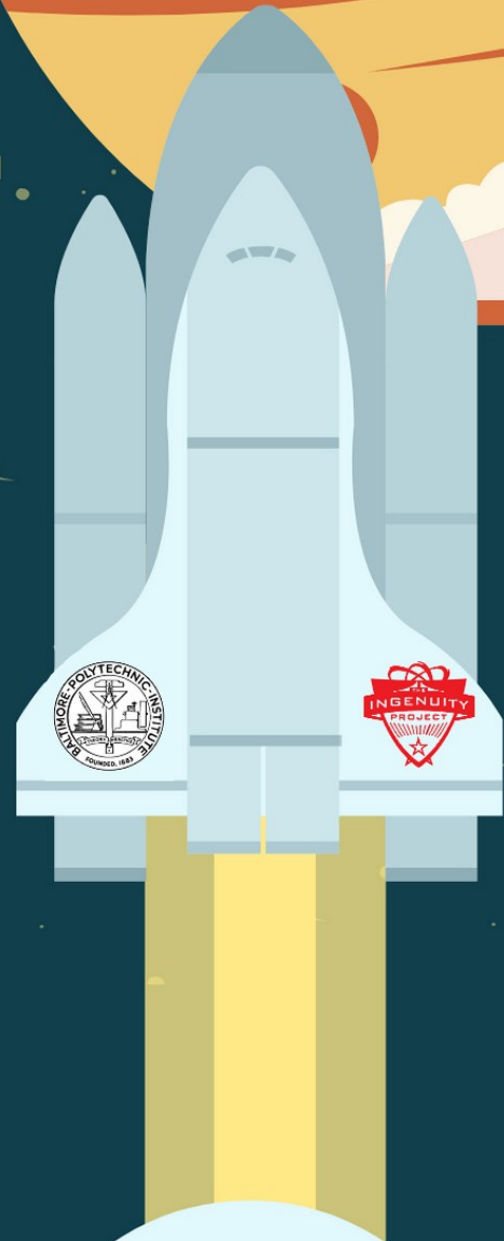


THE 18TH ANNUAL

# Math & Science Symposium

The Ingenuity Project  
@ Baltimore Polytechnic Institute

2019-2020







Dear Guests,

Thank you for being a part of Symposium Celebration. While this is not the way we hoped this year of amazing research accomplishments would culminate, we are grateful for the community of STEM teachers, parents, and mentors who have worked so hard with our outstanding students to get them where they are today. Because of the opportunities you gave them, they are entering college with unparalleled STEM experience and knowledge.

COVID-19 has taught us many lessons – including the importance of flexibility and innovation during challenging times. We are looking ahead to see how we can continue to provide research experiences for our students in different platforms until we can resume in-person activities. In addition to Research Practicum, we now also offer students the opportunity to engage in Innovation Practicum, a new off-campus experience designed for students to solve real-world problems with professionals in the fields of applied math, computer science, data science, and statistics. nine juniors forged the Innovation Practicum this year, and we are so eager for more rising juniors to take part next year in local start-ups, private sector, and university settings.

As you all are well aware, Ingenuity students are the next diverse generation of STEM leaders. Their persistence, creativity, and leadership amaze me every day -- and the skills they develop now will help them solve the challenges of the future. Thank you for providing them with your wisdom, insight, and expertise. Together, we're shaping STEM's future. Here's to an amazing class of 2020!

Sincerely,

A handwritten signature in black ink that reads "Lisette S. Morris". The signature is written in a cursive, flowing style.

Lisette S. Morris  
Executive Director

# Table of Contents

|                                |    |
|--------------------------------|----|
| Program Overview               | 5  |
| <b>Abstracts</b>               |    |
| Seniors, Research              | 6  |
| Seniors, Math                  | 14 |
| Juniors, Research              | 16 |
| Juniors, Innovation            | 29 |
| Sophomores                     | 33 |
| College Acceptances            | 48 |
| Math Education in Ingenuity    | 51 |
| Ingenuity Awards and Honors    | 52 |
| Ingenuity Science Competitions | 53 |
| Class Photos                   | 55 |
| Acknowledgements               | 64 |

Student research presentations on YouTube: [bit.ly/ResearchProjects2020](https://bit.ly/ResearchProjects2020)

# High School Program

## Baltimore Polytechnic Institute

Baltimore Polytechnic Institute, founded in 1883, has maintained a standard of excellence for over 120 years and is a Blue Ribbon School of Excellence. Founded as a technical (engineering) school, Poly gives students an advanced education in mathematics and science. Poly students consistently maintain standardized test scores above state and national averages. The Poly faculty is comprised of highly qualified individuals who provide valuable insights into the subjects they teach. They work beyond the regular school hours running sports, clubs, and other extracurricular activities. Not only are the students and faculty among the best in the state, but the Poly Alumni Association is also of the highest caliber. Alumni invest countless hours and dollars in support of Poly, keeping the school strong. Jacqueline Williams, class of 1983, has been the director of Poly for five years and has done an exceptional job in bringing great heart and vision to this already prestigious school.

## The Ingenuity Project<sup>®</sup>

The Ingenuity Project is a seven-year advanced STEM program in Baltimore City Public Schools, offered in four middle schools (Hamilton, James McHenry, Mount Royal, and Roland Park) and one high school (Poly). A 501(c)3 organization, Ingenuity is a joint effort of the Baltimore City Public School System, The Abell Foundation, and Baltimore's math and science community. We are the only comprehensive advanced math and science instructional program for high-achieving students in grades 6-12 in Baltimore City that has demonstrated consistent positive student outcomes.

Ingenuity is committed to ensuring the program reflects the ethnicity, gender, and income of Baltimore City households by recruiting and cultivating students with high potential and interest in STEM from historically underserved populations.

## Research Programs

The Ingenuity Research Curriculum is a three-year program spanning the sophomore to senior years, serving as an incubator for future scientists, engineers and mathematicians. During the Research Practicum experience, students work with mentors at local colleges, universities, and other research institutions to develop independent research projects. Students contribute to the body of research and, in some cases, have their work acknowledged in scientific papers. They are required to submit their work to national pre-college competitions. For some, this will mean entering the Regeneron Science Talent Search, the nation's oldest and most prestigious science and mathematics competition. Juniors and seniors submit their research to local science fairs as well.

The Innovation Practicum is a two-year sequential in-school and off-site research curriculum for 10th-11th grade Ingenuity students. Students gain hands-on experience in Applied Mathematics, Computer Science, Machine Learning, Data Science, and/or Statistics and learn coding languages and/or statistical analysis programs. The primary goal is for student investigators to plan and implement their own scientific research project. The program is open to any Ingenuity student in good academic standing who wishes to apply, as the curriculum is designed to meet students' individual needs and ability levels.

## Mathematics Program

The Ingenuity Mathematics Program has been designed by master mathematician Dr. Mikhail Goldenberg. He uses a variety of textbooks and selects topics that enable students to go into unusual depth in their understanding of the beauty of mathematics, while also enjoying the challenge that problem solving represents.

Incoming ninth grade students must take an Algebra I entrance examination and pass with at least an 80% grade. Those who do not score 80% are required to complete an Ingenuity summer algebra course, and have the opportunity to take the examination again. Ninth grade students complete a year of Geometry; tenth grade students complete a year of Algebra II, and a semester each of Trigonometry and Probability/Statistics. The majority of eleventh grade students complete Advanced Placement Calculus (AB), with the option of taking the AP examination at the end of their junior year. After studying advanced topics in calculus as seniors, many students take the AP Calculus (BC) examination. Students with extraordinary aptitude may take accelerated classes, and some work independently with Dr. Goldenberg. Through the years, many students have also qualified to take classes at Johns Hopkins University through the JHU Future Scholars Program.

Student success is documented through many mathematics competitions such as Maryland Math League, the American Mathematics Competitions, American Invitational Mathematics Examination and the University of Maryland High School Mathematics Competition.

# Senior Research Abstracts

The seniors' presentations represent the culmination of their research efforts. Students completing Ingenuity Research Practicum with Dr. Nicole Rosen worked with members of the scientific community for fifteen months during their junior year. Each student has written a formal research paper detailing the results of their respective projects. The papers were submitted to national pre-college competitions, including Regeneron Science Talent Search, Baltimore Science Fair, and Junior Science and Humanities Symposium.



Front Row (from left to right): Miriam Herrera, Marie Badiola, Samantha Yoseph

Middle Row: Matt Arcillo, Fiona Zabel, Maya Pulliam, Donaysia Torbit

Back Row: Jarra Omar, Alexander Nishiura, Raekwon Williams, Ari Harris-Kupfer, Caleb Clark, Isaiah Roberts

# Senior Research Abstracts

## Stability Test of *Vibrio cholerae* DNA Preserved onto Various Types of Filter Papers

Matt Ervince S. Arcillo

**Mentor:** Dr. Kawsar Talaat

**Supervisor:** Mark Jones

**Institution:** Center for Immunization Research, Johns Hopkins Bloomberg School of Public Health

*Vibrio cholerae* most commonly known as cholera, remains an urgent public health crisis in developing regions, specifically those in Africa and South-East Asia. The disease is spread through contaminated drinking water and can be fatal if not treated immediately. Its main symptoms include diarrhea and dehydration. Because of the lack of surveillance in certain regions, an exact number of infections and deaths is unavailable in certain regions, but the global death estimate is approximately 150 thousand annually. An increase in the need for surveillance of the disease, through early detection and genotyping, also increases the need for cheaper materials and methods. Decreasing the cost for the DNA extractions process will help researchers in the affected regions study the behavior of cholera more effectively. For this study, we aim to compare the DNA concentrations over time preserved various filter papers, which are used to preserve DNA from samples, specifically the Whatman 903 Protein Saver Cards, Whatman W1, Fisher P8, paper towel, and a Cholera Rapid Diagnostic Test when extracting cholera culture DNA. I used the Chelex method to extract DNA from the filter papers and verify our results with PCR. The data shows consistency in concentrations over the six months of data collection, and that the standard filter paper brands, which are already used for DNA extractions, are more effective and more reliable than the non-conventional paper towels that were tested.

## Diagnosing Schistosomiasis for a Study of Hepatitis in Uganda

Marie Badiola

**Mentor:** Dr. Clive Shiff

**Supervisor:**

**Institution:** Department of Molecular Microbiology and Immunology, Johns Hopkins Bloomberg School of Public Health

One of the most widespread infectious parasitic diseases is schistosomiasis. The diagnosis for this parasite is important because an estimated 800 million people are at risk of contamination. Schistosomes are carried by certain types of freshwater snails and humans become contaminated by coming in contact with the contaminated freshwater, where the snails live. Most human infections are caused by *Schistosoma mansoni* and *S. haematobium*. These parasites affect two different parts of the body, *S. mansoni* affects the mesenteric veins while *S. haematobium* affects the bladder and adjacent organs. Recently, a study was conducted where the relationship between *S. mansoni* and hepatitis are analyzed because being infected with *S. mansoni* can result in damage to the liver, which can overlap with the symptoms of hepatitis. Samples from the study were collected from Gulu, Uganda and were tested for *S. haematobium*. The samples were diagnosed through DNA extraction through dried urine samples. It has been found that DNA extraction through urine has been successful in diagnosing parasitic diseases. This method is less invasive and cost-effective. The extracted DNA from the filter paper is amplified through the use of the polymerase chain reaction (PCR) and analyzed through gel electrophoresis. 27% of the samples were positive for both *S. mansoni* and *S. haematobium*. The proportion of people that had either *S. mansoni*, *S. haematobium*, or both was analyzed to show if *S. haematobium* was another parasite that could also affect the liver and overlap symptoms of hepatitis.

# Senior Research Abstracts

## Effects of curvature on Topological Defect Formation in Liquid Crystals

Caleb Clark

**Mentor:** Dr. Francesca Serra

**Institution:** Henry A. Rowland Department of Physics and Astronomy, Johns Hopkins University

Liquid Crystals (LCs) are a state of matter between solid and liquid. They have an elongated shape and tend to self-align along the long side. Topological Defects (TDs) are regions of disorder in ordered systems. In LCs, TDs form when the molecules are unable to self-align. TDs are present across many fields of physics and have applications in data storage and quantum computing. However, in LCs they are easiest to observe and manipulate. Moreover, TDs in LCs act as lenses, and manipulating their position is useful when controlling light. I am interested in defect formation around curved features in glass microchannels during the isotropic to nematic and nematic to smectic phase transitions. I observe defect formation during the phase transitions near “bumps” in glass microchannels. Defects are counted during two phases of the isotropic to nematic transition: when there are no longer LCs in the isotropic phase and just before the molecules regain their stable state of perpendicular molecular alignment. In most cases, defects form near curved regions in the glass microchannels. During the nematic to smectic transition, regularity among defects shows that they are influenced by curved regions. TDs tend to appear in patterns. This shows that defect formation is significantly affected by curvature of the bounding surface.

## Analyzing the Factors Contributing to Pulmonary Hypertension

Donaysia Torbit

**Mentor:** Eugenia R. Volkova

**Supervisor:** Dr. Sharon Gerecht

**Institution:** The Gerecht Lab, The Department of Chemical and Biomolecular Engineering, Johns Hopkins University

Pulmonary hypertension impacts millions of people worldwide. About one in three adults is affected by the disease, and many others remain undiagnosed. Hypertension happens when the blood pressure in the pulmonary arteries and can cause heart attack, stroke, and dizziness. When the disease develops, the arteries become narrowed and the blood flow is altered. This means that the body has to work harder to get blood to the organs of the body. Pulmonary hypertension is defined as rapid angiogenesis in the body, which is the sprouting of new blood vessels from preexisting ones. The leading cause of pulmonary hypertension is currently unknown. Some scientists theorize that certain protein factors, proliferation levels, and ECM deposition may lead to the disease. To understand the potential origins of pulmonary hypertension, we looked at the vessels explanted from mice. The arteries were surgically removed from the mice and imaged for any discrepancies. Staining of H&E, MAS, and VVG allowed measurements to be taken of the cell nuclei, blood cells, and collagen. The stains were then conducted in order to analyze if there was a relationship between the cell alignment in the nucleus.



# Senior Research Abstracts

## **Determining the Carbon Isotope Ratio of Sediment in the Turks and Caicos**

Ari Harris-Kupfer

**Mentor:** Dr. Maya Gomes

**Supervisor:** Dr. Emmy Smith

**Institution:** Earth and Planetary Sciences, Johns Hopkins University

The history of the Earth is written in the rocks. Earth's rock layers capture the chemical composition of the environment they were formed in. By looking at multiple consecutive Earth layers, a change in the chemical composition is visible. The chemical composition will change between layers as the environment changes between layers, so signs of environmental change can be identified by looking through past layers. The environment that layers form in could be uniform or isolated to the environment of other locations in the world. This can be determined by whether the environment is regulated by seawater, which circulates around the world and maintains a global environment, or by porewater which is limited to a local area and maintains a local environment. Thus, signs of environmental change found in the layers could be on a local or global scale. My research project is to determine whether the carbon isotope ratio of layers from the Turks and Caicos are closer to seawater or porewater influenced carbon isotope ratios. An isotopic ratio mass spectrometer was used to determine the carbon isotope ratio of sediment from the Turks and Caicos. The sediment had a close carbon isotope ratio to seawater sediment. With the knowledge that the carbon isotope ratio in the Turks and Caicos is similar to other places around the world that are circulated by seawater, any geological discoveries on past environments or environmental change could be consistent around the world.

## **CRISPR- Cas9 Modification of a Worm Gene to Permit Cell Specific Loss of a Gene**

Miriam Herrera

**Mentor:** Dr. Andrew Gordus

**Institution:** The Gordus Lab at Johns Hopkins University, Department of Biology

Neurons can chemically communicate with each other by releasing neurotransmitters to other neurons. Despite knowing this, questions still remain as to how such communication functions and what purposes it may serve. In *C. elegans*, *unc-18* promotes chemical communication between neurons by being involved in vesicle docking/release of neurotransmitters. To study the effects of cutting off chemical communication between neurons, we wanted to knock out the *unc-18* gene. Therefore, the goal of this project is to create a tool using the Cre-Lox system that will knockout *unc-18* by introducing LoxP sites around it. We are using molecular cloning to isolate the LoxP sites for insertion and CRISPR/Cas9 to insert these sites around the *unc-18* gene. This tool will contribute to future research relying on *unc-18* knockout to observe the effects of blocked chemical communication on organismal behavior, and provide implications regarding the function of such communication.

