2018 Ingenuity Math & Science Symposium



THE INGENUITY PROJECT

Baltimore Polytechnic Institute

Wednesday, May 23, 2018

BALTIMORE · POLYTECHNIC · INSTITUTE
THEORY PRACTICE
FOUNDED, 1883

Program Overview

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

The Ingenuity Project®

A four-year program for capable and motivated students who excel in mathematics and science, the Ingenuity Project at Baltimore Polytechnic Institute began in 1997. In conjunction with fast-paced, content-rich mathematics and science classes taught by experienced teachers, research is emphasized through classroom activities and off-campus opportunities.

To qualify for and remain in the Project, Ingenuity students must have excellent attendance, with no unexcused absences and attain an 80% average or higher in all coursework, including summer programs. Students are expected to maintain a demeanor that is respectful of others and reflects the importance of their school work.

Ingenuity Project Overview

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, the nation's most prestigious and financially rewarding contest. Juniors and seniors submit their research to local science fairs as well.

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 very deep in their understanding of the beauty of mathematics, while also enjoying the challenge that problem solving represents.

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

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

Program Overview 2

Map 4

Schedule of Events 5

About the Keynote 6

Abstracts

- Seniors 7
- Senior Math Abstracts 15
- Juniors 18
- Sophomores 27

College Acceptances 34

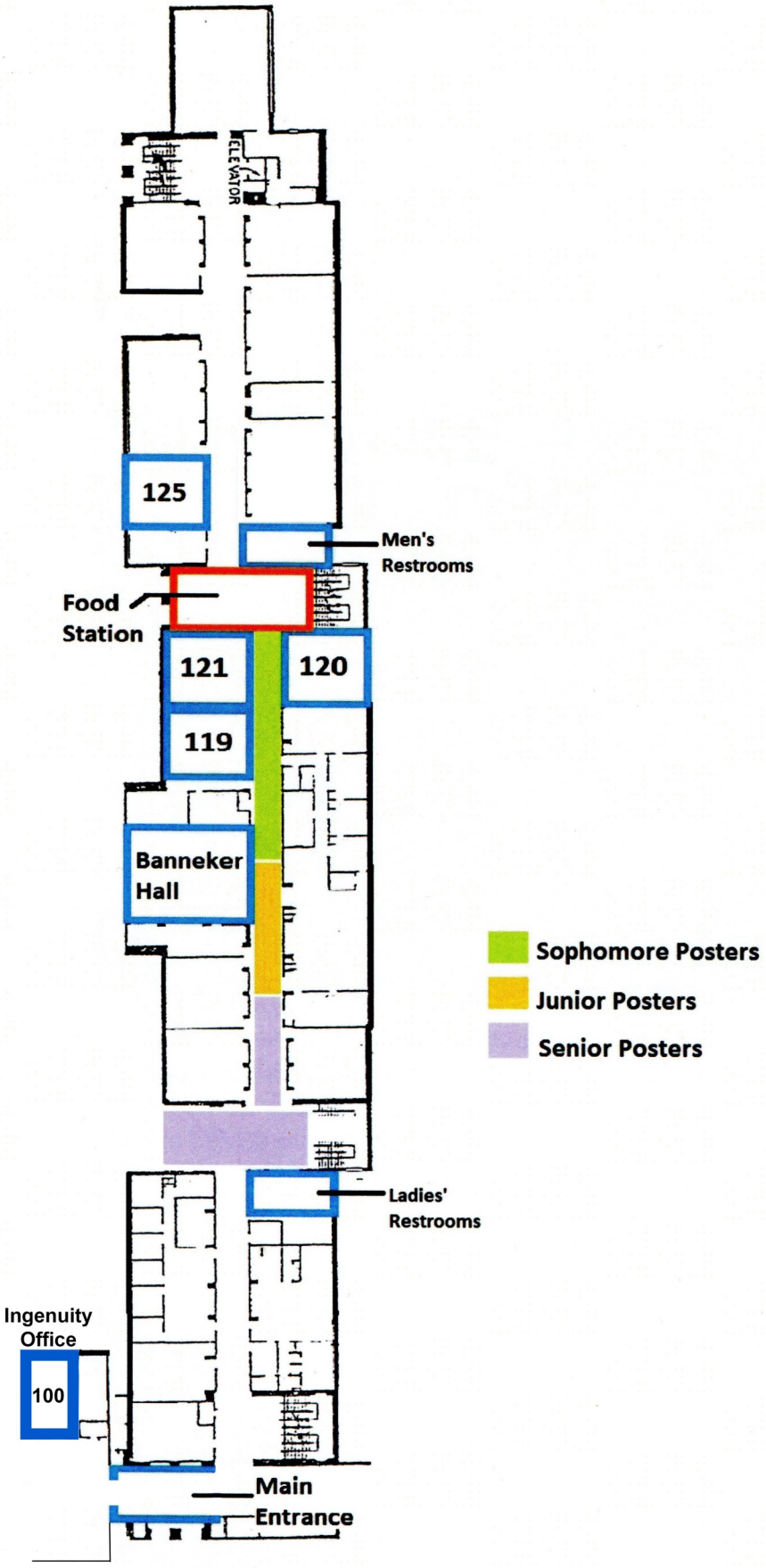
Scholarships, Awards, and Honors 37

Ingenuity Awards 41

Class Photos 43

Acknowledgements 48

Map


ELEVATOR
125
Men's Restrooms
Food Station
121
120
119
Banneker Hall
Sophomore Posters
Junior Posters
Senior Posters
Ladies' Restrooms
Ingenuity Office
100
Main Entrance

Schedule of Events

5:00 - 6:00 Poster Viewing and Refreshments
6:05 - 6:25 Opening Comments - **Banneker Hall**
MCs: Evains Francois and Karen Griffin

PRESENTATIONS

6:35 - 6:50

Banneker Hall	Impact of Inhibitory Biofilms on *E. coli* Filtration in Engineered Infiltration Systems — ***Claire Wayner***
Room 119	Developing a Reporter System for Exosome Fusion — ***Moufidatou Adedoyin***
Room 120	Constrained Extrema — ***Robert Blanchard and Duncan Parke***
Room 121	A Novel Chagas Disease Diagnostic — ***Caterina Erdas***
Room 125	Stereometry — ***Robert Henry and Nicholas Good***

6:55 - 7:10

Banneker Hall	Difficult Improper Integrals — ***Elijah Dukes & Issac Spokes***
Room 119	Blood Concentration in *Biomphalaria glabrata* Snails — ***Azeem Lyons***
Room 120	Fibonacci-Tribonacci — ***Cecilia Charney and Vivian Borbash***
Room 121	Using Oyster Filtration to Remove Coral Pathogens from the Marine Environment — ***Sherry Bossard***
Room 125	Counterexamples in Calculus — ***Ezra Szanton and Xander Easton***

Break: 7:10-7:20

7:20 - 7:35

Banneker Hall	Examining the Effects of Ccommon Mosquito Repellents on the Olfactory System of the Malaria Mosquito, *Anopheles Gambiae* — ***Sophia Hager***
Room 119	The Effects of Geometrical Constraints on the Mechanical Properties of Engineered Microtissues — ***Robert Blanchard***
Room 120	Microrheology of Active Nematics — ***Robert Henry***
Room 121	Developing an *in vitro* Small Molecule Screen to Modulate Actin Bundling Properties of Alpha-actinin-4 for Cancer Therapeutics — ***Nicholas Good***
Room 125	Examining Convergent Sequence of Polygons Using Complex Coordinates — ***Claire Wayner and Caterina Erdas***

7:40 - 7:55

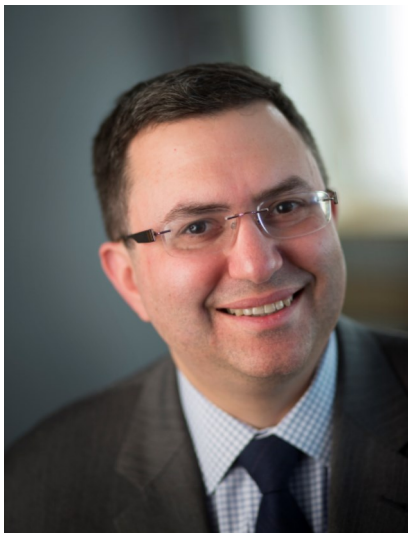
Banneker Hall	The Effect of Low Oxygen on Induced Pluripotent Stem Cell-derived Endothelial Cells — ***Rebecca Brody***
Room 119	Comparison of *in vivo* Killing of Three Different Classes of Malaria Partner Drugs with Artesunate in a Novel Blood Transfer Assay — ***Elijah Dukes***
Room 120	Testing Module Configurations for Hex DMR — ***Ezra Szanton***
Room 121	Effect of Sindbis Virus and Antibody on Neuronal Cytoskeletal Proteins — ***Mercedes Thompson***
Room 125	Some Nonlinear Second Order Differential Equations — ***Joseph Evangelista and Lily Batchelor***

AWARDS CEREMONY

8:05 - 8:45 **Banneker Hall**
MCs: Lily DeBell, Abby McKenna, and Chiad Onyeje

About the Keynote

Dr. Joshua Sharfstein



Vice Dean, Public Health Practice and Community Engagement

Professor of the Practice in Health Policy and Management at the Johns Hopkins Bloomberg School of Public Health

Director of the Bloomberg American Health Initiative

Dr. Joshua M. Sharfstein's book, *the Public Health Crisis Survival Guide: Leadership and Management in Trying Times,* will be published in May 2018 by Oxford University Press. Previously, Dr. Sharfstein served as Secretary of the Maryland Department of Health and Mental Hygiene from January 2011 to December 2014. In this position, he led efforts to align Maryland's health care system with improved health outcomes, culminating in the adoption of a revised payment model for all hospital care for Maryland residents. He also oversaw the development of a statewide health improvement process with 18 local public-private coalitions and the reshaping of state's approach to health information exchange, long-term care, and behavioral health.

From March 2009 to January 2011, Dr. Sharfstein served as Principal Deputy Commissioner of the U.S. Food and Drug Administration, where he oversaw the agency's successful performance management and transparency initiatives. From December 2005 to March 2009, as Commissioner of Health for Baltimore City, Dr. Sharfstein led innovative efforts that contributed to major declines in both overdose deaths and infant mortality rates. From July 2001 to December 2005, as minority professional staff and health policy advisor for Congressman Henry A. Waxman, Dr. Sharfstein was engaged in a wide range of oversight and legislative activities on health care topics, including emergency preparedness, HIV, and the politicization of science.

Dr. Sharfstein graduated summa cum laude with an A.B. in Social Studies from Harvard College in 1991. From August 1991 to August 1992, he worked on public health projects in Guatemala and Costa Rica with a Frederick Sheldon Prize Fellowship. He graduated from Harvard Medical School in 1996, from the Boston Combined Residency Program in Pediatrics at Boston Medical Center and Children's Hospital in 1999, and from the fellowship in general academic pediatrics at the Boston University School of Medicine in 2001. Dr. Sharfstein is an elected fellow of the Institute of Medicine (2014) and the National Academy of Public Administration (2013). He serves on the Board of Population Health and Public Health Practice of the Institute of Medicine and on the editorial board of the Journal of the American Medical Association. His awards have included the Jay S. Drotman Memorial Award from the American Public Health Association (1994), Public Official of the Year from Governing Magazine (2008) and the Circle of Commendation Award from the Consumer Product Safety Commission (2013). Dr. Sharfstein lives with his family in Baltimore, Maryland.

Senior Research Abstracts

The seniors' presentations represent the culmination of their research efforts. Students completing Ingenuity Research Practicum with Mrs. Lisa Fridman worked with members of the scientific community for fifteen months during their junior year. Each student has written a formal research paper detailing the results of his or her respective project. The papers were submitted to national pre-college competitions, including Regeneron and Junior Science and Humanities Symposium.



