2021 INGENUITY STEM RESEARCH SYMPOSIUM

MAY 27, 2021

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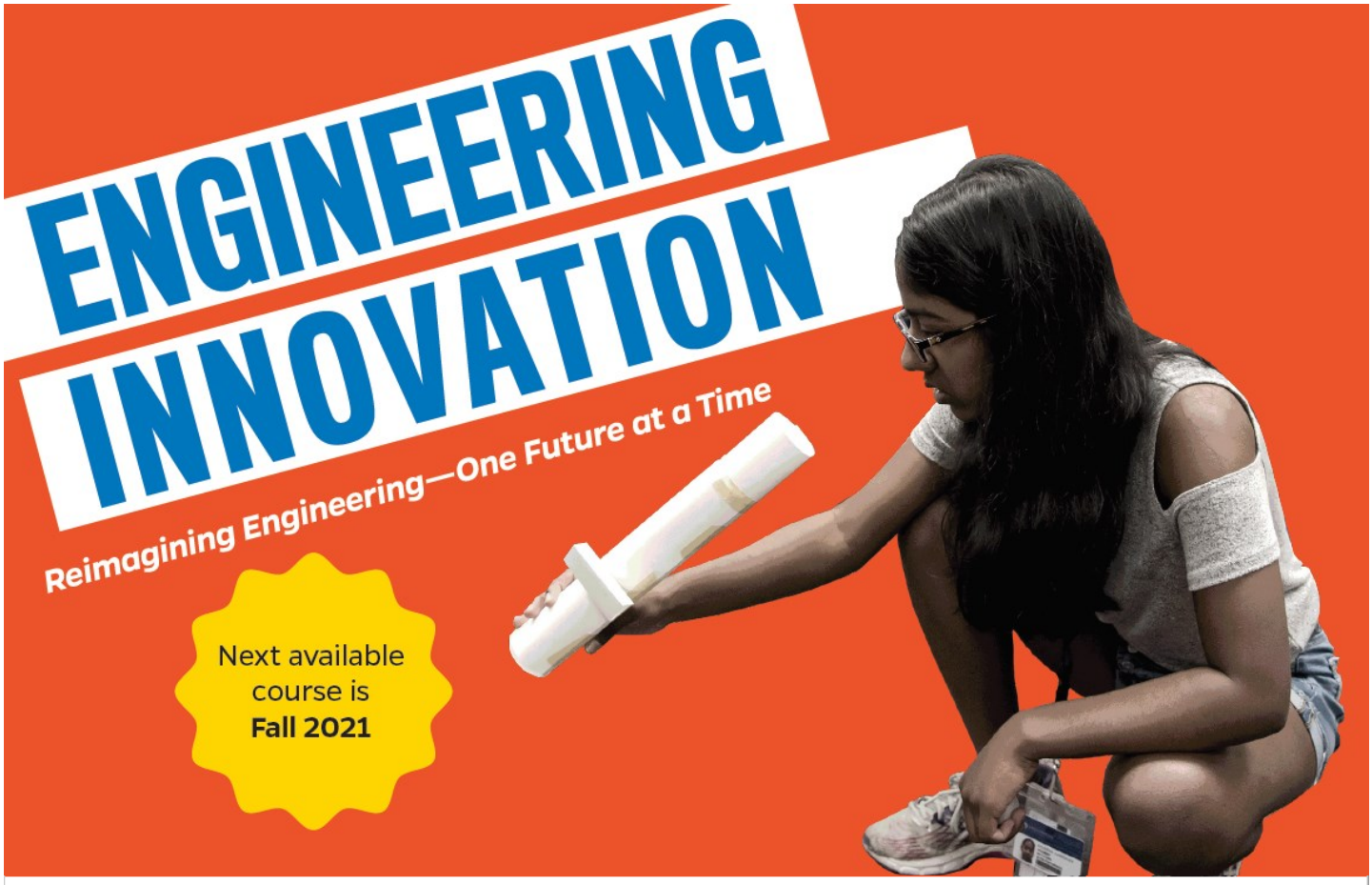

Biomedical Engineering Innovation (BMEI) puts the inner drive of talented high school students into high gear with an interactive sneak peek into engineering. This fully online course was designed by trusted scientists and engineers from Johns Hopkins and boasts plenty of hands-on, creative activities—all while teaching students to think like an engineer. And students have the opportunity to earn college credit from Johns Hopkins.

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For more information about the program, additional course offerings and to apply, please visit ***ei.jhu.edu***

Dear Guests,

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

This pandemic continues to teach us many lessons – including the importance of flexibility and innovation during challenging times. A year ago, we couldn't imagine what research would look like without students entering laboratories in person, but as you can see from the following research abstracts and the Symposium presentations, students gained valuable skills and made meaningful discoveries with scientists, researchers, and graduate students in virtual platforms across the city from their homes.

School year 2020-21 marks the second year of Ingenuity's Innovation Practicum where students are examining important issues in STEM through the fields of applied mathematics, computer science, data science, and statistics. Twenty-four students forged this new Innovation Practicum pathway over the last two years. We are so grateful for the mentors and partner institutions committed to this new endeavor.

As Ingenuity reflects on the past several years, expanding opportunities for students and adding new locations, we look closely at the current unprecedented challenges that our students, teachers, and communities are navigating as a result of Covid-19, a greater reckoning with racial injustice, and virtual learning. Through listening and learning with our community, I am confident we will step into next year with a bold vision for curriculum and support that cultivates student leaders with a passion for excellence, deep sense of curiosity, and strong desire to innovate and change systems for the greater good.

Sincerely,

Lisette S. Morris
Executive Director


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Baltimore Polytechnic Institute — Theory Practice — Founded, 1883

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&

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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 insight 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 eight years and has done an exceptional job in bringing great heart and vision to this already prestigious school.

The Ingenuity Project

A seven-year advanced STEM curriculum for capable and motivated students. Providing curriculum, enrichment, and support to over 800 students in four middle schools and close to 20% of students enrolled at Baltimore Polytechnic Institute (Poly). In conjunction with fast-paced, content-rich mathematics and science classes taught by experienced teachers, research is emphasized through a multi-year, independent off-campus practicum guided by an Ingenuity research teacher.

Ingenuity Project Curriculum

Research Program

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, and financially rewarding, contests. Juniors and seniors submit their research to local science fairs as well, including the Junior Science and Humanities Symposium (JSHS) and Morgan State Science and Engineering Fair .

The Innovation Practicum is a two-year sequential in-school and off-site research curriculum for 10th-11th grade Ingenuity students. Students work with mentors to create solutions to real challenges using Applied Mathematics, Computer Science, Machine Learning, Data Science, and/or Statistics and learn coding languages and/or statistical analysis programs.

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.

Ninth grade students begin their sequence with a year of Geometry: Proof and Problem Solving; tenth grade students complete a year of Algebra II and Elementary Functions, 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 such as a survey of Differential Equations and Linear Algebra. Some students have also qualified to take classes at Johns Hopkins University through the 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.

Table of Contents

Schedule of Events

5:00 - 5:25 Welcome and Keynote Address (Zoom Link: CLICK HERE)

Session 1, Junior Poster Presentations (5:00 - 5:40)

Zoom Room	Presenters
Session 1 - 5:25-5:40 1—**Bioengineering**	**Jonah Schwartz** Creating Circular Channels, and Studying the Effects of Channel size and Fluid Flow **Zen Gordon** Characterization of Ovarian Cancer-Associated Antigens that Enhance Cytotoxic T-cell Response
Session 1 - 5:25-5:40 2— **Public Health**	**Jordan Bass** Behavioral Health of Pregnant/ Parenting Youth in Baltimore **Ashantae Hayward** Seafood Production and Trade in Micronutrient Deficient Countries **Precious Conteh** The Role of Spiral Ganglion Neurons in Hearing Loss Induced by Sickle Cell Disease
Session 1 - 5:25-5:40 3—**Social Issues**	**Kayla Douglas** The Implications of Privacy in the Growing Technological World **Christina Sarbanes** An Analysis of Cigarette, Marijuana, Alcohol, and E-Cigarette Use Among Maryland High Schoolers **Diego Jovel** Comparing the Landscapes of Independent Episodes of Introgression Among Primates
Session 1 - 5:25-5:40 4—**Viruses**	**Jala Wallace** Antibodies' response in MeV Rhesus Macaques Treated with Remdesivir **Harriet Engelke** Diagnosis of Cystic Echinococcosis by Identifying Repeat Elements of cfDNA **Nico Del Pino** The Association Between Socioeconomic Status, Essential Worker Status, and COVID-19 Case Counts

Schedule of Events

Zoom Room	Presenters
Session 1 - 5:25-5:40 5—**Insurance/Finance**	**Muswe Pembamoto** A Study of the Effect of COVID-19 on Auto Insurance Rates **Henry Stone & Taylor Chase-Bynum** Determining Optimal Withdrawal Rates in Retirement Using Monte Carlo Simulations **Taylor Jones** The Effect of COVID-19 on Health Insurance
Session 1 - 5:25-5:40 6—**Machine Learning**	**Keith Ceruti** PACMan: Mitigating Bias In Proposal Reviews Utilizing Machine Learning **Daudi Mwangi** Analyzing and Comparing the use of Linear Regression through a 1980-2018 sea ice Database using WEKA and Python. **Oluwadamilola Akinola & Deondre Martin** Post Hurricane Damage Assessment Through Machine Learning

Session 2, Junior Poster Presentations (5:45 - 6:00)

Zoom Room	Presenters
Session 2 - 5:45-6:00 **1—Cells**	**Nyla Powell** SUMO Proteases (SENPS) as a Potential Cancer Biomarker **Aram Zaprosyan & Miles Fancher** Comparing the Landscapes of Independent Episodes of Introgression Among Primates **Andrew Haye** Cytoskeletal Influence in Signal Transduction
Session 2 - 5:45-6:00 **2—Machine Learning**	**Logan Sampath** Unexpected Events: Testing Current Capability of Autonomous Vehicles **Elyjah Bassford** Incorporating Intersectional Fairness Into Machine Learning **Johns Hopkins III** Using Machine Learning to Predict Ground Reaction Forces

Schedule of Events

Zoom Room	Presenters
Session 2 - 5:45-6:00 1—**Bioengineering**	**Jonah Schwartz** Creating Circular Channels, and Studying the Effects of Channel size and Fluid Flow **Zen Gordon** Characterization of Ovarian Cancer-Associated Antigens that Enhance Cytotoxic T-cell Response
Session 2 - 5:45-6:00 2—**Public Health**	**Jordan Bass** Behavioral Health of Pregnant/ Parenting Youth in Baltimore **Ashantae Hayward** Seafood Production and Trade in Micronutrient Deficient Countries **Precious Conteh** The Role of Spiral Ganglion Neurons in Hearing Loss Induced by Sickle Cell Disease
Session 2 - 5:45-6:00 **3—Ecology/Earth Sciences**	**Merideth Nishiura** Effects of An Urban Estuary on Blue Crabs and Blue Crab Diet **Annelise Olsen** Algae for Nutrient Remediation **Mia Schildbach** Studying the Ediacaran Period through the examination of a fossil from the Deep Spring Formation of Nevada
Session 2 - 5:45-6:00 **4—Public Health**	**Lillia Berninzoni** Association of Age-Related Hearing Loss and Cognitive Decline Using a Mouse Model **Hayden Benhart** Looking At Removal of RNA Containing Premature Stop Codons As a Novel Function of Extracellular Vesicles **Oluwayemisi Ojolayo** Efficacy of Different Cell Culture

Schedule of Events

Zoom Room	Presenters
Session 2 - 5:45-6:00 **5—Miscellaneous**	**Sam Elkins** Lateral Force Scaling During Legged Locomotion **Mika Prada Enzmann** Tele-Operation Through Time Delay **Jack Overton & Virtue Bama** Identifying Differences In Game Managerial Decision Making

6:00 - 6:05 Break

Session 3, Senior Poster Presentations (6:05 - 6:20)

Zoom Room	Presenters
Session 3 - 6:00-6:05 **Room 1**	**Juni Polansky** Isolation, Sequencing, and Annotation of Novel Bacteriophage
Session 3 - 6:00-6:05 **Room 2**	**Nicholas Pham** Identification and Quantification of Toxic Unsaturated C4-Dicarbonyl Ring Cleavage Products from the Chlorination of Varying Phenolic Compounds
Session 3 - 6:00-6:05 **Room 3**	**Riyan Campbell** Examining Microtentacle Formation University of Maryland, Greene-baum Cancer Center
Session 3 - 6:00-6:05 **Room 4**	**Elias Brody** The Effects of Shear Stress on Fibrillin-1 Production if Marfan Syn-drome Endothelial Cells

Schedule of Events

Session 4, Senior Poster Presentations (6:20 - 6:35)

Zoom Room	Presenters
Session 4 - 6:20-6:35 Room 1	**Tate Bothner** Determining the PAM sequence for the *Streptococcus thermophilus* CRISPR4 Cas1-Cas2 complex
Session 4 - 6:20-6:35 Room 2	**Ihemriorochi Amanze** Comparison of Sensor Types for Differentiating Properties of an Object
Session 4 - 6:20-6:35 Room 3	**Maddie Jaffe** Analysis of the Biodiversity of Baltimore's Inner Harbor
Session 4 - 6:20-6:35 Room 4	**Nhan Le** Zebrafish yolk phenotype screen reveals four potential genes involved in lipid metabolism

Session 5, Senior Poster Presentations (6:35 - 6:50)

Zoom Room	Presenters
Session 5 - 6:35-6:50 Room 1	**Tejal Schwartz** Ubiquitous Artifactual Periodicity in Covid-19 Data Sets: Extracting the Artificial Teeth of the Pandemic
Session 5 - 6:35-6:50 Room 2	**Sarah Li** A Novel Kinematics-based Approach to Inform Vestibular Rehabilitation
Session 5 - 6:35-6:50 Room 3	**Jacob Thompson** Evaluating the Impact of Early Marine Diagenesis on the Ediacaran-Cambrian carbon isotope record from Sonora, Mexico
Session 5 - 6:35-6:50 Room 4	**Chielota Uma** Cerebellar tDCS reduces time to task failure in healthy young adults
Session 5 - 6:35-6:50 Room 5	**Julia Alumbro** Examining Hach-Ammonia Nitrogen Trends in Baltimore City

Schedule of Events

Session 6, Senior Poster Presentations (6:50 - 7:05)

Zoom Room	Presenters
Session 6 - 6:50-7:05 Room 1	**Aaron Villahermosa** Using gravimetry to predict the gravity traverse of the upcoming 2020 Rover
Session 6 - 6:50-7:05 Room 2	**Tendai Coady** Leveraging Biological Mechanisms in Machine Learning-Based Breast Cancer Prognostication
Session 6 - 6:50-7:05 Room 3	**Maya Filipovitz** Comparing Web Diversity in the Spider *Uloborus Diversus*
Session 6 - 6:50-7:05 Room 4	**Talya Simcox** Improving Sensory Neuroprostheses: Measuring Vibrations with a Tactile Sensor
Session 6 - 6:50-7:05 Room 5	**Sabina Celnik** Determining Social Dominance Behavior in Mice

About the Keynote

Dr. Asamoah Nkwanta

Morgan State University
Mathematics Department
Chair and Professor

I have many years of teaching experience at the college and university levels. My academic interest is algebraic and enumerative combinatorics. In particular, I am interested in mathematical connections among topics from combinatorics, linear and abstract algebra, classical number theory, molecular biology (i.e., RNA sequence counting and prediction), and special functions. Other topics of interest are discrete computational biology, the history of mathematics, and mathematics education. I am currently working on an RNA sequence prediction or folding model. In this research I want to use certain lattice walks as a way to model strands of certain viral RNAs. In addition to the RNA research, I am working on developing new structural properties and combinatorial applications of the Riordan group.

