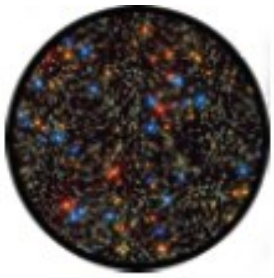


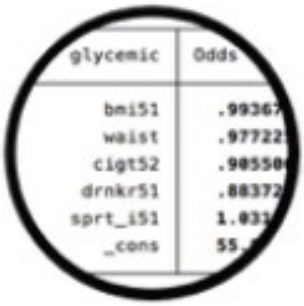
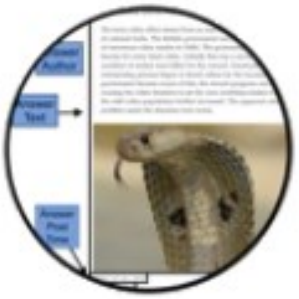
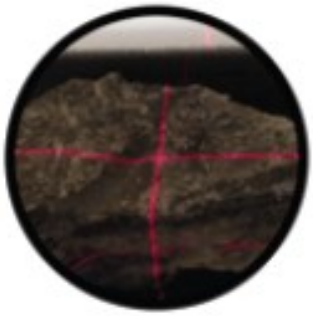
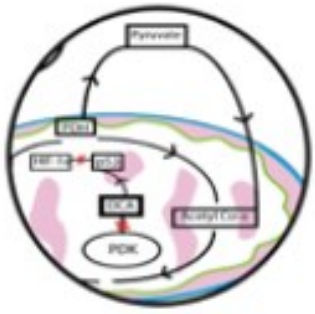



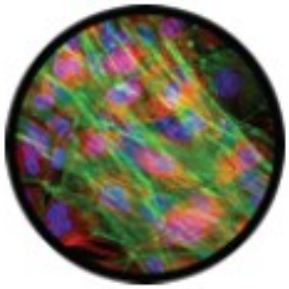
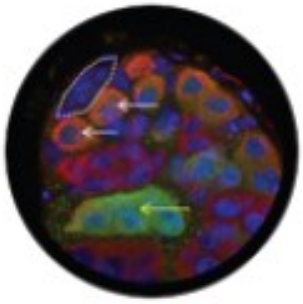

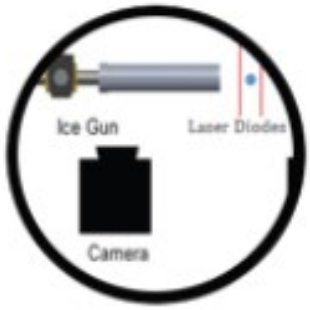
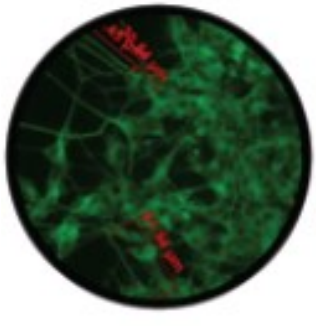
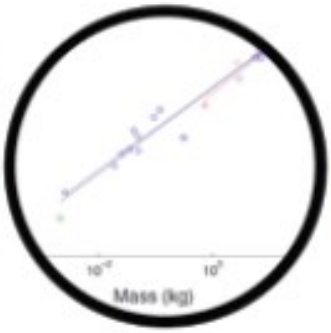


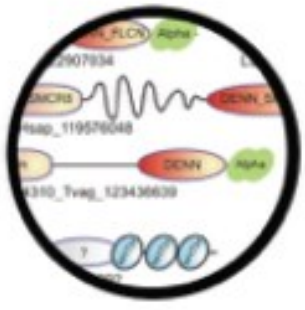

13th Annual Ingenuity Math & Science Symposium

May 21. 2015

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(Cover art by Will Povell)

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MCs: Cullen Bray, Kathy Le

PRESENTATIONS

6:40-6:55 **Banneker Hall** – Analyzing and Placing Limits on Light Curves Gen erated from HST/COS White Dwarf Data
Phoebe Sandhaus
Room 121 – Solving Cubic and Quadratic Equations
Allen (Lane) Easterling & Tula Raghavan
Room 119- Lateral Force Scaling During Legged Locomotion
Morgan Hobson & William (Gus) Meisner