Front Row (from left to right): Sherry Bossard, Sophia Hager, Rebecca Brody, Caterina Erdas, Robert Henry

Middle Row: Nicholas Good, Mercedes Thompson, Moufidatou Adedoyin, Azeem Lyons, Ezra Szanton

Back Row: Elijah Dukes, Claire Wayner, Robert Blanchard

Senior Research Abstracts

Developing a Reporter System for Exosome Fusion
Moufidatou Adedoyin

Mentor: Dr. Charles C. Bailey
Institution: Department of Molecular and Comparative Pathology, Johns Hopkins University

Like humans, cells can communicate. To do this, cells deliver information to one another such as RNAs. A vehicle that assists in this intercellular communication is the exosome. Exosomes are small vesicles that are secreted by cells. Exosomes are known to carry membrane-bound, short interfering RNAs between cells and can carry contents such as protein, drugs, and therapeutic drugs for cancer therapy. Upon their secretion, exosomes can fuse with neighboring cells to deliver their contents. Although much is understood about their formation and release, comparatively little is known about the exosome fusion process. This is the process by which exosomes are able to successfully attach to their target cells membrane in order to deliver their contents. Here we describe a prototype reporter system to measure exosome fusion. Knowing more about the exosome fusion process can allow for more targeted exosomal delivery. In my project, I made and transfected segments of nucleic acids into mammalian cells. I then added a drug to induce the incorporation of green fluorescent protein (GFP) into exosomes. Within 30 minutes, I observed the relocalization of the GFP reporter toward vesicles near the nucleus by fluorescence microscopy. I harvested exosomes from tissue culture supernatant; and measured the expression and exosomal incorporation of GFP via Western blot. Results from our experiments showed that green fluorescent protein was successfully incorporated into exosomes. This result shows that we can create cells that are able to package our reporter into exosomes which is necessary because in order for the reporter system to work exosomes must contain the reporter protein.

The Effects of Geometrical Constraints on the Mechanical Properties of Engineered Microtissues
Robert Blanchard

Mentor: Dr. Daniel Reich
Supervisor: Prasenjit Bose
Institution: Department of Physics and Astronomy, Johns Hopkins University

Cells and tissues constantly exert force on their surroundings. Inserting cell laden collagen solution into polydimethylsiloxane (PDMS) microcantilever tissue gauges (μTUGs) results in tissues with measurable force. However, the effect that different variations of the devices have on the properties of the tissues has not been examined. I contrasted survivability, shape, and force generation of tissues formed in a variety of different device variations to examine the effect of the variations and to determine the most efficient type of tissue for research using μTUGs. Tissues formed over time from cell lead self-assembly of a collagen matrix inside patterns of microwells on PDMS substrate, with each microwell containing two flexible pillars. My measurement of the deflection of pillars, after tissue development, allowed for me to quantify the force exerted by the types of tissue. I also evaluated the ability of the tissues to remain attached to their pillars and I examined the effect of different variations on the shape of tissues. I showed that short tissues exerted more force than long tissues, which is preferable because it means that they can be more easily studied in terms of exerting force, but long tissues tended to remain viable longer than short tissues. Because there are more short tissues per device, their reduced survivability is negated. Together, these two results show that short tissues are more efficient than long tissues for μTUG devices. While the differences in shape between oblong and circular tissues shows that microwell shape does have an impact on tissue qualities.

Senior Research Abstracts

Using Oyster Filtration to Remove Coral Pathogens from the Marine Environment
Sherry Bossard

Mentor: Dr. Colleen Burge
Supervisor: Dr. Amanda Shore-Maggio
Institution: Institute of Marine and Environmental Technology

The purpose of my project is to determine if oysters can remove the coral pathogen, *Serratia marcescens* from the marine environment. *S. marcescens* is a bacterium found in the human gut which causes white pox disease in corals. To determine if the oysters could remove the pathogen, I grew isolates from the mucus of live corals. I then attempted to isolate the pathogen from the live coral samples and use it in my oyster filtration experiment. This was unsuccessful, so I continued the experiment with a strain of *S. marcescens* obtained from another lab. I inoculated the *S. marcescens* into tanks of oysters and collected samples of the seawater over a period of time. Then, I measured the amount of *S. marcescens* left in the tank as time went on. Data showed that the oysters were able to reduce the amount of *S. marcescens*. This suggests that oyster filtration could be an effective, natural way to remove coral pathogens from the marine environment, especially in areas where wastewater treatment is lacking or ineffective.

The Effect of Low Oxygen on Induced Pluripotent Stem Cell-derived Endothelial Cells
Rebecca Brody

Mentor: Dr. Sharon Gerecht
Supervisor: Bria Macklin
Institution: Department of Chemical Bioengineering, Johns Hopkins University

Cardiovascular diseases are the leading cause of death worldwide and result in over 200 billion dollars in direct and indirect costs in the United States, yet treatments for these diseases still remain limited. However, human induced pluripotent stem cell-derived endothelial cells (hiPSC-ECs) represent a promising potential therapy to repair and replace blood vessels damaged by these diseases. hiPSCs are stem cells are created by reprogramming adult human fibroblasts, thus deriving ECs from them creates a potentially limitless source of cells that are matched to a patient. Blood vessel grafts could be created from this cell type without the risk of rejection. However, little is known about how hiPSC-ECs function compared to primary endothelial cells (HUVECs). Critical among these unknowns is the response of hiPSC-ECs to low oxygen conditions, which are known to stimulate vascular changes *in vivo*. The response to low oxygen conditions was investigated using an *in vitro*, collagen- based, three-dimensional model system that mimics the physiological conditions in which blood vessels form. This system allows the *in vitro* growth of vascular networks, which can be used to model the behavior of blood vessels. Using this system, it was shown that hiPSC-ECs differ from HUVECs in low oxygen environments in terms of oxygen consumption and network formation. Several mechanisms which might underlie this difference were tested. It was hypothesized that the difference seen between the hiPSC-ECs and HUVECs was related to the degree of differentiation, with hiPSC-ECs being a less differentiated cell type. To test this, hiPSC-ECs were compared to a less differentiated progenitor cell type. However, these progenitor cells did not demonstrate the same response as the hiPSC-ECs in a low oxygen environment, suggesting that differentiation level could not fully explain the difference observed. A second mechanism tested revealed that reactive oxygen species are needed by both hiPSC-ECs and HUVECs for network formation, evidence that this pathway cannot explain the difference seen between the cell types. These findings provide important preliminary data that will help to guide future research with the hiPSC-EC cell type and advance the field towards new treatments for cardiovascular disease.

Senior Research Abstracts

Comparison of *in vivo* Killing of Three Different Classes of Malaria Partner Drugs With Artesunate in a Novel Blood Transfer Assay

Elijah Dukes

Mentor: Dr. David Sullivan
Institution: Department of Molecular Microbiology and Immunology, Johns Hopkins Bloomberg School of Public Health

In endemic areas of sub-Saharan Africa and southeastern Asia, strains of *Plasmodium falciparum* are becoming resistant to multiple drugs, leading to treatment failure. In this study, we explore the killing capabilities of three different drugs: 8-aminoquinoline tafenoquine, 4-aminoquinoline pyronaridine, and the macrolide azithromycin all alone and each in combination with artesunate. We employ transgenic *P. berghei* expressing luciferase in an *in vivo* killing assay and with a novel blood transfer killing metric. At 40 mg/kg, pyronaridine is a more potent killer than tafenoquine after 24 hrs of exposure in the donor mouse. From the dilution experiment, a relationship was determined to connect time to return to the 10^5 benchmark to viable parasite population. For tafenoquine, at 15 mg/kg, after the transfer, there is a longer delay to return to 10^5 viable parasites for the group in combination with artesunate compared to tafenoquine alone, about a 2-3 day difference. The difference in return to 10^5 viable parasites is similar alone or in combination with artesunate for pyronaridine at 5 mg/kg. For azithromycin at 50 mg/kg, there is a two day delay to return to 10^5 viable parasites between azithromycin alone at a transfer point and in combination with artesunate. We conclude that tafenoquine and azithromycin are positively impacted by the addition of artesunate, but pyronaridine is not.

A Novel Chagas Disease Diagnostic

Caterina Erdas

Mentor: Dr. Alan Scott
Institution: Johns Hopkins Bloomberg School of Public Health

Chagas disease is a prevalent disease in South and Latin America, caused by the parasitic protozoan *T. cruzi*. While there are effective treatments for the acute phase of this disease, diagnosing infected patients with very low levels of the parasite in their system is difficult. Therefore, scientists have been trying to introduce sensitive and specific PCR diagnostics as a possible alternative, but this approach requires biological samples with sufficient quantities of parasite DNA for detection. I created and tested a novel diagnostic that captures parasitic DNA in urine samples and detects this with PCR. To increase sensitivity and incorporate better controls, I designed a novel filtration apparatus that concentrates the parasite DNA and developed a multiplex PCR that detects both parasite and human DNA to serve as an internal sample quality control. The methods used in this project were PCR, gel electrophoresis, and the designed DNA filtration/extraction protocol. The multiplex was successful, and the filtering system worked. For future work, a different DNA collection and extraction method should be tested, and the multiplex approach should be used on urine samples from infected individuals. This project contributes to the knowledge needed for a better Chagas disease diagnostic.

Senior Research Abstracts

Developing an *in vitro* Small Molecule Screen to Modulate Actin Bundling Properties of Alpha-actinin-4 for Cancer Therapeutics
Nicholas Good

Mentor: Dr. Douglas Robinson
Supervisor: Dr. Dustin Thomas
Institution: The Department of Cell Biology, Johns Hopkins University School of Medicine

Cancer is a worldwide problem that transcends social and economic boundaries. As it stands, the disease is being treated, but not cured. Cancer is difficult to cure due to its tendency to establish secondary tumor sites by a process called metastasis. Cellular protrusions are responsible for this metastasis, and the crosslinking protein alpha-actinin-4 (ACTN4) has been shown to localize in these protrusions as well as assist in the metastatic processes, which is why ACTN4 is the focus of the research. The goal of this research is to optimize the actin bundling process in the presence of WT and K255E ACTN4 and to refine the analysis software to yield reliable quantifications of the actin bundling. Actin bundling assays are used to polymerize actin into filaments, which are then bundled by ACTN4. These bundling assays showed an increase in actin bundling in the presence of both WT and K255E ACTN4, but varying concentrations of ACTN4 led to an array of different results. The analysis software must be further modified as well, for it often picks up on and quantifies regions of the images that are not a part of the large actin structures, which skews the results. Images of the bundles showed that K255E creates bundles that are looser and more sporadic than those formed by WT ACTN4, and because they function differently, both ACTN4 phenotypes should be studied. An ideal concentration of ACTN4 to be used in actin bundling assays is being identified, and then a drug screen can be run to identify compounds that affect the bundling, the next major step towards uncovering a treatment.

Examining the Effects of Common Mosquito Repellents on the Olfactory System of the Malaria Mosquito, *Anopheles Gambiae*
Sophia Hager

Mentor: Dr. Christopher Potter
Supervisor: Dr. Ali Afify
Institution: Center for Sensory Biology, Johns Hopkins University School of Medicine

Malaria is a serious problem in many countries. One of the most efficient methods of preventing malaria is to prevent vectors from reaching their targets. To this end, this project focused on gaining a better understanding of how repellents affect the olfactory system of *Anopheles gambiae*. To accomplish this goal, I used calcium imaging to measure the neural response of a female mosquito's antenna to six mosquito repellants and an attractant. I found that eugenol, linalool, and lemongrass oil, three mosquito repellents, activated neurons in the antenna of the mosquito, and three had no visible response. Furthermore, the other three repellents, IR3535, DEET, and picaridin, decreased the response of the mosquito to the attractant, suggesting that these repellents inhibit a mosquito's attraction to a host, while the others stimulate the neurons in the antenna, providing feedback to the mosquito that prompts it to avoid the potential host. This suggests that there are multiple ways in which a mosquito repellent could affect a mosquito, although they produce the same effect.