I'm also working on problems and applications that arise in lattice walk (or path) counting. This includes questions concerning: 1) constructing a generalization of a certain lattice walk counting prolems in higher dimensions and 2) finding correspondences between lattice walk problems and RNA secondary structure mutations (from molecular biology). In addition to my academic experience, I also have over ten years of industry experience in the areas of industrial mathematics, computer science, and systems engineering (operations research).

Education:

- Ph.D. Howard University, 1997
- M.S. University of Wisconsin at Milwaukee, 1984
- B.S. North Carolina Central University, 1981

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 their junior year and summer prior to their junior year. Each student has written a formal research paper detailing the results of his or her respective project. The papers were submitted to national pre-college competitions, including Regeneron Science Talent Search, Junior Science and Humanities Symposium (JSHS), and Baltimore Science Fair (BSF). (Note: some Ingenuity students elect to take Poly Research Practicum during their senior year.)

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

Senior Research Abstracts

Examining Hach-Ammonia Nitrogen Trends in Baltimore City
Julia Alumbro

Mentor: Dr. Ciaran Harman
Department of Environmental Health and Engineering, Johns Hopkins University

In Baltimore City, sanitary sewage overflows (SSO) have been a result of a faulty and outdated separated sewer system. 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, location, and site type, using the basis of a Hach-Ammonia Nitrogen threshold of 0.3 ppm. Data from the Department of Public Works were put under statistical analysis on Python and a GIS map was developed to represent the combined data. I took into account the drainage area, type of location (i.e channel, outfall, manhole), and observational limits for the dataset. The amount of ammonia content at each location varied but was evidently the largest as the sites got closer 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.

Determining the PAM sequence for the Streptococcus thermophilus CRISPR4 Cas1-Cas2 Complex
Tate Bothner

Mentor: Dr. Scott Bailey
Supervisor: Elvar Bjarkason
Department of Biochemistry and Molecular Biology, Johns Hopkins Bloomberg School of Public Health

CRISPR-Cas (Clustered Regularly Interspaced Short Palindromic Repeats-CRISPR-associated) systems are adaptive bacterial immune systems found in bacteria and archaea, used to fight against invaders. In S. thermophilus, type I-E systems utilize the Cas1-Cas2 complex to identify foreign DNA elements for adaptation. This is the first step in CRISPR immunity in which fragments of foreign DNA, known as protospacers, are integrated into the CRISPR array within the bacterial genome as spacers. A key component of the identification of foreign DNA is the protospacer adjacent motif (PAM) sequence, which is used by Cas1 -Cas2 to identify a potential protospacer before further investigation of the downstream target sequence. While previous studies have outlined the general functions and applications of the S. thermophilus CRISPR-Cas system, little is known about the PAM. The aim of this study was to determine the optimal PAM sequence of S. thermophilus. Based on a bioinformatics analysis of spacer sequences, the PAM was identified as AA or GA in the S. thermophilus CRISPR4 system. While next steps are required to validate this study, the PAM identification helps take a first step towards a greater understanding of the CRISPR-Cas system in this bacterium..

Senior Research Abstracts

The Effects of Shear Stress on Fibrillin-1 Production if Marfan Syndrome Endothelial Cells

Eli Brody

Mentor: Dr. Sharon Gerecht
Supervisor: Franklyn Hall
Department of Chemical and Biomolecular Engineering, Institute for NanoBioTechnology, Johns Hopkins University

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 aneurysm which is the rapid swelling in the upper part of the heart's main artery. Aortic aneurysm and many other health issues caused by Marfan syndrome result from blood vessel's lack of structural proteins and, therefore, compromised elasticity. In order to better understand how Marfan syndrome affects blood vessel 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. For my research, I am going to focus on endothelial cells (ECs) that line blood vessels. The main stresses 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 versus healthy ECs. My research hopes to discover how Fibrilin-1 and other protein production is affected by shear stress in Marfan endothelial cells as compared to healthy endothelial cells. This research may give key insight into how different cell types in persons with Marfan syndrome react to their environments as well as offering a model of blood vessels in Marfan patients.

Determining Social Dominance Behavior in Mice

Sabina Celnik

Mentor: Dr. Gul Dölen and Dr. Eastman Lewis
Department of Neuroscience, The Dölen Lab at the Brain Science Institute at Johns Hopkins University

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 across development to test whether a relationship between weight and dominance exists. Thus far, six out of 7 pairs of male mice exhibit a clear dominant and subordinate behavioral pattern as measured using the tube test. Results for the urine dominance assay and the tube test for four more pairs of mice will be obtained by the end of December for a total of eleven comparisons. Results will offer insight to whether the tube test assay of social dominance is a promising behavioral assay to assess typical and atypical social behaviors in adult mice.

Senior Research Abstracts

Exploring the Structural Phenotype of Microtentacles
Riyan Campbell

Mentor: Dr. Michele Vitolo
Greenbaum Center, University of Maryland School of Medicine

Microtentacles 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 constitutively activated and leads cells to proliferate in an uncontrolled way, which 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 systematically 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.

Comparing Web Diversity in the Spider *Uloborus Diversus*
Maya Filipovitz

Mentor: Dr. Andrew Gordus
Department of Biology, Johns Hopkins University

How behavior is generated, specific to individuals, is not well understood. Various methods used, in hopes of measuring similarities and differences between individuals, generally involve qualitative analysis, which is prone to human bias. In the Gordus Lab, spiders are used as model organisms to study behavior. Specifically, the lab examines various methods, with an emphasis on quantitative analysis, to determine how to best measure and observe spiders' web making process, which can tell us a lot about behavior. In this study, we relied on video recordings of spider web making in real time to observe both the spider's legs (50 Hz) and web (10 Hz) clearly visible. Using convolutional neural networks (CNNs), the legs were automatically tracked, while the final web structure was annotated by hand. With these annotations, the web geometry was analyzed using quantified metrics, such as line lengths and angles, which will allow for future comparisons to be made between webs and building individuality.

Senior Research Abstracts

Leveraging Biological Mechanisms in Machine Learning-Based Breast Cancer Prognostication
Tendai Coady

Mentor: Dr. Luigi Marchionni
Sidney Kimmel Comprehensive Cancer Treatment Center at Johns Hopkins University (currently Weill Cornell Medicine)

Incorporation of machine learning into personalized cancer treatment has been suggested as a promising field in oncology; however it has not yet been fully implemented in the clinical settings for the purpose of prognostication. A hindering factor is overfitting of prediction models, when the models perform very well in the dataset used to develop them, but fail on independent new data. Overfitting is caused by the "curse of dimensionality," a conundrum deriving from the discrepancy between the high number of features (e.g., all the genes expressed in a tumor) and the low number of samples containing these features (e.g., the patients). We tested the hypothesis that the use of prior biological knowledge to reduce the number of features used in the training process could help to circumvent the curse of dimensionality. We trained and tested two k-Top Scoring Pair (k-TSP) classifiers using relative gene expression levels in pairs to determine cancer prognosis in breast cancer patients from the METABRIC dataset. One classifier was trained using all possible gene pairs (agnostic), while the other was trained using only gene pairs justifiable via knowledge of biological mechanisms (mechanistic). Two Random Forest (RF) classifiers were also trained for the same purpose. Testing showed little difference in performance between mechanistic and agnostic classifiers for both classifier types. While our findings did not prove that the use of mechanistic biological knowledge with the mechanisms chosen can improve classification performance and reduce overfitting in this case, the approach merits further investigation.

Comparison of Sensor Types for Differentiating Properties of an Object
Ihemriorochi Amanze

Mentor: Dr. Jeremy Brown
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 used today suffer from a multitude of issues that need to be improved upon such as overpricing, weight, and feedback. Haptic feedback is the sense of touch we receive in response to contact with skin and nerves including things such as pressure, temperature, force, and vibration feedback. Prosthesis users are deprived of certain feedback making accurate and price control of the prosthesis more difficult. My research focused on developing and testing sensors for a prosthesis to discriminate between parts of a regular object. This is accomplished using a testing method that checks three parts of the cube in 10-second increments.

Senior Research Abstracts

Analysis of the Biodiversity of Baltimore's Inner Harbor
Madeline Jaffe

Mentor: Dr. Eric Schott
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 was to analyze environmental and biological data in order to begin to understand the complex relationships between biodiversity and environmental factors in the Inner Harbor. Biodiversity samples were collected on small plastic disks called biodisks, which were submerged in the water for a month at a time to allow for the building of microscopic communities. Biodisks were then recorded under a microscope in order to find species counts and calculate overall biodiversity. By calculating the rates of return of biodiversity after low-oxygen events, I found that biodiversity at an Experimental Site close to a healthy wetland simulation implemented to promote biodiversity in the Harbor had a faster rate of return from die-offs than that of the Reference Site further away, suggesting a more resilient ecosystem. I also researched the individual species of the barnacle from 2016-2018, a prominent filter in the Harbor ecosystem as well as a sign of healthy oxygen levels. The barnacle population at both sites was found to increase over time, with higher significance at the Experimental Site. This contributes to the understanding of how restoration projects could continue to improve the resilience of the Harbor ecosystem and reinforces the importance of oxygen for biodiversity.

Zebrafish Yolk Phenotype Screen Reveals Four Potential Genes Involved in Lipid Metabolism
Nhan Le

Mentor: Dr. Steve Farber
Supervisor: Maggie Shen
Department of Embryology, Carnegie Institution for Science, Johns Hopkins University

Dyslipidemia is a major cause of cardiovascular disease, however not much is known about the underlying mechanisms. The zebrafish is a powerful model for studying human disease, particularly lipid metabolic disorders, due to their transparent larvae, fecundity, and genetic tractability. During the first few days of development, the zebrafish solely relies on its yolk as the source of food. The yolk syncytial layer (YSL) that surrounds the yolk acts as a digestive organ, similar to the intestine and liver, which packages lipids from the yolk into lipoproteins and distributes them throughout the body. An opaque and darkened yolk phenotype has been demonstrated by prior work in the Farber lab as an indicator of altered lipid metabolism. This subtle phenotype is often overlooked in studies not involving lipid metabolism. Here I report the results of a systematic review of the zebrafish literature to identify abnormal yolk phenotypes within published zebrafish images. Using this approach I identified four potential genes, S-adenosylhomocysteine hydrolase (Ahcy), (pro) renin receptor (Atp6ap2), aryl hydrocarbon receptor (Ahr), and Liver X Receptor (Lxr), that may play an essential role in yolk lipid metabolism. These data not only provide the basis for future research on the role of Ahcy, Atp6ap2, Ahr and Lxr in lipoprotein metabolism but support an even bigger screen of published zebrafish images to identify additional genes regulating lipid metabolism.

Senior Research Abstracts

A Novel Kinematics-based Approach to Inform Vestibular Rehabilitation
Sarah Li

Mentor: Dr. Kathleen Cullen
Supervisor: Omid Zobeiri
Department of Biomedical Engineering, Johns Hopkins University

Nearly 100 million American adults have experienced vestibular dysfunction, which causes patients to experience position, balance, and movement issues. The current standard treatment for vestibular disorders is traditional vestibular rehabilitation therapy (VRT). However, traditional VRT relies on limited observations in the clinic. Accordingly, there exists a significant need for objective quantification of patient performance of VRT exercises. This study seeks to evaluate the value of kinematics-based analysis in VRT to improve the quality, management, and delivery of VRT. Shimmer3 inertial sensors were used to record kinematic data of vestibular schwannoma surgery patients and age-sex matched healthy controls during VRT exercises. Patients were tested pre-operatively and during six postoperative clinic visits. Data from gaze stabilization exercises were compared between patients and controls. We found that one week post-surgery, patients moved their heads significantly slower than healthy controls did during execution of gaze exercises. Following the second postoperative assessment, patients moved their heads quicker over time at a velocity similar to the healthy controls. 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. A mobile app was also developed to allow users to access objective feedback about performance of VRT exercises. The app offered feedback to users based on how much kinematics-based indicators deviated from a specific value. These findings allow for future leveraging of technology to better personalize VRT programs to fit patient needs and ultimately optimize treatment outcomes for vestibular patients.

Identification and Quantification of Toxic Unsaturated C4-Dicarbonyl Ring Cleavage Products from the Chlorination of Varying Phenolic Compounds
Nicholas Pham

Mentor: Dr. Carsten Prasse
Department of Environmental Health and Engineering, The Prasse Lab, Johns Hopkins University

Around the world, chlorination is the most widely used method of water disinfection due to its low cost and effectiveness. However, despite its effectiveness in removing pathogens, the addition of chlorine to water containing organic and inorganic constituents can also result in the formation of toxic disinfection byproducts (DBPs). A novel and toxic DBP species from chlorination that has drawn more attention recently is cis-2-butene-1,4-dial (BDA). This study focuses on the yields of BDA from different phenolic precursor compounds. Bench scale chlorination experiments were conducted on methylparaben, 4-hydroxybenzophenone, and 2-naphthol, simulating conditions similar to those observed in drinking water treatment plants (at a neutral pH of 7.5). N-α-acetyl-lysine (NAL) was added to samples after chlorination for derivatization of BDA. Samples were analyzed by an ultra high-performance liquid chromatography-high resolution mass spectrometer (uHPLC-HRMS) in order to detect transformation products from the chlorination reaction. It was found that all the selected model phenolic compounds produced BDA or its analogues, revealed from the detection of lysine adducts, the products from derivatization.

Senior Research Abstracts

Isolation, Sequencing, and Annotation of Novel Bacteriophage
Juni Polansky

Mentor: Dr. Joel Schildbach
Supervisor: Russell Hughes
Department of Biology, Johns Hopkins University

Antibiotics are the most common treatment for bacterial infections. However, as bacteria develop antibiotic resistance, treatments are becoming less effective. One solution to this problem is bacteriophages, or phages, which are viruses that infect and kill bacteria. Phage research holds promise, as phages target specific pathogens without affecting harmless bacteria. In order to further the field of phage research, it is crucial to expand the dataset of discovered phages. Each phage has a specific host range, so having a wider scope of discovered phages enables a more comprehensive range of bacteria to be targeted and possibly treated. For this project, five distinct phages were identified, isolated, purified, and concentrated into lysates (aqueous phage samples). The concentration and morphology of each phage were determined, and the samples were sequenced. The results from sequencing yielded three novel bacteriophages. Ideally, to complete this process, these sequenced genomes would be annotated and added to the Actinobacteriophage Database. Due to COVID -19, this was not immediately possible, so instead, the genome of previously sequenced Cluster M1 phage SirSheldon was annotated. A genome announcement was written for that phage. Through this project, the bank of discovered phages was increased as well as the understanding of the M1 phage cluster.