# Senior Research Abstracts

## **Cold-formed Steel Shear Wall Chord Stud Optimization for Seismic Performance**

Alex Nishiura

**Mentor:** Dr. Benjamin Schafer

**Institution:** Department of Civil and Systems Engineering, Johns Hopkins Whiting School of Engineering

Shear walls are an important structural system for absorbing lateral forces, which are commonly generated by earthquakes. The large supporting columns, or chord studs, located on either end of a shear wall, are responsible for dissipating the stress from the wall to the ground. This type of column's traditional design is outdated and is a lacking area of research in seismic engineering, shown by its relatively low strength. It is easy to increase the strength of a column by adding more material, but it is inefficient. The goal of the current study is to design an efficient and effective column that uses the same amount of material by changing its shape. This is done by performing elastic buckling analysis in a program called CUFSM, or Constrained/Unconstrained Finite Strip Method. A column cross-section with the same area but a higher predicted strength will be designed. Combining elastic buckling results with the Direct Strength Method, accounting for buckling mode interaction, leads to a single design value for member's overall strength that can be compared to that of what is currently used. Analysis of a common stud column shows that it is very strong at resisting distortional buckling, but the overall strength is lacking because of local and global buckling modes failures. While still to be confirmed by physical testing, predicted results have shown moving material from the length of the web to the length of the flanges to significantly increase overall strength.

## **Analyzing Synapses onto Somatostatin Interneurons**

Jarra Omar

**Mentor:** Dr. Hey-Kyoung Lee

**Supervisor:** Bryce Grier

**Institution:** The Zanvyl Krieger Mind/Brain Institute, Johns Hopkins Whiting School of Engineering

The loss of vision causes a variety of changes in the primary visual cortex. The brain can compensate for this deprivation by heightening the remaining sensory functions; however, many of the changes underlying this compensation are still unknown. Researching these changes in the deprived visual cortex could provide a basis for rehabilitation of brain injuries and defects. This study aims to analyze the distribution of excitatory synapses on somatostatin (SOM) interneurons from both intracortical and thalamocortical projections through immunohistochemistry and confocal microscopy. Initial results indicate that we are able to visualize intracortical synapses onto SOM cells with VGlut1 and thalamocortical synapses with VGlut2. Analysis of synapse density near the soma found a difference between the two populations of synapses. With these protocols, it will be possible to generate protocols for different antibodies to explore the nature of excitatory and inhibitory synapses located on SOM cells and highlight changes over different periods of visual deprivation.

# Senior Research Abstracts

## **The Relationship Between First Line HIV Therapies and Blood-Brain Barrier Function**

Maya Pulliam

**Mentor:** Dr. Dionna Williams

**Supervisor:** Ms. Lisa Fridman

**Institution:** Miller Research Building, Johns Hopkins Bloomberg School of Public Health

There is a limited understanding in the field as to how first line antiretroviral therapy (ART) affects brain endothelial cells at the blood-brain barrier. Due to the prevalence of cognitive issues in patients, despite undetectable virus in their blood streams, it is sufficient to consider these HIV therapies as possible contributors to the problem. Endothelial cells are responsible for sealing the barrier as well as nutrient transport in and out of the brain, thus endothelial dysfunction may include changes in nutrient transport and barrier integrity which is very serious. Glucose is the main energy source of the brain it is important to consider as well as tight junctional proteins such as claudin-5 and occludin which have been seen to lead barrier deterioration if downregulated. By means of western blotting, qRT-PCR, and flow cytometry, I examined how GLUT1, occludin, and claudin-5, are affected by ART. Although data shows some fold changes as a result of treatment, none were seen to be statistically significant. However, this does not mean that other nutrient transporters and tight junctional proteins are not being affected by ART. More research should be done looking into possible brain endothelial dysfunction due to ART. Information on how ART affects the blood-brain barrier would have implications on how patients are treated for their virus as well as what preventative measures are taken to prevent infection in HIV-negative groups who are more at risk of contracting the virus.

## **Reanalysis of Possible Shorelines in the Arabia Terra Region of Mars**

Isaiah Roberts

**Mentor:** Dr. Kevin Lewis

**Institution:** Earth and Planetary Sciences, Johns Hopkins University

The idea that an ocean could have existed on Mars in the ancient past is still not fully proven, however evidence points to the possibility of its occurrence. One major piece of evidence is the presence of possible shoreline features on Mars. Although previously identified shorelines do not lie at a constant elevation, a recent study proposes that the reason for the current deformed status of the shorelines is a result of true polar wander (TPW) and lithospheric loading by volcanoes. However, that study relied on relatively low-resolution elevation data that could potentially introduce errors. In order to test the Mars ocean hypothesis, I am remapping the shorelines at higher resolution using new elevation data. Stereo images from the Context Camera (CTX) are used to construct Digital Elevation Models (DEMs). By remapping the proposed shorelines, I can get more precise elevation values. Although all data has not been gathered, current results suggest that Citron's data were valid. Still, further mapping of additional segments of the shorelines will help test the ocean hypothesis.

# Senior Research Abstracts

## Targeting Glutamine Metabolism in M2 Tumor-Associated Macrophages in Prostate Cancer

Raekwon A. Williams

**Mentor:** Dr. Jelani Zarif

**Supervisors:** Fan Shen, Thomas Nirschl, and Debebe Theodros

**Institution:** Department of Oncology-Prostate Cancer, Bloomberg Kimmel Institute for Cancer Immunotherapy, Johns Hopkins University School of Medicine

Macrophages display significant plasticity and can perform different roles depending on the presence of specific signaling molecules in the microenvironment. Alternatively activated (M2) macrophages suppress an antitumor immune response in prostate cancer and promote the spreading of cancerous cells from the primary tumor. Unlike M2 macrophages, classically activated macrophages (M1) can trigger immune responses against invaders. Glutamine, heavily present in the tumor microenvironment of prostate cancer, has been shown to play a crucial role in M2 polarization. The pathways at which M2 macrophages metabolize glutamine during polarization are not well mapped out. My project focused on depriving M1 and M2 macrophages of glutamine during and after polarization to determine differences in gene transcript and protein expression levels, which we hypothesized may help to revert the suppressive M2 macrophages to the inflammatory M1 macrophages. I observed the changes that occurred on the transcriptional and translational levels using qRT PCR and immunoblotting. Glutamine deprivation significantly caused decreases in both gene transcript and protein expression of CD163, a canonical M2 marker, suggesting that glutamine is a good target to possibly revert M2 macrophages to M1 macrophages. Additionally, glutamine deprivation increased expression of the pro-inflammatory mediator IFN- $\gamma$  which is associated with M1 macrophages. Interestingly, I observed a marked decrease in gene transcript of IL-10, which is typically associated with immune suppression and M2-macrophages in cancer. My results suggest that glutamine deprivation could be used to impede M2 macrophages survival and reverse their polarization in the tumor microenvironment of prostate cancer to overcome tumor immunity.

# Senior Research Abstracts

## Mouse Embryonic Fibroblast Cell Isolation Using Deformability-activated Cell Sorting

Samantha Yoseph

**Mentor:** Dr. Soojung Claire Hur

**Institution:** Department of Mechanical Engineering, Johns Hopkins Whiting School of Engineering

Cost and accessibility are major elements affecting the quality of general healthcare of the public. To create simple, yet equally efficient products, researchers have miniaturized and specified biological processes through microfluidics, a method that takes advantage of fluid dynamics and condenses it to a microscale level. I am working to utilize the microfluidic process with label-free methods, isolating cells based on cell deformation. In turn, cell filtration will be more effective in practice due to improved speed and accuracy. By developing a deformability-activated cell sorting (DACS) device consisting of a single inlet through which cells enter, and expanding into five outlets through which cells leave, I used cell deformation as a plausible biomarker. Mouse embryonic fibroblast (MEF) cells were used to determine if DACS could be used to distinguish between knockout cells, which have an inoperable gene, and wild type cells, which are cells in its most natural state. Experiments were unsuccessful in distinguishing knockout from wild type, but successful in determining cell filtration patterns and movement. To identify other differences possibly present within the MEF cells, I looked into cell size, lipid content, and focusing positions instead of collection. In the future, more testing will be done observing the knockout and wild type cells for comparison purposes and to ensure the accuracy of results. This device will improve upon emergency and low-resource type medical applications, providing low cost treatment and ease-of-access.

## Cognitive Impact of Superfund Site Exposure in Baltimore City

Fiona Zabel

**Mentor:** Dr. Michelle Carlson

**Supervisor:** Breanna Crane

**Institution:** The Carlson Lab, Johns Hopkins Bloomberg School of Public Health, Departments of Mental Health and Epidemiology

This study aims to investigate the association between proximity to superfund sites and risk of developing dementia as a population. The importance of understanding the effects of superfund sites is crucial due to site prevalence. There are currently 1,322 superfund sites on the National Priority List, most with towns of large populations living around them while being exposed to the emitted organic pollutants. To test for the association between proximity to superfund sites and risk of dementia, this study analyzed data from the Baltimore Experience Corps Trials Study, including geo-tracking software that can pair superfund sites with the participants' location. This study aims to understand the level to which different areas of Baltimore are affected by the superfund sites found within the city. For each site, the specific chemical toxicant was identified (e.g. dioxins) to determine the most impactful chemical. This study hypothesizes a positive association between proximity to superfund sites, or number of superfund sites in the area, and higher incidence rates of dementia in the surrounding populations. If areas with more superfund sites yield a higher prevalence of dementia diagnoses, then the chemicals emitted from superfund sites will likely have influenced the cognition of the participants. While analyses are still underway, preliminary findings suggest a higher frequency of Mild Cognitive Impairment cases in more polluted areas as opposed to dementia cases. Future steps will be taken to investigate the mechanism of this decline in cognition and develop interventions to combat the effects of exposure to environmental toxicants.

# Senior Math Projects

Each of the following mathematics projects was conducted under the supervision of Dr. Mikhail Goldenberg, the Ingenuity Math Department Head. After completing their coursework for the Calculus BC course, the students selected topics for in-depth study and solved a complex problem on that topic.

## **Maxima and Minima of the Functions of Two Variables**

Maya Pulliam, Samantha Yoseph, and Fiona Zabel

In this project, we are discussing two approaches in solving extrema problems of the function of two variables. One of them is to use the necessary conditions, and then find critical points, and then the sign of discrimination to determine the nature of critical points. Another one is to use the given restrictions and apply Lagrange's multipliers. When approaching word problems we used the provided information to develop equations and to optimize some quantity. In such a way we were able, for example, to maximize the volume of a rectangular prism when its surface area is given. We also solved some other classical optimization problems.

## **Properties of Some Special Quadrilateral**

Corinne Charney, Naomi Naka, and Marie Badiola

Quadrilaterals we study in school geometry can be determined by properties of their diagonals. Parallelogram, for example, can be defined as a quadrilateral in which diagonals bisect each other. Diagonals of a rhombus are perpendicular and bisect each other. We consider in this project a quadrilateral (call it Squeer) which is not a trapezoid and in which diagonals are equal and perpendicular. The study shows that the Squeer is reach of interesting properties. For example, one may construct a line related to a Squeer which is similar in some sense to the Euler line of a triangle. Moreover, in the Squeer configuration one can find 12 lines which all concurrent at one point. We believe that it is possible to discover many more properties of a Squeer.

## **Method of Substitution in Solving Some First and Second Order Differential Equations**

Peter Hope, Jarra Omar, and Isaiah Roberts

Differential equations compare one or more functions and their derivatives. When studying differential equations, we took solutions of the differential equations and the properties of solutions into account. This presentation will solve complex first and second-order differential equations through the use of various methods substitution, making the problem more approachable and easier to solve.

# Senior Math Projects

## Introduction to 3D Geometry

Matt Arcillo, Caleb Clark, and Jacky Le

Non-Euclidean geometry consists of the study of lines, planes, and shapes in three dimensions. This topic uses the combination of theorems and axioms from Euclidean geometry as well as some of its own to make general statements about the relationships between lines, planes, and shapes in three dimensions. In this project, we develop a few of non-Euclidean geometry, such as the “theorem about two perpendiculars” and the “theorem about three perpendiculars.” We will also develop some problems about three-dimensional shapes such as the “3D Pythagorean theorem,” and the “surface area of a pyramid with square base,” and the, “angle at which the cross-section of a rhombus prism is a square.” Non-Euclidean geometry has many real-world applications, from GPS to the General theory of Relativity, however, many of these applications are very complex. Our project aims to provide a general introduction to 3D geometry.

## Solving Future Scholars Problems

Helen Schott and Lucy Canick

Every year, the Johns Hopkins Future Scholars entrance exam allows high school students to test their problem solving skills and mathematical agility for a chance to enroll in university classes. These entrance exams, though usually seem a mere stepping stone to the opportunity to study at Johns Hopkins, are in and of themselves interesting mathematical feats. Each test consists of a dozen meticulously designed questions, whose topics vary widely, to integrals to series summations to proof of equalities. All provide their own unique challenges and require out-of-the-box application of mathematical skills and logic. Using a bedrock of calculus knowledge, we solved many of these problems, and in this project will highlight several that we found particularly compelling. Our project presents a rigorous examination of these Future Scholars questions—both their solutions, and the mathematical theories that allow us to solve them.

# Junior Research Abstracts

The juniors are entering the final phase of their Research Practicum placements. Throughout the previous summer and the current school year they have worked with their mentors on their independent research projects. Many will continue their work this summer to complete their projects. The posters on display represent recent progress. Juniors submit their work to local competitions, including the Baltimore Science Fair and Maryland Junior Science and Humanities Symposium. The juniors are also responsible for organizing the Symposium event.



**Front Row** (from left to right): Kristiana Smith, Julia Alumbro, Juni Polansky, Abby Torregoza, Isabelle Richard, Tejal Schwartz

**Second Row:** Tendai Coady, Seth Chng-Lim, Sabina Celnik, Chielota Uma, Riyan Campbell, Sarah Li

**Third Row:** Nicholas Pham, Madeline Jaffe, Maya Filipovitz, Aaron Villahermosa

**Back Row:** Elias Brody, Talya Simcox, Ihemriorochi Amanze, Nhan Le, Tate Bothner

Not Pictured: Jacob Thompson



# Junior Research Abstracts

## **Examining Water Quality Trends in the Jones Falls Stream**

Julia Alumbro

**Mentor:** Dr. Ciaran Harman

**Supervisor:** Dr. Carsten Prasse

**Institution:** Department of Environmental Health and Engineering, Johns Hopkins Whiting School of Engineering

In Baltimore City, sanitary sewage overflows (SSO) are a result of a faulty and outdated separated sewer system. However, with a series of new developmental plans, ranges of water quality parameters are subject to change depending on a location in the city. Previous research was conducted at these locations to track the water quality changes and the system's functionality. My study aims to understand the relationship between water quality, socioeconomic factors, land use, and location. Data from the Department of Public Works was put under statistical analysis on Python and a GIS map was developed to represent the combined data. We took into account drainage area, type of location (i.e channel, outfall, manhole), and the percent error in the dataset. The amount of ammonia content at each location varied but was evidently the largest closest to the Baltimore Harbor. This suggests that areas with larger and more interceptable drainages contain more extreme water quality measurements. Moreover, relationships between watershed quality vs. area are being explored to further solidify this conclusion.

## **A Wearable Anthropomorphically Driven Prosthesis With a Built-In Haptic Feedback System**

Ihemriorochi Amanze

**Mentor:** Dr. Jeremy Brown

**Supervisor:** Ethan Miller

**Institution:** Department of Mechanical Engineering, Johns Hopkins University

In this country 2.1 million people live with limb loss and of those people 75% use a prosthesis of some sort. Current prosthesis users today suffer from overpricing, weight, and feedback, all of which need to be improved upon. Haptic feedback is the sense of touch received in response to contact with skin and nerves, this includes pressure, temperature, force, and vibration feedback. Prosthesis users are deprived from certain feedback making accurate and price control of the prosthesis more difficult. My research focused on developing and testing control methods for prosthesis. These methods could then be used in conjunction with a skin stretch Haptic feedback method, ultimately giving prosthesis users more accurate control of their prosthesis. This is accomplished using a previous testing method known as the box and blocks test which has prosthesis users attempt to move as many blocks as they can to another side of a container in a single minute.