Senior Research Abstracts

Microrheology of Active Nematics
Robert Henry

Mentor: Dr. Robert Leheny
Institution: Department of Physics and Astronomy, Johns Hopkins University

Active Nematics are systems of particles that move using their own internal energy. When these particles approach one another in the system, they tend to move in directions that are parallel or antiparallel to one another. The goal of this study is to understand how this system reacts to probes that interfere with their motion. I insert a 40nm nickel disk into the active nematic system so that we can rotate it and observe the effects that the probe has on the motion of the particles. After rotating the disk at varying frequencies, I observed that the disk creates a vortex that pulls the particles of the nematic into itself. This vortex also releases defects into the nematic after being sustained in the system for a sufficient amount of time determined by the properties of the nematic. From this, we learned that the vortex formed by the rotating disk creates a vortex in the system that has some effects on the defects in the system.

Blood Concentration in *Biomphalaria glabrata* Snails
Azeem Lyons

Mentor: Dr. Clive Shiff
Institution: Department of Molecular Microbiology and Immunology, Johns Hopkins Bloomberg School of Public Health

Schistosomes are one of the most widespread human-infecting parasites, and they utilize Biomphalaria glabrata snails as intermediate hosts, granting the B. glabrata snails significance in the realm of vector control for schistosomes. This project assessed blood cell concentration as a metric for healthy conditions in B. glabrata snails and investigated the effect of schistosome infection on the blood concentration in said snails. This would serve to gather information to develop an early-warning system for colony infection and prevent human casualties. Samples of blood were taken from B. glabrata snails of different sizes, both healthy and infected with schistosomes, and analyzed to determine the concentration of blood cells within. The results indicate that a healthy concentration of blood cells does in fact correlate to the size of the snail, with larger snails having a higher concentration of cells per given volume of blood in a healthy organism. In the infected snails, smaller organisms contained less blood cells than healthy snails of equivalent size, but larger infected snails contained more blood cells than the larger healthy snails. This suggests that infection inhibits blood cell production in smaller snails but promotes it in larger snails, effects varying based on capabilities of immune function.

Senior Research Abstracts

Computer Vision for Tracking and Identification for Automated Behavior Analysis
Duncan Parke

Mentor: Dr. Ralph Etienne-Cummings
Supervisor: Fabio Marcuccio
Institution: Department of Electrical and Computer Engineering, Johns Hopkins University Whiting School of Engineering

This project attempts to automate the analysis of animal behavior by implementing modern computer vision techniques such as point-to-point image matching using inner distance shape contexts and frame by frame head and tail tracking in addition to physical identifiers such as metal ear tags. These techniques are being used to tackle the initial problem of successfully identifying and tracking individual animal models, in our case mice, over long durations of interactions with other animal models. Fully automating the analysis of animal behavior will allow for studies with much larger sample sizes without the need of manually labelling and analyzing all of the data being produced.

Testing Module Configurations for Hex DMR
Ezra Szanton

Mentor: Dr. Gregory Chirikjian
Supervisor: Joshua Davis
Institution: Laboratory for Computational Sensing and Robotics, Johns Hopkins University

Robots are limited by the need for human intervention when broken. The Hexagonal Distributed Modular Robot system (Hex DMR) is a group of robots capable of self-repair because their modules are interchangeable. While the ability to replace modules gives the system the flexibility to change its properties to accomplish a task, the volume of possibilities makes it difficult to find the correct arrangement for that task. One property important to all tasks is how long a robot survives in harsh conditions: its *robustness.* One way to organize configurations is by their number of wheels. I first implemented a case study which found that robots with six wheels were more robust. Then, I tested systems of three six-wheeled robots for their *robustness* as a unit, using three methods which yielded differing results. Finally, system configurations were run through a destructive simulation and those which reached a predetermined threshold were stored. To study the effectiveness of robot configurations, these system configurations were broken into data points, and the configurations of the robots which made them up were analyzed by their similarities in number of manipulator modules: the main determining factor in their success. When the robot configurations were categorized by similar characteristics, it became evident that symmetrical robots without manipulator modules were the most successful. This project shows that not every advancement is inherently better and begins to explain when parts which contribute utility but are not inherently necessary are optimal.

Senior Research Abstracts

Effect of Sindbis Virus and Antibody on Neuronal Cytoskeletal Proteins
Mercedes Thompson

Mentor: Dr. Diane E. Griffin, MD, PhD
Supervisor: Jane Xie
Institution: Department of Molecular Microbiology and Immunology, Johns Hopkins Bloomberg School of Public Health

Viral encephalomyelitis is the inflammation of the brain and spinal cord from viral infection, and is of significant public health concern due to its high mortality rate and association with permanent brain damage; currently, no targeted treatment methods or vaccines exist to combat the rising number of cases worldwide. While antibody 127 was identified as a mechanism of viral clearance within the central nervous system (CNS), little is known about the manner in which antibody mediates this clearance within the immune system. Since viruses utilize cytoskeletal structures to infect cells, I investigated the hypothesis that antibody may clear virus by changing the cytoskeletal shape of the neuron to be detrimental for viral replication. Cytoskeletal proteins actin and tubulin were investigated through imaging and protein and gene expression level analysis following time points after virus infection and antibody treatment. In mature neurons, results suggest the cytoskeletal filaments and shape appear to be positively impacted by antibody treatment when compared to cytoskeletons of solely infected neurons; gene expression of these proteins following antibody treatment was down regulated. Further investigation of inhibition of cytoskeletal proteins is warranted to determine whether the cytoskeleton is a mechanism for antibody-mediated clearance.

Impact of Inhibitory Biofilms on *E. coli* Filtration in Engineered Infiltration Systems
Claire Wayner

Mentor: Dr. Sarah Preheim
Supervisors: Dr. Eric Sakowski, Andrea Fraser, Yue Zhang
Institution: Department of Environmental Health and Engineering, Johns Hopkins University Whiting School of Engineering

Stormwater runoff often becomes contaminated with biological pathogens such as *Escherichia coli* which pose a threat to public health. Engineered infiltration systems (EIS) have become a popular solution to mitigate this pollution, but little is known about how the biological characteristics of EIS such as the growth of naturally-occurring bacterial biofilms affect *E. coli* removal. In this study, I examine what impact biofilms have on *E. coli* transport through EIS, specifically investigating whether biofilms able to inhibit *E. coli* growth lead to enhanced *E. coli* removal. I measured the amount of *E. coli* retained by EIS models coated with four single-species biofilms (two inhibitory and two non-inhibitory biofilms, representative of two genera). Results indicate that biofilms on EIS, regardless of inhibitory properties, likely enhance *E. coli* removal compared to EIS without biofilms. There was no clear correlation between inhibition and *E. coli* removal. Over the longer term, some biofilms on EIS increased *E. coli* concentration in the EIS effluent, suggesting that biofilms could be less beneficial than has been shown in previous studies.

Senior Math Projects

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

Counterexamples in Calculus
Ezra Szanton, Xander Easton

Proofs often require specific statements that are infrequently relevant, which makes them easy to forget. While they may hold up to weak testing, these statements are not rigorous and so are not useful. To show why certain statements are needed in proofs it is sufficient to find a counterexample of the seemingly intuitive statements. Then we can analyze why that counterexample was possible to construct and add back the necessary statements, except in one special case. We successfully constructed counterexamples to disprove some "statements" which are incorrect due to some missed conditions in the mathematical areas of study: Functions, Limits, Continuity, Differential Calculus and Integral Calculus.

Stereometry
Robert Henry, Nicholas Good

Stereometry is the study of three dimensional geometry, and it explores the properties of lines, planes, and shapes that exist in this space. The knowledge necessary to understand and apply the laws of stereometry is founded upon the axioms and theorems relating these structures to one another and describing how they interact. Axioms are statements that are self-evidently true, and have been accepted across the field, such as the statement that a plane is defined by any three points which are not on the same line. Following from these axioms are theorems, less evidently true statements that are proved through a string of logical conclusions paired with reference to the axioms, such as the theorem stating that if a given line is parallel to a line in a given plane then the given line is parallel to the plane. The main problem of three dimensional geometry is being able to apply these theorems and axioms to less general cases involving more complex figures and proofs. In this project, we will be developing several theorems and then applying them to give a number of proofs, including the unique problem of proving "Pythagorean Theorem" for the case of a three dimensional figure. An application of stereometry is in computer graphics, as it is essential to efficiently depicting art and data to the user in a meaningful way. Building off of that, shape geometry has made astounding advancements to all forms of media, from movies to video games to animations. The function of this presentation is to provide an introductory understanding of the subject.

Examining Convergent Sequence of Polygons Using Complex Coordinates
ShinShin Erdas, Claire Wayner

Many problems in geometry can be solved using complex-valued coordinates, which simplify the representation of figures over n-dimensional spaces. In this presentation, we examine and prove a theorem about the convergence of infinite sequences of polygons by employing complex numbers. First, we introduce our overall approach by representing one iteration of a sequence of quadrilaterals in the complex space, proving through complex coordinates that the second quadrilateral generated through the sequence has perpendicular and equal diagonals. After solving this initial problem, we progress to infinite iterations of the sequence, shifting to the problem of a sequence of triangles. Through the same complex coordinate approach, as well as the introduction of a coordinate matrix, we prove that "over time," the triangles in this infinite sequence will converge to the shape of an equilateral triangle.

Senior Math Projects

Fibonacci-Tribonacci
Vivian Borbash Cecilia Charney

The Fibonacci sequence is a recursive sequence in which each term is defined as the sum of the two previous terms, beginning with 0 and 1. Named for the Italian mathematician Leonardo Bonacci, the Fibonacci sequence may have arisen as early as 200 B.C.E., and remains a topic of interest for mathematicians today. In this project we found general terms and matrix representations for Fibonacci and Tribonacci sequences and their Lucas counterparts; proved properties of the matrix representations of the sequences; and used directional cosines and the formula for distance from a point to a line to show that when graphed in a coordinate system, the sequences of points with Fibonacci and Tribonacci coordinates have asymptotes.

Some Nonlinear Second Order Differential Equations
Lily Batchelor and Joseph Evangelista

In a typical differential equations class, the standard approaches to linear differential equations are introduced. We will first provide common types of linear differential equations, and the methods used to solve them. To solve separable equations, the variables are separated and both sides of the equation are integrated. To solve first-order linear equations that are not separable, one can either use the uv method, in which the substitution y = uv is made, or the method of variation, in which the integration constant is treated as a function of the independent variable and substituted into the original equation. To solve second-order linear differential equations, one starts by making the substitution y = eλt and solves the resulting equation for λ. By using the Principle of Superposition, which states that the linear combination of two specific solutions is also a general solution of the equation as long as the two solutions are linearly independent, we can find a general solution to the equation. There is no standard approach to solving nonlinear differential equations, but certain equations can be solved with substitutions that reduce them to familiar equations. Some common examples of first-order nonlinear equations are Bernoulli equations and homogeneous equations. Bernoulli equations can be solved with the substitution z = y1-n . Homogeneous equations can be solved with the substitution z = . There are also examples of second-order nonlinear equations x y which can be solved using this method. When x is absent from the equation, the substitution y' = p can be made. When y is absent from the equation, the substitution v = y' can be made. Once the equations are reduced to first-order equations, we can use the previously discussed standard approaches to solve the equation.

Constrained Extrema
Robert Blanchard and Duncan Parke

We live in a 3 dimensional world in which a single variable is not always sufficient to solve problems. Multivariable calculus builds on the foundations laid by single variable calculus, allowing mankind to better solve complex real world problems that are influenced by many factors. While there is a standard method to find extrema of a function of 2 variables, constrained extrema problems require a special approach to minimize or maximize the function F(x,y,z) =0 with constraint Phi = (x, y, z). Lagrange suggested to consider the function (Trident)(x,y,z,lambda) = F(x,y,z) + lambda(phi(x,y,z) of 4, not 3 variables. In our presentation we introduce the Lagrange method and show its power by solving several interesting problems about the concept of extrema.

Senior Math Projects

Difficult Improper Integrals
Elijah Dukes and Isaac Spokes

By definition, an integral can be interpreted geometrically as the numerical measure of the area bounded above by the graph of a given function. An improper integral is one in which either one or both limits are infinite or there is an integrand that approaches infinity at one or more points in the range of integration. In this project, we will show that the improper integrals of some functions which are difficult to integrate do in fact converge to a real value despite being improper integrals. We will first make substitutions in each problem, then take any steps necessary to reach the final answer, following the proper methods of integration, some of which come from outside of typical calculus.