Ubiquitous Artifactual Periodicity in Covid-19 Data Sets: Extracting the Artificial Teeth of the Pandemic
Tejal Schwartz

Home-based research

Accurate epidemiological data are crucial for modeling pandemics, and for designing and instituting public health measures to minimize spread and societal impact. Data for Covid-19 incidence, hospitalizations, and death, as presented in the most widely viewed publicly accessible sources, exhibit a remarkably constant pattern of recurring peaks and troughs with a periodicity averaging 7 days. This tightly constrained interval is seen across state, national, and international data sets, and does not conform to known or modeled super-spreader event bursts of transmission. The 2-14 day asymptomatic SARS-CoV2 incubation period yields localized outbreaks spanning weeks or months. I confirmed the non-random nature of the data periodicity, identified fixed temporal shifts in data sets when reported by secondary vs. primary sources, and demonstrated highly significant correlations between troughs and weekends for primary source data. In total, these findings support my hypothesis that the observed recurring 7 day interval between troughs is an artifact caused by deficits in testing and/or recording of data on weekends at primary sites of data generation (labs and hospitals). Additional weekend deficits in transmission of data between primary, secondary, and tertiary data aggregators may contribute to the artifactual patterns observed in almost all graphically presented data sets. Given the enormous political, economic, and public health ramifications of these data, and the unprecedented erosion of public confidence in current official sources issuing data and recommendations, it is important to minimize unintended, artifactual errors in data presentation and interpretation, and to clarify the reason for weekly oscillations in Covid-19 events.

Senior Research Abstracts

Evaluating the Impact of Early Marine Diagenesis on the Ediacaran-Cambrian carbon isotope record from Sonora, Mexico

Jacob Thompson

Mentor: Dr. Emmy Smith
Department of Earth and Planetary Sciences, Johns Hopkins University

The Ediacaran-Cambrian transition marks a pivotal moment in Earth's environmental and biological history. This moment in time records a number of crucial changes in Earth's biosphere, including the disappearance and possible extinction of the Ediacaran biota, some of Earth's first macroscopic multicellular lifeforms, and the subsequent appearance and diversification of complex animal life. Also recorded during this time is a major perturbation to the carbonate carbon isotope record, a negative carbon isotope excursion known as Basal Cambrian carbon isotope excursion (BACE). Carbon isotope data, captured as carbonate rocks precipitate from seawater, can reveal shifts in the global carbon cycle and thus the mechanisms by which Earth's environment functioned and changed. However, these data can also record local alteration events, like the introduction of a fluid with foreign geochemical composition that is not reflective of primary, global ocean chemistry when the carbonate formed. This project aims to determine whether the BACE, as recorded by Ediacaran-Cambrian carbonate strata from Sonora, Mexico, is the product of global seawater changes or local and/or secondary, "diagenetic" processes. To answer this question, major and minor element data were analyzed from a set of carbonate rocks that record the BACE. These data do not point toward a diagenetic origin for the recorded carbon isotope excursion, although they do suggest a change in mineralogy from aragonite or calcite to dolomite. These data provide a glimpse into the geochemical and mineralogical histories of the Ediacaran-Cambrian carbonate strata from Sonora, Mexico. Future work pairing these data with calcium and magnesium isotope data will further elucidate the impact of diagenesis on the Sonoran Ediacaran-Cambrian carbon isotope record.

Cerebellar tDCS reduces time to task failure in healthy young adults

Chielota Uma

Mentor: Dr. Agostina Casamento-Moran
Department of Physical Medicine and Rehabilitation, Johns Hopkins University

Fatigue reduces the force that an individual can exert. Fatigability limits motor control, impairs learning, and reduces cerebellar excitability. The goals of this study were (1) to determine if the application of transcranial direct current stimulation (tDCS) on the cerebellum would improve motor learning under fatiguing conditions and (2) understand the effect(s) of cTDCS on fatigability. Twenty-seven healthy young adults randomly received five blocks of anodal tDCS (active and sham tDCS) over three consecutive daily sessions while completing a sequential visual isometric pinch task (SVIPT). Participants completed a fatiguing task before and after stimulation for each session. Motor skill acquisition, retention and transfer resulted in similar levels for both groups. There was a significant decrease in maximal force for both groups after the fatiguing task. Participants that received active tDCS exhibited a shorter time to task failure than the other group, indicating that cTDCS reduces time to task failure in fatigued individuals.

Junior Research Abstracts

Throughout the previous summer and the current school year, juniors have worked remotely with their mentors to conduct independent projects. Juniors committed to the Innovation Practicum have concluded their work, while students fulfilling the Research Practicum will continue this summer with their independent projects. The posters featured on the symposium website showcase their progress. Some juniors submitted their work to local competitions, including the Morgan State University Science Fair and Maryland Junior Science and Humanities Symposium. The juniors are also responsible for organizing the symposium event.

Hurricane Disaster Detection
Deondre Martin and Oluwadamilola Akinola

Mentor: Dr. Maryam Rahnemoonfar
Department of Information Services, University of Maryland, Baltimore County

Damage left by hurricanes can be really devastating, putting people, property, and certain areas at high risk when bracing the storm. Even when people do evacuate, they have to come back to the destruction of their homes and communities that are very expensive to rebuild. Though this is nature, a force in which we cannot stop, machine learning and computer vision gives us a chance to cut losses. Image classification is a branch of machine learning, naming the ability of a computer to take an image and evaluate every pixel of it. This is done through the use of Convolutional Neural Networks, man made algorithms that mimic the human brain to process images through layers of filters. Image classification can be used to evaluate hurricane damage sites very efficiently and safely using birds-eye-view images, categorizing sites based on damage level and possible means of access such as roads. Knowing the ins and outs of damaged sites before they are even addressed causes for easier planning, which saves lots of money, and potentially lives as neighborhoods are rebuilt more prepared for hurricanes.

Identifying Differences in Intentional Walk Decision Making
Virtue Bama and Jack Overton

Mentor: Sig Mejdal
The Baltimore Orioles

For decades, sports teams have been utilizing statistics to inform and develop strategies that have allowed for extremely successful seasons and careers. The use of statistical analysis has saved some franchises and caused the downfall of others. Although statistical analysis has caused controversies across the sport, correctly developed statistical analysis can be a big advantage. In this paper, we identify the trends of MLB managers when they call for intentional walks. We received data from a query from the Baltimore Orioles. This data was the complete record for intentional walks over the 2020 season. We then analyzed this data using Excel and R. We saw significant differences in how managers utilized their decision-making. We saw basic similarities in the scenario the teams called for the intentional walk but there were still vast differences in the frequency of these decisions by team. These differences show there is still major optimization possible when calling for intentional walks.

Junior Research Abstracts

Behavioral Health of Pregnant and Parenting Youth in Baltimore
Jordan Bass

Mentor: Dr. Jenny Afkinich and Dr. Margo Candelaria
Department of Social Work, University of Maryland

Homeless youth encounter many challenges, and homeless youth who are parents may face additional challenges. Bmore SUCCEEDS is a project dedicated to helping youth that face substance abuse, homelessness, and pregnancy or parenting. I analyzed data that was collected by service providers for the Bmore SUCCEEDS project. Our goal was to see the effect that being a parent has on homeless youth's mental health and substance abuse. This information could be used to identify risk factors and possibly help develop solutions to the problems. My hypothesis was that those who were parents would have a greater rate of both mental health issues and substance abuse compared to those who are not parents. Previous research found that homeless youth who were parents participated in high risk behaviors. The study includes 45 participants, 12 of whom were pregnant or parenting at the time of data collection. No one who was pregnant or parenting reported using drugs or alcohol. Nine of these people said their living situation was not emotionally safe, while three said it was. Five said that they were diagnosed with a psychological or behavioral problem, one said they were not, and the rest did not answer. Seven said that they have seen a mental health professional or are currently seeing one. Four said that they have never seen a mental health professional. I have conducted t-tests in order to test the significance of my findings. These t tests showed that there was no significant distance between the parenting and non-parenting groups. Future research might include making comparisons between my study and the same kind of study in other areas. It could also include re-running the tests with a larger sample size.

Incorporating Intersectional Fairness Into Machine Learning
Elyjah Bassford

Mentor: Dr. James Foulds
Department of Information Systems, University of Maryland, Baltimore County

With the prevalence of machine learning algorithms in everyday life, such as in social media platforms and job recommendations, unbiased outcomes necessitate proper definitions of fairness. Predictive policing, using algorithms to predict crime locations and likelihood of further offenses, among other actions, particularly requires a check against bias. In this work, we utilize differential fairness, a definition of fairness that incorporates the modern intersectional fairness principle, in producing a machine learning algorithm to accurately predict crime locations. We propose exploiting the structure of convolutional neural networks to maximize tasks performed by the algorithm. This definition of fairness will greatly exceed standard accuracy, among other types of machine learning algorithms, compared to algorithms using definitions such as infra-marginality which does not compensate for societal bias and often resulting in the targeting of certain demographics.

Junior Research Abstracts

Using VCF files To Study Whether Extracellular Vesicles Remove RNA Containing Premature Stop Codons

Hayden Benhart

Mentor: Dr. Sarven Sabunciyan
Stanley Division of Neurovirology, Johns Hopkins School of Medicine

The study of extracellular vesicles is a relatively new and unexplored field. They are small lipid bound particles that are secreted by cells to carry out different bodily functions. Two of the major functions of extracellular vesicles are transport of macromolecules, primarily nucleic acids and proteins, and the removal of misfolded proteins. We are curious about other functions that may not have been fully explored and if they have an impact on psychiatric disorders. We suspect that RNA containing premature stop codons is released by the cell in an effort to prevent the production of truncated proteins and that this RNA is then removed by extracellular vesicles. Using RNA sequenced from extracellular vesicles and stored in Variant Call Format (VCF) files, we can look for premature stop codons in the extracellular vesicles. The goal of our project is to determine whether or not extracellular vesicles contain more premature stop codons than the parent cells and evaluate whether or not the transport of RNA containing stop codons is in fact a novel function of extracellular vesicles. This would allow us to perform noninvasive blood tests, reducing risk to patients while also providing a method by which to study disease.

Association of Age-Related Hearing Loss and Cognitive Decline Using a Mouse Model

Lillia Berninzoni

Mentor: Dr. Amanda Lauer
Supervisor: Sergio Vicencio
Department of Neuroscience, The Center for Hearing and Balance, Johns Hopkins School of Medicine

Many individuals suffer from cognitive decline and dementia as a result of aging, the impacts of which are detrimental to daily life. Those with dementia can have trouble in social interaction, memory, and ability to do everyday tasks. Another condition found in the elderly is age-related hearing loss, which shares many of the same symptoms. This correlation has recently caused scientists to take a closer look at the relationship between cognitive impairment and hearing loss with age. The auditory efferent pathway is an area of the brain that remains understudied, despite its essential role in processing sound. It is made of descending neural projections from the auditory cortex to the olivocochlear bundle and surrounding structures in the brainstem. Its main function is in protecting the auditory system against noise and sound detection in noisy environments. This study analyzes data from behavioral tests in mice with hyper functional dysfunctional efferent systems with the goal of learning more about the auditory efferent system and its effects on cognitive ability. The results of this study could contribute to our understanding of the efferent pathway and the overall relationship of hearing loss and cognition. Further research is needed to determine the exact nature of this relationship and how it can be used in treatment.

Junior Research Abstracts

PACMan: Mitigating Bias In Proposal Reviews Utilizing Machine Learning
Keith Ceruti II

Mentor: Dr. Lou Strolger
Department of Instruments, Space Telescope Science Institute

It is often hard to allocate and distribute resources, most processes can be biased and arduous, requiring months to plan and accomplish with marginal success. In context, astronomers from around the world require access to the unique capabilities of the Hubble Space Telescope (HST) and the James Webb Space Telescope (JWST), as there are no other telescopes powerful enough to execute their research goals. The Proposal Auto-Categorizer and Manager, also known as PACMan, is a tool being developed to help with time allocation for the Space Telescope Science Institute (STScI) in Baltimore MD. STScI creates a Time Allocation Committee (TAC) to review thousands of scientific proposals received each year, making recommendations to assign time to a few hundred for HST and JWST. PACMan will assist the TAC in mitigating expertise bias in reviewer assignments, leading to more efficient and reliable selection. Through a combination of a naive Bayesian classifier, vector cosine similarity, and other machine learning techniques, PACMan makes proposal-to-panelists assignments with relatively good accuracy. However, PACMan still needs validation tests and metrics of its performance. Various testing will include analyzing raw scores against "experts", e.g., isolating scores for experts in the subject matter of each proposal, comparing PIs to their proposals, and abstracting only the top scores for a proposal. Through testing we should be able to identify the range of scores that define the "experts" of any given proposal.

Determining Sustainable/Optimal Withdrawal Rates Using Monte Carlo Simulations
Henry Stone and Taylor Chase-Bynum

Mentors: Nathan Henkel, James Whitehead III, Dr. Raymond Perkins, and Dr. Alex Hagen
T. Rowe Price

The topic of our research is Quantitative Finance and Lifecycle Research, along with the 4% rule. Quantitative finance is an area in finance that uses mathematical models to generate predictions on the stock market, generate profits for investors, and calculate and reduce the risk involved in investing. Lifecycle research is the study of target-date funds, which are retirement plans that allow the investor to set a specific date on which they want to retire. These funds allow for the diversification of the investor's portfolio in terms of their allocations of stocks, bonds, and cash. This fund also promotes a shift in allocations as the investor nears retirement, which in turn promotes security instead of growth (stocks to bonds). The 4% rule, instituted by William P. Bengen, is a very common rule for withdrawing in retirement. It encourages retirees to withdraw between 4% and 5% of their accumulated retirement funds annually when in retirement. Therefore, our goal is to use what we've learned about Lifecycle Research and Quantitative Finance to research optimal/sustainable retirement withdrawal rates. To do this, we will employ a Monte Carlo simulation coded in Python. Its function being to run many random samples to predict the trajectory of one's retirement balance. In doing this, we took the "4% rule" into account since we are researching its sustainability. And we also recognized that many other factors must be considered when planning for retirement. So we took salary, asset allocation, and market behavior into account as well.

Junior Research Abstracts

The Role of Spiral Ganglion Neurons in Hearing Loss Induced By Sickle Cell Disease
Precious Ekundayo Conteh

Mentor: Dr. Amanda Lauer
Department of Neuroscience, The Center for Hearing and Balance, Johns Hopkins School of Medicine

Sickle cell disease (SCD) patients are heavily impacted by their disease. Its symptoms include anemia, pain, increased frequency of infection, and much more. Individuals with SCD are more likely to suffer from sensorineural hearing loss (SNHL). In the field that studies the relationship between SNHL and SCD, individuals have explored many different facets of SNHL including hair cells, cochlear nerves, blood vessels, and more. One facet that lacks this exploration is the impact of SCD on the spiral ganglion neurons in the temporal bone. The temporal bone and its spiral ganglion neurons (SGNs) can provide insight into the hearing capacities of most mammals, including humans. Using two-dimensional analysis on the spiral ganglion count of human temporal bones will be taken and compared to normal hearing human controls. This allows for the quantification of the density of SGNs in various sickle cell temporal bone specimens and assess the amount of temporal degeneration. Assessing the amount and type of degeneration, the impact of SCD on SGNs will successfully be determined. This will contribute to future research and improving auditory treatments for individuals with SCD or any auditorily similar diseases.

The Association Between Socioeconomic Status, Essential Worker Status, and COVID-19 Case Counts
Nicolas M. Del Pino

Mentor: Dr. Jacky M. Jennings
Center for Child and Community Health Research, Johns Hopkins University

The SARS-CoV-2 pandemic has ravaged the entire planet and in particular the United States. At the time of this writing, the U.S. is reporting around 3000 deaths by COVID-19 per day. Further inspections of the data reveal that minorities and those of lower socioeconomic status (SES) are dying at disproportionately higher rates than white Americans and those of high SES; a pattern that exists with respect to most diseases. However, the data for the 2020 SARS-CoV-2 is further muddled by the addition of a new factor: essential worker status. Essential workers are people whose jobs are essential to upholding critical infrastructure operations. As a result, they are more likely to be exposed to a disease. The objective of this analysis was to determine the association between the cumulative case count of reported cases of COVID-19 and two factors: the proportion of essential workers and the proportion of persons living in poverty by zip code in Maryland. Using data from the American Community Survey and the Centers for Disease Control and Prevention, I performed statistical analyses testing these associations. I found that although poverty is not strongly related to case counts, essential worker status, depending on the industry, can have either a positive or negative association with case counts. This research gives us insight into how to prioritize the U.S.'s resources when trying to stop the spread of the disease.