# Junior Research Abstracts

## **Systematic analysis of PAM sequences on target interference in *E. coli* type I-E CRISPR-Cas systems**

Tate Bothner

**Mentor:** Dr. Scott Bailey

**Supervisor:** Haobo Wang

**Institution:** Department of Biochemistry and Molecular Biology, Johns Hopkins Bloomberg School of Public Health

CRISPR-Cas (Clustered Regularly Interspaced Short Palindromic Repeat-CRISPR associated) systems are adaptive bacterial immune systems found in bacteria and archaea to fight against invaders. In *E. coli*, Type I-E CRISPR-Cas systems utilize Cascade (CRISPR-associated complex for antiviral defense) to identify foreign DNA elements for interference, the third step in CRISPR immunity by which target DNA is degraded. To be more specific, Cascade interrogates the protospacer adjacent motif (PAM), a 3-nucleotide sequence adjacent to a potential target, before further investigating the downstream target sequence and ultimately initiating degradation. However, little is known about PAM recognition by Cascade at a molecular level. The aim of my study is to systematically determine the effects of PAM sequences on interference. Primarily, an *in vitro* DNA cleavage assay will be used to obtain results. I expect some of the PAM sequences to trigger robust target degradation, while others will display impaired interference activity. By collecting data from all 64 PAM sequences, I will be able to determine possible associations between PAM sequences and interference. As I am currently in the first stages of data collection, I do not yet have results to discuss; however, after the assays are conducted, the results should show how the PAM sequence affects target cleavage. Future work will include a series of *in vivo* assays to validate the *in vitro* results.

## **The Effects of Shear Stress on Fibrillin-1 Production in Marfan Syndrome Endothelial Cells**

Eli Brody

**Mentor:** Dr. Sharon Gerecht

**Supervisor:** Franklyn Hall

**Department:** Department of Chemical and Biomolecular Engineering, Johns Hopkins Institute for NanoBioTechnology

Marfan Syndrome affects an estimated one in five thousand people in the U.S., making it one of the more common genetic mutations. While the majority of cases of Marfan syndrome are not fatal, it can lead to severe health issues, such as thoracic aortic aneurysms, the rapid swelling of the upper part of the heart's main artery. Aortic aneurysms and many other health issues caused by Marfan Syndrome result from blood vessels' lack of structural proteins and compromised elasticity. In order to better understand how Marfan Syndrome affects blood vessels and cell structure, my research hopes to recreate the environment which mutated cells are exposed to. This includes the stresses imposed on the cells depending on their type and location. My research focuses on Endothelial Cells (ECs) that line blood vessels. The main type of stress experienced by ECs are shear stress caused by a liquid passing over the cells, and circumferential stress caused by the expanding of blood vessels as the heart pumps blood. My research will focus on the effects of shear stress on mutated ECs versus those on healthy ECs. My research hopes to discover how Fibrillin-1 and the production of other proteins is affected by shear stress in Marfan endothelial cells as compared to healthy endothelial cells. This research may give key insights into how different cell types in individuals with Marfan Syndrome react to their environments as well as offering a model of blood vessels in patients with Marfan Syndrome.

# Junior Research Abstracts

## Exploring the Structural Phenotype of Microtentacles

Riyan Campbell

**Mentor:** Dr. Michele Vitolo

**Supervisor:** Trevor Matthias

**Institution:** University of Maryland Marlene and Stewart Greenebaum Comprehensive Cancer Center

Microtentacles (McTN) are unique stabilized membrane protrusions on the surface of free-floating breast tumor cells that enhance the attachment of circulating tumor cells and aid in metastasis. Emerging research suggests that genetic alterations found in cells during primary tumor development and metastasis could result in an increase in McTN formation. Two genetic modifications found commonly in breast cancers are PTEN and KRAS. The PTEN gene, linked to cell regulation, interrupts cell signaling to begin the process of uncontrolled cell growth. The KRAS gene, commonly present in tumor cells, is activated and leads cells to proliferate or multiply uncontrollably. This rapid cell multiplication leads to tumor formation. When these genetic changes occur in cells in the breast, breast cancer can develop. Microtentacles can arise from highly conserved genetic modifications and this study investigates the effect of PTEN loss and KRAS overexpression in immortalized human breast cancer lines. By introducing each genetic modification individually, PTEN (-/-) loss and KRAS overexpression or in combination, you can examine the effects of these mutations as they relate to microtentacle expression and potentially metastasis. Through the use of confocal microscopy, using both WGA and DAPI staining, we examined the microtentacle expression of breast cancer cells with each individual genetic modulation and the combination of both mutations. Cells with the combination of mutations had the lowest increase in microtentacles, while those without the mutations had the highest. Interestingly, cells with the KRAS mutation showed a 50% decrease in McTNs when in comparison to the MCF-10A cells. MCF-10A is an immortalized normal cell line that we used to gauge each of our genetic modification with a known tumorigenic metastatic cell line. With the use of the MDA-MB-436, a highly metastatic breast cancer cell line, we examined the microtentacle frequencies with respect to our experimental genetic profile. We found that while PTEN loss and KRAS expression in combination has shown increased tumorigenicity, microtentacles frequencies do not correlate with metastasis in this model.

# Junior Research Abstracts

## **Determining Social Dominance In Mice**

Sabina Celnik

**Mentors:** Dr. Gul Dölen

**Supervisor:** Dr. Eastman Lewis

**Institution:** The Dölen Lab at the Brain Science Institute at Johns Hopkins

Autism Spectrum Disorder (ASD) is a developmental disorder that occurs in humans in which social deficits are a core diagnostic criteria. Mice can be used to model Fragile X Syndrome (FXS), a disorder similar to autism that appears in humans. In order to develop an assay to measure typical and atypical social behaviors in adult mice and better understand what changes in brain function could contribute to social deficits in adults with autism, an easily testable behavior is needed. We believe social dominance is an appropriate behavior because hierarchies are the foundation of cooperation between organisms. To determine if the tube test assay is a reliable measure of social dominance in mice, the tube test will be run on pairs of mice to determine the dominance status of mice. To test its validity, the tube test assay results will be compared to the results of the urine dominance assay. Furthermore, animal weight has been monitored throughout the assay to test whether a relationship between weight and dominance exists. Seven out of the 11 pairs of male mice exhibited a clear dominant and subordinate behavioral pattern as measured using the tube test. The urine assay was run on these pairs and when compared to the results of the tube test, only three of the seven (approximately 43%) pairs had similar results. I will be continuing to run the tube test and urine assay on more mice in order to verify my findings and account for any error or confounding variables that could have occurred.

## **Using Convolutional Neural Networks to Identify and Outline Shapes in Images**

Seth Chng-lim

**Mentor:** Dr. Elijah Roberts

**Institution:** Department of Biophysics, Johns Hopkins Krieger School of Arts and Sciences

Artificial intelligence (AI) is a branch of science poised to make massive contributions to the world. One of the most prominent types of AI is neural networks, computational algorithms created by scientists modeled loosely off the human brain. These networks can do many things, such as weather forecasting, medical research, experimental data validation, and risk management. Convolutional networks are a subclass of neural networks that are used for image recognition. A major issue with these convolutional networks is that they have trouble with image segmentation, a process of detecting objects within an image. Due to this, I worked on and created a neural network that can segment basic shapes from images. I developed a modified version of a neural network architecture called a U-net to perform segmentation, and I trained the network using simulated data that I generated computationally. I studied many different training properties to determine the optimal training strategy. Finally, I tested the performance of my network on real-world data that I found online.

# Junior Research Abstracts

## **Leveraging Biological Mechanism in Machine Learning-Based Breast Cancer Prognostication**

Tendai Coady

**Mentor/Supervisor:** Dr. Luigi Marchionni

**Institution:** Department of Oncology - Cancer Biology, Sidney Kimmel Comprehensive Care Center, Johns Hopkins University

Incorporation of machine learning technologies into cancer treatment has proven to be a promising field in oncology, but there has yet to be any implementation of it in the clinical setting for the purpose of prognostication, which is the determination of a good or bad outcome. A major issue thwarting this has been overfitting of models, caused by the so-called “curse of dimensionality,” a conundrum of the discrepancy between features to analyze (i.e. gene expression data) and samples from which to analyze them (patients). To circumvent this issue, we trained and tested a k-TSP machine learning algorithm, which uses selected gene pairs based on known biological mechanisms to build its decision rules, with gene expression data from breast cancer patients (ER-positive, HER2-negative), to determine cancer prognosis. Testing of the algorithm revealed correct determination of a bad prognosis in nearly every instance (high sensitivity), but less than 40% accuracy in correctly determining a good prognosis in patients (low specificity). This performance falls below clinically approved gene signature assays for prognostication, such as MammaPrint. Further research and revisions to the methodology, such as adjusting how the algorithm is trained, is required to improve performance in future tests.

## **Accuracy of Artificial Intelligence Algorithms in Tracking Spider Limb Movements**

Maya Filipovitz

**Mentor:** Dr. Andrew Gordus

**Institution:** Gordus Lab, Department of Biology, Johns Hopkins University

Artificial Intelligence (AI) has vastly gained popularity from the general public within the last few years. It has many uses in everyday life and research, from face recognition to drug creation, with its powerful abilities to analyze data and solve problems. By replacing humans with AI programs that can perform tedious and repetitive tasks, the focus and resources necessary for an individual to execute these tasks can be directed to more meaningful pursuits. In the Gordus Lab, spiders are used as model organisms to study behavior, with a focus on limb movements and webs as records of behavioral intent. Prior to the usage of AI, manual annotations were necessary in order to assess the data. Now, however, instead of requiring manual completion, machine learning algorithms can be trained to independently complete these annotations with a much higher data output when using convolutional neural networks (CNNs) such as LEAP and DLC. These manual annotations are used to assess CNN accuracy and they result in long term accuracy improvement from their base accuracy with their potential to improve through error-correction.

# Junior Research Abstracts

## **Analyzing the Biodiversity and Resilience of the Baltimore Harbor**

Madeline Jaffe

**Mentor:** Dr. Eric Schott

**Institution:** Institute of Marine and Environmental Technology

Baltimore's Inner Harbor ecosystem has faced numerous sources of pollution since its creation, including nutrient and sewage runoff, urbanization, and litter. As a result, there has been increased interest in enhancing and conserving the ecosystem, which has seen a decrease in heavy industry in the last half-century. The goal of my research is to analyze data in order to begin to understand the complex relationships between biodiversity and environmental factors in the Inner Harbor. Biodiversity is measured at two sites in the Harbor, one being near a constructed floating wetland intended to recreate a healthy Chesapeake Bay habitat. Biodiversity is measured using submerged biodisks, which are small plastic surfaces that develop communities of invertebrates over time. These disks are filmed under microscopes to document what species are present and how their numbers change over time. I used the data from the disks to calculate monthly biodiversity levels at each site using a formula called the Shannon Index. I then compared these numbers to environmental data from the same year, specifically dissolved oxygen, as this is a well understood influencer of aquatic biodiversity. This led me to explore how each site reacts to and rebounds from low-oxygen levels that lead to drops in biomass and biodiversity. By calculating the rates of return of biodiversity after low-oxygen events, I found that biodiversity at the Experimental Site closest to the healthy wetland simulation had a faster rate of return from die-offs than that of the Reference Site further away, suggesting a more resilient ecosystem. This contributes to the understanding of a need for future projects related to improving the resilience of the Harbor ecosystem, and it reinforces the importance of dissolved oxygen for biodiversity.

## **Streamlining Mealworm Production**

William Kardas

**Mentor:** Sam Glickstein

**Supervisor:** Luke Feeny

**Institution:** Biotrophics: Advanced and Sustainable Agriculture

The demand for animal protein is expected to rise by 70-80% by 2050. Considering that traditional livestock production is a major contributor to human greenhouse gas emissions, mitigating these effects is an important part of decreasing humans' negative effect on the global climate. *Tenebrio Molitor* larvae, otherwise known as mealworms, can convert low-grade carbohydrates into protein with a much smaller environmental impact than traditional agriculture. Although research on the biology and production methods of mealworms has been studied over the last century, there are still many holes in scientific knowledge regarding these topics. Due to a greater concern about humans' environmental impact, research in this field has been accelerating in recent years. Still, more research regarding production methods of mealworms must be completed to make them a more economical replacement for commonly used animal proteins. My research pertains to streamlining the production of mealworms. I conducted an experiment to evaluate the effect of population density and reproductive period of a parental population of *Tenebrio Molitor* on their respective offspring. This information is important because values for these two independent variables could be selected to maximize the efficiency of offspring production. Mealworms have many important applications, so production methods must be streamlined in order to make them an economically viable product.

# Junior Research Abstracts

## **Investigating apolipoprotein A-IV function in lipid metabolism using genetically modified zebrafish**

Nhan Le

**Mentor:** Dr. Steven Farber

**Supervisor:** Maggie Shen

**Institution:** Carnegie Institution for Science, Department of Embryology, Johns Hopkins University

Cardiovascular disease is the leading cause of death worldwide, and most of these cases are due to atherosclerosis. This term refers to the buildup of cholesterol plaques within the arterial walls as a result of issues with lipid metabolism. Lipids are hydrophobic, which requires them to be packaged into and transported by lipoproteins through circulation. These lipoprotein particles consist of various apolipoproteins, which play a role in providing structure and functionality. Studying apolipoproteins and their effects on lipid metabolism will provide crucial information needed to develop treatments and therapeutics for cardiovascular disease. Apolipoprotein A-IV (*apoA-IV*) has been demonstrated to play a variety of roles in lipid metabolism, such as inhibiting food intake, acting as an antioxidant, mediating reverse cholesterol transport, and regulating the size of lipoprotein particles. Studies have had mixed results, so apoA-IV's role in mediating lipoprotein lipidation remains elusive. My research uses zebrafish as an in vivo model to study the role of apoA-IV in regulating lipoprotein size. Utilizing a heat shock promoter and the LipoGlo assay, I am able to overexpress apoA-IV throughout the zebrafish and analyze its lipoprotein profile. Lipoprotein particle sizes are expected to increase, which would result in lower quantities of lipoproteins. I am currently in the process of data collection and no conclusions can be drawn as of yet.

## **A Kinematics-based Approach to Inform Vestibular Rehabilitation**

Sarah Li

**Mentor:** Dr. Kathleen Cullen

**Supervisor:** Omid Zobeiri

**Institution:** Department of Biomedical Engineering, Johns Hopkins University School of Medicine

Nearly 100 million American adults have experienced vestibular dysfunction, causing patients to experience position, balance, and movement issues. The current standard treatment for vestibular disorders is traditional vestibular rehabilitation. However, traditional vestibular rehabilitation relies on recommendations based on limited observations in the clinic. Accordingly, there exists a significant need for objective quantification of patient performance during vestibular rehabilitation. This study seeks to evaluate the value of kinematics-based analysis in vestibular rehabilitation in order to improve the management and delivery of vestibular rehabilitation. Shimmer3 motion sensors were used to record movement data of vestibular schwannoma removal surgery patients and age-sex matched healthy controls during vestibular rehabilitation exercises. Patients were tested pre-operatively and for six postoperative clinic visits. Data from gaze stabilization exercises were compared between patients and controls. We found that one week following surgery, patients moved their heads significantly slower than healthy controls during execution of gaze exercises. Patients also took longer to execute a cycle of the gaze exercise than the healthy controls. Following the second postoperative assessment, patients moved their heads more quickly over time, and at a velocity similar to the healthy controls during gaze exercises. Therefore, one week following vestibular schwannoma surgery, patient performance of gaze exercises was poor in comparison to healthy controls, but following the second week after surgery patient performance improved. These preliminary findings allow for future leveraging of affordable sensor technology to optimize treatment for vestibular patients by offering a more customized rehabilitation

# Junior Research Abstracts

## **Comparative Analysis of Disinfection Byproducts From the Water Purification Process**

Nicholas Pham

**Mentor:** Dr. Carsten Prasse

**Supervisor:** Zhuoyue Zhang

**Institution:** The Prasse Lab, Johns Hopkins Bloomberg School of Public Health

Chlorine is a common disinfectant added to water in order to provide a clean supply. However, the degradation of substances in the water by chlorine often leads to the formation of toxic byproducts. These byproducts have been extensively studied, and previous research at the Prasse Lab has detected cis-2-butene-1,4-dial, a dialdehyde harmful to human cells. This study focuses on the formation of cis-2-butene-1,4-dial from phenolic and furan compounds. These groups of compounds are commonly found in pharmaceuticals, plastics, and personal care products. Parent compounds were chlorinated, and samples were taken over time. Samples were analyzed using high performance liquid chromatography mass spectrometry and quantified to calculate cis-2-butene-1,4-dial yield. Yields ranged from 4% to 40% depending on the parent compound, with higher yields from furan compounds. Comparison of the structures and kinetics of these compounds is used to learn more about the reaction pathways that take place. As byproducts get smaller, it becomes harder to determine the proper mechanism that took place. Using a variety of compounds with varying structures leads to a wider range of mechanisms being observed, because each compound follows a different path.