7:00-7:15 **Banneker Hall-** The Development and Evaluation of a 3D-Printed Body Powered Prosthetic Hand
Karam Lyons
Room 121- The Effects of the Arts on Student Learning and Retention
Charlotte Fulwiler
Room 119 - Vectors and their Applications
Steven Tran & Spiros Reda

7:15-7:25 BREAK

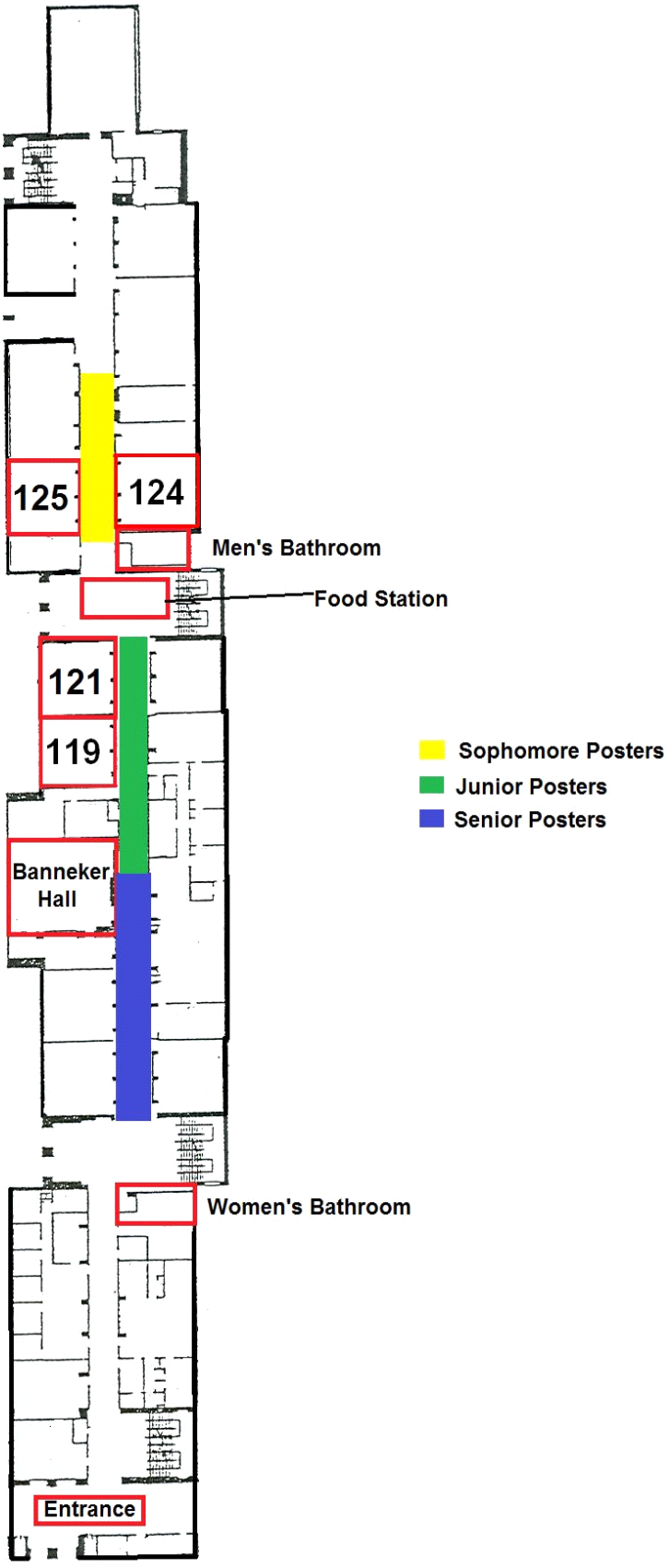
7:25-7:40 **Banneker Hall–** JHU Calculus BC Test
Benjamin Aladejebi & Omar Mahmoud
Room 121-Risk factor control in older adults with diabetes
Ina Rastegar
Room 119 - Dynamic Fragmentation of Saturn's E Ring Particles
Allen (Lane) Easterling