Junior Research Abstracts

The Implications of Privacy in the Growing Technological World
Kayla Douglas

Mentor: Dr. Foad Hamidi
Department of Information Systems, The DARE Lab, University of Maryland, Baltimore County

There is much room for improvement when it comes to privacy and knowing what it means for consumers. Already technology has issues connecting with its users that have special circumstances and needs. However, compromising privacy can easily become a problem for most or all groups of consumers. The aim of this research is to identify and bring attention to these issues with informing and bringing awareness. By allowing volunteers to complete the Privacy Checklist, researchers and volunteers are able to not only point out the gaps in knowledge about their privacy online, but also find ways to combat them. This includes factors such as cookies, third party groups, even terms of service among numerous others. The exact methods and results have yet to be determined. However, the gaps and patterns that may be identified throughout my research can significantly benefit consumers of the internet and technology alike by informing them about possible threats to their privacy, as well as help propose solutions to problems if they occur repeatedly.

Diagnosis of Cystic Echinococcosis by Identifying Repeat Elements of Cell-Free DNA
Harriett Engelke

Mentor: Dr. Alan Scott
Department of Molecular Microbiology and Immunology, Johns Hopkins Bloomberg School of Public Health

Cystic echinococcosis (CE) is a disease caused by the parasite *Echinococcus granulosus* and is prevalent in regions of South America. Diagnosis of CE is difficult and involves equipment that is not available in endemic areas. A new diagnosis method that is cost-effective and accurate is needed in order to detect the parasite in early stages of the infection when it is easiest to treat. Dr. Alan Scott and other researchers have been studying urine samples from CE patients that contain E. granulosus-derived cell-free DNA (cfDNA). His data is being used to determine the viability of using cfDNA in the diagnosis of parasite infection. This study analyzes data from different sources in order to identify repeat elements of cfDNA that can be found in patient urine samples.. The results of this study would allow researchers to increase the sensitivity and specificity of the diagnosis method. Further research is needed to determine the viability of this diagnosis method in endemic regions.

Junior Research Abstracts

Comparing the Landscapes of Independent Episodes of Introgression Among Primates
Aram Zaprosyan and Miles Fancher

Mentor: Dr. Rajiv McCoy
Supervisor: Stephanie Yan
Department of Biology, Johns Hopkins University

Introgression refers to the transfer of DNA between two species that are closely related. Previous research in the field of evolutionary genomics has focused on looking at the prominent genes that have been introgressed from Neanderthals into the ancestors of modern humans and their lasting implications on humans today. Some research has been conducted towards investigating ancient introgression among primates, though there has been very little research in comparing such episodes of introgression. We used computational methods to compare episodes of primate introgression with each other as well as with the introgression that occurred from Neanderthals to humans. We did this by calculating the overlaps in genes introgressed between episodes of introgression. We found there was much more of an overlap of introgressed genes between episodes of introgression when the species involved were evolutionarily close to each other. These results reaffirm what previous research had developed regarding how the evolutionarily closer two species are, the more of their genetic structure will be the same. Future research can be conducted to expand this research with other mammal species to investigate associations between introgressed genes and evolution. This research is significant because it shows that there are associations between various episodes of primate introgression; certain introgression episodes can act as models for understanding other introgression episodes. Thus, studying episodes of ape introgression can provide valuable information about introgression into humans, since they have a high overlap in introgressed genes.

Characterization of ovarian cancer-associated antigens that enhance cytotoxic T cell responses
Zen Gordon

Mentor: Dr. Tonya J.Webb and Zewde Ingram
Department of Microbiology and Immunology, University of Maryland, Baltimore

Ovarian cancer is the fifth leading cause of cancer deaths among women, thereby accounting for more deaths than any other cancer of the female reproductive system. It is known that ovarian cancer tissue contains lymphocytes; however, responsiveness to immunotherapy has been limited. Therefore, the purpose of our research project is to determine antigenic proteins in ovarian cancer cells that correlate with patient survival. Previous studies have identified several peptide antigens that have been demonstrated to induce potent T cell responses to ovarian cancer. We hypothesize that the overexpression of genes encoding these peptides will lead to better outcomes, due to the increased ability of the immune system to recognize tumor cells. In contrast, downregulation or mutations in these genes will correlate with poor outcomes. We are using resources such as cBioPortal, Uniprot, Cancer Genome/Proteome Atlas, and other NIH databases to investigate the level of expression and function of these genes in ovarian cancer. Future studies will focus on developing strategies to target these candidate antigens, as well as determine if ovarian cancer patients have T cells specific for these neoantigens. Collectively, our studies implicate a role for cancer-associated antigens in dictating responsiveness to immunotherapy.

Junior Research Abstracts

Cytoskeletal Influence in Signal Transduction
Andrew Haye

Mentor: Dr. Peter Devreotes
Department of Biological Chemistry, Johns Hopkins School of Medicine

The complex mechanisms that control cell movement are currently being uncovered. Diseases such as cancer, more specifically metastatic cancers utilize significantly increased cell division and migration to wreak havoc on healthy tissue. In order to move a cell, myosin motor proteins in coordination with actin filaments create protrusive and contractile events. Cytoskeletal proteins are organized by upstream Signal Transduction pathways. We want to uncover how these two networks, the Signal Transduction Excitable Network(STEN) and the Cytoskeletal Excitable Network (CEN) communicate with one another. Specifically, we set out to test the effects of myosin activity on signaling pathways. By combining synthetic biology and fluorescent microscopy, we measured how rapid changes in myosin activity affected STEN molecules such as Ras. Our data reveals that lowering myosin activity leads to an upregulation in signal transduction activity. Currently, we are testing how cells with reduced myosin activity respond to chemical cues that guide cell migration. These findings will help us further understand how cell mechanics can influence signaling activity.

Seafood Production and Trade in Micronutrient Deficient Countries
Ashantae Hayward

Mentor: Dr. Phillip McNab
Supervisor: Dr. Liz Nussbaumer
Johns Hopkins Center for a Livable Future

Many countries around the world face micronutrient deficiency crises. Previous studies have established the nutritional benefits of seafood and its potential to minimize micronutrient deficiencies. Some micronutrient deficient countries produce enough seafood to lessen their micronutrient deficiency crises, but they export over half of their catch. A collaboration with the Johns Hopkins Center for a Livable Future, the purpose of this project is to study trade policies and other factors that might drive seafood exports in countries with micronutrient deficiencies and to determine potential interventions to allow greater volumes of micronutrient-rich seafood to stay in these countries to support the health of their population. To achieve this goal, I will use a mixed-methods, case-study approach. More specifically, I will use R statistical software to quantify and create graphics of seafood imports and exports in Nigeria, a micronutrient deficient country. For the qualitative component, I will conduct an analysis of trade policies in Nigeria and review literature on programs and policies. This will enable me to discover the possible roots of micronutrient deficiencies and suggest possible interventions.

Junior Research Abstracts

Using Machine Learning to Predict Ground Reaction Forces
Johns Hopkins

Mentor: Dr. Ryan Roemmich
Center for Movement Studies at the Kennedy Krieger Institute, Johns Hopkins University

Every year there are almost 800,000 stroke victims in the US alone, about 80 percent of whom lose some walking abilities and require physical therapy. It is important for therapists to be able to track a patient's recovery using gait metrics that can indicate how far a patient has progressed. One measurement that has been shown to correlate with the severity of a victim's loss in walking abilities, and could possibly help track progress in physical therapy, is ground reaction forces, the force you exert on the ground when you walk. Measuring GRFs requires expensive equipment, like pressure pads, and trained staff, making it hard to use in a clinical setting. This study explores the use of machine learning to predict GRFs from video, which could allow them to be found with little to no equipment or training. Six different algorithms were trained with data from the Center for Movement Studies at the Kennedy Krieger Institute, found using motion capture and pressure pads. The most accurate of the algorithms was the random forest, with 90% accuracy. This shows the viability of machine learning in predicting GRFs, though more testing is needed to see if it can work in a clinical setting.

The Effect of Covid-19 on Health Insurance
Taylor Jones

Mentor: Dr. Candice Marshall
Department of Mathematics, Morgan State University

The pandemic has been very devastating for many people while also impacting factors at the societal level. Health insurance, for example, has changed as a result of Covid-19. In previous years, health insurance rates have been increasing each year since 2009. Previous research has found that the Affordable Care Act (ACA) has been the ultimate solution for providing insurance for the unemployed, and now may be taken away because of Covid-19. With the effect of Covid-19, I expect the increase rates to double from 2019, due to situations such as previously uninsured people seeking health insurance as a response to the pandemic. The ultimate goal of my research is to calculate health insurance rates for 2021, using computer language R. I expect the results to display rates increasing at least 30% in 2021. My research will also explore increased rates of remote therapy, which have gained in popularity over the course of the pandemic. I suspect that Covid-19 caused an epic increase percentage for insurance rates from 2019-2020 compared to rates from 2009-2019

Junior Research Abstracts

Factors that contribute to high rates of Disconnected Youth
Diego Jovel

Mentor: Dr. Tamar Mendelson
Department of Mental Health, Bloomberg School of Public Health, Johns Hopkins University

Since around 2007 there has been a marked increase in the number of disconnected youth, youth that are neither employed or enrolled in the education system, in America, a problem that has also sparked a dramatic increase in money that must be diverted to cover the costs of keeping this population of uneducated and unemployed youth afloat. Our research aim is to identify certain factors and patterns that contribute to the high rates of disconnected youth, especially factors like race, age, and gender. The Measure of America dataset is being used to identify these patterns of youth disconnection and visualize the information. With this dataset we have seen that this problem of youth disconnection tends to affect communities with a greater demographic of Black residents, while communities of white residents are affected as well. This problem has led to multiple millions of dollars to be diverted from areas like public schools, public health, and the like. Ongoing analysis will include the relationship between other demographics and rates of disconnected youth.

Comparisons and Similarities of Python and WEKA when analyzing a 1980-2018 sea ice database using Linear Regression
Daudi Mwangi

Mentor: Dr. Jianwu Wang
Department of Information Systems, University of Maryland, Baltimore County

Have you ever thought about being able to predict the future? Well using Linear Regression that is not so far off. Linear Regression is a way to model the relationship between one or more variables. I will be comparing two ways of doing the Linear Regression approach: through Python, and then through a visual interface called WEKA (Waikato Environment for Knowledge Analysis). Additionally, I hope to shed light on why Linear Regression is important and why it is used within the field of data analytics. The goal of my research is to inform the reader about how these two different programs operate and possibly which techniques are best suited for the individual when tackling Linear Regression problems. The methods that I plan to use in order to answer my research question is to analyze a database comprised of data about sea ice predictions within the time span of 1980-2018 using coding within a Python compiler and software called WEKA, and to compare these two programs in order to see where they shine and where some fall short.

Junior Research Abstracts

Influences of an urban estuary on blue crabs and blue crab diet
Meredith Nishiura

Mentor: Dr. Eric Schott
Institute of Marine and Environmental Technology

Increasing development and urbanization are widespread and critical issues facing marine estuaries, which are productive ecosystems that are crucial both ecologically and economically. The blue crab *Callinectes sapidus,* which functions as a prevalent predator and prey species, is one of the most important organisms in the Chesapeake Bay. The effects of life in urban estuaries on blue crabs have gone underexplored in the past, particularly their role in the food web dynamics of these urban areas. Comparing data on blue crab diet to existing data on the prey community of the area can allow for a complete picture of the interaction between blue crabs and the larger ecosystem. Data on the biodiversity of the Baltimore Inner Harbor were previously collected from biodisks, small disks placed in the harbor and allowed to accumulate a community of organisms. Organisms were counted from the disks, and these counts were converted to approximate biomass using a model of each organism's average mass. The resulting biomass better represents the prey available to blue crabs, with barnacles, dark false mussels, oyster flatworms and clam worms making up the majority of the biomass and thus being the most likely prey species. Future work will utilize the emerging technique of DNA metabarcoding to identify the species composition in the stomachs of blue crabs from the Baltimore Inner Harbor. The data may inform future research into the ecosystem dynamics of urban areas and provide insight into these precarious yet increasingly common communities.

Efficacy of Different Cell Cultivation Methods
Oluwayemisi Ojolayo

Mentor: Dr. Vincent Njar
Department of Pharmacology, University of Maryland

Cell cultivation, which is the controlled growth of cells for use in experiments, is useful in many diverse areas of science. Cell cultivation is used for in vitro testing in different studies that affect living creatures in some way. With there being many different types of cells, there are also many different methods of growing cells to choose from. I will be determining the most effective and most efficient method of cell cultivation. By analyzing and comparing various types of articles contributing to cell cultivation research, I will determine which types have the most success. Analyzing this may succeed in helping researchers determine breakthroughs in their research. Specifically, determining the best cell cultivation method for cancer cells will prove effective in reducing the amount of time it takes to experiment on them.

Junior Research Abstracts

A Study of the Effect of COVID 19 on auto insurance rates
Muswe Pembamoto

Mentor: Dr. Candice Marshall
Department of Mathematics, Morgan State University

Many automobile drivers have been using the road less since the beginning of the pandemic. Over many years the rate of auto insurance has never been constant and pandemic has added to that. At the beginning of the pandemic, some auto insurers even offered to give back some of the premium paid to them by their customers in order to retain their market share. With the rise in the unemployment rate, some people were unable to afford insurance. Each state in the United States has an annual insurance rate from 2011 to 2020. I have chosen 3 states to analyze, Maryland, Maine with the highest percent of change, and Michigan with the lowest percent of change. For my research, I will analyze the effects COVID-19 has on the auto insurance industry with these 3 states. Using linear regression, I will look at the trends in auto insurance rates from 2011 to 2020 and then predict auto insurance rates for future years.

The Usage of SUMO Proteases (SENPS) as Potential Cancer Biomarker
Nyla L. Powell

Mentor: Dr. Michael J. Matunis
Department of Biochemistry and Molecular Biology, Bloomberg School of Public Health

The small ubiquitin related modifier, SUMO, is a protein that is conjugated to other proteins through an enzymatic cascade of E1, E2, and E3 enzymes. SUMO can also be removed from proteins through the activity of SUMO proteases, called SENPs. Many cellular processes regulated by SUMOylation are essential for human cancers. Therefore, inhibitors of SUMOylation are being developed by drug companies to treat cancer. TAK-981 is one such drug currently in human clinical trials and inhibits the SUMO E1 enzyme. Interestingly, SENPs are often misregulated in human cancers. Therefore, we aim to test the hypothesis that cancer cells with higher levels of SENPs are more sensitive to TAK-981 compared to normal cells with lower levels of SENPs, and thus establish SENP expression as a biomarker for TAK-981 therapy. As a step towards testing our hypothesis, we conducted a bioinformatics analysis of cancer cell line mRNA expression data and identified naturally existing cancer cells with varying SENP expression levels. In future experiments, we will use these identified cancer cell lines to test our hypothesis that cells with higher levels of SENP expression will be more sensitive to TAK-981.