Junior Research Abstracts

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



Front Row (from left to right): Sumaita Ahmed, Lily DeBell, Ruth Martin, Raquel (Tori) Legaspi

Second Row: Chiad Onyeje, Elizabeth Zheleznyakova, Michelle Mokaya, Rachel Pontious, Karen Griffin

Back Row: John Halpin, Nathaniel Alper, Evains Francois, Rohan Kane, Abigail McKenna, Omobalade Odedoyin, Taylor Young

Junior Research Abstracts

Characterization of Cohesin Accessory Factor ECO-1 in Meiosis
Sumaita Ahmed

Mentor: Dr. Yumi Kim
Supervisor: Jocelyn Haversat
Institution: Department of Biology, Johns Hopkins University

The focus of my independent project is on the acetyltransferase, ECO-1, an ancillary component to cohesin complex. Cohesin refers to a multicomponent protein complex that is a major constituent of both mitotic and meiotic chromosomes. One of the main functions of this proteinaceous structure is the mediation of sister chromatid cohesion. Cohesin's role in the union of sister chromatids makes it essential in ensuring correct chromosome distribution during meiotic prophase. My protein of interest, ECO-1, is uncharacterized and unstudied. Scientists believe that this protein is necessary for the establishment and release of cohesion. Since there is no existing literature available on this protein within the *C. elegans*, my model system, the three main goals of my project are to localize the protein and confirm its presence within the germline, investigate with what the protein co-localizes, and determine the protein's function.

A Genetic Time Series of CsRV1 in Blue Crabs
Nathaniel Alper

Mentor: Dr. Eric Schott
Supervisors: Matthew Spitznagel, Mingli Zhao
Institution: Institute of Marine and Environmental Technology

The movement of marine organisms can be hard to model geographically because they often travel great distances. This is true for the blue crab (Callinectes sapidus), which can drift thousands of miles in ocean currents while in its month-long larval stage. Consequently, populations of blue crabs found thousands of miles apart may have shared genetic signatures. CsRV1 is a virus in the family Reoviridae which infects blue crabs. Its RNA genome is highly mutatable and does not pass from female to offspring or travel within larvae. Therefore, strong genetic similarities between CsRV1 populations are likely to be an indication of physical movement of crabs, which could assist in making an accurate model of the crab's movement. To create such a model, it is necessary to assess the variability or stability of a given population of CsRV1. To do this, I studied the stability of a small section of the CsRV1 genome from crabs caught in Georgica Pond, NY over a three year period. I identified two main strains of the virus; the first occurring in samples collected from 2011 and 2012, and the other from samples collected from 2012 and 2013. There are a 5 to 6 base pair differences between the two variations out of approximately 800 base pairs sequenced. At this point, more samples of the virus must be obtained from 2011 and 2013 to be able to draw firm conclusions about genomic stability. However, the data collected thus far provides a foundation to examine more sites, such as Rhode River, MD in the future, to get a picture of the stability of the virus genome in various environmental conditions.

Junior Research Abstracts

Metal Dependency of *E. coli* Cas1
Lily DeBell

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

CRISPR-Cas systems are the adaptive immune systems of bacteria and archaea. CRISPR systems allow cells to develop immunological memory by storing information from foreign DNA in the bacterial or archaeal genome itself. Adaptation, the stage of CRISPR immunity during which foreign DNA is incorporated into the prokaryotic genome, is an essential but poorly understood aspect of CRISPR-Cas immunity. Cas1 is a metal-dependent endonuclease required for recognition, processing, and integration of foreign DNA during adaptation. While previous studies have demonstrated that Cas1 requires the presence of a divalent metal cation for its nuclease and integrase activity, it is unclear which metal is preferred by Cas1 for robust nuclease and integration activity. I determined optimal metal conditions for Cas1-Cas2 facilitated integration of DNA into a CRISPR array in an *in vitro E. coli* CRISPR system. In the presence of Mn^{2+}, integration occurred more quickly and robustly than in the presence of Mg^{2+}. Future work includes determining the preferred metal ligand for Cas1 based on active site structure and which metal cation best supports the processing and trimming functions of the nuclease during adaptation

Altering Different Components in a Cockroach Inspired Robot
Evains Francois

Mentor: Dr. Chen Li
Supervisor: Rick Han
Institution: Laboratory for Computational Sensing and Robotics, Johns Hopkins University

Terradynamics is the description of animal movement in relation to the ground and can be useful in the design of robot locomotion. My lab uses the cockroach and terradynamics in our research to design robots capable of maneuvering through rough terrain. This project aims to look at how altering different components of a cockroach-inspired robot will affect its performance when colliding with a pillar. My project is split up into two parts; the robot assembly, and the robot testing. In this poster, I describe part one; the building process. The robot body design needed to satisfy three conditions: it must move smoothly in a relatively straight line, it must be able to hold a shell on top of it, and it must be small and compact. The first step was to design all of my parts on a 3D modeling software called SolidWorks. Then, starting with the chassis, I had to materialize all of my parts by either laser cutting or 3D printing them. The result was a small six-legged robot that could move at different speeds with an interchangeable shell. Although many issues arose with the individual parts, the final robot satisfied all three of my initial conditions and is ready to start part two, testing.

Junior Research Abstracts

Designing a Method to Study the Effects of Preventing Fetal Oocyte Attrition Using *chk2* and *Azidothymidine*
Karen Griffin

Mentor: Dr. Alex Bortvin
Supervisor: Marla Tharp
Institution: Carnegie Institute of Washington, Department of Embryology

Mammals are limited to the number of oocytes they have at birth, which only represents a small fraction of what the body had originally produced during fetal oogenesis, the creation of oocytes while the body is an embryo. Fetal oocyte attrition (FOA) is the phenomenon where the mammalian body destroys around 80% of its produced oocytes before birth. Checkpoint kinase 2 (chk2) is a DNA damage checkpoint gene involved in FOA that destroys damaged cells. Mice with the absence of chk2 and the addition of azidothymidine (AZT) retain 100% of its original number of oocytes produced. The overall goal of my project is to determine if the prevention of FOA is beneficial. To answer this question, I must first develop a protocol to measure the physical characteristics of the $chk2^{-/-}$ + AZT ovary at different stages of development. I show that using Hematoxylin and Eosin (H&E) and immunohistochemistry staining are a useful method to answer the larger research question. Further quantification of oocyte follicles at different stages is needed to accurately conclude the morphology of the $chk2^{-/-}$ + AZT ovary.

Studying Fatty Acid Binding Protein 2 Function Using CRISPR/Cas9 and Transposon Induced Mutant Zebrafish Lines
John Halpin

Mentor: Dr. Steven Farber
Supervisor: Monica Hensley
Institution: Carnegie Institute of Washington, Department of Embryology

Fatty acid binding protein 2 (*fabp2*) is an intracellular lipid binding protein that is involved in the uptake and metabolism of fatty acids. Scientists agree that *fabp2* is involved in intracellular lipid transport, but specific functions remain poorly defined. An efficient method of studying gene function is to mutate the gene and observe phenotype development, which I am doing in *fabp2* with two unique lines of mutant zebrafish. The first mutant zebrafish line includes a DNA sequence inserted into the *fabp2* gene. The sequence has a monomeric red fluorescent protein (mRFP) attached which allows for the simultaneous knock out of the gene and expression of mRFP. I have obtained images of RFP expression in the yolk syncytial layer, an extraembryonic metabolizing organ, under a fluorescent microscope through 7 days post fertilization, but there is a lack of physiological phenotypes to support these fluorescent images. The second mutant line was created by inducing a double stranded break at a targeted region of the *fabp2* gene using the CRISPR/Cas9 complex. I bred zebrafish with these mutations, isolated genomic DNA from the progeny, and ran multiple series of polymerase chain reactions to amplify my DNA product. I used gel electrophoresis to determine the base pair length of my DNA, and using that data I have successfully identified carriers of a CRISPR induced mutation. This work has furthered my understanding of *fabp2* and brought me closer to assaying the metabolic function of *fabp2.*

.

Junior Research Abstracts

Comparing Visual Morphologies and Structural Parameters to Understand Galaxy Mergers
Rohan Kane

Mentor: Dr. Jennifer Lotz
Institution: Bloomberg Center for Physics and Astronomy, Johns Hopkins University

Galaxy mergers are a field of astronomy which studies the effects of coalescence between a system of galaxies. There are two main types of galaxy mergers; major mergers occur between galaxies of similar sizes, and minor mergers occur between galaxies of vastly different sizes. The two can generally be differentiated by either a series of light-based parameters or the structural features resulting from the merger. As parameters become progressively less reliable at greater distances from our telescopes, I investigate a set of galaxies' merger features. By comparing the merger type found from features to the merger type found from parameters, I can check the accuracy of parameter measurements. In order to do this, I preform an image subtraction to reveal extraneous features in a galaxy. A model is generated based on a galaxy's structural parameters, and its light flux is then subtracted from that of an image of the galaxy to provide the subtracted image. Based on merger features, I expect to find my catalog of galaxies is made of 86% major mergers. However, the predictions from light distribution and concentration parameters project that rate to go down to 21%. From this, it is clear that those parameters alone are ineffective at determining merger type. Moving forward, I will be investigating relationships between specific features and an assortment of parameters concerning the galaxies' ages and sizes.

The Effect of Water Compared to Air on the Tack of Pressure Sensitive Adhesives
Raquel Legaspi

Mentor: Dr. Joelle Frechette
Supervisor: Preetika Karnal
Institution: Department of Chemical and Biomolecular Engineering, Johns Hopkins University

Tack, the property of a pressure sensitive adhesive (PSA) to bond with a surface under slight pressure, has made PSAs idyllic in a medical setting - where wound dressings need to be frequently changed, or medical devices need to be temporarily attached to a patient. Medical adhesives frequently come into contact with moisture in the form of sweat, blood, or exudates, must be able to adhere to the skin under these wet conditions. Here, I characterize the tack of three medical PSAs, Durapore, Micropore, and Transpore, in water and air using a ball rolling test. In both environments, I record the motion of smooth aluminum balls as they roll down an acrylic plane inclined at 30° onto a PSA secured to a horizontal plane. For both environments, I utilize four balls of varying diameters from 4.7 mm to 12.7 mm. I calculate the tack, measured as the weight of the ball divided by the distance the ball rolls on the adhesive (rollout distance), of all three tapes experienced by each ball. I found that the tack of all three PSA samples is greater in water, likely due to the viscosity of water decreasing the velocity of the balls - allowing the adhesive to form stronger bonds with them, and thus reducing their rollout distance.

Junior Research Abstracts

The Effect of Temperature Change in HMS-Beagle Transgenic Flies
Ruth Martin

Mentor: Dr. Zhao Zhang
Supervisor: Dr. Lu Wang
Institution: Carnegie Institution for Science, Department of Embryology

A transposon is a DNA sequence that can transfer, or jump, from one location to another within a genome. Transposition is the act of a transposon jumping, which often results in genetic mutations through deletions and insertions. Studies done with *Antirrhinum majus*, a flowering plant, show that there is a clear relationship between temperature and the rate of transposition. However, temperature effects on the rate of transposition in animals are not yet known. I hypothesize that temperature will affect the rate of transpositions in *Drosophila Melanogaster* flies. To address this hypothesis, I will expose the genetically modified *Drosophila Melanogaster* flies called HMS-Beagle-RP114-GFP, to 18°C, 25°C, and 29°C temperatures to analyze the relationship between temperature shift and transposition rate. The naming convention conveys the changes to the fly genome. HMS-Beagle is a retrotransposon that uses reverse transcription instead of normal transcription, and GFP is a protein that acts as a visual tag for the expression of certain genes. Preliminary data support my hypothesis with some indication that more GFP signals can be found in the flies kept at 18°C compared to flies exposed to 29°C.