7:45-8:00 **Banneker Hall-** Acriflavine: A Novel Treatment for Glioblastoma Multiforme
Tula Raghavan
Room 121 – Trigonometry as a Tool
Morgan Hobson & Karam Lyons

AWARDS CEREMONY

8:05-8:45 **Banneker Hall**
MCs: Luc Renaux , Eterick Stonely

Map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The High School Program

Baltimore Polytechnic Institute

Baltimore Polytechnic Institute, founded in 1883, has maintained a standard of excellence for over 120 years and is a Blue Ribbon School of Excellence. Founded as a technical (engineering) school, Poly gives students an advanced education in mathematics and science. Poly students consistently maintain standardized test scores above state and national averages. The Poly faculty is comprised of highly qualified individuals who provide valuable insight into the subjects they teach. They work beyond the regular school hours running sports, clubs, and other extracurricular activities. Not only are the students and faculty among the best in the state, but the Poly Alumni Association is also of the highest caliber. Alumni invest countless hours and dollars in support of Poly, keeping the school strong. Jacqueline Williams, class of 1983, has been the director of Poly for three 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 daily classes 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 Siemens Competition and the Intel Science Talent Search, two of the nation's most prestigious, and financially rewarding, contests. 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 into unusual depth in their understanding of the beauty of mathematics, while also enjoying the challenge that problem solving represents.

Incoming ninth grade students must take an Algebra I entrance examination and pass with at least an 80%. 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 Algebra II, and a semester each of Trigonometry and Probability/Statistics. The eleventh grade students complete Advanced Placement Calculus (AB) with the option of taking the AP examination at the end of their junior year. After studying advanced topics in calculus as seniors, many students take the AP Calculus (BC) examination. Students with extraordinary aptitude may take accelerated classes, and some work independently with Dr. Goldenberg. Several 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.

Senior Research Abstracts

The seniors' presentations represent the culmination of their research efforts. The students completing Ingenuity Research Practicum with Mr. David Nelson 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 Siemens, Intel Science Talent Search, and Junior Science and Humanities Symposium. (Note: some Ingenuity students elect to take Research Practicum during their senior year.)

From left: Charlotte Fulwiler, Gus Meisner, Phoebe Sandhaus, Tula Raghavan, Lane Easterling, Ina Rastegar, Morgan Hobson, Karam Lyons

Dynamic Fragmentation of Saturn's E Ring Particles

Allen (Lane) Easterling

Mentors: Dr. K.T. Ramesh, Dr. James Hogan
Institution: Johns Hopkins University, Extreme Materials Institute

Understanding the dynamic behavior of ice particles during impacts provides insight into the collisional evolution of Saturn's rings. Saturn's rings are primarily comprised of ice particles with orbital velocities averaging 230 m/s in the outer rings; collisional velocities are 5-10 m/s. Of particular interest is Saturn's E Ring because it contains the smallest and fastest particles. The majority of this ice comes from cryovolcanoes on a nearby moon (Enceladus). In this study, I investigate the impact response of ice particles. I have designed and built a compressed-air gun that launches ice projectiles to velocities of 10 to 15 m/s. The tested ice particles are approximately 10 mm in size, and the impacts are monitored with a high-speed camera, which captures the approach, impact, and aftermath of a launch. From these images, I have determined the velocity and size of the particle fragments. I present my methods for constructing the device, creating the ice projectiles and calculating the initial fragmentation results.