Junior Research Abstracts

A Simplified time-delayed testing environment
Mika Prada-Enzmann

Mentor: Dr. Peter Kazazides
Department of Computer Science, University of Maryland, Baltimore County

One of the most difficult parts of designing an autonomous rover is making sure that everything functions as designed. To test rovers engineers often test designs virtually for rapid prototyping in a more simplified environment; Although this does not replace real world testing it can aid the early parts of the design process by having a simplified environment where engineers can create *very* specific circumstances to test behavior. My work is helping with this by creating a simulation environment where various algorithms can be used to simulate time-delayed teleportation when constructing a simple structure. Such an environment, when completed, would allow for the rapid testing of new algorithms and the potential creation of a competition where people submit code to be tested to see how well it performs. We're creating this using AMBF, a real-time simulation software and Robot Operating System (ROS) a software framework designed for programming robots. I hope to help create a testbed of sorts which will allow for the rapid testing of autonomous routines. We hope that with this project completed we will be able to present it to NASA for their followup to the Space Robotics Challenge, a challenge in which students compete to program a virtual rover to complete tasks in a simulated moon environment. I hope that my work will allow for more rapid prototyping and simplified testing of autonomous routines.

Growing Scenedesmus Algae for Specialized Nutrient Remediation
Annelise Olsen

Mentor: Dr. Christopher Ward, Biological Sciences, Bowling Green State University

Excess nutrients in water can be incredibly harmful to aquatic ecosystems. In the Chesapeake Bay, excess nitrogen, from agricultural wastewater, is a major cause of algae blooms. When algae blooms, it produces oxygen, but when it dies, the oxygen is removed from the water as the algae decomposes. Fish and other aquatic animals require dissolved oxygen in the water for survival. When the oxygen is removed from the water, it creates "dead zones" with little to no aquatic life. Algae creates dead zones, but it can also prevent them from occurring. In this experiment, we are measuring the growth of scenedesmus algae and its ability to remove nitrogen from simulated wastewater. We use three different fertilizer mixes with different levels of phosphorus, potassium, and nitrate to simulate various types of agricultural wastewater. The main goal of the study is to discover to what extent and how quickly scenedesmus algae removes nitrogen while in the presence of other nutrients. If we discover that the algae removes nitrogen much faster in water with higher concentrations of a specific nutrient, it allows us to specialize wastewater remediation treatment for the nutrient composition of the wastewater.

Junior Research Abstracts

Unexpected Events: Testing Current Capability of Autonomous Vehicles
Logan Sampath

Mentor: Dr. Carolina Pacheco Oñate
Mathematical Institute for Data Science, Johns Hopkins University

Self-driving vehicles use sensors and onboard computers to automate transportation. They have the capability to drastically reduce road accidents while also increasing vehicle efficiency. Most vehicle crashes are caused by human error, and vehicles driven autonomously remove human error and can be shared more easily. However, autonomous vehicles cannot be allowed freely on the roads because they are not sufficiently accurate. The main challenge for self-driving cars is to adapt to novel situations. Many situations can be captured by training data, but at some point the vehicle must adapt to a new, rare situation. A "heavy tail distribution" can represent this issue, where there is a long list of possible events, each with a low probability, creating a long "tail" in a probability distribution graph. To quantify the extent of this issue, we will characterize the capability of current systems to generalize to novel situations. To test the ability of state-of-the-art detection systems for vehicles, we will use a Python-based, pretrained Mask R-CNN and the NuImages dataset. The NuImages dataset has detailed annotations of specific objects, important for testing unexpected events. We will compare the annotated and predicted bounding boxes and object categories. When testing the Mask R-CNN on the NuImages dataset, we can study the accuracy of the system and single out certain errors for further study. By observing the situations where mistakes are made, we can gain a greater understanding of what specifically needs to be improved in the field of autonomous vehicles.

An Analysis of Cigarette, Marijuana, Alcohol, and E-cigarette Use Among Maryland Teens
Christina Sarbanes

Mentor: Dr. Renee M. Johnson
Department of Mental Health, Johns Hopkins Bloomberg School of Public Health

Substance use in Adolescence may set one up to face many different challenges and lifelong struggles. Current studies in adolescent substance use have focused on risk factors, national youth substance prevalence, and other correlates (such as demographic). Current researchers have used this data in an attempt to address youth substance use and to prevent and aid it. If proper interventions and preventative factors are implemented properly, the number of individuals seeking and/or needing substance use treatment lessens across all ages. Many current articles address the statistics of youth substance use, risk factors, and variables that correlate (i.e., depression and marijuana use). However, few studies have focused on state data broken down by county. This project utilizes data from the Maryland High School Youth Risk Behavior Survey. Specifically, this study looks at the prevalence of Cigarette, Marijuana, Alcohol, and E-cigarette use among high school students in each Maryland county. Implications of this study may help inform future Maryland prevention strategies.

Junior Research Abstracts

Studying the Ediacaran period though the examination of a fossil from the Deep Spring Formation of Nevada
Mia Schildbach

Mentor: Dr. Emmy Smith
Supervisors: Lucy Webb and Mary Lonsdale
Department of Earth and Planetary Sciences, Johns Hopkins University

Paleontologists study fossils to learn about ancient organisms and their environments. Many paleontologists specialize in particular intervals of Earth history, for this project I specialized in the Ediacaran Period (635-541 million years ago), the interval directly before the Cambrian explosion. The Cambrian explosion was a diversification event where many modern animal phyla evolved. By studying Ediacaran geology and fossils, scientists can better understand the causes of the Cambrian explosion and how life evolved and diversified. Ediacaran research is still very new, and researchers are constantly learning how organisms in the Ediacaran were more diverse and prevalent than previously thought. To learn about these organisms, researchers can analyze fossils like the one I researched. This fossil was analyzed by comparing its features with the features of fossils described in scientific papers. The fossil has also been analyzed through scanning electron microscopy with electron dispersive X-ray spectroscopy (SEM-EDS). The SEM-EDS analyses found that the fossil was preserved with chlorite minerals. This was unexpected, because it was originally hypothesized to have been preserved with pyrite. In the future I will continue analyzing the fossil by comparing and contrasting it with other known fossils. Every fossil analyzed gives researchers more data to investigate their hypotheses. In addition to providing information about Ediacaran organisms, the analysis of Ediacaran fossils could have implications for research into whether there was a mass extinction between the Ediacaran and the Cambrian.

Fabrication of Circular Microfluidic Channels in Hydrogel
Jonah Schwartz

Mentor: Gayatri Pahapale
Supervisor: Dr. David Gracias
Department of Chemical and Biomolecular Engineering, Johns Hopkins University

All tissues in our body are interspersed with a vast network of microchannels that facilitate nutrient and oxygen distribution to cells and also drain the waste out from the cell. To mimic this network of microchannels in a laboratory setting, researchers use microfluidic channels, which are essentially microchannels or ducts through the cells' environment. The most common technique used to fabricate the microfluidic devices is lithography, which yields channels with square and rectangular cross sections. However, channels in the body are circular, so that feature is very valuable. Although there are methods like micro-milling and 3D printing to create circular channels, these do not offer the flexibility of material, design, and scalability. Thus, it is still challenging to create channels that simulate the geometry of the *in vivo* channels and are also biocompatible. This paper will discuss the fabrication of circular microfluidic channels using reflow lithography and soft molding. In a lab setting, we would mold the half channels created by lithography onto a gelatin hydrogel and bond the two halves using adhesive such as transglutaminase to create a fully cylindrical channel. Gelatin is biocompatible and acts as an extracellular matrix that would simulate in vivo. This method is efficient and straightforward, allowing rapid fabrication of a variety of microchannels. Unfortunately, due to lack of lab equipment, the experiment shown in this paper is a simplified representation of that; using sacrificial layers of various sizes in jello to form our channels, as well as experimenting with tree shaped channels that have many branches that form a network. Creating microchannels quickly and efficiently is essential for tissue engineering, and this study will offer a facile method for microfluidic fabrication.

Junior Research Abstracts

Antibodies' response in MeV infected Rhesus Macaques with Remdesivir
Jala Wallace

Mentor: Dr. Nadine Peart
Supervisor: Dr. Diane Griffin
Department of Molecular Microbiology and Immunology, Johns Hopkins Bloomberg School of Public Health

Measles is an infectious viral disease causing fever and a red rash on the skin, typically occurring in childhood. Immunoglobulin, also known as an antibody, appears after the first few days of the infection of measles. A specific antibody that is responsible for creating a long-lasting immunity to a virus, is Immunoglobulin G, IgG. The force between the IgG antibodies and the proteins of measles, also known as avidity is important, because the stronger the avidity, the stronger your immune memory is, which can prevent you from having future infections. Remdesivir is an experimental antiviral medication that inhibits viral replication by interfering with RNA-dependent RNA polymerase function. Monkeys have a similar immune response as humans do to measles infection, and we currently have a treatment model of measles in monkeys to evaluate this. We believe that if we treat measles-infected monkeys soon after infection, there will be a decrease in the IgG antibodies in the monkeys treated with Remdesivir compared to those that are not. We believe this because previous research has shown the data of the presence of IgG after the measles infection, and so if Remdesivir will reduce the production of a virus, we believe there will be a decrease in the production of IgG antibodies and a reduced avidity between the antibody and MeV antigen. I have adapted an IgG ELISA protocol which will be used to determine the IgG response in monkeys that are infected with measles and treated or not treated with Remdesivir.

Sophomore Interest Statements

The sophomores have completed the initial phase of the Ingenuity Research Program. During the first semester, they identified topics of interest, researched current information about their selected topics, and sought mentors from the local scientific research community. Those continuing with Research Practicum will begin work at their lab placements this summer. The posters the sophomores present on the Symposium website represent a first effort to present their research topics to a public audience.

Animal infectious diseases and zoonoses
Odin Adams

My research has been focused on infectious diseases in animal species and zoonotic diseases. Zoonotic diseases are diseases transmitted from humans to animals and reverse zoonoses is a disease transmitted from animals to humans. I am interested in public health and epidemiology. One current study investigated a COVID-19 outbreak on three mink farms. A second study reviewed the appearance of tuberculosis (TB) in grey wolves. A third, discusses a bat sarbecovirus that was related to SARS-CoV-2. Future work in the field of animal infectious diseases and zoonoses are expanding and with the rise of COVID-19 and Nipah, there will always be a need to understand and combat viruses. One way to help improve the field is communicate the information with the public. Some people are weary of vaccines because they are misinformed about viruses and vaccines, which can be corrected by scientists explaining their work in ways the public can understand. I will complete the Ingenuity Research Practicum and hope to find a mentor in the Department of Epidemiology or the School of Public Health at Johns Hopkins University

Mineralogy and Rock Structure of Mars
Julio Gabriel Alumbro

My research investigates the mineralogy and different properties of rocks and their specific origins on the planet Mars. One example of current research in my field was a study aiming to use a combination of old data and current data to determine the amount of volatile (easily vaporized) elements within meteorites from mars. I came across a second study that focused on minerals in a specific area on Mars using an instrument called the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM for short), which helped researchers conclude that there was Hydrated Silicate material and H2O. Lastly, I read about a study that used geographic mapping and spectral analysis of the Jezeral crater to establish information about its watershed and basin. This research is critical for our future in order to prepare for human exploration. This information can help determine if Mars is habitable, and should humans ever need to relocate to another planet. Thanks to previous studies and current research, we are better prepared for changes in our planet, as well as understanding possible destinations if evacuation is needed. I plan on continuing with Ingenuity Research Practicum and hope to find a mentor in the Department of Earth and Planetary Sciences at Johns Hopkins University.

Marine Plant Life's Response to Environmental Issues
Mara Coughlin

My research topic is in the field of marine biology. My project is focused on marine plant life's reaction to the global issues our oceans are facing. Plant life in marine settings are impacted by a plethora of environmental issues, including global warming, rising sea levels, rising sea temperature, rising sea salinity, pollution, microplastics, and harmful human interaction. Understanding this reaction is important because plant life is a major part of the marine ecosystem and other organisms are affected by plant life. This research is important because once we know how plant life is responding to changes in the ocean, we can make informed decisions on how to solve this problem. Seeing how plant life responds to the environmental issues will allow better understanding of how to combat said issues. I plan to complete the Ingenuity Research Practicum and want to study marine biology and specifically, aquatic vegetation and restoration work.

Sophomore Interest Statements

Marine Ecosystem Microbiology
John Dugan

My research is focused on marine ecosystems responses to increases and decreases in amounts of certain microbial organisms. I read a study about scientists tracking changes in phytoplankton diversity in a section of the Songhua river in China. The scientists measured and compared these changes to the overall function of the environment they were present in. I found another study where scientists found that the amount of zooplankton throughout the world's aquatic ecosystems was impacted by human activity. The final research paper discussed how the increasing amounts of microplastics in marine ecosystems can negatively affect plankton populations. From the research presented in my poster we can gain an increased understanding of how the microbial population in marine ecosystems affects plankton health. I will complete Ingenuity's Research Practicum and hope to find a mentor in the field of marine biology.

The Social Impacts of Coral Bleaching
Ouisie Engelke

My research is the economic and social impacts of coral bleaching, as well as the causes, current solutions, and possible solutions for the future. The main cause of coral bleaching is rising ocean temperatures. The immediate solution would be to lower the temperatures by reducing air pollution, however this is a big undertaking and alternate solutions are imperative to the survival of corals. A good portion of this research drew from genetic studies, which examined how genomes can predict coral bleaching. For instance, genetic sequencing can identify different strains of corals, which can reveal which corals have the capacity to live at higher temperatures. Other studies examined how the presence and health of reefs impact people's lives, especially those living in coastal communities. For instance, about 1 billion people rely on coral reefs for food. Fish move away from dying reefs, which impacts fishing, and thereby may contribute to economic instability in coastal communities. Additionally, dying coral do not bring in large touristing income which also impacts the economy. I am hoping to continue researching coral bleaching and learn more about how genetics can be used to further understand this problem. I will continue with Ingenuity's Research Practicum and hope to find a mentor who can teach me more about the symbiosis between coral and their intracellular algal symbionts, which is critical for the survival of coral reefs.

Particle Physics and its Revelations in the Modern Era
William Grant

My research that I conducted was about the many experiments, discoveries, and revelations being made in particle physics. In particular, I was interested in how the construction of large particle colliders, like the well-known Large Hadron Collider in Bern, Switzerland, speed up and contribute to those advancements. One interesting area that I looked into was that of particle detectors and how their development shaped particle colliders. Another interesting topic I explored was the development of new colliders and how higher collision energies (superior to those currently) might be achieved. Finally, some articles I reviewed were about how the LHC is being utilized to contribute to discoveries and verifications even now, in areas such as top quark decay and muons. I think that research, experiments, and theories that are presented in my poster will help fuel new discoveries, but also to build support internationally and potentially financially for investment into particle physics research. I am continuing with the Ingenuity Research Practicum and will be mentored by Dr. Andreea Petric from the Space Telescope Science Institutes (STScI).

Sophomore Interest Statements

Experimental Treatments for Cardiomyopathy
Sai Gayathri Kurup

My research topic is cardiology, the study and treatment of conditions affecting the heart and circulatory system. I specifically looked at experimental treatments for cardiomyopathy, a set of acquired or genetic heart conditions that make it difficult for the heart to pump blood properly. In one study, scientists observed that a combined treatment of cardiac and mesenchymal stem cells significantly increased heart function than either type of stem cell alone. In another study, researchers found that intravenous injections of mesenchymal stem cells had anti-inflammatory effects that improved patient health as a whole, despite a lack of direct effect on cardiac function. A third study showed that intracoronary stem cell transplants improved heart function by increasing left ventricular output and decreasing inflammatory cytokines. The presented research can improve the lives of millions of people around the world that are affected by cardiomyopathy. While many heart diseases are caused by unhealthy lifestyles or behaviors, cardiomyopathy is often genetic and puts even young children and competitive athletes at risk of sudden cardiac death. By finding an effective treatment for this disease, people's quality of life can be significantly increased, and advancements can be made in treating other heart diseases as well. I plan to pursue the Research Practicum with Ingenuity, and I hope to work in the field of cardiology or oncology.