## **Analyzing the Impact of Starving Conditions on Bacteriophage**

Juni Polansky

**Mentor:** Dr. Joel Schildbach

**Supervisor:** Russell Hughes

**Institution:** Department of Biology, Johns Hopkins University

Antibiotics are the most commonly used treatment for bacterial infections; however, they are becoming less effective as bacteria develop antibiotic resistance. One solution to this problem is bacteriophages, or phages, which are viruses that kill bacteria. Phage research is very promising, as phages target specific pathogens without impacting other bacteria. Understanding how phages function in diverse environments is an important, but minimally studied topic. Nutrients are not always readily available to bacteria populations, and studying phage-host interactions under starving conditions may provide useful insights. In this study, reduced carbon sources will be used to induce nutrient deficiency. Once starving conditions are induced, RNA-seq will be used to study the cell's transcriptome after phage infection and determine the specific impact carbon limitation has on infected cell transcription. Results from this study may offer insight into phage-host interactions in natural environments. A full understanding of how phage affect their hosts under non-laboratory conditions is essential to safely employing and developing phage therapy.



# Junior Research Abstracts

## **Determining the Toxicity of Chromium Found in Electronic Cigarette Vapor**

Isabelle Richard

**Mentor:** Dr. Ana Rule

**Supervisor:** Mina Tehrani

**Institution:** Department of Environmental Health and Engineering, Johns Hopkins Bloomberg School of Public Health

Electronic cigarettes (e-cigarettes) are handheld battery powered vaporizers which stimulate smoking. The usage of electronic cigarettes has exploded in recent years, hitting especially hard in the teenage community. This is a large issue due to the fact that these devices indicate danger to human health. As of February 4, 2020, 2,758 people were hospitalized and 64 people died due to injuries related to these devices including 64 deaths, according to the Center for Disease Control and Prevention. A possible factor contributing to this danger is the discoverance of the metals cadmium, manganese, nickel, lead, and chromium in the vapor of e-cigarettes. Due to this, I decided to look into the chromium content found. Chromium is commonly found in two oxidation states, one of which is toxic. Knowing which type of chromium is in e-cigarettes is important, as this knowledge could possibly influence treatments towards injuries as well as policies regarding these devices. Through the use of a high performance liquid chromatography instrument paired with an inductively-coupled plasma mass spectrometer, I am able to separate out the particles of e-cigarette vapor and quantify them. Therefore, I am determining the toxicity of the chromium in the vapor of electronic cigarettes.

## **Analyzing effects of post-transplant cyclophosphamide on T cells**

Tejal Schwartz

**Mentor:** Dr. Leonido Luznik

**Supervisor:** Rupkatha Mahopadhaya

**Institution:** Johns Hopkins Sidney Kimmel Comprehensive Cancer Center

To better understand the body's response to foreign tissue, transplant immunology makes use of "mixed chimerism," a mixture of both host cells and donor cells following a transplant, achieved through hematopoietic stem cell (HSC) transplantation via the bone marrow. Transplant patients receiving HSC transplantation have a considerable risk of developing graft versus host disease (GVHD). Previous research showed that administering a high dosage of cyclophosphamide post-transplant (PTCy) successfully induces tolerance in HLA-mismatched related blood or marrow transplantation through depletion of actively proliferating T cells, which contain low levels of the enzyme aldehyde dehydrogenase (ALDH). However, Tregs, containing high levels of ALDH, are crucial for the maintenance of long term allotolerance and chimerism, and would not be ideal for them to be depleted with the administration of cyclophosphamide. I am studying interactions between donor and host immune cells and how these are affected by PTCy by observing different metabolic pathways, as well as studying how Tregs would be affected by an administration of cyclophosphamide. I used a mixed lymphocyte reaction (MLR) system to model the alloresponse *in vitro*, with the administration of cyclophosphamide and glutathione treatment to study the effect on Tregs. T cell analyses were performed after a week of culture, and included proliferation, marker expression, and cytokine production; results were analyzed using flow cytometry.

# Junior Research Abstracts

## **Improving Sensory Neuroprostheses: Measuring Vibrations with a Tactile Sensor**

Talya Simcox

**Mentor:** Dr. Nitish Thakor

**Supervisor:** Mark Iskarous

**Institution:** Neuroengineering & Biomedical Instrumental Lab, Johns Hopkins University

Approximately 1.3 million Americans are living with some form of limb loss, causing many to turn to using prosthetic limbs. The benefits of prosthetic limbs include more mobility and ability to perform daily tasks, increasing independence. When the prosthetic limb is connected to the nervous system, it is referred to as a neural prosthesis. Neural prostheses allow for more intuitive or naturalistic control of the prosthetic limb and allows for sensory feedback to the amputee. Sensory signals are sent to the neural prosthesis interface in order to mimic the biological hand. The tactile sensor is force or pressure sensitive and is designed by crossing strips of conductive fabric that are separated by a piezoresistive tactile layer. The biological finger uses vibration to understand texture information; therefore, we examine how the tactile sensor is able to measure vibration stimuli. The results from the sensor reading showed that the vibrations fanned out from where the stimulation was given off and the distribution was dependent on the frequency strength. This study shows how similar the neural prosthesis functions in relation to the biological hand and how vibrations are distributed to improve future neural prosthesis to mimic how vibrations are elicited.

## **Optimizing Live Cell Imaging of Lamina Associated Domains**

Kristiana Smith

**Mentor:** Dr. Karen Reddy

**Supervisor:** Victoria Hoskins

**Institution:** Center for Epigenetics, Department of Biochemistry, Johns Hopkins University School of Medicine

The function of a cell is determined by the activation of specific sets of genes. Understanding how genes are selectively expressed to yield unique cell types will provide insights on how cell fate and roles are established. The three-dimensional organization of the genome has been implicated in guiding the activation or repression of genes. The genomes of higher eukaryotes are segregated into A-compartments containing actively transcribed DNA and B-compartments containing repressed portions of the genome. The composition of B-compartments, or Lamina Associated Domains (LADs), varies between cell type, and this variation directs the development of cell fate and function. Studying the visualization of LADs will lead to further understanding about how these structures are established and their dynamics throughout the cell cycle. LADs have primarily been visualized using a fluorescent cellular construct known as the m6A Tracer System. This project seeks to improve the stability of the m6A Tracer System by implementing an additional construct known as HaloTag. Through restriction enzyme digests and ligation, it is anticipated that a DNA vector containing both the m6A component and HaloTag will be generated. This vector will then be incorporated into the genome of Mouse Embryonic Fibroblasts through viral transduction and be assessed for improvements in image quality.

# Junior Research Abstracts

## **Analyzing the Effects of Diagenesis on Marine Carbonates**

Jacob Thompson

**Mentor:** Dr. Emmy Smith

**Supervisors:** Mary Lonsdale and Lyle Nelson

**Institution:** Department of Earth and Planetary Sciences, John Hopkins University

The Ediacaran-Cambrian boundary marks a pivotal moment in Earth's environmental and biological history. This time period is host to a number of crucial changes in Earth's biota, namely the disappearance and possible extinction of Ediacaran organisms, some of Earth's first multicellular forms of life. This disappearance was followed by the subsequent appearance of numerous animal phyla and their diversification. A number of geochemical markers accompany the vibrant fossil record of this time, namely a large carbon isotope excursion, known as BACE (basal Cambrian carbon isotope excursion). Carbon isotope data can reveal shifts in the Earth's carbon cycle and thus the mechanics through which Earth's environment functioned and changed. This data, as well as BACE, is preserved in carbonate rocks, which form in shallow marine environments and thus capture information about the surrounding seawater and environment. However, in order to validate that BACE is truly a global phenomenon reflective of a Cambrian-era environment and seawater rather than a regional occurrence is a significant issue. It is necessary to prove that this excursion is the product of global seawater changes rather than processes such as diagenesis, which can alter the geochemistry of carbonate formations. Diagenesis occurs as meteoric fluids infiltrate into these formations and in doing so change their chemistry and mineralogy. We believe that trace element data and calcium isotope ratios determined from carbonate rocks can reveal the presence of diagenetic alteration and its possible effects. These values will exhibit known variation in response to diagenesis and can thus be used as a proxy for it. However, at this stage in our research, results have not been fully processed. Trace element concentrations have been found using an ICP-MS (inductively coupled plasma mass spectrometer), while calcium isotope data will be analyzed at Princeton University at a later date.

# Junior Research Abstracts

## **Syphilis infection associated with methamphetamine use among gay, bisexual, and other men who have sex with men in Baltimore, MD**

Abby Torregoza

**Mentor:** Dr. Jacky Jennings

**Supervisor:** Carla Tilchin

**Institution:** The Center for Child and Community Health Research, Johns Hopkins Bayview Medical Center

Syphilis is a common sexually transmitted infection: transferred through anal, oral and vaginal contact. Primary and secondary syphilis rates have been increasing in Baltimore, Maryland since 2013, disproportionately affecting the population of gay, bisexual, and other men who have sex with men (MSM). In 2017, MSM accounted for 70% of syphilis cases in Baltimore City, and 60% of cases nationwide. Illicit substances, specifically methamphetamine, are commonly used by MSM to enhance, and prolong sexual intercourse. Psychological and physiological effects from this occurrence, referred to as 'party-n-play' (PnP) increases sexual and drug related risk behaviors. Thus, putting individuals at an increased risk for syphilis infection. When left untreated, syphilis first enters the asymptomatic latent stage, and then the tertiary stage where the bacteria can cause nerve damage and lesions on the skin and intestines. Little is known about the relationship between methamphetamine use and syphilis in Baltimore. The Understanding Sexual Health in Networks (USHINE) study is a longitudinal cohort study which aims to understand syphilis trends in Baltimore, Maryland. Participants are asked questions about access to healthcare, social experiences, drug use, sexual behavior, sex partners, sex partner meeting venues through an ACASI (Audio Computer-Assisted Self-Interview) survey. Self-given samples are collected and tested for HIV, syphilis, gonorrhea, and chlamydia. Baseline data from USHINE is used to determine the following: 1) the prevalence of syphilis, 2) the prevalence of illicit drug use, and 3) the association between drug use and syphilis infection. Findings from this project may be considered in public health efforts to prevent and control the transmission of syphilis in priority populations.

# Junior Research Abstracts

## Under Fatiguing Conditions, Cerebellar Direct Current Stimulation Enhances Learning of The Wrong Memories

Chielota Uma

**Mentor:** Dr. Pablo Celnik

**Supervisor:** Dr. Agostina Casamento-Moran

**Institution:** Center for Movement Studies, Kennedy Krieger Institute Outpatient Center

ctDCS is a type of brain stimulation that increases brain excitability. It has been shown that ctDCS can facilitate motor skill learning, meaning it might facilitate motor learning during fatigue. Fatigue negatively affects healthy people and victims of neurodegenerative disorders, and keeps us from performing motor tasks correctly. The cerebellum is important when learning new skills. When fatigue alters cerebellar excitability, it has detrimental effects on motor learning. Thirty young adults practiced a sequential visual isometric pinching task for 3 consecutive days and were randomly assigned to either a Fatigue<sub>ctDCS</sub>, Fatigue<sub>sham</sub>, or No-Fatigue-Control<sub>sham</sub> groups. Participants were only stimulated on Day 1, during 5 blocks of 30 practice trials under either fatigue or non-fatigue conditions. Those in the fatigue groups were asked to squeeze a force transducer as hard as they could for as long as they could before each block. On Days 2 and 3, all groups did the same task with no fatigue. We tested their memory at the end of Day 1, and before and after Days 2 and 3. Fatigue resulted in a slower learning rate compared to no fatigue. ctDCS improves learning on Day 1 for Fatigue<sub>sham</sub>, but didn't improve offline or total learning, nor counteracted the fatigue effects compared to No-Fatigue-Control<sub>sham</sub>. Fatigue<sub>ctDCS</sub> continued to exhibit superior sequence accuracy on Days 2 and 3, but they exhibited greater distance errors than other groups. These results mean the effort required to execute the task on Day 1 continues when training under ctDCS, which causes greater distance errors even without fatigue. Overall, ctDCS boosts motor learning even with fatigue, but it can't fully counteract fatigue's effects.

## Mars Gravimetry and Exploration

Aaron Villahermosa

**Mentor:** Dr. Kevin Lewis

**Supervisor:** Jacob Adler

**Institution:** Department of Earth and Planetary Sciences, Johns Hopkins University

Gravimetry, the study of minute changes in a gravitational field, is a dynamic and useful way to explore Mars. In the past, gravimetry has been used to unearth the past of Gale Crater and how Mount Sharp came to be by inferring the density of Gale Crater's subsurface rocks. I plan to do something similar with the upcoming Mars 2020 Rover that is set to land on Jezero Crater. Utilizing the bouguer formula and gravity equations, I have made graphs that predict the relationship between the density of the subsurface material during the rover's traverse and the gravity of Mars as well as the relationship between the elevation of the traverse and the Gravity of Mars. Building off of those graphs, I have created a colorgraph that combines the impact of both the local elevations and the theoretical densities throughout the whole traverse. Although I have the raw data needed to come up with final results, I have not yet closely analyzed and discussed the implications of the data that I have compiled. That, along with devising a map on QGIS depicting the possible traverse, gravity values, and geological features that could be seen during the rover's journey, is the final step that I must complete.

# Junior Innovation Abstracts

The Innovation Practicum is a two-year sequential in-school and off-site research curriculum for 11th grade Ingenuity students. Students gain hands-on experience in Applied Mathematics, Computer Science, Machine Learning, Data Science, and/or Statistics and learn coding languages and/or statistical analysis programs. The primary goal is for student investigators to plan and implement their own scientific research project. The program is open to any Ingenuity student in good academic standing who wishes to apply, as the curriculum is designed to meet



**Front Row** (from left to right): Lucy Canick, Isaiah Chapman

**Second Row:** William Kardas, Lucinda Borbash, Stephanie Fishkin, Frank Tagaytay

**Back Row:** Chelsea Thompson, Michael Aladejebi, Alejandro Barrera

# Junior Innovation Abstracts

## Youth Homelessness in Maryland

Michael Aladejebi

**Mentor:** Dr. Margo Candelaria

**Supervisor:** Jessica Fry

**Institution:** University of Maryland School of Social Work, Institute for Innovation and Implementation

Homeless youth, as defined by the University of Maryland School of Social Work Institute for Innovation and Implementation, are people under the age of 25 who lack a fixed, regular, and adequate nighttime residence. Studies have shown that 575 thousand to 1.6 million youth in America may be living without a home or without a family. There are lots of young people that do not have a relationship with their parents and have to survive on the streets at a very young age. Across Maryland there are youth and young adults living on their own and experiencing homelessness and housing instability, unsure of where they will sleep each night. Many social scientists believe that the demographic most affected by this homelessness crisis are those in the LGBTQ communities. There is especially a lot of discrimination against LGBTQ youth, even from their own parents, causing them to be homeless. Youth with minority sexual orientations appear to be disproportionately at risk for homelessness. Gay, lesbian, and bisexual youth are at risk for a variety of adverse health outcomes, including sexually transmitted infections, the human immunodeficiency virus, unplanned pregnancy, suicide attempts, depression, and sexual victimization.