The Effects of the Arts on Student Learning and Retention

Charlotte Fulwiler

Mentors: Dr. Mariale Hardiman, Dr. Ranjini JohnBull
Institution: Johns Hopkins University School of Education

Arts integration is an instructional approach in which arts are the main vehicle for instruction and learning. The proposal for this research is that arts integration will improve long-term retention of subject content. Rehearsal of information and elaboration on content received by students will occur when arts-integrated courses are implemented. Enactment will naturally occur during performing arts-integration activities and this leads to increased recognition and better memory of information. Information that can create an emotional response is retained at higher rates than information that has neutral effects on a student's emotions. Concepts are more likely to be remembered when associated with images and generated information as well more memorable for students. These ideas were the basis for the proposal for this research which was tested through a study in which curriculum was written for arts-integrated and control courses in science units for elementary age students. Six schools participated in a main study which saw the implementation of four science courses in fifth grade classrooms. This main study looked at the retention rates among all of the student participants, including arts-integrated and control classes. My personal research focused on the art forms used throughout the lessons, and compared the effectiveness of the art forms (such as visual and music). Results from this research showed very little significant differences in the effectiveness or retention rates between art forms. These findings could have an impact on instructional strategies and teacher practices in the future.

Senior Abstracts

Lateral Force Scaling During Legged Locomotion

Morgan Hobson & Gus Meisner

Mentors: Dr. Noah Cowan, Dr. Sarah Stamper, Dr. Shahin Sefati
Institution: Johns Hopkins University, Dept. of Mechanical Engineering

While lateral ("side-to-side") forces have been known to be present in animal locomotion for years, few studies have ever been put forward to explain their purpose in legged movement. We hypothesized that lateral forces help overcome the trade between maneuverability and stability thought to exist in animal locomotion, and that lateral forces scale with an animal's mass according to $F_x = aM^b$. We suspected that $b < 1$, implying that smaller animals generate stronger lateral forces relative to mass, because of their tendency to adopt a sprawled posture which facilitates the production of lateral forces. We gathered data through a literature review and through the collection of unpublished data from separate labs and compiled them for a graphical and numerical analyses. We also gathered data on other values in locomotion for future analysis. We found that smaller animals tended to exert stronger lateral forces relative to their mass than larger animals. In our analysis of lateral force, $b = 0.79$, supporting our hypothesis. Additional research must be done to normalize our data based on the scaling of speed with lateral force. A model for lateral forces in animal locomotion could be applied in robots to improve their stability and maneuverability during movement.

The Development and Evaluation of a 3D-Printed Body Powered Prosthetic Hand

Karam Lyons

Mentor: Dr. Albert Chi
Institution: Johns Hopkins School of Medicine, Dept. of General Surgery

The goal of this project was to evaluate the efficiency of different 3D printed hand designs to determine which are most effective for children and young adults that are not able to access more expensive prosthetic options. Few families can afford advanced prosthetics which often cost $40,000 or more. For children the situation is even more difficult because as children grow they need a series of these expensive devices. The high cost of advanced prosthetics forces most families to just do without. A 3D printed prosthetic hand can be produced for under $50. The low cost of the 3D printed prosthetic hands makes it possible for all children that need a hand to have one.

At the Trauma Motor Control Lab at the Johns Hopkins School of Medicine in Baltimore, seven hand designs were built and evaluated. Modifications and improvements were made where possible. The hands were made available to subjects for trial use and passive observation. Based on qualitative assessments of the performance of other design iterations, a final *Raptor* design was created as an optimal 3D printed prosthetic hand for children.

The effects of the antiglcolytic agent Dichloroacetate (DCA) when used in combination with carboplatin on glioblastoma multiforme (GBM)

Tula Raghavan

Mentors: Dr. Betty Tyler & Antonella Mangraviti
Institution: Johns Hopkins School of Medicine, Dept. of Neurology

Currently, chemoresistance is a major barrier to be overcome in the treatment of Glioblastoma Multiforme (GBM). Specifically, carboplatin and other platinum-based drugs are often ineffective once a tumor is chemoresistant. In this study, the efficacy of treating rats with carboplatin and an antiglycolytic apoptotic promoting drug, dichloroacetate (DCA) to overcome this chemoresistance was explored. DCA and carboplatin were found to have a synergistic relationship *in vitro* when given simultaneously at their respective ED50s and were found exhibit strong synergism when DCA was given as a pretreatment followed by carboplatin (both at their respective ED50s. Rats were treated with Temozolomide (TMZ), the standard anti-tumor drug, TMZ+DCA, DCA alone, carboplatin alone, and carboplatin + DCA. Rats treated with TMZ, TMZ+DCA, or DCA alone had the same median survival of the control group (13 days). DCA alone group had a median survival of 15 days. Carboplatin alone had median survival of 20 days (p=.0899 vs. control). Carboplatin+DCA had a survival of 39 days (p=.016 vs. control).