Alzhemier's Disease Treatment
Yuki Lin

My field of research is looking at how the progression of Alzheimer's Disease might be slowed down or treated. In one clinical phase 3 trial, researchers conducted a double blinded, placebo experiment with three groups of patients. Their results showed that semagacestat does not improve cognitive abilities as compared to the placebo group. Another study conducted a double blinded, placebo experiment and found that patients who received verubecestat had worse cognitive abilities than the placebo group. Patients that have moderate or severe Alzhimer's Disease and have been treated with donepezil for at least three months and continued as compared to those who discontinued scored higher on the Standardized Mini-Mental State Examination (SMMSE). From my research poster, people are able to see the possible treatments that are able to slow the progression of Alzheimer's Disease; they are able to see the type of treatments that will not work as compared to those that will. I plan to continue with Ingenuity's Research Practicum and want to find a mentor in the Department of Neuroscience at Johns Hopkins University.

Physical Therapy's Impact on Athletes with Knee Injuries
Holland Low

My research focuses on athletes with knee injuries. More specifically, I am exploring the impacts that physical therapy has on those athletes. One current study looked at how physical therapy has the ability to provide injured athletes with the opportunity to regain strength in their knee quickly and make the patient stronger than they were pre-injury. Another study focused on the impact that sports injuries have on young athletes' socialization. Sport injuries provide potential threats to an athlete's mental health and social skills. Lastly, another study focused on the importance of the bond between a physical therapist and an athlete. This relationship can provide the injured athlete with motivation, which can have a positive affect on their recovery. My research demonstrates the importance of physical therapy in order to build physical and mental strength, and to connect with the many athletes who have likely experienced a traumatic injury throughout their athletic careers. I intend to continue with the Research Practicum and want to work with a mentor in the Physical Medicine and Rehabilitation branch at Johns Hopkins University. This branch focuses on restoring movement to those with physical impairments or disabilities.

Sophomore Interest Statements

Development of prosthetic and robotic assistance
R'Reeyah Mabry-Francis

My research interest is observing prosthetic tactile sensory application. Over the past years researchers have developed sensory detailing of prosthesis and have increased the range for which prosthesis can be used. The traditional concept of a prosthetic is to replace limbs or tissue that a person lost, however prostheses have evolved to become intellectual mechanical software that is being used to detect stimulation, give back the perception of touch to amputees, and help regain the ability to perform tasks like eating and grabbing objects. To help guide sensory development of prosthesis one study I have read about experiments with a Rubber Hand Illusion (RHI) to give a false sense of belonging to an amputee. The goal was to see if the RHI between an amputee and healthy person showed similar activation in the cerebellum. Another study investigated the influence of robotic assistance in vitreoretinal surgery. The study showed robotic assistance improved accuracy and precision of the surgery. A third study found apparent moving sensation and TENS (transcutaneous electrical nerve stimulation) through electrolysis a viable way to create a distinguished sensation in hands. This research can help provide important sensory information to amputees to help them in tasks and regain lost connections. I am doing Ingenuity Research Practicum and will be working with Dr. Jeremy Brown in the Department of Mechanical Engineering at Johns Hopkins University.

The Cause of Mental Illness in Adolescents
Sarah Patterson

There are many factors that can impact if and how a young person develops a mental illness, such as anxiety, depression, or ADHD. My research explores which factors may have this influence. One study I read about focused on how the development of a child affects their mental health. It was found that environmental factors, such as poverty or enduring hardships as a child, correlates with accelerated maturation along with stress and, therefore, there is a greater risk of developing mental health issues. Another study I reviewed examined the relation between the Alexithymic trait and an adolescents' developing depression or generalized anxiety disorder. The Alexithymic trait is the inability to identify emotions in others or oneself. Finally, a third research article discussed the idea that when first transitioning into poverty, a child is at greater risk of developing mental health problems. From this research, a better understanding of mental illnesses can be achieved and stigmas can be replaced with accurate information. I will pursue the Ingenuity Research Practicum and will be mentored by Dr. Jacky Jennings, in the Department of Pediatrics and Epidemiology at Johns Hopkins School of Medicine.

The Paleobiological History of The Maryland Bay Area
Kaif Rehman

The Maryland Bay Area has a very rich paleobiological history, which is the study of ancient life on earth. There are many different types of animals that originate and live in the bay. Much of ongoing research in the area is concerning the Calvert Cliffs Formation, one of the most paleo-ecologically rich and diverse areas in Maryland. Calvert Cliffs has a history of unusual sharks, from small sharks, with teeth unlike any other today, to species of megalodon, which is the largest shark to ever swim the ocean. Calvert Cliffs is also home to many types of river dolphins and other cetaceans, which are mostly confined to South America today. While the Maryland Bay Area has changed dramatically throughout the years, crabs have remained a consistent resident of Maryland for millions of years. Understanding paleobiology helps inform what we know about the present. Developing an understanding of marine life in the bay can help create a historical track record, which can tell us the history of different species of the Maryland Bay Area. This information can inform decisions pertaining to current efforts in restoring and maintaining the bay. I am interested in pursuing the Research Practicum with Ingenuity and would love to secure a placement in paleobiology, paleoecology, or any other field pertaining to the study of ancient life.

Sophomore Interest Statements

Predicting Alzheimer's Disease
Nicholas Santiago

My research is focused on neurodegenerative disease, more specifically Alzheimer's Disease. Alzheimer's Disease is a progressive disease that slowly destroys one's memory and cognitive abilities. One study that I found was about creating predictive models for the disease and improving them by exploring more genetic risk factors that could potentially lead to Alzheimer's. A second study that I encountered was about analyzing gene panels which could be linked to pathogenic or causative variants. They would be able to identify mutations in those with early-onset Alzheimer's. The last study that I read was about researchers who predicted Alzheimer's disease based on blood gene expressions using three public data sets. Researching Alzheimer's disease prediction is very crucial for today's world, as there is no current cure for the disease. Therefore, predicting if someone has Alzheimer's early in life versus later is much better for receiving treatment and being able to plan ahead. I will pursue Ingenuity's Research Practicum and hope to continue researching Alzheimer's Disease with a researcher from Johns Hopkins University.

Seaweed Farming and Climate Change
Mia Urban

My research focuses on environmental science and how seaweed aquaculture, or the farming of seaweed, can be used to help reduce the impacts of climate change. One study I found showed that by adding a type of red seaweed called Asparagopsis taxiformis into cattle feed, the amount of methane released by the cattle was reduced by up to 98%. Another study showed that seaweed can be converted into biofuel, taking the place of around 10-20% of harmful fossil fuels being used and preventing more carbon dioxide from being emitted into the atmosphere from these fossil fuels. A third study showed that, just by cultivating seaweed, excess carbon dioxide in the ocean can be reduced, and, when farmed alongside fish, seaweed can absorb the damaging excess nutrients produced by fish wastes. The research being done on seaweed aquaculture can provide some suggestions on how to lower the world's carbon footprint; however, more research and technologies must be created to make large-scale seaweed aquaculture feasible and have the greatest potential to reduce climate change. I am continuing with the Research Practicum and will be mentored by Dr. Chen Li in the Department of Mechanical Engineering at Johns Hopkins. Dr. Li studies how snakes and cockroaches move, to inform how robots can be made to mimic these movements.

The Use of Machine Learning in Personalizing Education
Hero Williams

My research is focused on machine learning and its application in the field of personalization of education. A personalized education system tailors curriculum for students based on their individual needs and preferences. Utilizing machine learning may improve data collection and help create more accurate categorization of students. The issue with traditional education is that teachers cannot always accommodate every students' learning speed and their unique ways of learning. With machine learning algorithms, data can be collected about students learning, which can inform personalized curriculum. The tradeoff between a human teacher and an algorithm-based assessment of a student is often the students' emotional and mental needs. This can be fixed if a hybrid model is employed - the teacher and student work together to determine the student's goals and motivation while an algorithm fine-tunes the rest. This research can help students learn at their own pace and hopefully be more motivated in the process. Education is the foundation for an individual. I am hoping to continue with the Research Practicum and find a mentor who focuses on machine learning biases at the Space Telescope Science Institute (STScI).

Sophomore Interest Statements

Effects of Hormonal Profiles in Elite Athletes
Harrison Yezzi

My research focuses on endocrinology and hormonal profiles in elite athletes. Some studies have found that testosterone is the driving hormone impacting athletic advantage, whereas other researchers attribute bone structure as being a key influencer. Heightened testosterone levels result from a variety of factors. A common genetic variation leading to these high levels is hyperandrogenism resulting from the ACTN3 genotype. A 2015 study revealed that athletes with this genotype had higher testosterone levels than their competitors and commonly had more athletic bone structures. Genetic variation also plays a role in what disciplines athletes thrive in. One study analyzed different hormonal profiles across athletic disciplines and determined that despite differences in hormone levels, there was no evidence that heightened testosterone levels were common in elite athletes. Similarly, it was determined that it is more likely that bone structure aids in athletic performance more than hormone levels. Another factor often discussed in sports is female athletes with Y chromosomes. A study researching the benefits of Y chromosome in female athletes similarly concluded that despite slightly increased testosterone levels, hormonal profiles did not show any significant relationship with athletic prowess. Future research may involve how bone structure can create an athletic advantage for some. This will be important in creating limitations and groupings for athletes. Dr. Daniel Reich will be my mentor for the Research Practicum. My placement is in the Department of Physics Johns Hopkins University.

Genetic Engineering Tool: CRISPR-cas9
Iris Zheng

Genome engineering is a branch of biology that deals with the manipulation of nucleic acids in order to express a trait of interest. CRISPR-cas9 is a form of adaptive immune system found in bacterial cells. The system recognizes viral DNA and creates a double strand cut of the DNA backbone inorder to deactivate the viral DNA. Currently, CRISPR-cas9 has been transformed into an effective lab tool by disabling its cleaving mechanism and leaving only the recognition portion of the system, allowing researchers to locate genes of their interest. Base editor was created by engineering CRISPR-cas9 so it replaces one nucleotide instead of cleaving the backbones, which reduces the risk of mutations. CRISPR-cas9 has also been used as a potential treatment for Human Immunodeficiency Virus (HIV) related disease by destroying the gene responsible for creating the receptor protein on HIV-targeted cells. In the future, the CRISPR-cas9 system can be used to model the cause of different illnesses, allowing researchers to develop effective treatments for those illnesses. CRISPR-cas9 can potentially be used as treatments for genetic diseases untreatable by conventional drugs. I plan on continuing with Ingenuity's Research Practicum and hope to find a mentor so I can continue studying the implementation of genetically engineered substances as a treatment for different illnesses.

Neural Basis of Decision Making
Malcolm Connor

Cognitive neuroscience is a branch of neuroscience that is focused on how events in the brain correlate with and give rise to behavior and thought. I focused on the decision making aspect of this relationship. Different aspects of decision making correlate with activity in brain regions related to emotion, social cognition, reward and loss, risk evaluation, and executive control of behavior. The insular cortex, related to personal empathy, was active when subjects made decisions about social fairness in a wealth distribution game. Many brain areas related to reward, including the striatum, showed increased activity during gambling decisions when potential rewards were high and decreased activity when they were low. The dorsolateral prefrontal cortex, associated with executive control, was found to be active when overriding emotionally grounded decisions, in a task involving evaluating fair and unfair proposals. A deeper understanding of decision making processes in the brain can inform therapies for self destructive or irrational decision making, including gambling addiction and substance abuse. I would like to work in a cognitive neuroscience lab analyzing brain activity and how it relates to constructive and destructive aspects of behavioral control.

Innovation Interest Statements

The Ingenuity Innovation Practicum is a new pathway within The Ingenuity Project. The Innovation Practicum is a one year experience during junior year and a portion of summer that provides Ingenuity students with an out-of-school experience in the field of data science, statistics, machine learning, and applied mathematics. Using mathematical software and receiving mentorship from a participating business/organization, students will learn about data analytics and problem-solving as it relates to mathematics and real data analysis.

Technology In Aircrafts
Samuel Doroja

Aerospace engineering is a branch of engineering focused solely on the development of spacecraft and aircrafts. One current study I looked at relates to the general idea of technologies within an aircraft that keep it airborne. The most important forces are that of lift, weight, thrust, and drag, all acting along with the object's design which makes it air-worthy. Future aircraft are using fewer parts and morphing wing designs to help boost fuel economy. Aircrafts drag, especially at high speeds, which uses more fuel. Compared to flying insects, planes are not very fuel efficient. People can gain the understanding of the very real possibilities of better airplanes for travel. I plan on continuing with the research practicum and hope to gain more knowledge in the field of aerospace engineering.

Decellularized scaffolds as a platform for bioengineered organs
Murad Habtu

Decellularized scaffolds are made from the use of biotechnology to recreate organs, so they can be used for transplants. The research I completed focused on the decellularized scaffolds that are made to help people who need organ transplants without the need of a donation. One study was about an airway that was bioengineered with a scaffold and looked at how it was able to help the patient. Another study was about the materials that scaffolds are usually made of and how it is not completely understood how certain aspects of the material work. The research of decellularized scaffolds can impact the lives of people who need transplants in areas where there are no organs to be transferred, so the organs can be made from a scaffold of another organ. I would like to pursue the research practicum and work in the bioengineering field to learn about the scaffold materials.

Innovation Interest Statements

Hyperaccumulation in Sunflowers
Chloe Harrison

My research is focused on botany, the scientific study of plants, specifically the function of hyperaccumulator plants. Hyperaccumulation is the process of plants absorbing metals through the soil and can only be performed by certain plants. The three studies I reviewed related to hyperaccumulators and their purposes. The first source was a study about hyperaccumulator sunflowers and their ability to take in certain metals. Another study was about the processes in which hyperaccumulator plants can be used in the environment. Finally, the last study gave a real example of how hyperaccumulators have been used to decontaminate certain areas of the earth. Hyperaccumulator plants have the potential to become essential in reducing pollution. By breeding these plants to make them stronger, they will be more helpful to cleaning the environment. One example of how hyperaccumulators can help the environment is to clean areas such as nuclear blast sites, where there are so many metals and chemicals that other plants canot survive. After more research, scientists will be able to use these plants in areas all over the world. I will be pursuing the Ingenuity Innovation path where I hope to work in a field involving computer science.

The Ins and Outs of Computer Science
Jalen Henson

My research consists of explaining the concepts and career paths in computer science. Three articles I have read relate to artificial intelligence (AI), game development, virtual reality. The gaming development article discussed the college degrees needed to be successful in the field of computer science, specifying that a gaming developer can make $59,000-$103,000 yearly. The article about AI gave insight on how the latest technology in AI can be used in the future. One of the many things that can be obtained from my research is a simple understanding of the field of computer science and how it impacts our lives. I will be pursuing the Ingenuity Innovation Practicum and hope to find a placement in computer science and video games.