## Applications of Machine Learning (with visual inputs)

Alejandro Barrera

**Mentor:** Dr. Rene Vidal

**Supervisor:** Carolina Pacheco Oñate

**Institution:** Mathematical Institute for Data Science (MINDS), Johns Hopkins University

Machine learning is a computer program that finds patterns within data, and then uses those patterns to make predictions about unknown and unseen data. Machine learning is widely used, and with good reason, because data is being generated at blinding speeds. For example, 500 hours of videos are uploaded to YouTube everyday. With a dataset like this, it is impossible for a human to process and effectively organize this data, and this is where machine learning algorithms can shine. If somebody creates an algorithm which can find features from these YouTube videos which are relevant to their classification and finds these features fall into patterns, then these videos can be efficiently classified and analyzed. The problem with machine learning algorithms is that they are also susceptible to making mistakes, and the goal within creating an algorithm is to minimize these mistakes made as much as possible while also retaining efficiency. My research deals with the classification of handwritten digits, known as the MNIST dataset. Within my research, I am exploring how different methods of feature extraction and classification differ from each other and which methods are most efficient and accurate, starting with the use of a Histogram of Oriented Gradients (HOG) and a Support Vector Machine (SVM).

# Junior Innovation Abstracts

## **Theoretical Machine Learning: Exploring the Recursive Teaching Dimension**

Lucinda Borbash and Lucy Canick

**Mentors:** Dr. Vincent Guingona and Dr. Miriam Parnes

**Institution:** Jess and Mildred Fisher College of Science and Mathematics, Towson University

Machine learning is all around us; it's what allows us to build more precise and more accurate models, it's what helps us make sense of the past and anticipate the future, and, most importantly, it's what helps Netflix recommend your next favorite show. The phrase generally brings to mind images of sleek, futuristic innovations: sentient cyborgs, drones scouring rugged landscapes, and robots that speak forty languages. These are incredible feats of technology — but they would be nothing without the theoretics behind them. This theoretical pathway is what we have chosen to focus on in our research. Specifically, we're examining several characteristics that are integral to understanding datasets. Our python program calculates the various characteristic dimensions of binary data strings. The resulting teaching dimensions, recursive teaching dimensions, and VC dimensions provide insight into the complexity and learnability of the sets, allowing us to better prepare and improve for the world of the future.

## **Correlation Analysis of Lead Exposure, Crime Rates and Standardized Test Scores**

Isaiah Chapman

**Mentor:** Dr. Mingchao Cai

**Supervisor:** Dr. Asamoah Nkwanta

**Institution:** Department of Mathematics, Morgan State University

Lead poisoning is a huge problem affecting millions of children in America. It is caused when lead starts to build up inside of the body. Lead gets into the body through ingestion and inhalation. Lead is mainly stored in soil and dust found around housing built before the 1970's. These houses were built with lead based materials such as lead paint and pipes. Urban areas such as Baltimore City have huge rates of lead exposure due to the lack of lead remediation being done within highly lead dense areas. Through research, scientists know that lead exposure decreases IQ/ information retention rates, creates behavior issues, etc. Correlation analysis can help better understand how much lead exposure affects a person's information retention rate and behavior. Looking at communities as a whole inside of Baltimore City shows how different areas are affected by lead exposure. Neighborhoods are being compared based on their total crime rate, the number of children with elevated blood lead levels, and an area's standardized test scores from schools. There are lurking variables such as socioeconomic status and poverty can change the results of the data. Socioeconomic status and poverty of a neighborhood is mainly looking at how much money is coming into that neighborhood. This study can help identify areas where remediation needs to happen within Baltimore City.



# Junior Innovation Abstracts

## **The Predictive Relationship Between Personality Theory and Social Determinants**

Stephanie Fishkin and Chelsea Thompson

**Mentor:** Anne Claggett

**Supervisor:** Dr. Heather Meyers

**Institution:** Traitify

The Five Factor Model of Personality measures an individual's personality level on a numerical scale and consists of five personality dimensions: Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Using the Five Factor Model, Traitify, a job performance research company, creates personality assessments for clients. These assessments give clients personality insights, pair test takers with specific career paths, attract job applications, and make for an easier interview selection process. Our project evaluates a test dataset from one of Traitify's previous personality assessments. Using this dataset and statistical functions, we analyzed if a participant's age, gender, education level, or test instruction are predictive of a certain personality dimension score. Overall, we found personality level to be situationally significant across demographics. Our results displayed an increase in openness, conscientiousness, and emotional stability levels as education level increased. When compared to women, we found men tended to be higher in emotional stability and lower in agreeableness. As age increases, agreeableness, conscientiousness, and emotional stability levels increase. Lastly, we found that participants that tested for employment tended to score higher on openness, agreeableness, and emotional stability. Our research project is significant as finding as it helps researchers to understand if certain groups are more or less prone to possess a specific personality dimension level. In addition, it allows Traitify to find if their assessments are concurrent with previous research.

## **The Segmentation of Crosslinked Nanofibers**

Frank Tagaytay

**Mentor:** James Dolgin

**Supervisor:** Kurt Civin

**Institution:** Civin Lab, University of Maryland School of Medicine

Almost all clothing in the modern world is made through a process of weaving together threads in a way so that the threads follow the shape of the final product. Nanofibers are just like the threads of clothing, where fibers overlap and cross each other. The main differences between threads on people's clothes and nanofibers are their sizes and organization. Unlike the uniform patterns used in designing clothes from yarn, scaffolds of nanofibers are made by shooting a charged solution through a syringe onto a grounded plate. These fibers that are tenths of a hair thick form scaffolds in random arrangements. These arrangements make it difficult to find the diameters of fibers, which are needed to judge the quality of fibers after a process called crosslinking. In order to quickly and efficiently find the diameters of fibers, the use of machine learning must be introduced. Current programs for image analysis do a good job in the analysis of non-crosslinked fibers, however, due to the swelling and increased amount of overlaps from soaking the fibers in the crosslinking solution, some programs fall short. The program that I have been developing focuses on the automated analysis of crosslinked fibers.

# Sophomore Interest Statements

All sophomores participate in the initial phase of the Ingenuity Research Program by taking a course titled Introduction to Scientific Research. In this course, students learn how scientific research is conducted, identify individual topics of interest, research current information about their selected topic, and learn modes of scientific communication. Students choosing to continue with Research or Innovation Practicum have sought mentors from the local scientific research community and will begin work at their lab placements in the summer.

## **Marine Conservation Biology: Will marine life still be here?**

Virtue Bama

My field of interest is marine conservation biology. Marine conservation biology is about how we can help the marine environment. Some strategies include reducing carbon emissions and looking into the food chain within the ecosystems. There is a current study of sharks, looking at the decline of the sharks prey's body size and how it affects the sharks population. Another study examined how small plastics the size of prey are affecting the fish who eat it. This shows how the pollution humans create can affect the fish and their ecosystem. A third study looked at how microplastics affect and decrease oyster reproduction. Research used in this poster can impact our lives because marine life plays a huge part in our ecosystems. With this fact, they can also play a huge part into how we get our food, or how we can affect the food webs. I'm planning to continue with Ingenuity Research Practicum and will work with Dr. Kit Bowen in the Department of Chemistry at Johns Hopkins University.

## **Detecting Steganography in Images through Steganalysis**

Elyjah Bassford

My research topic is steganography, which is the study of hidden messages within a medium such as an image or audio file. More specifically, my research topic is the detection and, if possible, removal of steganography from images, which is called steganalysis. Many of the studies I encountered regarding steganalysis involved the usage of neural networks in developing steganalysis programs. One study utilized a Generative Adversarial Network to encode and then decode steganography-filled areas in an image. Another study utilized evolutionary algorithms to minimize unnecessary data collected, eliminating the "Curse of Dimensionality." A third study used a neural network to analyze the semantic relationship between words in order to find steganography in text via replaced synonyms. This research can greatly impact our future lives positively by detecting malicious messages, removing possible viruses that may arise from steganography, and revealing secret message chains that can reveal powerful information. I would like to continue with the Research Practicum, and I am currently pursuing working with at the Johns Hopkins University Applied Physics Laboratory, which pursues digital forensics and the acquisition of digital evidence, including which steganalysis. I would also like to develop my coding skills to produce a steganalysis program.

# Sophomore Interest Statements

## **Somesthesis in Prosthetic Limbs**

Me'Shiah Bell

My research topic is on improving the functionality of prosthetic limbs. By doing this, we are able to increase the quality of life for amputees. The goal of this research is to make prosthetic limbs that function as closely to natural limbs as possible, and in order to do this, they need to be able to accept and interpret somatosensory feedback. One example of current research is being conducted by the Johns Hopkins University Neuroengineering Lab. The goal of this research is to build and develop prosthetic limbs for amputees by using electrical components, along with computers that are able to convert data from the brain into quantitative data (called brain-machine interfaces). Another example of current research, from the University of Pittsburgh, focuses on improving prosthetic control by providing naturalistic sensory feedback. A final example, conducted by the University of Pittsburgh RNEL, focuses on recording electrodes to improve the amount of sensory information available for prosthesis. I am planning on pursuing Ingenuity Research and I would like to work in neuroengineering. I would like to study neuroscience and biomedical engineering to be able to apply these concepts to prosthesis.

## **Mental Illness and Neurological Conditions**

Hayden Benhart

The topic of my project is anxiety, autism, and ADHD in children. My goal is to research possible treatment for these individuals and potentially identify a cause. One research project looked at the effects of childhood trauma (attempted suicide, neglect, abuse) on individuals afflicted with Autism Spectrum Disorder (ASD). The goal of this study was to develop possible treatments for the effects. Another project studied the potential use of machine learning to help individuals with ASD. By using machine learning we can expand our knowledge of ASD, as well as develop treatment to improve the lives of those individuals. A third project examined the structural abnormalities associated with comorbid ASD and Attention Deficit Hyperactivity Disorder. The information presented can help find treatment for ASD and other mental illnesses, which can help individuals cope with these ailments in a more productive manner. It can also help individuals better adapt to living a life that is not impaired by the illness they have been diagnosed with. I will be continuing with the Ingenuity Research Practicum. I hope to continue my path at the Department of Psychiatry and Behavioral Sciences at the Kennedy Krieger Institute at Johns Hopkins University with Dr. Jonathan Pevsner.

## **Memory Loss in Schizophrenia**

Lillia Berninzoni

My research is in cognitive neuroscience and psychology, specifically the symptom of memory impairment in schizophrenia. Schizophrenia is relatively common, with 1% of the population being affected. One study demonstrated that estrogen improved memory in patients with schizophrenia. Another study I found in my research analyzed the effects of transcranial direct current stimulation (electric current treatment of specific parts of the brain) on schizophrenia patients. Finally, a third study explored the relationship between emotion and memory in schizophrenia. These three studies demonstrate alternative methods of treatment for memory loss in schizophrenia. This research is important because it helps us understand the disease and find methods of treatment for it. Cognitive effects are one of the least studied symptoms of schizophrenia, despite it being one of the most debilitating. I plan on continuing with the Ingenuity Research Practicum and will be mentored by Dr. Amanda Lauer in the Department of Otolaryngology at Johns Hopkins University.

# Sophomore Interest Statements

## Treatments for Depression

Precious Conteh

The fields of neuroscience and depression are very closely interrelated, and by analyzing and using the connection between the two of them, treatments for depression could become much more efficient. Some examples of effective treatments directly affecting the brain are neuromodulation treatments and direct transferring of brain tissues. There are multiple studies in which the data from neuromodulation, which is the modification of nerve action through the focused transfer of stimuli, is proven to be effective. One experiment involving electro-acupuncture showed results of having fewer side effects than conventional medicines and had better results on the Hamilton Rating Scale for Depression (HRSD) in cognitive disturbance and diurnal variation. Another test was on electroconvulsive therapy (ECT), which had a 15% decrease in the Montgomery-Åsberg Depression Rating Scale (MADRS) score, and that is a significant sign of early improvement. Regarding the direct transfer of brain tissues, there was a study regarding Parkinson's disease and implanting mesencephalic tissue with dopamine cells that were proven effective, and while not depression similar concepts lie in both. This research could make depressed peoples' lives better if they had sound treatment options. I intend on pursuing the Ingenuity Research Practicum and will be doing research with Dr. Amanda Lauer in the Department of Otolaryngology at Johns Hopkins University.

## Animal Motion

Sam Elkins

My research is animal and robotic motion. Animals have a much easier time moving through their environments and spend far less energy. To get more robots moving outside and in less controlled environments researchers look at how animals move. One of the most looked at animals is the cockroach. It is extremely agile. It can cross large gaps without jumping, right itself, and climb steep terrain. Whegs robots have very similar components to a cockroach. By watching how cockroaches move these robots can move over unstable terrain, climbing walls 175% over leg height. Potentially researchers are looking at pneumatic cylinders instead of electric motors. Pneumatics would increase balance by allowing a little give when pushed like animals. These also can be used to mimic muscle more closely. A lot of research goes into tracking animal movement. A common method is using a computer to track infrared markers on animals. Smaller animals have been found to move in a Levy Walk, a type of search pattern, when looking for food. This field of research is very important for search and rescue operations. I wish to be placed somewhere studying biological motion like under Dr. Cowan at Johns Hopkins.

## Methods of Tuberculosis Diagnosis

Harriett Engelke

Epidemiology is a branch of medicine that deals with the spread of diseases. Tuberculosis (TB) is a dangerous disease that affects more than 1.8 billion people and epidemiologists are working to control it by creating easier and more efficient methods of diagnosis. My research explores the three main methods of tuberculosis diagnosis and determining which one is the most effective. One study that I read discusses directly observed treatment short-course (DOTS) which accurately diagnosed patients 95% of the time. Another study focused on using radiography to detect latent TB. A final study showed how chemotactic signaling can recognize early signs of the disease such as the immune system weakening. This research can be used to identify an accurate and cost-effective method of diagnosing TB that will prevent the continued spread of the disease and allow people to enter into treatment earlier in the course of the disease. Future research would include the prevention of a reemergence of the disease using continuous testing methods and immediate treatment to anyone with TB symptoms. I plan on continuing the Ingenuity Research Practicum in an epidemiology lab at the Bloomberg School of Public Health with Dr. Alan Scott. I am especially interested in the diagnosis and treatment of pulmonary infectious diseases.

# Sophomore Interest Statements

## **Viruses in Human Evolution**

Miles Fancher

The role of viruses in our evolution is not researched nearly as much as other drivers of evolution, such as natural selection. They may have a larger role in the progression of life on Earth than they are given credit for. I pursued three studies that concerned the involvement of viruses throughout the history of cellular life. It was once a largely unfamiliar field for researchers, but studies have expanded our knowledge of it. One group introduces megaviruses as a potential fourth domain of life, a development that would affect the way biologists look at their work. The discovery that such viruses and infectious diseases were a key driver in evolutionary processes like competition and sexual reproduction has led researchers to believe that there is more to their role in evolution than is currently known. However, many of the questions they have interlock, which means it will take extensive research as the field progresses and expands. I plan on continuing with the research practicum under Dr. Rajiv McCoy, in the biology department at Johns Hopkins University. His lab focuses on computational genomics, meaning they study the human genome entirely through programming.

## **The Application of Nanorobotics in the Delivery of Pharmaceuticals to Cure Diseases**

Zen Gordon

Nanorobotics is a field of technology that involves using miniature robots to move around the body and target any threats to remove. This branch of research consists of numerous studies, such as the focus on how nanorobots could use various techniques in performing surgery that result in minimal damage to the patient. One study looked at how the use of DNA information can become prominent in guiding nanorobots in locating certain materials like proteins, that represent the presence of potential tumors. Numerous works have taken a look into the idea that nanorobots could use soft material as their foundation to improve features such as durability. These adaptations may allow nanorobotics to take on diseases like cancer or cardiovascular diseases that were previously incurable and ensure safety of patients during and after the procedures. If this will become more prominent and efficient, more lives will be saved in the long run. I am interested in pursuing the research practicum with Ingenuity and working in the Department of Nanorobotics at Johns Hopkins University, studying how we can modify the designs of nanorobots to improve their functionality and mechanics.