Effect of Curvature on Cell Response
Abby McKenna

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

Cell culturing can be classified in the field of biomimetics: the study of replicating the *in vivo* environment in an *in vitro* setting. Three dimensional culturing techniques can be used to study the growth, differentiation, and interactions of cells. We have developed cellular scaffolds using hydrogels with microcurves that effectively replicate the tissues of the human body. Thus far, scaffolds have been on the order of a thousand times stiffer than those of the human brain, making them less applicable for research. Future work will be focused on optimizing the stiffness of the scaffolds. An improved understanding of the cells interactions in the *in vivo* environment can be applied to diseases mechanisms in the body, which will lead to the advancement of therapies targeting degenerative diseases. I hope to apply the laboratory techniques I have learned in order to replicate a tumorous tissue in the body to study transport mechanisms in tumors.

Junior Research Abstracts

Detection of Parasitic Transrenal DNA from Filtered Urine Samples Using a Multiplex PCR
Michelle Mokaya

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

There are many infections caused by parasites which go undetected for individuals who are asymptomatic, show no obvious clinical symptoms of infection, or those with low levels of parasitic DNA present in their system. To address this issue, a new approach of detection using polymerase chain reaction (PCR) has revealed promising results as a highly sensitive diagnostic test. The goal of this project was to develop a PCR assay to detect specific parasites in urine samples. The PCR procedure referred to as multiplex, is a procedure which uses more than one primer set to target multiple DNA templates in the same reaction mixture. This project uses parasitic primers to target parasitic DNA and human primers to target human DNA in human urine samples at the same time. So far, a PCR assay using human primers was sucessful; however, the assay using primers from the parasite *Schistosoma mansoni* has not yet yielded successful outcomes. My goal is to first create an assay using *S. mansoni* primers, and the second goal is to develop a thermocycling procedure which can properly amplify *S. mansoni* and human DNA in one reaction mixture.

Quantifying Neural and Cochlear Efferent Neurons to Analyze the Potential Contribution of Hearing Loss in Kabuki Syndrome
Omobolade Odedoyin

Mentor: Dr. Amanda Lauer
Institution: Department of Otolaryngology/Head and Neck Surgery, Johns Hopkins University School of Medicine

Kabuki syndrome (KS) is a multisystem disorder with classical phenotypic features, including distinctive facial features, skeletal and abnormalities, and mental retardation. Researchers have described more than 100 cases of the syndrome in Europe and discovered that children affected by this syndrome may also have a severe hearing impairment, pending the urge for precautionary mandatory early testing. Hearing loss, mainly due to recurrent ear inflammation is a common finding in KS. Sensorineural hearing loss leading to deafness has been a rare finding among persons diagnosed with KS as reported in 2005 in two individuals by Tekin et al. The link between hearing dysfunction and KS is not well understood, prompting the importance for developing and refining prescriptive and diagnostic procedures to improve the quality of life and reduced the symptoms of this disorder. Overlooked hearing loss may exacerbated negative cognitive outcomes. Here we focus in on the top-down auditory olivocochlear system, which is dysfunctional in many conditions affecting the brain (migraine, Schiz, autism, etc.). We used immunohistochemistry to label the neurons in mouse model brain and cochlea in a background strain, C57 mice with age related hearing loss, for a comprehensive baseline study must be conducted to provide information regarding auditory and neural cognitive activity in comparison to KS model mice. Intermediate results are necessary for comparison of neural activity of controls, partial cell count of inhibitory neurons. Expected data should exhibit variation in hearing loss and providing a better understanding in the underlying mechanism linking hearing loss and KS. More present inhibitory neurons should suggest more inhibitory function with the efferent system and this neural inactivity could have some impeding relation to the hearing loss of the samples as well.

Junior Research Abstracts

Analyzing Thalamic Inputs to PSS in the Ferret
Chiad Onyeje

Mentor: Dr. Kristina Nielsen
Supervisor: Augusto Lempel
Institution: Department of Neuroscience, Johns Hopkins University

In humans and monkeys, it has been shown that the perception of motion depends on a series of visual areas that are specialized for this task. The Nielsen lab has recently shown that the ferret visual cortex similarly contains a visual motion pathway. This pathway begins in the retina, and then includes the lateral geniculate nucleus (LGN), primary visual cortex (V1) and a higher order visual area (PSS). In the monkey, the LGN also projects directly to a higher order motion cortex, as do other thalamic nuclei such as the pulvinar. Whether this is also the case in the ferret is currently unknown. One goal of my study is to determine whether a connection between the thalamus and PSS exists in adult ferrets, which would suggest a shared anatomical layout of the motion pathway across species. I will investigate these connections both in adult ferrets and during their early development. I will investigate connections between the thalamus and PSS by investigating several ferret brains. The project will be divided into three phases: In phase one, I will determine which parts of the thalamus project to PSS in adult animals. For these experiments, I will be analyzing a set of ferret brains that have received a retrograde tracer (Rhodamine B dextran) injection in PSS. I will be using immunohistochemistry (primary antibody: mouse anti-Parvalbumin; second antibody: GFP conjugated anti-mouse) to reconstruct the anatomical layout of the thalamus. This will allow me to identify the location of any labeled neurons. Phase two will repeat the same experiments in young ferrets. In phase three, I will compile the data from phases one and two to describe thalamic connections to PSS in adults, and to identify changes across development.

Investigating the Dynamics of Denitrifying Bacteria in Denitrifying Biofilters
Rachel Pontious

Mentor: Dr. Sarah Preheim
Supervisor: Yue Zhang
Institution: Department of Environmental Health and Engineering, Johns Hopkins University

Nitrogen is a major pollutant in bodies of water and can lead to the depletion of dissolved oxygen vital to the ecosystem. Much of this nitrogen pollution comes from stormwater runoff, which washes pollutants on land into the water when it rains. Engineered infiltration systems (EIS), a commonly used form of bioretention device, can hold and filter stormwater after a rain event to help curb pollution. Denitrification, a biological process performed by bacteria, can help remove nitrogen pollution in EIS. EIS that are modified to promote denitrification are called denitrifying biofilters. My project goal is to learn more about the dynamics of denitrifying bacteria themselves in denitrifying biofilters and the environmental conditions/modifications that influence these biofilters. To accomplish this, I have designed a laboratory model of a denitrifying biofilter. Because the nosZ gene is expressed by all denitrifying bacteria, the amount of this gene in a sample is an indirect measure of the amount of denitrifying bacteria. I have designed a protocol to measure nosZ in samples, and have found it to be present in stormwater. Continuing my project, I will design ways to measure denitrification in these models and eventually be able to set parameters on them that represent different environmental conditions or modifications, and observe how they affect denitrification.

Junior Research Abstracts

Defective Autophagy in C9-ALS
Taylor Young

Mentor: Dr. Tom Lloyd
Supervisor: Kirstin Maulding
Institution: Department of Neurology, Johns Hopkins University School of Medicine

Amyotrophic lateral sclerosis (ALS) is a neurodegenerative disease that affects the nerve cells of the individual who has it. Axonal transport defects have been shown to contribute to the beginning of ALS. Axonal transport is the process responsible for the movement of many cell components along the axon of a neuron. Autophagosomes are one of the components that are transported by this process. Autophagosomes play a major role in the degradation of damaged or surplus cytoplasmic cargo. The process of autophagy refers to the degradation of these components by fusion with the lysosome. In ALS, the autophagic system displays a reduced number of autophagosomes and defects in movement. In Phase One of my research, I will examine various methods for studying autophagy in a *Drosophila* model of ALS.

Computational Simulations of DNA Nanotubes
Elizabeth Zheleznyakova

Mentor: Dr. Rebecca Schulman
Supervisor: Dr. Michael Pacella
Institution: Department of Chemical and Biomolecular Engineering, Johns Hopkins University

The miniaturization of modern technology requires the development and investigation of new materials to build increasingly small components. DNA nanotechnology harnesses DNA's property of self-assembly – the ability to form predictable higher-order structures. One crucial component that has many potential uses in DNA nanotechnology and beyond is the DNA nanotube, a rolled-up lattice of interconnected tiles made out of short DNA strands. Two DNA nanotubes with complementary ends can join together, a process that can potentially allow researchers to assemble large, complex nanotube architectures. Before this can be achieved, the properties of DNA nanotubes and their motion, such as how quickly they join, must be investigated. Experiments conducted in our group suggest that the joining rate of two DNA nanotubes does not depend on their length. In my project, I reinforce this experimental work with a computational model. Using oxDNA, a molecular dynamics software package encompassing physical laws and characteristics of nucleic acids, I conduct numerical simulations of the motion of two nanotubes. To optimize the efficiency of existing simulation components, I developed a Python code implementing the forward flux sampling method for rare event simulations. This code will guide the simulations to completion and make calculations to determine the nanotubes' joining rate, allowing me to model the joining rate as a function of the nanotubes' length. In the future, my application of the forward flux sampling method and the theoretical model of two DNA nanotubes can be applied to more complex nanotube systems so that we can better understand and predict their behaviors.

Sophomore Abstracts and Interest Statements

All sophomores participate in the initial phase of the Ingenuity Research Program by taking a semester-length course titled Introduction to Research. In this course, students learn how scientific research is conducted, identify individual topics of interest, research current information about their selected topic, and learn modes of scientific communication. Students choosing to continue with Research Practicum have sought mentors from the local scientific research community and will begin work at their lab placements this summer. Abstracts are from students that have completed their information search whereas Interest Statements are from students in the process of completing their information search. The posters the sophomores present at Symposium represent a first effort to communicate their research topics to a public audience.



Front Row (left to right): Miriam Herrera, Colton Ross, Matt Arcillo, Mya Smith, Maya Pulliam, Sam Yoseph, Marie Badiola, Donaysia Torbit, Trinity Stephens

Back Row: Jarra Omar, Raekwon Williams, Caleb Clark, Alex Nishiura, Noah Lee, Isaiah Roberts

Not in the picture: Helen Schott, Fiona Zabel

Sophomore Abstracts

Viral Vaccinology
Matt Ervince Arcillo

The topic of my research is viral vaccinology. Three recent studies of viral vaccinology involve how we can improve upon our current vaccine methods against viruses. The first study, which may have a more direct impact on our lives, is researching the development for a long-lasting universal influenza vaccine by "training" the immune system against a different region of the virus. The second research addresses another flaw of the influenza vaccine: the way it is made. Influenza vaccines are mass produced within chicken eggs, and this can often produce ineffective viruses. This research is developing a way to create viruses using bacterial cells, which is cheaper and less prone to errors but is more difficult at the moment. The final research involving this topic studies the flawed viral vaccine practices in non-human animals. An animal vaccination does not prevent infections, but instead, it prolongs the host's life. The next step of this research is to improve vaccines and to avoid imperfect vaccine practices. I plan on continuing with the Ingenuity Research Program next year and will be working at the Johns Hopkins Bloomberg School of Public Health to help increase my understanding of viruses and vaccinations. I have found a mentor, Dr. Kawsar Talaat, researching newly developed vaccines.

Epigenetics and CRISPR
Marie Louise Abbey Badiola

The topic that I have taken an interest in is molecular biology. Epigenetics and CRISPR can be used to advance the medical field. Epigenetics is the study on how heritable changes in gene expression do not involve changes to the underlying DNA sequence. The debate on whether a person is the way they are is due to the way they were raised, or they were born that way is what the topic of epigenetics can help. CRISPR, my other topic, is a tool that can change the DNA of an organism. The study on gene drives and modifying embryos can show us a few uses for CRISPR. We can learn a lot about how we may live in a future where there are no diseases and pests to harm the economy. In an experiment explaining the differences in twins, we can see how epigenetics can explain how our environment, diet, and social conditions can affect which genes are expressed and which aren't. I plan on continuing with research practicum and I will be working in a lab with Dr. Maya Gomes and Dr. Emmy Smith. Their research focuses on topics such as the Cambrian explosion and its environment at the time.