Risk factor control in older adults with diabetes

Ina Rastegar

Mentors: Dr. Elizabeth Selvin & Christina Parrinello
Institution: Johns Hopkins School of Public Health, Welch Center

Diabetes is a prevalent, and costly, disease in the United States. It has been reported that diabetics who have glycemic, lipid, and blood pressure control experience a decrease in the effects of diabetes. However, this association is not well established in a population of older adults, though that group has the highest prevalence. My research aims to assess which factors are associated with risk factor control, and to document how prevalent glycemic and cardiovascular risk factor control are in the population. The population has been collected from the Atherosclerosis Risk in Communities (ARIC) study. My research uses data collected as part of Visit 5 (2011-2013). To determine the association between risk factor control and different variables, I ran a logistic regression using various models. Model 1 and Model 2 focus on physical and lifestyle characteristics, while Model 3 focuses on physical functioning. Results show that variables such as race and gender are positively associated with lipid control, but not with glycemic and blood pressure control.

Analyzing and Placing Limits on Light Curves Generated from HST/COS White Dwarf Data

Phoebe Sandhaus

Mentor: John Debes
Institution: Space Telescope Science Institute

Since white dwarfs are just as prevalent as sun-like stars, they can be turned to in the ongoing search for exoplanets. In addition to this, they have radii similar to that of earth, theoretically providing a basis for a deeper analysis of earth-sized planets. White dwarfs are particularly bright in the ultraviolet, thus the Cosmic Origins Spectrograph (COS) on the Hubble Space Telescope (HST) which looks into the near and far ultraviolet is good for looking into the spectra data of white dwarfs. As the first step in this proof-of-concept experiment, I looked into the sensitivity of the Hubble instrument COS by using a sample of about one hundred targets and comparing the expected standard deviation to the measured standard deviation. This determined that COS was seemingly photon-limited when observations had moderate to high count rates. Next, I proceeded to look at the light curves of the white dwarfs GD153, GD71, and WD0308-565 and look for outliers beyond five standard deviations away from the mean, which could potentially indicate a planetary transit. While no such deviations were found in this analysis, I only had a full period's worth of data for periods of shorter lengths, so it is a possibility that if there had been a planet with a longer period, it would go undetected. Although a planetary transit is yet to be discovered around a white dwarf, there are many upcoming missions that are designed to specifically target earth-sized planets through means of transit photometry (i.e. JWST, TESS). If these missions do find a transiting exoplanet around a white dwarf, then the instrument COS could be used to further investigate these planetary transits.

Senior Practicum

The following students elected to take Research Practicum during their senior year with Ms. Sally Kutzer. They presented their results to a public audience at Poly on May 8, 2015.

From Left to Right:

Enyioha Ike-Amaechi - The Rheological Properties of Polyethylene Oxide

Tenee Blackett - Comparison of Aluminum versus Steel in Structural Design

Ma'at Ankobia - Bacterial community analysis of blue crabs

Brooke Smith - Harnessing Hyperoxia for Vascular Regeneration

Chikaodi Nwanegwo- Studying the effect of Granzyme B Cleavage of IFI16

Ngozi Amanze - E-health Machine

Blair Smith - Imaging of dietary lipid digestion in a live vertebrate utilizing the Finotyper algorithm

Jasmine Braxton - Developing Transgenic Tools to Study the Zebrafish Brain

Zach Byrd (not shown) - Study of Droplet Impact on a Superhydrophobic Surface

Senior Math Projects

The mathematics projects were conducted under the supervision of Dr. Goldenberg, the chair of the Ingenuity mathematics department. After completing their coursework for the Calculus BC class, the students chose topics for an in-depth study and solved a complex problem on that topic.