Psychology and Issues in the US Legal System
Frebruk Mikre

The legal system in the US, like many other systems present in America, is full of flaws that can be prevented easily and have solutions backed by science and statistics. Psychology can be applied and help improve many issues present in legal institutions, such as false eyewitness testimony, biased interrogation techniques, and fingerprint or tire tread identification. Eyewitness accounts remain one of the most powerful tools available to incarcerate a suspect even though they have been found to be very malleable and often inaccurate. Studies on confirmation bias have shown that many interrogations often result in inaccurate and skewed conclusions that can possibly even force a false confession from an innocent person. Tunnel vision, the tendency to omit any suggestion of opposition to one's beliefs, is an extreme flaw that is reinforced by the pressure on lawyers to close cases and gain convictions. Dehumanization is arguably one of the most integral factors when it comes to the wrongful conviction of a person or the improper treatment of inmates in prison. In an already judgmental society, there is no question that we have to reform the way we think of criminals, justice, and psychology related issues. The US, although it calls itself a first-world country, has cities with some of the highest homicides per capita in the world and the highest prison population on the globe, showing that there needs to be a serious discussion regarding not just the way legal institutions think of crime, but the way the public thinks of it also. I am pursuing Ingenuity Innovation and will work with Dr. Nicole Shoenberger, in the Department of Sociology at Loyola University Maryland. Through a criminological lens, I will explore the connection between perceived safety and COVID by examining data.

Innovation Interest Statements

Black Women's Maternal Mortality
Eden Rhodes

My research is about identifying factors that heavily contribute to the high rates of maternal mortality experienced by black women compared to white women. Maternal mortality is the death of a mother while she is pregnant, shortly after birth, or during birth. I researched the effects of four factors on the rates of maternal mortality in black women. The first study discussed systemic racism and the lack of trust between the black community and the medical field. The second study was about the health status of black women as it relates to preeclampsia and eclampsia. Preeclampsia is high blood pressure whereas eclampsia is a more detrimental stage of preeclampsia. While they cannot stand alone as determinants, access to quality prenatal care and socioeconomic status affects how black women experience pregnancy. The research presented in my poster will allow lots of people to become more aware of one of the modern-day challenges that black women face. As a part of Innovation Practicum, I would like to find a mentor in the Department of Electrical and Computer Engineering at Johns Hopkins University. I am hoping to learn more about photoacoustic imaging.

Personal sensing and education
Jordany Roman-Gonzalez

Personal sensing, also known as digital phenotyping, is the collection of a person's daily data through their mobile device. My topic is on the use of personal sensing in the education field. One of the current studies used Fitbits and college students to monitor their mental health. The college students also had to fill out an Ecological Momentary Assessment (EMA) questionnaire when a stressful event occurred. Another study also used the EMA questionnaire for college students to learn about their Fitbits and smartwatches. The last study used wearable devices, smartphone features, and the PSS and MCS questionnaires to understand college students' mental health. This research could impact our lives because this information can help students become self-aware of how their interactions with their mobile devices may impact their mental health. It can also help their parents understand and help their child's mental well-being. I will pursue the Ingenuity Innovation Practicum and hope to work with a mentor in the Information Systems Department at the University of Maryland, Baltimore County, so I can learn more about the connection between machine learning and mental health.

Using Data Science and Epidemiology to Track Public Health Concerns
Anna Rousos

Data science within epidemiology uses statistics, data, machine learning, and coding to track diseases and study public health in different populations. An example of current research using data science and epidemiology explains how algorithms that predict and model Covid-19 cases in multiple countries were created by researchers. The researchers used past algorithms, as models for the algorithms they created. An additional example of current research using data science and epidemiology studies the noncompliance with Covid-19 restrictions among young adults in Switzerland. The researchers found that a lack of trust in the government was one cause of noncompliance. One last example of current research using data science and epidemiology studied how sleep affects social contact. The researchers found that sleepiness was a likely factor in non-voluntary social contact. The findings presented in my research can impact our lives because it provides ways that data science is being used alongside public health to predict and model the development of current and future health concerns. I will continue with the Ingenuity Innovation Practicum and Dr. Jeffrey Gray, from the Department of Chemical and Biomolecular Engineering at Johns Hopkins University, will be my mentor.

Innovation Interest Statements

Smart Robotic Surgery
Skylar Strickler

My research focuses on medical robotics in complex surgeries. This field aims to create more intelligent surgical robots to help assist in surgeries. Some current research that I have found in relation to my topic includes image-guided robotic surgery. This relies on using a combination of different types of sensors to relay images and data in order to perform surgical procedures. Another research study I have found within my field was about minimally invasive robotic surgery that tries to create smaller robotic devices. One example of this is robotic machines that are created to be very precise and make clean cuts to ensure no unnecessary trauma is caused. Finally, one specific robot called the STAR performed surgery on a pig using sensors and cameras. Future work in this field includes fully automating the surgical process and making robots more perceptive by being able to react and adapt to the patients' individual needs. I am continuing with Ingenuity's Innovation Practicum and will be mentored by Dr. Axel Krieger, from the Department of Mechanical Engineering at Johns Hopkins University. I am hoping to gain research experience in the Intelligent Medical Robotic Systems and Equipment Lab (IMERSE), which specializes in creating intelligent surgical robotic systems and implementing augmented reality in surgery.

Class of 2021: College Acceptances

* denotes the college /university the senior will be attending

Michael Aladejebi
Morgan State University
Pennsylvania State University
Towson University – Hackerman Scholar*
UMBC
University of Maryland, College Park

Julia Alumbro
Johns Hopkins University*
UMBC

Ihemriorochi Amanze
Howard University
UMBC
University of Maryland, College Park*
Morgan State University
Rensselaer Polytechnic Institute

Obafemi Anjorin
University of Louisville*
University of Maryland, College Park (Spring Semester)
Morgan State University
Pennsylvania State University
The Ohio State University

Alejandro Barrera
Drexel University (Honors Program)*
Fashion Institute of Technology
UMBC
Morgan State University
The New School (Parsons)
Towson University

Ana Basoco
Johns Hopkins University*
Rochester Institute of Technology
UMBC

Kaitylnn Beahn
Towson University*

Shantika Bhat
Case Western Reserve University
Johns Hopkins University – Baltimore Scholar*
McDaniel College
Morgan State University
UMBC
University of Maryland, College Park – Honors Program

Jolynn Blankson
Frostburg State University
George Washington University
Howard University*
Loyola University of Maryland

Lucinda Borbash
Carnegie Mellon University
University of Maryland, College Park – Honors Program
Rensselaer Polytechnic Institute
University of Toronto*

Tate Bothner
Bowdoin College*

Collin Brandon
Bradley University*
Rensselaer Polytechnic Institute
Virginia Polytechnic Institute

Elias Brody
University of Maryland, College Park –
Scholars Program
Pennsylvania State University
Rensselaer Polytechnic Institute
Rochester Institute of Technology
University of Toronto
University of Vermont
Virginia Polytechnic Institute*

Class of 2021 College Acceptances

Henry Bushnell
Emory University
Indiana University
University of Maryland, College Park – Scholars Program*
University of Michigan
University of South Carolina – Columbia (Honors)

Lucas Calderon
University of Utah*

Lucy Canick
Binghamton University *
Colorado School of Mines
Fordham University
University of Colorado, Boulder
University of Vermont
The College of Wooster

Riyan Campbell
Brown University*
Emory University
Johns Hopkins University
UMBC – Meyerhoff Scholar
University of Maryland, College Park – Honors Program
Towson University
University of Virginia

Sabina Celnik
University of California, Santa Barbara
University of California, Santa Cruz
Colgate University
University of Colorado, Boulder
Washington University in St. Louis
University of Wisconsin-Madison
University of Minnesota-Twin Cities
University of Massachusetts, Amherst
Washington University in St. Louis*

Isaiah Chapman
UMBC
University of Maryland, College Park – Incentive Awards Program Scholar*
Morgan State University
Virginia Polytechnic Institute

Vina Chen
Drexel University
University of Maryland, College Park – Honors Program *
Salisbury University

Seth Chng-Lim
University of California, San Diego*
University of Maryland, College Park
UMBC
University of Toronto
University of Wisconsin, Madison

Tendai Coady
Williams College – QuestBridge Scholar*

Tahdai Crews-Harris
Bowie State University
Bucknell University*
University of Louisville
Morgan State University

Jordan Dia
UMBC
University of Maryland, College Park*

John Djeuf
Howard University – Karsh STEM Scholars
University of Maryland, College Park – Scholars Program, Incentive Awards Program Scholar*
Morehouse College
Morgan State University
North Carolina A&T State University
University of Notre Dame
University of Richmond
University of Southern California
Towson University

Peter Filardi
Brandeis University
Denison University
Dickinson College
Fairfield University
Gettysburg College
Salisbury University
St. Mary's College of Maryland
UMBC – Honors
University of Maryland, College Park – Scholars Program*

Class of 2020 College Acceptances

Maya Filipovitz
Loyola University of Maryland
University of Maryland, College Park – Honors Program*
Pennsylvania State University
Syracuse University
University of Virginia
Virginia Tech

Rian Finney
Loyola University of Maryland
St. John's University*

Stephanie Fishkin
American University
Brandeis University
Carnegie Mellon University
UMBC
University of Maryland, College Park – Banneker/Key Scholar, Gemstone Program*
University of Pittsburgh
Wellesley College

Jerome Hamilton
Michigan State University – Distinguished Scholars/ Honors Program*
Princeton University
Purdue University
Towson University
University of Maryland, College Park – Banneker/Key Scholar

Anna Hilger
UCLA*
University of Colorado, Boulder – Honors Program
University of California, Los Angeles
University of Maryland, College Park – Scholars Program*

Darius Hill
University of Delaware
Pennsylvania State University
Widener University*

Miranda Hull
Dickinson College
University of Maryland, College Park
Mount Holyoke College*

Madeline Jaffe
Hamilton College
Ithaca College – Park Scholars Program*
Salisbury University
Smith College
Syracuse University
Washington College
Wesleyan University

Akashia Johnson
Cedar Crest College*
Clark Atlanta University
Hampton State University
Lincoln University
Loyola University Maryland
University of Maryland, College Park – Promise Scholar
Morgan State University
Pennsylvania State University
Spelman University
Towson University

Nolan Johnson
Bowie State University
Clark Atlanta University
Hampton University
Howard University
University of MD – College Park
UMBC
University of Maryland Eastern Shore
McDaniel College
Morehouse College
Morgan State University
North Carolina A&T State University – Dowdy Scholar*

William Kardas
Drexel University
UMBC
University of Maryland, College Park*

Class of 2021 College Acceptances

Nhan Le
Johns Hopkins University – Baltimore Scholar*

Sarah Li
University of Pennsylvania, Wharton School*

Wyatt Lyions
Baltimore City Community College
Loyola University Maryland*
University of Maryland, College Park
Maryland Institute College of Art
Towson University

Charlotte Malmin
Morgan State University
Portland Bible College*
Towson University

Luce Marchionni
Boston University
CUNY Bernard M Baruch College
CUNY Brooklyn College
CUNY John Jay College of Criminal Justice
University College of London
University of Edinburgh*
University of Saint Andrews

Kacey McKenna
Indiana University - Bloomington*

Aquib Mokkadem
University of Baltimore
University of California, Riverside
University of Maryland-Baltimore County
University of Maryland, College Park - Carillon Communities*
St. Mary's College of Maryland
Virginia Commonwealth University
Virginia State University

Patience Odeh
University of Maryland, College Park
Morgan State University – Honors Program
Towson University – Hackerman Scholar*
University of Virginia

Jaela Paraniliam
Goucher College
University of Maryland, College Park – Honors Program*
Towson University
University of California, Irvine
University of California, San Diego

Mason Petros
Harrisburg University of Science and Technology
York College of Pennsylvania
United States Navy*

Nick Pham
University of California, Berkeley
University of California, Davis
University of California, Los Angeles
University of British Columbia*
University of Colorado Boulder
University of Maryland, College Park – Honors Program
Lewis and Clark College
UMBC
University of Washington, Seattle
University of Toronto

Jocelyn Pinkney
Bowie State University*
Hampton University
University of Maryland, College Park
University of Maryland Eastern Shore
Morgan State University

Juni Polansky
Amherst College
Bowdoin College
California Institute of Technology*
Carnegie Mellon University
UMBC
University of Maryland, College Park – Honors Program
Swarthmore College
Tufts University
University of Virginia
Washington University in St. Louis
Wesleyan University

Class of 2020 College Acceptances

Edward Restelli
University of Colorado Boulder
Drexel University
University of Maryland-College Park – CIVICUS Program*
UMBC
University of Pittsburgh-Pittsburgh Campus
Temple University

Isabelle Richard
Bryn Mawr College*

Jayden Rhodes
University of Baltimore
George Mason University
George Washington University, Corcoran School of the Arts
University of Maryland, College Park – Honors Program
UMBC – Linehan Scholar*
Maryland Institute College of Art
Massachusetts College of Art and Design
Millersville University of Pennsylvania
Pratt Institute
Rhode Island School of Design
School of Visual Arts
Towson University
Tufts University, School of the Museum of Fine Arts

Boubacar Sall
Loyola University of Maryland
UMBC
University of Maryland, College Park – FIRE Program*

Logan Samuel
Morgan State University
Pennsylvania State University
UMBC*

William Schmitz
UMBC
University of Maryland, College Park - Carillon Communities*

Mariah Scott
The University of Alabama
Emory University
Fordham University
Morgan State University
Temple University
Washington and Lee University*

Tejal Schwartz
Dartmouth College*
University of Maryland, College Park – Honors Program

Sheikh Selim
UMBC*
Mount St. Mary's University – Maryland
Pennsylvania State University

Talya Simcox
University of California, Davis
University of California, Los Angeles
University of Colorado Boulder
University of Maryland, College Park – Honors Program*
George Washington University
University of Massachusetts-Amherst
Syracuse University
Villanova University
University of Wisconsin-Madison

Kristiana Smith
Brown University
Cornell University
George Mason
Gettysburg College
Johns Hopkins University – Baltimore Scholar*
Lafayette College
Lehigh University
Rensselaer Polytechnic Institute
Temple
Towson
UMBC – Meyerhoff Scholar

Class of 2021 College Acceptances

Presley Smith
International College of Innovation at National Chengchi University in Taiwan*

Simon Spahn-Rodriguez
Elon University
Lake Forest College*
Loyola University of Maryland

Frank Tagaytay
UMBC*

Devon Thomas
Carnegie Mellon University
Cornell University*
Loyola University of Maryland
University of Maryland, College Park – Scholars Program
Rensselaer Polytechnic Institute
Rochester Institute of Technology

Kyle Thomas
University of Maryland, College Park - Carillon Communities
Pace University
Rensselaer Polytechnic Institute*

Chelsea Thompson
Johns Hopkins University – Baltimore Scholar*

Jacob Thompson
University of California, Berkeley*
University of California, Los Angeles
University of California, San Diego
Lewis and Clark College
Occidental College
University of Toronto
Washington University in St. Louis

Abby Torregoza
CCBC*
Daemen College
Drew University
Goucher College
UMBC
University of Maryland, College Park
New College of Florida
St. Mary's College of Maryland

Chielota Uma
Carnegie Mellon University
Howard University
Temple University
UMBC*
University of Maryland, College Park

Aaron Villahermosa
UMBC*
University of Maryland, College Park – FIRE Program

Zachary Weybright
Drexel University
Frostburg University
Loyola University
Mount St. Mary's University*
University Of Maryland College Park

Morgan Wilder
Clark Atlanta
Frostburg State University
Hampton University
McDaniel College – McDaniel-College Bound Full Tuition Scholar*
North Carolina A&T
Spellman University

Jennifer Zheng
Boston University
Salisbury University
Temple University*
University of Maryland, College Park – Honors Program

Kyla Zurlage
University of Maryland, College Park – Banneker/Key Scholar*
University of North Carolina, Chapel Hill
University of Virginia
Wesleyan University

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: Julia Alumbro, Ihemriorochi Amanze, Tate Bothner, Elias Brody, Riyan Campbell, Sabina Celnik, Tendai Coady, Maya Filipovitz, Madeline Jaffe, Nhan Le, Sarah Li, Nicholas Pham, Juni Polansky, Tejal Schwartz, Talya Simcox, Jacob Thompson, Aaron Villahermosa.