Hybrid Organic-Inorganic Perovskite (HOIP) Technology in Photovoltaic Cells
Caleb Clark

HOIP technology is a relatively new form of solar generation. It has grown the level of efficiency of silicon cells in only eight years. HOIP solar cells are cheap and easy to manufacture but contain lead which is toxic to the environment. Researchers have found that perovskite structure reacts to light in a way that prevents interference from defects in the surface material. Additionally, they have found a way to narrow the band-gap so that the most light is accepted and transformed into electrical energy. Finally, researchers have engineered a nano-camera that analyze high efficiency and low efficiency areas of the HOIP cells. Advancements in HOIP technology are necessary because fossil fuels are a nonrenewable resource and the sun is one of the few reliable sources of power. Future research should try to either isolate or remove the lead that is present in HOIP structure, as lead is toxic to humans and the environment. Additionally, further research into extending the lifespan of HOIP solar cells should be conducted, because the current lifespan is only five months. I plan on continuing work with research practicum. I would like to find a mentor in an environmental science department, as sources of renewable energy are a branch of sustainability and environmental science.

Sophomore Abstracts

Epigenetic Application in Medicinal Research
Miriam Herrera

Epigenetics is the study of changes in gene expression and how they can be inherited. It is already known that epigenetic mechanisms can be used to silence the expression of potentially harmful genes and that these changes may potentially be inherited. The research presented uses epigenetic mechanisms to help identify/ solve problems related to the usage of the epigenome. Such research can help us gain a greater understanding of how epigenetics can be used to improve human health. The first study demonstrates the ability to use abnormal gene expression as a biomarker to identify dementia, which thus helps scientists to develop cures and solutions for it. The other two studies presented both offer potential solutions to age-related deterioration and cancers. They suggest integrating epigenetic mechanisms into cancer treatment or using them to alter gene expression and produce a positive, combative effect. In accordance with this research I have looked for placement in research lab that focuses on either the effects of epigenetics or genetics in organisms, which I have found in the research lab of Dr. Andrew Gordus.

Bacteria Derived Drugs and Pharmacokinetics
Maya Pulliam

Pharmacology focuses on the use of microbiology. This includes the use of bacteria derived drugs and the pharmacokinetics and pharmacodynamics of drugs. The first study I looked at was an experiment using genetically modified baker's yeast to produce artemisinic acid (a compound used to treat malaria) through fermentation. Another experiment looked at the steps in making morphine from opium poppy. Researchers found the missing DNA strand out of an opium poppy plant that could not produce morphine. They were able to find what instructions were needed to create morphine and confirmed their results by injecting the DNA strand into an E. coli bacterium. The last experiment I looked at focused on the pharmacokinetics and pharmacodynamics of a drug. Originally researchers were looking at how felodipine reacts with alcohol, but instead found that it reacts with grapefruit juice in a way that causes it to not be fully broken down by the body. Pharmaceutical research like this is essential for aiding and expanding the lives of humans and has already been used to do so globally. I do plan on continuing with Research Practicum. Under the mentorship of Dr. Dionna Williams, I plan to conduct research relating to HIV-associated neurocognitive diseases.

CRISPR's Present and Future Applications in Genetically Modifying Organisms
Colton Ross

I am interested in studying genetic engineering with a focus on using CRISPR to edit animal embryos. CRISPR is a tool used to genetically modify organisms. I recently read about a late 2017 study in which Chinese scientists were able to effectively engineer a pig with CRISPR-Cas9 to allow it to maintain homeostasis better by burning fat to keep warm. Another research article published in October of 2017 detailed how a new type of genetic modifying tool, CRISPR-Cas13 was used to accurately modify RNA rather than DNA and make reversible changes. Finally, a research article published in August of 2017 explained how U.S. scientists were able to effectively modify a mutation from a human embryo. All of this research helped contribute to the further improvement of genetic engineering tools which brings humans closer to genetically engineer humans and animals on a larger scale, changing the lives of humans with genetic disorders and allowing for more abundant food production. I will be studying ribosomes under my mentor, Dr. Green, in the Green Lab at the Johns Hopkins School of Medicine from the summer of 2018 until the summer of 2019.

Sophomore Abstracts

Urban Agriculture
Helen Schott

Urban agriculture includes the indoor and outdoor growth of plants in an urban setting, including gardens, farms, and technologically advanced forms, such as hydroponics, aeroponics, and green roofs. Urban agriculture is a subset of urban ecology which covers the limitations to urban agriculture and its interactions with climate change. One major concern to urban agriculture is lead contamination in urban soil, but studies show that fruits of crops grown in lead contaminated soil do not contain detectable amounts of lead. Climate change is also a concern to urban agriculture; although increases in CO2 and temperature can positively affect plant growth, dramatic increases in temperature, and the presence of air pollutants associated with climate change and human activity, decrease plant growth. Urban agriculture also has the potential to decrease the immediate effects of climate change by reducing the Urban Heat Island effect, through absorbing solar radiation. Urban agriculture has the potential to make cities more sustainable, decrease the effects of climate change, and take pressure off of industrial agriculture. I will work with Dr. Christopher Swan, who studies wildflower growth on vacant lots in Baltimore City, to restore biodiversity and reduce runoff.

CRISPR: The Gene Editing Phenomenon
Mya Smith

My main field of interest is molecular genetics in the field of molecular biology. My main topic CRISPR is involved in a lot of current research studies. CRISPR has been used in one study where scientists injected it into liver cells in mice, which was interesting because it can help give information on how to use CRISPR in human liver cells. Another study was when scientists used CRISPR in cells of mice yet again, but this time, it was used to help gain more information about Duchenne muscular dystrophy (DMD). This study can also help scientists gain information about DMD in human cells. A final study was the first time a U.S. team edited human embryos using CRISPR. This was a milestone for gene editing because it had only been done once before. There is a lot to come for CRISPR now that it has gained popularity and has become quite the phenomenon. Not only can it be used to edit embryos to help eliminate diseases, but the concept of "designer babies"; babies that are in our eyes perfect, isn't far off either. I do want to continue with Research Practicum, and Dr. Daniela Drummond-Barbosa at the Bloomberg School of Public Health will be my mentor. I will be studying Drosophila genetics in her lab.

The Science Behind Epigenetics
Donaysia Torbit

The general field that I am interested in studying is epigenetics. Epigenetics is the study viewing changes in a gene expression without altering the DNA sequence. It relates to the study of epigenetic inheritance, epigenetic tags, and phenotypic behavior. Epigenetics is an open area of research where scientists are trying to figure out the influence of human factors in the process. A current research project being analyzed through epigenetics is its influence on nutrients. Researchers have begun analyzing specific nutrients and seeing if someone's gene expression affects their consumption efficiency level. Another current research project was analyzing the influence of learned behavior on a particular species and seeing the effects on its offspring. The last current research project I examined was the development of gene expression based on phenotypic behavior. In the future scientists hope to understand which tags are altered during gene expression. They know in a broad sense if the gene expression is repressed or activated, but they don't know the tag being altered. Continuing on with Research Practicum, and I will be working with Eugenia Volkova in the Gerecht Lab at Johns Hopkins.

Sophomore Abstracts

Immunotherapies
Raekwon Williams

Immunology is the study of how organisms kill and fight off diseases. There are two types of systems that assist in fighting diseases: adaptive and innate immunity. The adaptive immunity is changed to effectively eliminate invading microorganisms. The innate immune system lacks the complexity of the adaptive immune system. Researching innate and adaptive immunotherapy methods could help establish treatments for diseases and infections. The first study presented considered immunotherapies used for cancer. The survival of these diseases is a result of bonds with proteins and sugars on the surface of the cells and the immune cells. The second study focused on understanding changes in T cells with age. They have different forms and can lose genes as time passes. The loss of these genes causes the cell to become toxic. Results showed that drinking wine can prevent aging of T cells. The final study researched how a bacteria such as B. dellovibrio can kill other bacterial strains such as E. Coli, Shigella, and Pneumonia. I plan on participating in research practicum during my junior year. I am interested in medical topics such as immunology, which consist of researching how the immune system works and how it can be altered to yield desired results.

Solar Energy Propulsion in Space Crafts
Sam Yoseph

Aerospace engineering is a branch of mechanical engineering that focuses on the building and developmental design of a spacecraft using applied physics. The three studies I pursued involved an area of focus on solar electric propulsion (SEP). SEP has often been discussed conceptually, but this mission applies it to vehicles used to transport material and orbit around astronomical bodies to collect data. The SMART-1 Mission uses SEP to perform fly-bys, rendezvous missions, and weak capture missions from the Earth to the moon. An explorer program found a way to reduce zodiacal background, enabling broad-band imaging by increasing observatory performance through 2 AU orbit done using SEP. The research in developing a craft that runs on solar energy can revolutionize human travel and exploration methods and prolong missions so a craft could travel further to collect more data. I plan on continuing research practicum at Johns Hopkins under Dr. Soojung Claire Hur. Dr. Hur works in the Department of Mechanical Engineering and develops microfluidic mechanics to work with fluid dynamics and study cellular functions. I would like to study inertial focusing, which takes observations of microchannel flow and manipulates it to filter particles based on shape or size.

Air Pollution Epidemiology
Fiona Zabel

My research focuses on air pollution epidemiology, specifically the link between environmental pollutants and cognitive loss. My research explores a study on cognitive loss in elderly men who had previously been exposed to black carbon. I encountered a study showing that exposure to air pollution can worsen the effects of hereditary neurodegenerative diseases such as Amyotrophic Lateral Sclerosis (ALS). Finally, I reviewed a study regarding a cognitive loss in young children based on children from a polluted city compared to children in a less polluted city. The researchers found severe deficits between the groups of children. This research is imperative to study the impact of air pollution on human health and the impending health deficits that are caused by pollution. This research is currently utilized to impact public policy. This field's expansion focuses on studying the effects of these pollutants after a cognitive loss has already been inflicted. The field is identifying specific pollutants which cause severe problems and studying how to minimize their effects. I will be researching at the Bloomberg School of Public Health under Dr. Carlson. I will be participating in a study surrounding the tracking ability of Alzheimer's using virtual reality gaming surrounding a cognitive loss. This study will involve collecting data over time on the participant's success in the cognitively testing game.

Sophomore Interest Statements

Sustainable Architecture
Noah Lee

I am very curious about the field of sustainable architecture, and how to develop it for even greater work. I am interested in designing/developing structures that are functional, stylish, and efficient for both work and the surrounding environment without using too many resources for production or maintenance. I am excited to explore different techniques for accomplishing this goal, whether that be through the use of renewable energy, green materials, efficient designs, or a combination of these and other techniques. Currently, I do not have a mentor, but I am looking into fields such as ecological design, environmental engineering, and environmental sustainability in order to get a general understanding/skills for the future. A potential mentor for myself is Dr. Monique Head, who is in the Department of Civil Engineering and Center for the Built Environment and Infrastructure Studies at Morgan State University. I look forward to working with Dr. Head or any other potential mentors this summer.

Structural Engineering
Alex Nishiura

I am interested in structural engineering. I want to learn more about how material and structural design impact building strength in extreme or unusual forces like seismic events. I'm also curious about how structural design can allow for more freedom with artistic design and space while maintaining building strength. I am going to be working with Dr. Benjamin Schafer at the Johns Hopkins department of Civil Engineering. He has worked on research on structural integrity during seismic events with thin walled manufactured steel. He also uses laser modeling to figure out how much manufactured parts deviate from actual specifications they are supposed to fit. His findings are implemented into actual industry building code.

Cross-Modal Plasticity
Jarra Omar

I have always been interested in neuroscience after reading the book Gifted Hands by Ben Carson. In my introduction to research class I've further focused this interest to understanding memory and how exactly the brain works and functions. I will be researching under Dr. Hey Kyoung Lee in the Zanvyl Krieger Mind/Brain Institute at Johns Hopkins University. Dr. Lee is interested in the cellular and molecular changes that happen at synapses to allow memory storage. Currently, the goal of her research is to explain the mechanisms underlying cross-modal synaptic plasticity which is when the brain makes changes to our neural connections when a sensory function is lost. When this occurs, your brain will heighten your other senses in order to compensate for the loss of another.

Sophomore Interest Statements

The Composition of Mars
Isaiah Roberts

I am interested in the Earth and Planetary Sciences since in this day and age that field is becoming more important. A lot of research is going towards planetary science, and I believe that it won't be too long before man sets his foot on the red planet. Specifically, I would like to understand the composition of Mars, look for possible past life on Mars, and study other interesting things about the red planet. I will be working with Dr. Kevin Lewis in the Department of Earth and Planetary Sciences at the Krieger School of Arts and Sciences at Johns Hopkins University. Dr. Lewis's research focuses on problems in planetary geophysics. Specifically, he has worked on the nature and properties of sedimentary rocks on Mars and how they could relate to the planet's past composition.