## **Cancer cell Biology**

Andrew Haye

Cancer has an ongoing conversation in the field of cellular and molecular Biology. I've found a specific interest in the process by which chronic inflammation leads to different cancers. Previous studies have shown that inflammatory response and immunity play an important role in tumor development. In addition, research on treatments for cancer has shown that microbial treatments for pathogens in the stomach's microbiome can target tumor-promoting agents such as inflammation through pathological pathways. Along with these discoveries, 3D cell models such as organoids have proven to be more effective than 2D models in providing a more accurate model of gastrointestinal cancers such as colon cancer. 3D models allow scientists to retain phenotypic, epigenetic and genetic characteristics of tumors to improve cancer therapies which align with specific patient sensitivities. Research on these processes can help improve current methods being implemented into cancer treatment and prevention. I would like to continue pursuing the Ingenuity Research Practicum through the Cell Biology Department of Johns Hopkins School of Medicine. There I will hopefully work in the Rong Li lab and continue research on the relationship between chronic inflammation and cancer.

# Sophomore Interest Statements

## **The Environmental Impacts of How We Produce Our Food**

Ashantae Hayward

My research is focused on the environmental impacts of how we produce food. More specifically how food production is adding to the greenhouse gasses in the atmosphere. In a recent study, scientists are not only looking at food production's impact on the environment, but also the impact on human health. Diets that involve high amounts of meat (specifically beef), have a higher risk of developing certain cancers. Another study that I have read states that many of the greenhouse gasses coming from food production is stemming from eutrophication of animal waste and animal urine on surrounding bodies of water. The last current article that I have read focused on the allotment of land and water for food production. A lot of the world's freshwater is being used to support food production. In order to keep up with the demand of land to produce food, forests are being cut down which further adds to the greenhouse gasses in the atmosphere. From understanding the harm attached to the way we produce food we can change our eating habits to better suit the environment in the future. For my research practicum, I will be working with Dr. Philip McNab in the Johns Hopkins Center for a Livable Future.

## **Using Computers to Simulate Brains**

Johns Hopkins

Computational neuroscience is a branch of neuroscience that seeks to understand the brain through the use of algorithms. I am focusing on brain simulations, the use of computer simulations to model brains. If we succeed in simulating most of the brain, this may provide a powerful research tool for neuroscientists. It could allow them to look into cures for rare brain diseases and allow a much more full understanding of how the brain works on both a large and small scale. One of the sources I found focused on minimizing how much computing power it takes to simulate the connections between neurons. I also looked at a study that was making sure these simulations were accurate at large scales, which they were. Lastly, I looked at a large scale attempt to combine many different tools into a large scale simulation of the whole brain using supercomputers. I hope to complete my research practicum with a mentor at the Zanvyl Krieger Mind Brain Institute at Johns Hopkins University.

## **How Shape Memory Alloys Affect Our Everyday Lives**

Diego Jovel

SMA's, or Shape Memory Alloys, are alloys capable of returning to a certain form when introduced to heat or pressure, or reducing vibration art forces by absorbing them. Alloys can be used in a wide range of fields including Aerospace Engineering, Civil Engineering, and Biomedicine. Current research on these relatively new alloys includes their use in the designs of Bridges to reduce the amount of vibrational force and increasing the structural integrity in the case of a Seismic event like an Earthquake. This research will not only improve the structural integrity of our bridges, but as the integration of Shape Memory Alloys becomes more refined, we will see them impact our lives in more facets, in transportation for shock absorbers, and in Civil Structures as Restrainer and Support Bars. The field that I would likely choose would be an extreme Materials or Alloys Lab, hopefully in the field of Aerospace or Aeronautical Engineering for my research practicum.

# Sophomore Interest Statements

## **Ecological Impacts of Marine Restoration**

Meredith Nishiura

Marine ecosystems provide humans with a variety of services, from nutrient cycling to habitat for commercially crucial species. Unfortunately, they are being threatened and destroyed at an unprecedented rate by human activities. Marine restoration, a field that seeks to return ecosystems to their previous state and function, will be critical in the future to preserve marine habitats and mitigate the effects of human influences. My research focuses on the effects and success of marine restoration. One study I encountered demonstrated that living shorelines, a form of natural erosion control, can enhance the nursery function of marshes, allowing more juvenile organisms to live there than at natural marshes. Another study suggested that coral gardens made up of naturally heat-resistant corals can better withstand the devastating effects of bleaching events. A final study concluded that utilizing the natural biodiversity of seagrass beds in restoration efforts can create ecosystems close in function to natural ones. This research demonstrates that restoration can result in healthy and functioning habitats, which will be crucial in preserving many marine ecosystems and the services they provide to humans. Scientific evaluation of restoration efforts can measure their success and aid in the design of future projects. I will be continuing with the Ingenuity Research Practicum at the Institute of Marine and Environmental Technology with Dr. Eric Schott, who is currently studying the ecology of the Baltimore Inner Harbor and blue crab populations in the Chesapeake Bay. I hope to gain lab experience and a greater understanding of marine life and ecosystems.

## **Pharmacology in Metastatic Breast Cancer**

Oluwayemisi Ojolayo

My field of interest is in pharmacology. Pharmacology is the study of the use of a certain drug, the reaction to a certain drug, the chemical makeup of the drug, etc. My research is specifically on how certain drugs that affect metastatic breast cancer that has been previously treated with anthracycline and taxanes would work differently when combined with each other. One current study explored the effect of Ixabepilone plus capecitabine in metastatic breast cancer. I came across another study that was researching the effects of Gemcitabine plus paclitaxel. A third study looked at the effects of vinorelbine and gemcitabine. The research shows that certain combinations of medicines for metastatic breast cancer work better than one medicine alone. It is estimated that 42,690 people (42,170 women and 520 men) will die from breast cancer this year. Metastatic breast cancer will cause the vast majority of those deaths so knowing that combinations of medicines work better together will help women (and men) with metastatic breast cancer live longer. I will be continuing with Ingenuity Research and I would like to work at the University of Maryland, Baltimore under the guidance of Dr. Vincent Njar. I will be conducting research on the development of novel small molecules with potential for the treatments of a variety of cancers, especially breast, prostate, and pancreatic cancers.

## **Distributed Drinking Water Systems**

Annelise Olsen

Distributed drinking water systems are decentralized methods of water treatment, collection and storage. They are more flexible, resilient, and have lower startup costs than typical centralized water systems. The three selected studies focus on developing specific technologies for treating small quantities of water. One study describes how researchers have discovered how to make the treatment of organic matter using hydrogen peroxide and UV light more accessible. Another shows how UV light can help trace metals bond to the small amount of iron oxide naturally present in water, so one does not have to add additional iron oxide to remove trace metals. The lack of resource dependency makes the method useful for small, decentralized water systems. A third study shows how materials based on natural structures such as the pitcher plant's peristome surface can increase efficiency and allow for easier salt collection in solar powered desalination. The new technologies being researched will make distributed drinking water systems more accessible and adaptable to a wide variety of situations, which will increase access to clean drinking water. I will continue to Research Practicum and am seeking a mentor in the field of water chemistry and microbiology.

# Sophomore Interest Statements

## **High-Temperature Superconductivity in Materials Science and Engineering**

Jack Overton

Materials Science and Engineering (MSE) combines engineering, physics, and chemistry principles to solve real-world problems associated with nanotechnology, biotechnology, information technology, energy, manufacturing, and other major engineering disciplines. Superconductivity is the strange property that an object can have that when cooled to an extremely low temperature, the object will let a current pass through it with absolute efficiency. When superconductors were first discovered, they only worked at absolute zero or near absolute zero temperatures. Over time, more superconductors have been developed at higher temperatures. The current high-water mark for a high-temperature superconductor is 250 K (-23 degrees Celsius). Two of the studies I am pursuing are related to the application of superconductors to new technology. The other paper I am studying is written by the lab who set the 250 K record for a superconductor a few years ago. Much can be gained from developing a room-temperature superconductor. This development would allow for many new technological advances including quantum computers and a much easier path to environmentally friendly energy. For my research practicum, I will be mentored by Dr. Kit Bowen in the Department of Chemistry at Johns Hopkins University.

## **Molecular Biology and Cancer Medical Research**

Nyla Powell

Molecular biology is the study of the function and structures of macromolecules. Specifically, my research looks at the protein modifier, and its usage in cancer biomarker research. SENPS or SUMO proteases have been seen to be good candidates for potential cancer biomarkers. In a study, researchers found that SENP1 could be used as a biomarker for a drug called the ML-792 when they have a lot of MYC tumors. Another study shows SENP biomarkers could be very useful and efficient in radiotherapy through lung cancer. A third study discovered that SENP1 regions could be used with miRNA-145 for a new method of dealing with prostate cancer cells (PC-3). This research is important for our future medical history, it shows new methods of dealing with all types of cancer. Chemotherapy is the main technique used to treat cancer and is very dangerous to the health of our essential cells, causing patients to get sick. Using protein modifiers would be a safer and more effective option for chemotherapy for most patients and doctors. This research will impact our medical treatments for the better. I will be completing my research for the Ingenuity Research Practicum in the Matunis Lab in the Bloomberg School of Public Health under the mentorship of Dr. Michael Matunis.

## **How to Increase Access to Space with Nanosatellites**

Mika Prada Enzmann

Space is no longer the final frontier, now for most people, it is gathering enough money to get to space. There are two main ways to reduce the cost for space exploration; making satellites cheaper and lighter and making nano-satellites self-propelled, allowing many to be launched with one vehicle, after which they could alter their orbits independently. One study tested the feasibility of solid micro thruster arrays which allow satellites to cheaply add various propulsion schemes to their nanosatellites. A second study examined how a cheap burn-wire mechanism can be used to deploy mechanisms on satellites by burning through a tie-down cable. A third study focused on equations and software to control a satellite in proximity situations, their final equations could navigate around any non-planer object given enough time and fuel. The research in bringing down the cost of satellites means that soon space could become more open to everyone, no longer requiring deep pockets to fund and launch a payload. The cheap access to space would allow human-rated equipment to be tested without financial risk. I am seeking a mentor in the ASCO lab. I hope to help develop novel ways to manufacture and maneuver a nanosatellite.



# Sophomore Interest Statements

## **Risk Factors of Adolescent Substance Use**

Christina Sarbanes

My research is focused on using statistical methods to evaluate the risk factors of youth substance use. Meaning, what preliminary factors may lead to an increase of drug use among adolescents. Current studies have focused on risk factors such as childhood trauma, divergence from a two-parent household, education, personality traits, adolescent social culture, and family substance use history. Many positively correlated risk factors relate to situations that tend to cause poor mental health. If risk factors can be identified, target groups can be aided in an attempt to prevent substance use before it occurs. In turn, the number of individuals seeking and/ or needing substance use treatment would decrease. While perusing Ingenuity Research, I will be working under the guidance of Dr. Renee Johnson. Dr. Johnson is a professor of mental health at the Johns Hopkins Bloomberg School of Public Health. Her work focuses on the mental health of adolescents and young adults with a focus on substance use, violence, and marginalized populations.

## **The Study of Mass Extinctions**

Mia Schildbach

My research is on paleontology, specifically the study of mass extinctions. Paleontology is the study of prehistoric life, usually through fossils and the environments that they lived in. Mass extinctions are extinction events in which over 75% of life on earth goes extinct. There have been five mass extinctions over the course of Earth's history. Recently, scientists found sulfur levels increased before the K-Pg extinction and decreased afterward. This disruption of the sulfur cycle could endanger certain creatures. In another study, researchers found that the creation of Large Igneous provinces correlated with multiple mass extinctions. The volcanic activity that forms LIPs cause greenhouse gas emissions and ocean acidification that can kill creatures. In a third study, researchers compared modern extinction rates to rates during mass extinctions and concluded that current extinction rates could cause another mass extinction in a few centuries. Studying mass extinctions can determine how life has evolved and can guide future conservation efforts. It can also help us learn what the effects of our current climate crisis could be. I will continue with Ingenuity Research Practicum and will be mentored by Dr. Emmy Smith in the Department of Earth and Planetary Sciences at Johns Hopkins University.

## **Prosthetics and Mechanical Engineering**

Jonah Schwartz

My general field for my project is mechanical engineering and how it can be applied to prosthetics to make them more efficient and capable, while maintaining comfort. Three examples of current research are using new and better technology for prosthetics such as digitizers you have to explain what this means that are more advanced. Another example is using different coatings from different materials to line the prosthesis. A third example is very recent; they are working to connect prosthesis to your brain so that you can control it with your mind just like your normal body. these are good examples, though not thorough - more information is needed. Some ideas of future research is making prosthetics even better than normal limbs so if people like soldiers and firefighters lose a limb they can actually get an upgrade. I am pursuing Ingenuity research and the field I would like to work with a mentor in the field of is bioengineering and molecular biology. I want to work with this field because it is part of engineering and it would be different from my prosthetics research while still relating because it studies biological systems and incorporates themes from prosthetics research.

# Sophomore Interest Statements

## **The Study of Synthetic Biology and its Effects on the Future**

Jacquelyn Sin

My research topic is synthetic biology, which is a new field that incorporates the engineering of biological systems. Scientists in this field aim to create artificial cell and bacterial systems to improve future and current health care. Projects in synthetic biology involve both in vitro and in vivo research – in vitro focusing on the engineering of biopolymers and self-replicating systems and in vivo involving the engineering of bacteria and larger-scale projects. Another example of current research in the synthetic biology field is that where scientists looked into the creation of cell-free systems to use in prototyping genetic circuits where it was found that only certain topics of study can only be controlled in artificially created cell-free reactions. It is the hope of scientists to learn how synthetic biology can be used to improve upon medicine, medical treatments, and the betterment of public health. This could be done through the implementation of synthetic biology in personalized medicine; where one could create cells to replace and repair sick and damaged ones. I will pursue Ingenuity Research and am looking for a mentor in the Department of Medicine at Johns Hopkins University.

## **Public Health Services**

Jala Wallace

I am interested in public health service, since I am planning to become a future pediatrician. I strongly believe that having Dr. Nadine Peart as my mentor will help me achieve my future goals. Dr. Nadine Peart is an alumni from Spartan Health Sciences University School of Medicine and has an residency at Hurley Children's Hospital. Dr. Nadine Peart and I will be researching the immune response to vaccine strain of measles virus and this research will take place at John Hopkins University.

## **The Correlation Between Abnormalities in Centrosomes and Mutations**

Aram Zaproshyan

Cancers usually progress through mutations in the cells of organisms, and understanding how certain mutations are caused can help in treating cancers. My topic is within molecular biology, and it involves understanding how such mutations may be caused by specific components of cells called centrosomes and microtubules, which act as the backbone of cells. An example of current research is when scientists tested the presence of mutations in chicken cells that lacked centrosomes; chromosomal instability (CIN) was present alongside mutations in these cells. Another group's research focused on the relation between an excess in centrosomes and cellular stability, and they found that aneuploidy (abnormal chromosome count) and inviable cells were results of such circumstances. A final instance of current research was where scientists discovered that excess centrosomes result in missegregation during mitosis, alongside genome instability. This research can positively impact our lives as it gives us insight into the causes of mutations which can increase our understanding of cancers. I will be participating in the Ingenuity Research Practicum and will be working with Dr. Rajiv McCoy at Johns Hopkins University, in the Department of Biology.

# Innovation Interest Statements

## **The Future of Artificial Intelligence**

Oluwadamilola Akinola

Artificial Intelligence (AI) is a new ever-expanding horizon in the field of technology which brings the challenge of trying to replicate human thinking and understanding in machine programming. One current study in AI examines neural network machines, which can reveal patterns in gene sequences to predict certain hereditary diseases. This can be used around the world to have a positive effect on people with hereditary diseases. Another study looks at how AI can model machines and can be used for educational games that can predict how much a student can learn. This has a chance to lead to better learning environments and conditions for students everywhere who struggle with processing new information. A third study found that having a deep learning model (which these researchers designed themselves to find chemical features in molecules) proposes a new type of drug to fight against antibiotic bacteria. The research presented on this poster can impact our lives mostly in positive ways such as improving the quality of life, creating new jobs, and making new devices that would not be possible with our human constraints. I intend on pursuing Ingenuity Innovation Practicum and hope to work in the Software development/ Machine Learning field.