JHU Future Scholars Program Calculus Admission Exam

Ben Aladejebi and Omar Mahmoud

Every year the Math Department of JHU offers several openings for Maryland juniors to study one of many advanced math courses for free. To be accepted to this Future Scholars program, one needs to pass a challenging math exam on Calculus BC level. In this presentation, we are discussing the problems from the exams of both 2014 and 2015. The problems discussed in this presentation range from those discussing limits and continuity, basic theorems about continuous functions, sophisticated methods of integration, and problems involving polar and parametric representation of functions and curves. Solutions to many problems are relatively short, but require mathematical intuition and strong knowledge of all Calculus BC topics. We hope our presentation will attract new applicants to the Future Scholars program.

Some Applications of Vector Algebra

Spiros Reda and Steven Tran

Vector algebra is a study of vector operations (in two or three dimensions) on vectors and their properties. Linear operations on vectors, scalar and vector product of vectors are very useful in mechanics, physics, and other branches of science. But these operations have also been used to solve problems inside mathematics and prove important mathematical statements. The goal of this project is to show how vectors can be applied to solve some advanced and sophisticated problems, for example, how to prove the famous “Theorem about two perpendiculars” and how to prove one of the generalizations of the Pythagorean theorem.

Solving Equations of Third and Fourth Degree in Radicals

Tula Raghavan and Allen Easterling

In high school algebra we develop and use the Quadratic formula, in which the roots of a quadratic equation are expressed in terms of its coefficients using four arithmetic operations and operation of taking a square root. In other words, the general quadratic equation can be solved in radicals. Is that true for equations of higher degree? In our project we show that the answer is yes for cubic and quartic equations. We discuss special methods which can be used to establish the formulas to solve these equations in radicals. It is known (and this is one of the greatest achievements of classical mathematics) that the general equation of degree five (quantic equation) cannot be solved in radicals.

The Many Uses of Trigonometry

Morgan Hobson and Karam Lyons

Due to its wide-ranging applications, trigonometry stands as one of the most important and influential branches of mathematics. With it, many complex problems in everything from geometry to calculus are simplified, and advanced mathematics becomes much more accessible. Trigonometry on its own can be used to solve many intriguing problems. An example of this is finding $\cos(36^o)$ using trigonometry. Following this, one can examine the uses of trigonometry in geometry. This can be shown by proving that the sum of the squares of the sides of a parallelogram is equal to the sum of the squares of the diagonals. This proof, shown as 2a^2 +2b^2 =d1^2 + d2^2, can be done using the law of cosines, a rule specific to trigonometry. Trigonometry can also be used in calculus, with notable examples being finding the maximum area of a rectangle and using trigonometric substitutions to greatly simplify complex integrals. Without trigonometry, these fields would be much less accessible. With our project, we hope to explain how trigonometry plays a role in simplifying the world of mathematics.

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 independent research projects. They will continue their work this summer to complete their projects. Next fall, they will write their final research papers. The posters on display are their entries to this year's Baltimore Science Fair and Maryland Junior Science and Humanities Symposium. The juniors are also responsible for organizing this Symposium event.

From left: Eterick Stonely, Simon Benzer, Yitzhak Oshry, Luc Renaux, Humza Yaqoob, Cullen Bray, Will Povell, Harry Huntley, Si Lin, Alex Hilger, Kathy Le

The Relationship between Osteopontin and Axonal Growth in the Neuroblastoma Cell Line SH-SY5Y