Immune Response and T-Lymphocytes
Trinity Stephen

I am very interested in attempting to understand immune response, specifically, the adaptability of T-lymphocytes. I would like to understand how these cells use immunological memory and how the cells' ability to be genetically modified can be implemented into many different topics of concern. I also would like to understand more about the significance and function of different sub-groups of T lymphocytes. Currently, I am looking for potential mentors in the fields of cell biology and pathology at the Johns Hopkins School of Medicine. I will be looking for professors with research in at least one sub-group of white blood cells, but it would be even better if he/she has a direct focus on T-lymphocyte. I am hoping to work with one of 120 full-time faculty members in the Department of Pathology at the Johns Hopkins School of Medicine that study many aspects of pathology, including immunology.

Class of 2018: College Acceptances

* denotes the college /university the senior will be attending

Moufidatou Adedoyin
Dartmouth University
Johns Hopkins University (Baltimore Scholar)*
Lafayette College
Morgan State University
University of Maryland, Baltimore County
University of Maryland, College Park (Honors Program)
Washington University in St. Louis (Danforth Scholar)
Williams College

Dexter Amata
Bucknell University
Johns Hopkins University
UMBC (Meyerhoff Scholar)
University of Maryland, College Park

Audrey Bernier
Maryland Institute College of Art*
Moore College of Art and Design
Savannah College of Art and Design

Shiwani Bishwokarma
Howard University
Temple University
University of Maryland, College Park*

Robert Blanchard
Carnegie Mellon University
Case Western Reserve University
Duke University
Georgia Institute of Technology (School of Engineering)
Johns Hopkins University
Ohio State University (College of Engineering)
University of Maryland, Baltimore County
University of Maryland, College Park (Honors Program, Banneker /Key Scholar)*

Vivian Borbash
Carnegie Mellon University (Engineering)
Drexel University (Honors Program and Stars Program)
University of Maryland, College Park (Honors Program)*

Sherry Bossard
Johns Hopkins University (Baltimore Scholar)*
University of Maryland, Baltimore County
Williams College

Max Breitmeyer
University of Maryland, Baltimore County*
US Coast Guard Academy

Rebecca Brody
Emory University
Pennsylvania State University (Schreyer Honors College)
University of Maryland at College Park (Honors Program, Banneker/Key Scholar)
Williams College*
Washington University in St. Louis

Cecilia Charney
Illinois Institute of Technology (Architecture Program)*
North Dakota State University (Architecture Program, Honors Program)
Northeastern University (Architecture Program)
Pennsylvania State University (Architecture Program, Honors Program)
University of Maryland, College Park (Honors Program, Banneker/Key Scholar)

Iven Chen-Van Dyk
University of California, Los Angeles*
University of Maryland, College Park (Scholars Program)
University of Nevada, Las Vegas (Honors Program)

Justin Damon
Howard University
Temple University
University of Maryland, Baltimore County (Meyerhoff Scholar)*
University of Maryland, College Park

Elijah Dukes
Case Western University
Cornell University*
Johns Hopkins University (Baltimore Scholar)
McDaniel College
Northeastern University
Northwestern University

Class of 2018 College Acceptances

Elijah Dukes (continued)
University of Maryland, Baltimore County
University of Pittsburgh
Washington University in St. Louis

Caterina "ShinShin" Erdas
Goucher College
Lafayette College (Marquee scholar)
University of Maryland, Baltimore County
University of Maryland, College Park
University of Richmond*

Jace Geiger
Towson University*

Nick Good
North Carolina State University
University of Maryland, Baltimore County
University of Maryland, College Park (Scholars Program)*
Worcester Polytechnic Institute

Hannah Greene
Colby College
Johns Hopkins University (Baltimore Scholar)
New York University in Abu Dhabi*
Northeastern University
Pomona College
St. Mary's College of Maryland

Estefan Gudino
Goucher College
Morgan State University
University of Maryland, Baltimore County*

Sophia Hager
Carnegie Mellon University
Luther College
Mt. Holyoke College
Smith College*

Anders Hartmark
New Jersey Institute of Technology
The Ohio State University
University of Maryland, College Park (First-Year Innovation & Research Experience)
University of North Carolina – Chapel Hill*
University of Maryland, Baltimore County

Michael Heck
Fordham University
University of Maryland, Baltimore County
University of Maryland, College Park (Scholars Program)*

Robert Henry
University of Maryland, College Park*

Russell Huntley
James Madison University
Rutgers University
Towson University
University of Maryland, College Park*

Emily "Drew" Junker
Tulane University
University of Maryland, College Park
University of Miami
University of South Carolina (Honors College)*

Sydney Junker
Tusculum College*

Faheel Kamran
University of Maryland, Baltimore County*
University of Maryland, College Park
Drexel University

Alexander Li
University of Maryland, College Park*

Azeem Lyons
University of Maryland, College Park (Scholars Program)*

Mikell Myers
Morgan State University
University of Maryland, College Park
University of Southern California*

Jacob Noffsinger
University of Maryland, College Park*
Virginia Tech

Class of 2018 College Acceptances

Duncan Parke
Capitol Technology University
Johns Hopkins University* (Baltimore Scholar)
University of Maryland, College Park (Scholars Program)
University of Washington, Seattle
University of Wisconsin, Madison

Phoebe Parker
McDaniel University
Northeastern University
University of Maryland, College Park
University of Pittsburgh*
University of Rochester
University of Maryland, Baltimore County

Jaylin Roundtree
College of St. Rose*
Frostburg State University
Morgan State University
Notre Dame University of Maryland

Belen Rugerio-Mejia
Guilford College
Notre Dame University of Maryland
Smith College*

Mahmoud Shalby
University of Maryland, Baltimore County*
University of Maryland, College Park (Engineering)
University of Miami

Ian Simko
Johnson & Wales University (Providence)*

Isaac Spokes
Brown University
Dartmouth University*
McGill University
University of Maryland, College Park (Honors College)
University North Carolina, Chapel Hill (Carolina Research Scholar Program)
University of Rochester
University of Virginia

Ezra Szanton
George Washington University
New York University
Temple University
Tufts University*
University of Maryland, College Park

Mercedes Thompson
Alaska-Pacific University
Baylor University
Duke University
Eckerd College
Emory University
Fordham University
Grinnell College
Johns Hopkins University (Baltimore Scholar)
Stanford University*
Tulane University

Justin Watford
Bowie State University
Howard University
Morgan State University
Towson University
University of Maryland, Baltimore County (Friend of Meyerhoff Scholars)*

Claire Wayner
Princeton University*
University of Michigan

Notable College Scholarships

2018 Baltimore Scholars

Six Ingenuity students received scholarships to the Johns Hopkins University: Moufidatou Adedoyin, Sherry Bossard, Elijah Dukes, Hannah Greene, Duncan Parke, and Mercedes Thompson

Brower International Youth Award: Mercedes Thompson and Claire Wayner

Bucknell University – Charles T. Bauer Scholarship: Dexter Amata

Coca-Cola Scholarship: Mercedes Thompson

Elks Most Valuable Student Scholarship: Mercedes Thompson, Claire Wayner

Lafayette College: Marquis Grant & Scholarship: Moufidatou Adedoyin

Ron Brown Scholarship: Elijah Dukes

Tulane University – Distinguished Scholar Award: Mercedes Thompson

University of Maryland, College Park Banneker/Key Scholars: Robert Blanchard and Rebecca Brody

University of Maryland, College Park Incentive Award: Moufidatou Adedoyin

Williams College Scholarship: Sherry Bossard

To date, the Class of 2018 has earned well over $7,000,000 in scholarship money!

Research Awards and Honors

The Regeneron Science Talent Search

Rebecca Brody and **Claire Wayner** were selected as scholars (or semi-finalists) in the 2018 Regeneron Science Talent Search (formerly named Intel Science Talent Search). Rebecca completed her project at the Johns Hopkins University Department of Chemical and Biomolecular Engineering. Dr. Sharon Gerecht and graduate student Bria Macklin mentored Rebecca as she grew stem-cell-derived blood vessel cells to understand the effects of low oxygen on these cells which could have potential implications for tissue repair and regeneration. Claire investigated how bacterial biofilms impact the movement of *E. coli* pollution through engineered infiltration systems used for filtering storm water. She conducted her research in the Department of Environmental Health and Engineering at Johns Hopkins University under the mentorship of Dr. Sarah Preheim and graduate students, Andrea Fraser and Yue Zhang. Scholars were selected from more than 1,800 applicants hailing from 555 high schools in 45 states and six overseas high schools. Since 2005 twelve Ingenuity at Poly students were named Intel/Regeneron semifinalists and three of them were named Intel winners.

The Baltimore Science Fair (BSF)

Sponsor Awards at BSF

Grand Prize for Biological Science: **Lily DeBell** for her project "Characterization of Optimal Protospacer Structure for Adaptation in Type I-E CRISPR-Cas Systems." She attended the 2018 International Science and Engineering Fair in Pittsburgh, PA in May.

1st Place for Biological Science: **John Halpin**

2nd Place for Biological Science: **Rebecca Brody**

Honorable Mention for Physical Science: **Rohan Kane**

Honorable Mention for Biological Science: **Nathaniel Alper**, **Claire Wayner**

Special Awards by Independent Groups at BSF

United States Army Award of Merit for an Outstanding STEM Project: **Claire Wayner**, **Omobolade Odedoyin, Mercedes Thompson**

Office Naval Research—Naval Science Award for Outstanding Scientific Achievement: **Rebecca Brody**

National Society for Black Engineers, Baltimore Metropolitan Professionals Chapter: **Omoboloade Odedoyin, Claire Wayner, Mercedes Thompson**

Arizona State University Walton Sustainability Solutions Award: **Claire Wayner**

Society for *In-Vitro* Biology — Most outstanding 11th grade exhibit: **Rachel Pontious**

National Institute on Drug Abuse, NIDA, Intramural Research Program: **Karen Griffin** – 1st Place Award (mentored), **Mercedes Thompson** – 3rd Place Award (mentored), **Evains Francois** – 3rd Place Award (non-mentored)

National Space Society Best Space-Related Project :**Rohan Kane**

International Council on Systems Engineering – Chesapeake Chapter: Honorable Mention Achievement in Science and Engneering: **Elizabeth Zheleznyakova**, **Evains Francois**

Intel Excellence in Computer Science Award: **Elizabeth Zheleznyakova**

Towson Fisher College of Science and Mathematics Dean's Award for Excellence in Science: **John Halpin**, **Lily DeBell**

Research Awards and Honors

Marine Science Paper Competition

Claire Wayner's paper has been awarded 1st place prize at the Marine Science Paper Competition of American Salvage Association and North American Marine Environmental Protection Association. Claire was awarded $500.00 and was invited to attend the awards dinner at PIER A in New York City.

Stockholm Junior Water Prize Competition

Claire Wayner won the U.S. Stockholm Junior Water Prize Regional Award and was announced as the Maryland State Champion. She has been invited to compete at the Stockholm Junior Water Prize National Competition in Charlotte this summer.

Maryland Junior Science and Humanities Symposium 2018 (JSHS)

Oral Presentation Awards

2nd place – **Lily DeBell** – Lily was awarded a $1,500 scholarship and trophy. She attended the National JSHS Competition in April with her project "Characterization of Optimal Protospacer Structure for Adaptation in Type I-E CRISPR-Cas Systems"

3rd place – **Sophia Hager** - Sophia was awarded a $1,000 scholarship and trophy. She attended the National JSHS Competition in April with her project "Examining the Effects of Common Mosquito Repellents on the Olfactory System of the Malaria Mosquito, *Anopheles Gambiae*"

Poster Presentation Awards

1st place – **Caterina (ShinShin) Erdas** - ShinShin was awarded a $300 scholarship and trophy. She attended the National JSHS Competition in April with her project "A Chagas Disease Multiplex PCR Diagnostic"

2nd place – **Moufidatou Adedoyin** - Moufie received a trophy and attended the National JSHS Competition in April with her project "Developing a Reporter System for Exosome Fusion"

National Junior Science and Humanities Symposium 2018

Lily DeBell won 3rd place at the national competition for her oral presentation in the category Molecular/Cellular Biology. Lily was awarded a $4,000 scholarship and a medal.