## **Anemia Demographics**

Jordan Bass

Understanding public health involves studying the health of populations, as opposed to individuals. My research topic examines how anemia affects different demographics throughout the world. An example of a current study on this topic is about scientists trying to determine areas that are most affected by malaria. This is relevant to my topic because through my research I've found that malaria can lead to anemia. Another study included a collection of statistics of measles in a certain area. Scientists found that in that area, hospital exposure and measles were strongly associated. Lastly, a third study examined the prominence of the flu in certain areas. The study of demographics of anemia can help people know the risk of it and allow them to be aware of the causes if they should ever develop this deficiency. Also, people may be more cautious about the decisions they make that could lead to them developing anemia. As part of the Innovation Practicum, I would like to work at Towson University in the Department of Health Scientists.

## **Application of Artificial Intelligence with wireless communications**

T'sairus Beasley

Artificial intelligence (AI) is a subdiscipline of computer science that focuses on the intelligence of a machine that has the ability to learn any task that can be done by humans. My research explores a study introducing the concept called edge learning, which uses a combination of wireless communication and machine learning to overcome the limited information that can be stored and processed on a computer device. I read a study showing how wireless communication can help improve the reliability and the work efficiency of AI-Based vehicles like self-driving cars, unmanned aerial vehicles, etc. Finally, I found a study regarding how the implication of AI into a wireless network's wireless communication can improve its intelligence while making it more able to handle larger amounts of information from users and other outside variables more efficiently. The research being presented can impact our lives because it will make doing certain human tasks more efficient for humans which would lead to more opportunities for our society to evolve in the future as technology advances. I will pursue the Ingenuity Innovation Practicum and will be mentored by Dr. Lou Strolger at the Space Telescope Science Institute.

# Innovation Interest Statements

## Dark Matter

Keith Ceruti

Research on dark matter studies the non-baryonic matter, also known as perceivable matter, responsible for 27% of the universe. Dark matter is currently invisible to current instruments, however, we know its existence based on the necessity for the galaxies to rotate. Due to the elusive nature of dark matter, scientists conduct searches through particle colliders. Examples include the ATLAS experiment at the Large Hadron Collider, The China Dark Matter Experiment, and the Annual modulation with the NAI Scintillators experiment by COSINE-100. The previous entries intended to search for axions, a popular theoretical particle that the majority of researchers believe is responsible for dark matter. It is imperative that we resolve the mysteries behind dark matter because it will allow us to understand the universe and many unknown interactions between celestial bodies. In hopes of conducting research on dark matter, I will continue with Ingenuity Innovation Practicum and focus on astrophysics and astronomy. **I will be doing research at the Space Telescope Science Institute with Dr. Lou Strolger.**

## Racial Disparities in Healthcare

Taylor Chase-Bynum

Racial disparities in healthcare is an avenue of sociology. Sociology is the study of the development, structure, and function and structure of human society. Sociology also examines how human society functions. My research looks into how socioeconomic disparities, along with other factors such as environmental and social factors contribute to the evident inequalities and disparities among people of color in the United States. I have paid specific attention to how these disparities contribute to the maternal mortality rates among black women. Current research looks into how the socioeconomic divide amongst races contributes to the decline in the quality of health and care inside the black community. Also, current research focuses on possible interventions or methods to eliminate these disparities. By understanding these gaps, social change may be achieved. This knowledge will also give the reader the responsibility to support or contribute to the change that is needed. I am pursuing the Ingenuity Innovation Practicum and will be working with Drs. Raymond Perkins and Alex Hagen at T. Rowe Price to gain hands-on experience with applied mathematics and statistics.

## Optimization Algorithms and Applications

Nico Del Pino

The field of optimization is concerned with finding the best possible solution to a problem. Researchers in this field focus on problems where there are many possible solutions and finding the one that best fits a parameter, like cost, is impossible to do by hand. Therefore, most are involved in coding algorithms to find these solutions. A great example of this is the development of optimization algorithms to represent 3D shapes, called meshes, by creating an energy function that takes vertices and side length into account. Another study I found developed an optimization algorithm that used a 2D model of birds to find optimal solutions to non-bird related problems. Finally, I encountered a study on the best way to construct optimization algorithms. The researchers found that the method of gradient descent worked the best, but several subcategories work in specific situations. This research is important because it can be used in many fields. Every field or industry has, at one point or another, asked how to best use its own resources. I hope to receive a placement that focuses heavily on statistics and applied mathematics with Ingenuity Innovation Practicum.

# Innovation Interest Statements

## **Matter-Antimatter Asymmetry**

Kayla Douglas

Observational astronomy focuses on interpreting the mysteries of the universe. A subfield of observational astronomy is matter-antimatter asymmetry, which dives into the mystery of why there is more matter than antimatter in our universe. My research looks at the link between antimatter and dark matter in order to find the general connection by using Baryon Antibaryon symmetry. Another article demonstrates how the physics of matter and antimatter particles can change depending on the energy level of their environment. Finally, a third study shows how controlling systematic uncertainties for an EDM in a storage ring also contributes to this topic. The implications of this field helps further the discovery beyond our Earth, and can even stretch out to other planets and theories that can lead to other worlds like ours, and matter-antimatter asymmetry can be useful for reaching new places and for discovering new places and resources for whenever our own natural resources start to diminish completely. I intend on pursuing the Innovation Practicum, going deeper into the mystery of matter-antimatter asymmetry to figure out its general impact on our future lives with our developing technologies.

## **Gamification In Education**

Adrian Jackson

My research mainly revolves around the uses of gamification for real world problems, but mainly education. Gamification simply said is the implementation of game mechanics into the real world Vr(virtual reality )is now being implemented into many different parts of education. It's proven that having a firsthand virtual experience helps you retain information taught. These vr headsets provide a high level of immersion that makes the participant really feel like they are "there". Ar otherwise known as "augmented reality" is a higher level of virtual reality. It moves virtual objects into your real life area. There are studies that show that ar helps improve student motivation and contribute to academic achievement. These studies are great, but ar is still extremely expensive if you are talking about ar headsets. So there is research to see if it is possible to make mobile ar on par with ar headsets. Gamification is being tested in many different educational topics. It is mainly being researched in its use for in class activities, and whether or not it will keep children interested with a particular lesson. Gamification is going to be a huge step into the future for the educational field as children become more and more tech savvy throughout the years. The field that I really want to enter is game design and I'm not really sure on education but it's still a great option.

## **Personality Theory in Relation to Multiple Research Topics**

Taylor Jones

Personality theory is applying categorical personalities into different topics. The Big Five is typically mentioned when discussing personality theory. The Big Five is a way to measure personality on a large scale. The Big Five Personality traits are: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. While researching this topic, I reached a conclusion that personality theory is used and applied to conduct research on various topics. For example, Researchers studied the relationship between substance abusers and personality disorder, using The Big Five measurement scale. Moreover, I reviewed a study in which the relationship between spending styles and personality, using the Big Five measurement scale, was analyzed. Lastly, I encountered a study that used the Big Five measurement scale to analyze how personality can distinguish and religious person, from a non-religious person. These studies impact our lives because as people, we do not realize the huge effect personality has on our lives, and everyday decisions. I have decided to continue with ingenuity innovation at Morgan State University under Dr. Candice Marshall. At Morgan State, I will be examining actuarial science, a mathematical field that applies to risk in insurance, finance, and more.

# Innovation Interest Statements

## **Obesity in Children and Adolescents**

Deondre Martin

My research examines child and adolescent obesity, which describes children, whether young or transitioning into adulthood, that are overweight, or have a Body Mass Index of over 30. Specifically, I am exploring methods of prevention and/or intervention that help to lower child obesity percentages. Researchers are studying the balance of insulin and fat distribution in children to help determine what are some biological causations of obesity. Other studies conclude that it is important for the research and practice communities to work in complement to one another, researchers exploring methods and reasoning while the practice community executes policies and helps with children's' physical activity. Finally, I found a study that looked at the potential relationships between infants' time spent in the mother's womb, infant activity, and childhood obesity. Promoting infant activity is a potential obesity prevention intervention. This research can save countless lives as obesity is the cause of millions of children's' deaths worldwide. Preventing obesity in our children can save the future generations yet to come. For my research path, I intend to pursue Ingenuity Innovation and hope to find a placement where I can learn more about applied mathematics.

## **Advanced Biological Machine Learning in Civil Facilities**

Daudi Mwangi

My field of interest centers around using advanced coding systems in order to enhance the general hospital experience and to bring innovation to the medical field so that more advanced ways of operating on patients is achieved. Ideally, increasing the efficiency of the machines that are used in the treatment of patients would also be beneficial. Three examples of current research that is being done in this field include: a study on how scientists are trying to create a prosthetic with more realistic touch sensors, upgrading medical equipment so that immediate emergency response is an option, and making devices that can detect illnesses to be more accurate and sensitive. This research can impact our lives by showing that improvements in the medical field are imminent and will change how we live. Furthermore, illnesses would be able to be cured or prevented with this new technology. I am interested in studying machinery and coding in Biology. I am also in finding a mentor for the Innovation Practicum.

## **Pedestrian Safety: The Dangers of the Road**

Muswe Pembamoto

Crossing the street is a two-way interaction, the driver, and the person crossing. My interest is what happens during the time of crossing. For example, as a large group of students from school crossing a high-speed road with a short amount of time. Three current studies on this topic include a study on the safety at school zones and how students can be affected when crossing roads, another study on the ability of self-driving cars to detect pedestrians, and a third study on how pedestrian crossing behavior depends on the crossing time. I hope this work inspires people to think about how and when to cross and to pay attention to their surroundings. With more research, I can discover more information about pedestrian safety. I am continuing with the Innovation Practicum and will be mentored by Dr. Candice Marshall in the Department of Mathematics at Morgan State University. For this practicum, I will be learning more about actuarial sciences.

# Innovation Interest Statements

## **Improvement of Autonomous Vehicles Through Machine Learning**

Logan Sampath

Machine learning techniques have been applied to computer vision and automated vehicles for some time. These techniques are implemented in deep learning systems and help to avoid dependence on researchers' algorithms for self-driving cars, which could have human error. Researchers are currently using machine learning algorithms to extract features from images using an autonomous car's camera. Others are using new technology to improve the speed of pedestrian detection. Within each frame, windows containing pedestrians are detected, and histograms and other statistical models are made based on the pixel values of each image. Another study used inverse reinforcement learning techniques to create a driving system that mimics a human driver's style. For this, parameters for the driving system are made using a human demonstration as input. This research can impact society by improving the safety of automated vehicles. Self-driving automobiles can also impact human lives in other ways, such as improving the mobility of elderly or disabled people. I aim to secure a placement at the Johns Hopkins University Mathematical Institute for Data Science, where pioneering work is done in artificial intelligence and machine learning fields.

## **The Use of Stochastic Models in Science**

Henry Stone

The research topic I chose is stochastic modeling and its uses, specifically in scientific fields. A stochastic model is a model used to determine the likeliness of certain outcomes that take random variables into consideration. It is used in research in many different kinds of science, for example it helps figure out the dynamics of a limit order book, which is a record of particularly sufficient data on different stocks and the interest of potential buyers and sellers. Stochastic models are also being used in research by forecasting population trends, which can even take very random things into account. Finally, in physics, they are used to predict certain events on the quantum level. This is especially hard because much of quantum physics revolves around what happens when something is observed, versus what happens when it isn't. Something that can be gained from this research is knowledge about the math that is used in finance. For my Innovation Practicum I will be mentored by Drs. Ramond Perkins and Alex Hagen at T. Rowe Price. I want to do research there because I predict it will give me an idea of what I want to do in that field when I get older.

# Class of 2020: College Acceptances

\* denotes the college /university the senior will be attending

## **Hazel Amodia**

The Catholic University of America  
Drexel University  
Loyola University Maryland\*  
New York University  
Notre Dame University of Maryland  
Stevenson University  
Towson University  
University of Maryland, College Park  
UMBC

## **Matt Arcillo**

Georgia Tech  
Johns Hopkins University\*  
UMBC

## **Marie Badiola**

McDaniel College  
Washington College  
UMBC\*  
University of Maryland, College Park (FIRE Program)

## **Cameron Bolden**

Bucknell University  
Emory University  
Howard University\*  
McDaniel College  
North Carolina A&T  
University of Maryland Eastern Shore  
University of Pittsburgh

## **Hannah Bossard**

Bowie State University  
Bucknell University  
Clemson University  
Hampton University  
Hood College  
Howard University  
Loyola University of Maryland  
Morgan State University  
Mount St. Mary's University\*  
St. Mary's College of Maryland

## **Shania Brown**

Bowie  
Clark Atlanta  
Drexel  
McDaniel College\*  
Mount St. Mary's  
North Carolina A&T  
Towson University  
Spelman

## **Corrine Charney**

Clark University  
College of Wooster  
Dickinson College\*  
Hobart and William Smith  
Lewis and Clark  
Oberlin  
University of Delaware

## **Caleb Clark**

Calvin University\*  
Grove City College  
LeTourneau University  
Taylor University

## **Mouhamed Diouf**

The Ohio State University  
Purdue University  
UC Florida  
Virginia Tech  
UMBC  
University of Maryland, College Park\*

## **Gabriel Forbes**

Dickinson College  
Drexel\*  
Hollins College  
Howard University  
Morgan State University  
Ringling  
Temple University  
UMBC

## **Kamran Guchemand**

University of Maryland, College Park\*

## **Ella Halpin**

Notre Dame of Maryland \*

## **Ari Harris-Kupfer**

Carnegie Mellon  
Cornell  
Johns Hopkins University (Baltimore Scholar)\*  
Morgan State University  
Northwestern  
University of Central Florida  
University of Pittsburgh  
University of Maryland, College Park (Honors Program)



# Class of 2020 College Acceptances

## **Erik Hernandez**

Loyola University Maryland  
Morgan State University\*  
UMBC

## **Miriam Herrera**

University of Maryland, College Park  
(Banneker Key Scholar)\*  
UMBC (Meyerhoff Scholar)  
University of Delaware (Honors Program)  
Howard University  
Muhlenberg (Honors Program)  
Johns Hopkins University  
Franklin and Marshall

## **Adam Hofert**

Bard College  
Lafayette College  
UCLA  
University of Maryland, College Park (Honors)\*

## **Peter Hope**

Goucher College  
St. Mary's College of Maryland  
Towson University\*  
UMBC  
University of Maryland, College Park

## **Jacky Le**

UMBC\*

## **Noah Lee**

NCAT  
Tulane  
UMBC  
University of Maryland, College Park\*

## **Katrina Marinelli**

College of Wooster  
George Washington University  
Ithaca College  
Pennsylvania State University  
St. Mary's College of Maryland  
Temple University – Honors Program  
University of Maryland, College Park  
(Honors College)\*

## **Naomi Naka**

DePauw University – Honors College\*  
Gettysburg  
Ithaca College  
James Madison University – Honors College  
Millersville – Honors College  
Truman State University  
University of Maryland, College Park  
College of William and Mary

## **Jarra Omar**

Brown University\*  
McDaniel College  
Morgan State University  
University of Maryland, College Park  
(Scholars Program)

## **Ellie Parker**

Dickinson College\*  
Fairfield University  
Ithaca College  
McDaniel College  
St. Mary's  
University of Vermont  
Ursinus College  
Washington Colleg

## **Maya Pulliam**

Allegheny College  
Johns Hopkins University (Baltimore Scholars)  
McDaniel College  
Temple University  
UMBC  
University of Maryland, College Park  
(Banneker Key Scholar)\*

## **Isaiah Roberts**

Hampton University  
Howard University – Karsh STEM Scholars\*  
Johns Hopkins University  
Morgan State University  
North Carolina A&T  
University of Maryland, College Park  
(Scholars Program)  
UMBC