Simon Benzer

Mentor: Dr. Amanda Brown
Institution: JHU Dept. of Neurology

Osteopontin (OPN), a pro-inflammatory cytokine, has been shown to be increased in the brain and Cerebral Spinal Fluid (CSF), as well as serving as a catalyst for HIV replication, in individuals infected with HIV (Brown et al). This finding indicated the necessity of further research of OPN's relationship with HIV-associated neurocognitive disorders (HAND). One avenue for this research was on its relationship with axonal length. In an effort to investigate this relationship, the neuroblastoma cell line SHSY-5Y was cultured then used for 8 separate controls consisting of OPN, +βIII Tubulin, HIV Envelope, and amalgamations of them. These controls were stained with the Green Fluorescent Protein (GFP) antibody, in order to allow fixation upon axons for measurement. Under the mercuric lamp, photographs were taken with the same exposure and focus values, in order to maintain experimental consistency. Once the images were taken, measurements were made with Zeiss AxioVision software, then inserted into the GraphPad Prism software for statistical analysis where assays were performed and significance between groups was calculated. Importantly, significance was found between the groups of the same concentrations, including 12.5 OPN (Envelopes and +IIIB Tubulin *with* OPN) and 12.5 +IIIB (Envelopes and +IIIB Tubulin, *without* OPN), as well as between 25. OPN and 25. +IIIB. Interestingly, there was *not* significance found between the two concentrations of 6.25 OPN and 6.25 +IIIB. This result indicates a need to replicate the experiment, as the comparison between them is far from consistent with comparisons between other groups.

CPCs and the Beta-adrenergic Pathway

Cullen Bray

Mentor: Dr. Kathleen Gabrielson
Institution: Johns Hopkins University Department of Molecular and Comparative Pathobiology

Cardiac Progenitor Cells (CPCs) are stem cells that have been recently found in the hearts of vertebrates, and it is believed by some that these cells could be used to heal damaged tissues. The problem is very little is known about CPCs, including the way they react to beta-adrenergic pathway stimulation, the pathway responsible for increased heart rates in response to threatening stimuli (the fight-or-flight response). My goal is to further study the response of CPCs to this stimulation.

Drones Equipped with LiDAR Abstract

Alex Hilger

Mentor: Mark Dhruv
Institution: EA Engineering, Science, and Technology

This project will utilize a drone, with an onboard LiDAR sensor, which will map the topography of an environment. This technology will benefit organizations because it will generate more accurate, precise measurements of area, while saving capital. The demand for this application is immense because it will expand the number of activities that can benefit from a 3D map, which could not previously due to the high cost. 3D point clouds are generated which are composed of all of the points generated from the LiDAR sensor that are then given spatial referencing information so that they can be placed accurately on a 3D map. With many millions of these points connections can be formed to generate planes and geometric shapes showing the typography of the area from which they were generated. The data will then be processed and rendered making 3D maps with an ESRI software, such as ArcGIS. The drone will need to be made so that it can accommodate the payload of a LiDAR sensor and other components that the LiDAR sensor will need. Some of the other components may in include, but are not limited to: GPS unit, IMU unit. The 3D point clouds are output into a ".las" file-type that will then be rendered through ArcGIS and creating a finished 3D map.

Applications of a Self-Sufficient Farm Model in Urban Food Deserts

Harry Huntley

Mentor: David Nelson
Institution: Ingenuity Project

Most food grown in the United States is produced on large, industrial farms. However, still many people are unable to find or afford fresh produce in, mostly poor, areas called food deserts. This has become a critical public health issue, both because of pollution produced by industrial farms and because of health issues associated with poor nutrition. The project is to create a model for a self-sufficient farm, free of the issues with industrial agriculture and to apply that model to an urban food desert to alleviate food insecurity. This model includes calculating space required to produce food for entire family, graphic of fields to produce it, graphic of barn, graphic and written plan for storage, a list of animal breeds to be raised, a written and possibly visual explanation of the rotation system to be used, a list of the tools required, an analysis of compostable material and compost plan, and an explanation of any easy changes that could be made to suit preferences. The project also includes changing the developed self-sufficient model to make it suitable and most helpful for a community garden in a food desert. A model is created for a farm that provides all the food needed for a family, then is modified to make a community garden most effective at relieving food insecurity and malnutrition in food deserts. This community garden will increase healthy eating and reduce malnutrition-related diseases in food deserts.