Mathematics Achievements

Future Scholars Program

Colton Ross and **Elizabeth Zheleznyakova** have been accepted into the Future Scholars Program at the Johns Hopkins University Department of Mathematics. The Future Scholars Program is an opportunity for high school seniors to take college math classes for Johns Hopkins credit.

Vivian Borbash, **Ezra Szanton**, and **Claire Wayner** successfully completed math courses this year at Johns Hopkins University as Future Scholars.

University of Maryland College Park High School Mathematics Competition

Best solvers: **Gerson Kroiz**—88 points, **Colton Ross**—84 points,
Isaac Spokes—82 points, **Robert Blanchard**—72 points

American Mathematics Competition (AMC)

Ingenuity team won 2nd place in Baltimore City.

Among best scorers in the State of Maryland, **Colton Ross** shared places 33-38
and **Gerson Kroiz** shared places 39-47.

Ingenuity team also included **Duncan Parke**, **Isaak Spokes** and **Ezra Szanton.**

Maryland Math League

Best solvers: **Colton Ross**—23 points, **Gerson Kroiz**—22 points,
Ezra Szanton—17 points, **Isaac Spokes**—15 points, **Duncan Parke**—7 points

Average SAT Scores for the Class of 2018

Math—735, Reading-700

800 SAT and SAT 2 Scores

Lily Batchelor: 800 Math, 800 Math 2, 800 Chemistry, 800 Reading
Robert Blanchard: 800 Math 2
Vivian Borbash: 800 Math 2
Alida Schott: 800 Biology, 800 Math, 800 Reading
Isaac Spokes: 800 Math 2
Claire Wayner: 800 Biology, 800 Math, 800 Math 2, 800 Reading

Ingenuity Award Descriptions

The Leadership Award is presented to the student in each grade level who has demonstrated outstanding leadership, as well as initiative in helping others and contributing to the welfare of the whole high school community as noted by their peers and teachers. Seniors who receive this award are also presented with a college scholarship.

The Camaraderie Award is presented to the student in each grade level who demonstrates amiability and a collaborative nature, as noted by their peers and teachers. Seniors who receive this award are also presented with a college scholarship.

The Scholastic Balance Award is presented to the student in each grade level who demonstrates dedication to their extracurricular activities (e.g. sports, jobs, clubs, etc.) and effectively balances their activities with their school work. Seniors who receive this award are also presented with a college scholarship.

The Community Betterment Award is presented to the student in each grade level who demonstrates outstanding dedication to helping and giving back to their communities through hours of volunteering in school clubs or outside organizations. Seniors who receive this award are also presented with a college scholarship.

The Research Poster Award is presented to the student in **each grade level** with the most captivating research topic and excellent poster design as noted by faculty, staff, and students.

The Stephanie Franklin Miller Research Scholarship is presented to the **junior** who has demonstrated outstanding dedication to research and the overall significance of their research. The award is presented by Ms. Miller who selected this student based on a written submission. The award has been established by Ms. Miller's family in recognition of her career-long dedication to education, notably her service as Ingenuity's first science curriculum coordinator.

The 13th Annual Karol S. Costa Ingenuity Award is presented to the student in each grade level who demonstrates outstanding inventiveness, originality, and ingenuity in the classroom, as noted by their peers and teachers. The Board of Directors established this award in 2005 in grateful recognition of Ms. Costa's contribution as the Founding Director of the Ingenuity Project. Seniors who receive this award are also presented with a college scholarship.

The Dolores Costello Tenacity & Grit Award is being presented to the student in each grade level who, despite encountering challenges, has demonstrated the perseverance, effort, self-advocacy, resiliency and passion to achieve long-term academic and personal goals.

Ingenuity Award Descriptions

Seniors Only

The Science Achievement Award is presented to the **senior** who consistently has demonstrated outstanding overall achievement in science.

The Math Achievement Award is presented to the **senior** who consistently has demonstrated outstanding overall achievement in Math.

The STEM Achievement Award is presented to the **senior** who has distinguished himself or herself through exceptional work in computer science, computer engineering, or data science in or out of class.

The Nancy Forgione Humanities Scholarship is presented to the **senior** who has demonstrated outstanding achievement in social science and humanities as noted by his or her humanities and social science teachers. The Hill family (Owen, class of 2006 and Albert, class of 2003) established this award in loving memory of their mother.

The Mathematics Originality and Creativity Award is presented to the **senior** who has broadened the knowledge of the class as a whole by proposing innovative methods of solution and unique perspectives regarding seemingly ordinary problems as determined by the primary mathematics teacher.

The Mathematics Problem Solving Award is presented to the **senior** who consistently has demonstrated advanced topical skill and has received outstanding competition scores, as applicable as determined by the primary mathematics teacher.



Adedoyin, Moufidatou | Amata, Dexter | Batchelor, Lily | Bernier, Audrey | Bishwokarma, Shiwani | Blanchard, Robert | Blazey, Sebastian



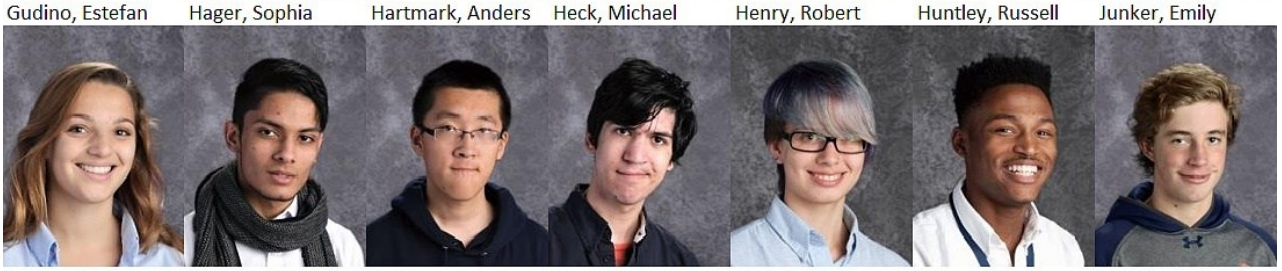
Borbash, Vivian | Bossard, Sherry | Breitmeyer, Max | Brody, Rebecca | Charney, Cecilia | Chen-Van Dyk, Iven | Damon, Justin



Dukes, Elijah | Easton, Xander | Erdas, Caterina | Evangelista, Joseph | Geiger, Jace | Good, Nicholas | Greene, Hannah



Gudino, Estefan | Hager, Sophia | Hartmark, Anders | Heck, Michael | Henry, Robert | Huntley, Russell | Junker, Emily



Junker, Sydney | Kamran, Faheed | Li, Alexander | Lyons, Azeem | Miciche, Hailey | Myers, Mikell | Noffsinger, Jacob



Parke, Duncan | Parker, Phoebe | Pierce, Conor | Roundtree, Jaylin | Rugerio-Mejia, Belen | Schott, Alida | Shalby, Mahmoud



Simko, Ian | Spokes, Isaac | Szanton, Ezra | Thomas, William | Thompson, Mercedes | Watford, Justin | Wayner, Claire

Class of 2018



Ahmed, Sumaita | Allston, Ayden | Alper, Nathaniel | Anderson, Erika | Berry, Amanda | Booker-Godfrey, Taylor | Brooks, Roger



Calderon, Matias | Caverly, Keara | Clark, Khayree | Cole, Chelsea | DeBell, Lily | Dillow, Brandon | Francois, Evains



Frock, Christopher | Glaros, Corbett | Goldsmith, Lily | Griffin, Karen | Halpin, John | Harkness, Samuel | Henley, Camille



Holland, Ula | Honablew, Timothy | Howarth, Michael | Hudnall, Faith | Kane, Rohan | Lai, Ryan | LaVorgna, Cecilia



Legaspi, Raquel | Martin, Ruth | McCullum, Chenille | McIlwain, Daisha | McKenna, Abigail | Mokaya, Michelle | Mwangi, Adi



Odedoyin, Omobolade | Onyeje, Chiad | Owens, Ifasoke | Pearson, Christian | Pontious, Rachel | Rivera Lavaire, Nayely | Rodesno-Hercules, Henry



Tsung, Wilfred | Weiss, Alyssa | Young, Taylor | Zheleznyakova, Elizaveta

Class of 2019



Class of 2020



Class of 2021



Nelms, Wayne | Odeh, Patience | Paranilam, Jaela | Parmer, Eli | Petros, Mason | Pham, Nicholas



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



Samuel, Logan | Sanchez-Alvarez, Jor | Schmitz, William | Schwartz, Tejal | Scott, Mariah | Selim, Sheikh



Simcox, Talya | Smith, Kristiana | Smith, Presley | Spahn-Rodriguez, Si | Tagaytay, Frank | Thomas, Devon



Thomas, Kyle | Thompson, Chelsea | Thompson, Jacob | Torregoza, Agnes Al | Uma, Chielota | Villahermosa, Aaron



Weybright, Zachary | Wilder, Morgan | Williams, Elijah | Zheng, Jennifer | Zurlage, Kyla

Class of 2021

Acknowledgements

The Ingenuity Project would like to acknowledge the support of: Baltimore City Public Schools and the foundations which support our program: Abell Foundation, T. Rowe Price Foundation, Lockhart Vaughan Foundation, Joseph and Harvey Meyerhoff Family Charitable Funds, Thomas Wilson Sanitarium for the Children of Baltimore City, Goldseker Foundation, Harry and Jeanette Weinberg Foundation, Jacob and Hilda Blaustein Foundation, Hoffberger Family Philanthropies, Robert W. Deutsch Foundation, and Alvin and Fanny B. Thalheimer Foundation.

Our supporters maintain Ingenuity as the longest-standing advanced STEM program in Baltimore City.

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

Ingenuity Project Board of Directors

Ben Yuhas. Ph.D. **(Chair)**
Steven A. Farber. Ph.D. **(Vice Chair)**
Andrea Bowden, Ph.D.
Ariel S. Bowers
Raveesh Dewan
Harris W. Eisenstein, Esq.
Christopher P. Gibson
Bonnie Legro, MAT **(Secretary)**
Peter J. Griffin III **(Treasurer)**
Douglas E. Harrison, MBA
Stephanie Miller, MAT
Lara Ohanian
Gary Pasternack, M.D. Ph.D.
James E. West

Ingenuity Project Staff

Executive Director	Lisette Morris, M.S.	Dean of Research	Lisa Fridman, M.S.
Associate Director	Sergei Zverev, Ph.D.	Admission Coordinator	Jocilyn Harris, MSW
Dean of Students	Gale Fletcher, M.S.	Dean of Student Engagement	Shani Ortiz, M.A.
Math Department Head	Mikhail Goldenberg, Ph.D.	Office Manager	Keyha Royster
Development Associate	Jamie Cole	Computer Lab Supervisor	Shannon Katona

Baltimore Polytechnic Institute Administration

Director	Jacqueline Williams	Guidance Chair	Kathryn Wickham
Dean of Academic Services	Gretchen Lawson	Guidance	Jennifer Askey
Dean of Discipline	Renay Riddick	Guidance	Dwayne Green
Dean of Technology	Brian Ray	Guidance	Christian Lorenzo
Dean of Curriculum and Instruction	Matthew Woolston	Guidance	Wanda Williams
Business Manager	Mark Sawyer	College-Bound	Anthony Harold
		College-Bound	Beth Green

Symposium Committees

Publicity	Lily DeBell, John Halpin, Abby McKenna, Rohan Kane
Event Night	Sumaita Ahmed, Tori Legaspi, Evains Francois, Omobolade Odedoyin
Program	Karen Griffin, Nathaniel Alper, Rachel Pontious, Elizabeth Zheleznyakova
Awards	Chiad Onyeje, Ruth Martin, Michelle Mokaya, Taylor Young