## **Gregory Rosario**

University of Maryland, College Park  
(Banneker Key Scholar)\*

## **Colton Ross**

Duke University  
Harvard University\*  
University of Michigan  
Vanderbilt  
Washington University in St. Louis  
Yale

## **Liam Sauchuk**

Towson University  
University of Baltimore\*

## **Helen Schott**

Colorado State University  
University of Connecticut  
(STEM Achievement Scholar)\*

# Class of 2020 College Acceptances

## **Mya Smith**

Drexel University  
Emory University  
Howard University  
McDaniel College  
Morgan State University  
UMBC  
University of Maryland, College Park  
(Banneker Key Scholar)\*  
Xavier University Louisiana  
(Presidential Scholarship)

## **Ian Stadelmaier**

Bard College  
Highpoint University  
Lehigh University  
Syracuse University  
University of Maryland, College Park (Honors)\*  
University of Massachusetts, Amherst

## **Trinity Stephen**

Rochester Institute of Technology  
University of Maryland, College Park\*

## **Emma Texter**

Colorado State University  
University of Delaware  
University of California San Diego\*

## **Noel Thomas**

Salisbury University  
University of Maryland, College Park  
University of New Hampshire-Main Campus  
University of Vermont\*  
Virginia Tech

## **Donaysia Torbit**

Case Western Reserve University  
Howard University  
Mercer University  
Morgan State University  
North Carolina A&T  
Temple University  
University of Maryland, College Park  
(Scholars Program)\*  
UMBC – Meyerhoff Scholar

## **Tessai Watts**

Drexel University  
Roanoke College\*

## **Raekwon Williams**

Johns Hopkins University (Baltimore Scholars)  
North Carolina A&T  
UMBC  
University of Michigan  
University of North Carolina, Chapel Hill\*  
Xavier University Louisiana

## **Ronald Wingate**

Frostburg State University  
McDaniel  
Mount St. Mary's University  
Towson University  
UMBC  
University of Maryland, College Park  
(Incentive Awards Program Scholar)\*  
University of Pittsburgh

## **Samantha Yoseph**

Texas A&M University  
University of Maryland, College Park\*

## **Fiona Zabel**

Chatham University  
Drexel University  
UMBC (Superintendent's Scholarship - \$12,000/year)  
University of Maryland, College Park  
(Banneker Key Scholar)\*  
University of North Carolina, Chapel Hill  
University of Pittsburgh  
University of Rochester  
Washington University in St. Louis

## **NOTABLE SCHOLARSHIPS**

Dave Goldberg Scholars Program – Raekwon Williams  
Howard University Karsh Scholars Program –  
Isaiah Roberts  
UMBC Superintendent's Scholarship – Fiona Zabel  
DEPAUW Merit Award – Naomi Naka  
University of Maryland, College Park Banneker Key  
Scholars – 4

More than 11 million dollars total scholarships.

# Math Education in Ingenuity

Every year some Ingenuity students choose math as their college major or minor. Since 2001, approximately 40 Ingenuity graduates attended leading colleges and universities and became professional mathematicians.

The Future Scholars Program at Johns Hopkins University is a great opportunity for high school seniors to take college math classes for credit. Students are able to register for one course per semester without tuition costs. Nominated students are given a challenging qualifying exam to be considered for this highly selective program. Each year up to 10 students are chosen to be Future Scholars. These students earn Hopkins University math credits, bypass the AP system with actual university courses, and enjoy the advice and mentorship of the Hopkins Mathematics Department.

Every year one to four Ingenuity rising seniors pass the exam and are accepted to the Future Scholars Program to study Linear Algebra, Advanced Linear Algebra, Differential Equations, Multivariable Calculus, Number Theory, or Abstract Algebra. Some of these students later earned Ph.D.s. in Mathematics or Physics.

**Lucinda Borbash** has been accepted into the Future Scholars Program at the Johns Hopkins University Department of Mathematics for the 2020-21 school year. **Colton Ross and Fiona Zabel** successfully completed math courses this year at Hopkins as Future Scholars.

The Ingenuity Math Club at Poly was established by Dr. Goldenberg in 2001 and he has moderated the club every year since. Annually about 20 students participate in the club, studying advanced math topics and solving Math Olympiad-like problems. Dr. Goldenberg prepares club members for high school math competitions. Every year Ingenuity students participate in three competitions: the Maryland Math League, the University of Maryland High School Mathematics Competition, and the American Mathematics Competitions AMC-10 and AMC-12.

Since 2002, our students have won multiple prizes and become school and city winners. On a regular basis our AMC participants are invited to participate in the American Invitational Math Examination, which is the next level of this national math competition.

Starting in the 2020-21 school year, Ingenuity will offer a new advanced math course titled Honors Linear Algebra, Differential Equations, and Mathematics Projects. This course will cover a range of advanced topics of elementary mathematics and some topics which are usually taught in college.

# Research Awards and Honors

Congratulations to Ingenuity seniors and juniors for their dedication to research. Despite the unprecedented situation in research and education due to the COVID-19 pandemic, they were able to complete their work.

Seniors: Matt Arcillo, Marie Badiola, Caleb Clark, Ari Harris-Kupfer, Miriam Herrera, Alexander Nishiura, Jarra Omar, Maya Pulliam, Isaiah Roberts, Donaysia Torbit, Raekwon Williams, Samantha Yoseph, Fiona Zabel.

Juniors: Michael Aladejebi, Julia Alumbro, Ithemriorochi Amanze, Alejandro Barrera, Lucinda Borbash, Tate Bothner, Elias Brody, Riyan Campbell, Lucy Canick, Sabina Celnik, Isaiah Chapman, Seth Chng-Lim, Tendai Coady, Maya Filipovitz, Stephanie Fishkin, Madeline Jaffe, William Kardas, Nhan Le, Sarah Li, Nicholas Pham, Juni Polansky, Isabelle Richard, Tejal Schwartz, Talya Simcox, Kristiana Smith, Frank Tagaytay, Chelsea Thompson, Jacob Thompson, Agnes Torregoza, Chielota Uma, Aaron Villahermosa

## Stockholm Junior Water Prize

**Nicholas Pham** has been selected as the Maryland state winner of the Stockholm Junior Water Prize. His paper, *Identification and Quantification of Toxic Unsaturated C4-Dicarbonyl Ring Cleavage Products from the Chlorination of Varying Phenolic Compounds* exemplifies the mission of the SJWP, and he is a strong competitor for the national competition.

## The National Consortium of Secondary STEM Schools (NCSSS)

Kristiana Smith will be participating in the 2020 NCSSS Student Research Conference.

## Student Publications

Sankar, S., Brown, A., Balamurugan, D., Nguyen, H., Iskarous, M., **Simcox, T.**, et.al. *Texture Discrimination using a Flexible Tactile Sensor Array on a Soft Biomimetic Finger*. 18th IEEE Sensors, SENSORS 2019 (p. 8956704). Institute of Electrical and Electronics Engineers Inc.

Sevil Yasar, Kyle D. Moored, Atif Adam, **Fiona Zabel**, Yi-Fang Chuang, Vijay R. Varma, Michelle C. Carson. *Angiotensin II Blood Levels Are Associated with Smaller Hippocampal and Cortical Volumes in Cognitively Normal Older Adults*. Journal of Alzheimer's Disease vol. Pre-press, no. Pre-press, pp. 1-9, 2020, DOI: 10.3233/JAD-200118

**Since 2005, there have been -28 Ingenuity student publications in peer reviewed journals.**

# Ingenuity in National and International Science Competitions

## Intel/Regeneron Science Talent Search

### 3 winners, total 14 semifinalists

2019: Michelle Mokaya, semifinalist  
2018: Rebecca Brody and Claire Wayner, semifinalists  
2017: Amy Zhang, semifinalist  
2016: Kathy Le, semifinalist  
2014: Kelly Khare and Lucas Winch, semifinalists  
2011: Dan Borgnia and Ilenna Jones, semifinalists  
2010: Wuqiong Fan, semifinalist  
2007: Emma Call, winner, 10th place  
2006: Abe Davis, winner, 7th place; Owen Hill, semifinalist  
2005: Ryan Harrison, winner, 5th place

## Intel International Science and Engineering Fair (ISEF)

### 5 Grand Prize winners and 15 finalists (total 20)

2017: Alida Schott, Grand Prize 4th place in Physics & Astronomy  
2014: Darius Johnson, Grand Prize 3rd place winner  
2012: Michael Tontchev and Elias Weston-Farber, finalists  
2011: Michael Tontchev, finalist  
2008: Shauna Linn, 2nd Place Award winner  
2006: Emma Call, 2nd place winner; Nahathai Srivali and Tiffany Steele, finalists  
2005: Elizabeth Banks, Wayland Chen, finalists  
2004: Anna Kalmykov, Grand prize 4th place winner; Eric Rosenberg and Rachel Pierson, finalists  
2003: Anthony Agyapong, Lani Martinez and Dung Tran, finalists  
2002: Chelsey Hash and April Ruffin, finalists  
2001: Craig Turner, finalist

## Siemens Competition

### 7 semifinalists

2011: Weston-Farber, semifinalist  
2009: Wuqiong Fan, semifinalist  
2008: Ariel Bowers, semifinalist  
2007: David Lai, semifinalist  
2006: Emma Call, semifinalist  
2005: Tam Nguyen, semifinalist  
2004: Abe Davis, semifinalist

## National Junior Science & Humanities Symposium (JSHS)

### 8 winners and finalists

2019: John Halpin, 3<sup>rd</sup> Place winner  
2018: Lily DeBell, 3rd place winner  
2017: Rebecca Brody, 2nd place winner  
2010: Anna Manalad, finalist  
2009: Kayleigh Horst, finalist  
2006: Emma Call, 4th place winner; Elizabeth Banks, finalist  
2005: Ryan Harrison, finalist

# Ingenuity in National and International Science Competitions

## Baltimore Science Fair (BSF)

### 16 Grand Prize winners

2018: Lily DeBell  
2017: Stephen Grabowwski  
2015: Phoebe Sandhaus, Isaiah Thomas  
2014: Darius Johnson  
2013: Nathan Greene, Evan Smith  
2012: Michael Tontchev, Elias Weston-Farber  
2011: Michael Tontchev  
2008: Shauna Linn  
2006: Emma Call, Nahathai Srivali  
2004: Anna Kalmykov  
2003: Lani Martinez  
2002: Chelsea Hash

## The USA Biology Olympiad

### 8 national semifinalists

2012: Stephen Timmel, semifinalist  
2009: Caryn Carson, Illena Jones, Dana Katzenelson, Lawrence Wang, semifinalists  
2008: Shauna Linn, semifinalist  
2006: Danielle Weissman, semifinalist  
2005: Amy Peyrot, semifinalist

## Young Epidemiology and Naturalist Scholars Competition

### 1 winner, 2 finalists, 1 semifinalist

2009: Hannah Bands, finalist; Jasmen Rice, semifinalist  
2006: Justin Tibbles, winner; Molly Broach, finalist

# Notable College Scholarships

## Baltimore Scholars Program

Between 2007 and 2019, **98** Ingenuity students have been accepted into the Baltimore Scholars Program at the Johns Hopkins University.

# 800 SAT and SAT Subject Test Scores

Between 2001—2019, Ingenuity students received **120** perfect 800 SAT and SAT subject test scores. For this time period, the average Math SAT score was 693, and the average SAT Math 2 score was 699.

The first Ingenuity student to receive an 800 on Math SAT was Robert Watkins in 2001. Robert went to Yale and graduated from Columbia Law School in patent law and technology law. Currently he is a senior legal counsel at Apple.

# Class of 2020



Amodia, Hazel Jianne   Arcillo, Matt   Badiola, Marie Louise   Bolden, Cameron   Bossard, Hannah   Brown, Shania



Charney, Corinne   Clark, Caleb   Diouf, Mouhamed   Forbes, Gabrielle   Guchemand, Kamran   Halpin, Ella



Harris-Kupfer, Ari   Hernandez-Centeno, Erick   Herrera, Miriam   Hofert, Adam   Hope, Peter   Le, Jacky



Lee, Noah   Marinelli, Katrina   Naka, Naomi   Nishiura, Alexander   Omar, Jarra   Parker, Elizabeth



Pulliam, Maya   Roberts, Isaiah   Rosario, Gregory   Ross, Colton   Sauchuck, Liam   Schott, Helen

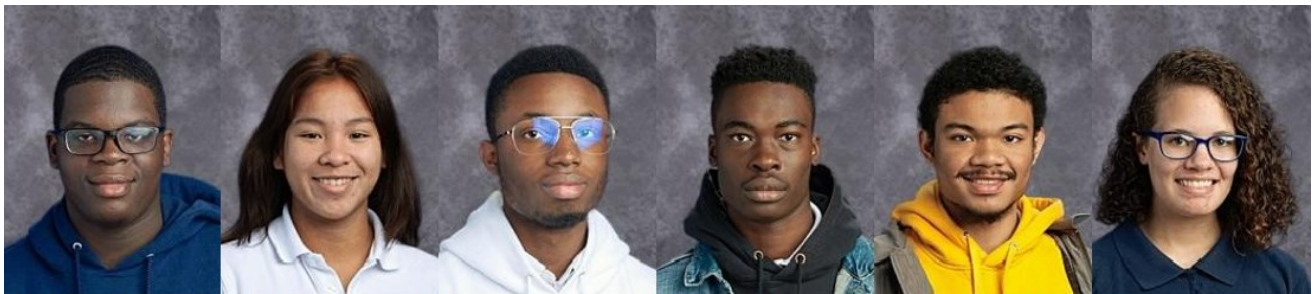


Schutz, Alden      Smith, Mya      Stadelmaier, Ian      Stephen, Trinity      Texter, Emma      Thomas, Noel



Torbit, Donaysia      Watts, Tessai      Williams, Raekwon      Wingate, Ronald      Yoseph, Samantha      Zabel, Fiona

## Class of 2021



Aladejebi, Michael      Alumbro, Julia      Amanze, Ihemriorochi      Anjorin, Obafemi      Barrera, Alejandro      Basoco, Ana



Beahn, Kaitlynn      Bhat, Shantika      Blankson, Jolynn      Borbash, Lucinda      Bothner, Tate      Brandon, Collin



Brody, Elias      Bushnell, Henry      Calderon, Lucas      Campbell, Riyan      Canick, Lucy      Celnik, Sabina





Chapman, Isaiah    Chen, Vina    Chng-Lim, Seth    Coady, Tendai    Crews-Harris, Tahdai    Dia, Jordan



Djeuf, John    Filardi, Peter    Filipovitz, Maya    Finney, Rian    Fishkin, Stephanie    Hamilton Jr., Jerome



Hilger, Anna    Hill, Darius    Hull, Miranda    Jaffe, Madeline    Johnson, Akashia    Johnson, Nolan



Kardas, William    Le, Nhan    Li, Sarah    Lyons, Wyatt    Malmin, Charlotte    Marchionni, Luce



McKenna, Kacey    Mokaddem, Aquib    Odeh, Patience    Paranilam, Jaela    Petros, Mason    Pham, Nicholas



Pinkney, Jocelyn    Polansky, Juni    Restelli, Edward    Rhodes, Jayden    Richard, Isabelle    Sall, Boubacar



Samuel, Logan    Schmitz, William    Schwartz, Tejal    Scott, Mariah    Selim, Sheikh    Simcox, Talya



Smith, Kristiana    Smith, Presley    Spahn-Rodriguez, Simon    Tagaytay, Frank    Thomas, Devon    Thomas, Kyle



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Wilder, Morgan    Zheng, Jennifer    Zurlage, Kyla

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Nishiura, Meredith Odedovin, Aruoriwo Ojolayo, Oluwayemisi Olsen, Annelise Onyike, Ketandu Orellana-Guzman, Jose



Overton, John Patterson, Whittney Paulk, Elisabeth Pembamoto, Muswe Poole, Riauna Powell, Nyla



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Lin, Yuki Low, Holland Lumpkins, Jewel Lyons, Aydin Mabry-Francis, R'Reeyah Malone, Margaret



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# Acknowledgements



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