Juniors: Oluwadamilola Akinola, Virtue Bama, Jordan Bass, Elyjah Bassford, Me'Shiah Bell, Hayden Benhart, Lillia Berninzoni, Keith Ceruti, Taylor Chase-Bynum, Precious Conteh, Nicolas Del Pino, Kayla Douglas, Samuel Elkins, Harriett Engelke, Miles Fancher, Zen Gordon, Andrew Haye, Ashantae Hayward, Johns Hopkins III, Taylor Jones, Diego Jovel, Deondre Martin, Daudi Mwangi, Meredith Nishiura, Oluwayemisi Ojolayo, Annelise Olsen, John Overton, Muswe Pembamoto, Nyla Powell, Mika Prada-Enzmann, Logan Sampath, Christina Sarbanes, Mia Schildbach, Jonah Schwartz, Henry Stone, Jala Wallace, Aram Zaprosyan.

Morgan State University Science-Mathematics-Engineering Fair

Nyla Powell is the 2021 overall winner. Her research studied *SUMO Proteases as a Potential Cancer Biomarker*. She was invited to compete in the 2021 Regeneron International Science and Engineer Fair (ISEF).

The winners in separate categories are as follows.

Earth and Environmental Science:

1st Place - **Nicholas Pham**, 3rd Place - **Jacob Thompson**, 5th Place - **Maddie Jaffe**

Engineering, Mathematics and Computer Science:

1st Place - **Ihemriorochi Amanze**, 2nd Place - **Sarah Li**, 4th Place - **Nico Del Pino**

Biological Science:

2nd Place - **Nyla Powell**, 5th Place - **Jala Wallace**

Physical Science:

3rd Place - **Aaron Villahermosa**

Excellence in Mobility Engineering, Honorable mention – **Tayla Simcox**

Society of Women Engineers Specialty Award, Biological Science: Outstanding Engineer - **Tejal Schwartz**.

Student Publications

Miller, Ethan; **Amanze, Ihemriorochi**; Brown, Jeremy. "*A Wearable Anthropomorphically-Driven Prosthesis with a Built-In Haptic Feedback System*." 2020 International Symposium on Medical Robotics (ISMR). IN-SPEC Accession Number: 20287229.

Anita Ramachandran, Lesley Summerville, Brian A. Learn, **Lily DeBell**, Scott Bailey. "*Processing and integration of functionally oriented prespacers in the E. coli CRISPR system depends on bacterial host exonucleases*." Journal of Biological Chemistry, December 2019. Manuscript RA119.012196.

Since 2005, there have been 29 Ingenuity student publications in peer reviewed journals.

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.

Johns Hopkins University Future Scholars Program
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. **Aram Zaprosyan** has been accepted into the Future Scholars Program at the Johns Hopkins University Department of Mathematics for the 2021-22 school year.

Math Club and Regional Competitions
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.

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

Baltimore Future Scholars Program

Between 2007 and 2021, **100** Ingenuity students have been accepted into the Baltimore Scholars Program at the Johns Hopkins University. Students take two Hopkins math courses for credit for free.

800 SAT and SAT Subject Test Scores

Between 2001—2021, Ingenuity students received **123** perfect 800 SAT and SAT subject test scores. For this time period, the average Math SAT score was 695, 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 Ap-

Ingenuity in National and International Science Competitions

Intel/Regeneron Science Talent Search

3 winners, total 14 semifinalists

Winners: Emma Call, Abe Davis, Ryan Harrison.

Semifinalists: Dan Borgnia, Rebecca Brody, Wuqiong Fan, Owen Hill, Ilenna Jones, Kelly Khare, Kathy Le, Michelle Mokaya, Claire Wayner, Lucas Winch, Amy Zhang.

Intel International Science and Engineering Fair (ISEF)

5 Grand Prize winners and 16 finalists

Grand Prize winners: Emma Call, Darius Johnson Anna Kalmykov, Shauna Linn, Alida Schott.

Finalists: Anthony Agyapong, Elizabeth Banks, Wayland Chen, Chelsey Hash, Lani Martinez, Eric Rosenberg, Rachel Pierson, April Ruffin, Nahathai Srivali, Tiffany Steele, Michael Tontchev (2 times), Dung Tran, Craig Turner, Elias Weston-Farber, Nyla Powell

Siemens Competition

7 semifinalists

Ariel Bowers, David Lai, Emma Call, Abe Davis, Wuqiong Fan, Tam Nguyen, Weston-Farber

National Junior Science & Humanities Symposium (JSHS)

8 winners and finalists

Elizabeth Banks, Rebecca Brody, Emma Call, Lily DeBell, John Halpin, Ryan Harrison, Kayleigh Horst, Anna Manalad , Juni Polasky

The USA Biology Olympiad

8 national semifinalists

Caryn Carson, Illena Jones, Dana Katzenelson, Shauna Linn, Amy Peyrot, Stephen Timmel, Lawrence Wang, Danielle Weissman

Young Epidemiology and Naturalist Scholars Competition

1 winner, 2 finalists, 1 semifinalist

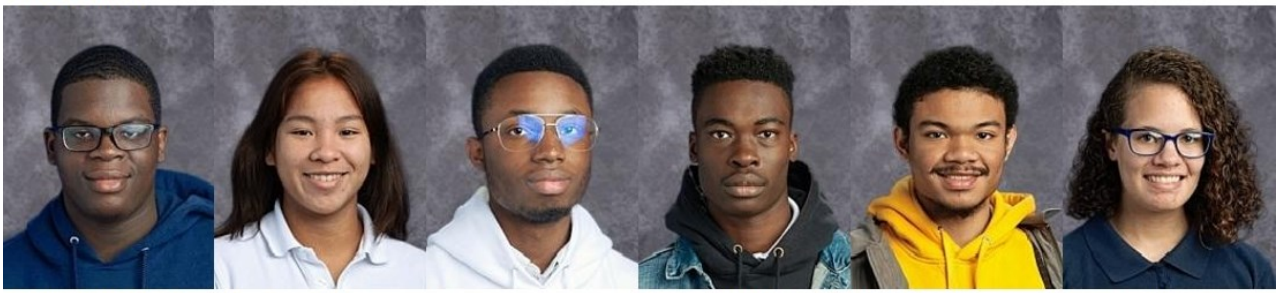
Hannah Bands, Molly Broach, Jasmen Rice, Justin Tibbles

Baltimore Science Fair (BSF)

16 Grand Prize winners

Emma Call, Lily DeBell, Stephen Grabowkski, Nathan Greene, Chelsea Hash, Darius Johnson, Anna Kalmykov, Shauna Linn, Lani Martinez, Phoebe Sandhaus, Evan Smith, Nahathai Srivali, Isaiah Thomas, Michael Tontchev (2 times), Elias Weston-Farber

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 | Lyions, 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

Thompson, Chelsea | Thompson, Jacob | Torregoza, Agnes Abigail | Uma, Chielota | Villahermosa, Aaron J | Weybright, Zachary

Wilder, Morgan Zheng, Jennifer Zurlage, Kyla

Class of 2022

Adante, Ron Marc Akinola, Oluwadamilola Allen, Angelique Bama, Virtue Bass, Jordan Bassford, Elyjah

Beasley, Tsairus Benhart, Hayden Berninzoni, Lillia Bhat, Shubhan Buise, Dylan Campbell, Amare

Ceruti, Keith Chase-Bynum, Taylor Cheng, Ethen Conteh, Precious Couch, Lillian Del Pino, Nicolas

Dia, Nicole Douglas, Kayla Duke, Alexis Elkins, Samuel Engelke, Harriett Fancher, Miles

Frederick, Justin | Gantert, Caitlyn | Gardner, Taylor | Garrison, Niles | Gordon, Zen | Green-Dorsey, Khrysti

Griffin, Nasia | Hamal, Avipsa | Harris, Jaden | Haye, Andrew | Hayward, Ashantae | Hopkins, Johns

Islas, Gael | Jackson, Adrian | Johnson, Walker | Jones, Taylor | Jovel, Diego | Le, Kayla

Martak, Madeline | Martin, Deondre | McCormick, Liyah | Mister, Jordan | Mwangi, Daudi | Naka, Marie

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

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

Prada-Enzmann, Mika

Roberts, Ilijah

Rugerio-Mejia, Jose

Sampath, Logan

Sarbanes, Christina

Schildbach, Mia

Schwartz, Jonah

Sin, Jacquelyn

Smith, Kendall

Stone, Henry

Thorpe, Jazmyn

Torregoza, Jose Enricc

Wallace, Jala

Wies, Louie

Yuhas, John

Zaprosyan, Aram

No photo:
Bell, Me'Shiah
Dowdy, Chesapeake

Class of 2023

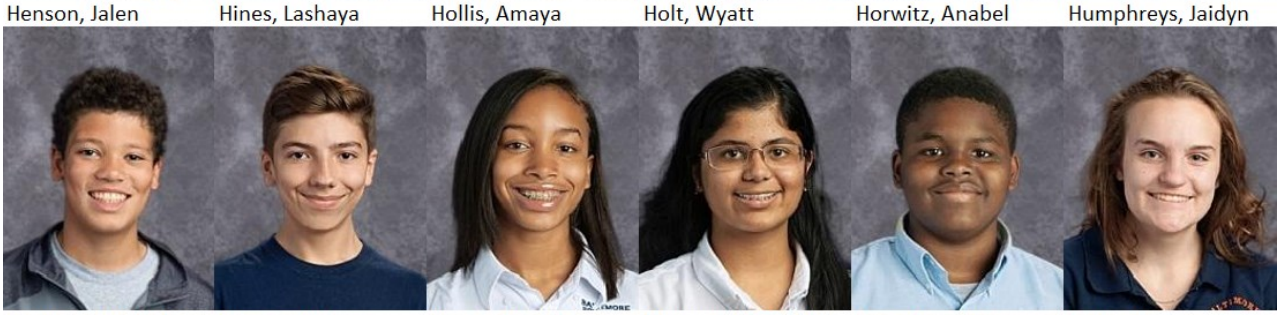
Adams, Odin | Alvarado jr, Jose | Anderson, David | Blackman, Evelyn | Breitmeyer, Hannah | Budhai, Rohan

Calderon, Marcos | Celnik, Lucas | Chinn, Malakai | Connor, Malcolm | Coughlin, Mara | Cure, Peter

Diaz-Franco, Alexandra | Doroja, Samuel Rufus | Dugan, John | Engelke, Edith | Estep, Kenneth | Franco, Brandon

Frock, Matthew | Grant, William | Habtu, Murad | Harris, Keyierra | Harrison, Chloe | Heaggans, Jaelin

Henson, Jalen | Hines, Lashaya | Hollis, Amaya | Holt, Wyatt | Horwitz, Anabel | Humphreys, Jaidyn



Jacobson, Nicholas | Jimenez, Royce | Jones, Azariah | Kurup, SaiGayathri | Lee, Alexander | Lesko, Eva

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

McDaniel, Ethan | Meredith, Donald | Mikre, Frebruk | Mintz, Tijah | Mukherjee, Ayesha | Norman, Carmen

Offor, Michael | O'Maonaigh, Elliot | Paranilam, Jaeci | Patterson, Sarah | Rahim, Muhammad | Rehman, Kaif

Reichelt, Julian | Rhodes, Eden | Rollins, Anthony | Roman Gonzalez, Jordany | Rousos, Anna | Rubenight, Evyenia

Rumber, Kaliah | Sandoval, Olivia | Santiago, Nicholas | Sheppard, Tehnard | Smith, Dayvonte' | Smith-Burden, Alexander

Solefack, Cerena | Solis Ruiz, Alen Jerson | Sparrow, Kyliah | Strickler, Skylar | Sun, Kevin | Thomas, Tres'jour

Urban, Mia | Waller, Daphney | Watts, Mazario | West, Malik | Williams, Hero | Wolf, Miles

Woody, Denmark | Wynn, Sorensen | Yezzi, Harrison | Yoseph, Stephan | Zheng, Iris

No photo:
Clark, Temar

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Ankobia	Kimathi
Atkins	Felisha
Baker	Tiyonna
Barksdale	Darius
Beauvois Ransome	Elizabeth
Bender	Sophia
Berninzoni	Matteo
Billotte Bermudez	Cosima
Boehringer	Leo
Boykin	Jasmine
Buckhanon	Cameron
Castelan	Cristofer
Chen	Maria
Clark	Levi
Coffey	Camille
Davis	Markell
Dickens	Alexander
Drummond	Madison
Dungee	Jackson
Dyer	Finneus
Eblaghie	Ethan
England	Jhamari
Erdas	Antonio
Fancher	Henry
Felder	Kendall
Freeman	Sara
Gapeev	Vladimir
Gedansky	Dean
Geller	Ira
Glaros	Reid
Griffin	Ellen
Grigsby	Kai
Hall	Lavender
Hartman	Abigail
Hastings	Cenae'
Hayrapetyan	Aram
Hong	Zoe
Isbell	Brandon
Jefferson	Harrison
Jones	Jason
Langkammerer	Hudson
Lapp	Louis
Lawson	Caleb
Leith	Christian
Lemon	Katelyn
Lin	Alvin
Lindsey	Ryan
Lipscomb	Jerrod
McCalla	J'Zanae
McKenna	Eliza
Mese-Jones	Kei
Mese-Jones	Miya
Molina	Maya
Moss	Aaron
Myers	Kayla
Odeh	Anthony
Ojolayo	Oluyinka
Overton	Amelia
Pevsner	Ava
Polansky	Ruby
Reichelt	Cecelia
Reilly	Liam
Rivas Arita	Elmer
Roach	Toni
Romerio	Antonio
Schenkel	Penelope
Schmelyun	William
Schmitz	Margaret
Schreier	Reuben
Schulman	Luke
Shrestha	Krrish
Simcox	Noah
Singleton	Ta'Quory
Smith	Jaiden
Stanton	Kayla
Stanton	Kierra
Stine	Anson
Tagle	Josh Daniel
Tantleff	Gavin
To	Henry
Torres-Hernandez	Erick
Valery	Bowen
Vey	Charles
Wharton	Saniah
Wheeler-Oluwagbenga	Zari
Wilcox	Cereniti
Wilkerson	Melia
Williams	Mahalia
Zaprosyan	Vahe

Acknowledgements

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The accomplishments of Ingenuity students would not be possible without the commitment and support of board members, scientists and faculty across Baltimore City.

Congratulations to Max Eblaghie, new Ingenuity Board Member and BD associate, for being the 2021 BD Becton Volunteer Impact Program Award! The award is a competitive program designed to recognize excellence and creativity in community involvement by BD associates, while honoring the late BD Director Henry P. Becton, Sr.'s lifelong commitment to community. The program honors the outstanding volunteer efforts of selected associates by making charitable contributions in the winners' names to the organizations for which they volunteer. As a result, **The Ingenuity Project** will receive a grant in the amount of **$2,500** in the associate's honor.

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