Activating Mutations in FgFr and Ras Lead to a Competitive Advantage in Drosophila Germ-line Stem Cells

Kathy Le

Mentor: Leah Greenspan, and Dr. Erika Matunis
Institution: Department of Cell Biology, Johns Hopkins University School of Medicine

The Paternal Age Effect describes how older men are more likely to have children with genetic disorders, such as Apert's syndrome, than younger men. This is attributed to an age-related accumulation of sperm with spontaneous mutations that are thought to originate in sperm-producing (or germline) stem cells (GSCs). Advantageous mutations in stem cells can cause a competitive advantage over other stem cells. While competition has been observed in various stem cell systems, competition between GSCs is still poorly understood and is difficult to study mechanistically in humans. Therefore, we are using the Drosophila testis to study the Paternal Age Effect. Spermatogenesis is similar in flies and humans, but more easily studied in the well-characterized genetic model system of Drosophila. We find that activating mutations in two components of the MAP-Kinase (MAPK) signaling pathway, Fibroblast growth factor receptor (FGFR) and Ras, caused mutant GSCs to appear more frequently than non-mutant GSCs, suggesting that they confer a competitive advantage to GSCs. In contrast, activating mutations in another component of the MAPK pathway, Raf, did not result in more mutant GSCs than non-mutants. Further uncovering the mechanisms that underlie the Paternal Age Effect disorders will be the prerequisite for finding a way to prevent mutation accumulation and genetic defects.

Role of C9orf72 Mutation in Amyotrophic lateral Sclerosis

Si Lin

Mentor: Dr. Jiou Wang
Institution: JHSPH Dept. of Biochemistry and Molecular Biology

Amyotrophic Lateral Sclerosis is a neurodegenerative disease that affects motor neurons resulting in paralysis and respiratory failure. Mutation in the *C9orf72* gene leads to ALS but it's not known how. One hypothesis is that the mutation causes a decrease in *C9orf72* proteins, and this loss is detrimental to the cell. However, how this decrease in *C9orf72* protein contributes to ALS development is poorly understood since the function of the *C9orf72* protein is unknown. One way to determine protein function is by analyzing how and where the protein binds to another protein. Previous work at the Wang lab shows that the *SMCR8* protein binds to the *C9orf72* protein. However, the binding site is unknown. Versions of the *SMCR8* gene (each with certain sections of the gene deleted) were cloned and inserted into cells for protein expression. Next, microscopy will be used to analyze interaction between the *SMCR8* protein and the *C9orf72* protein. If the proteins still bind after a section is deleted, then the deleted section is not necessary for binding. If the proteins no longer bind, then the deleted section must be important for binding. Interaction between the two proteins can reveal further insight into the function of the *C9orf72* protein and possibly the pathway through which the *C9orf72* mutation leads to ALS. Further understanding of a major pathway can possibly lead to the development of a cure.

Security in TCP/IP networks

Yitzhak Oshry

Mentors: Paul D. Martin, Dr. Avi Rubin
Institution: JHU Information Security Institute

TCP/IP was created as a standard for connecting various networks together and is now used in almost all computer systems and networks. TCP/IP is developed to be fast, easy to use, and easy to implement. Though there is one major problem, the lack of security built into the system. This lack of security, while making it easier to use and implement, also makes it rela-

tively easy to attack, or hack, into a simple TCP/IP network. Solutions require additional layers of security to be added on by other sources. Security includes encryption, authentication, and other steps not offered by a normal TCP/IP network. I am therefore building a simple client-server TCP/IP network to simulate one that would exist within the real world. Once the server is complete I will then diagnose different security issues and then attempt to reconstruct the server to halt, if not, prevent different attacks that could be performed.

Collection and Analysis of Data From Question and Answer Threads on Quora

William Povell

Mentors: Dr. Matt Post, Frank Ferraro
Institution: JHU Center for Language and Speech Processing

Question and answer (Q&A) forums contain a wealth of information that is useful as training data for related machine learning and natural language processing tasks. Previously published literature has explored problems such as answer identification and automated question answering which are largely based on information from Q&A sites. However, the models proposed in these projects require large amount of data to train on. The dataset created in this project is meant to help resolve this problem for some and supply a dataset capable of training or augmenting these models. Over two months, more than 114,000 Q&A threads taking up 7.8GB of storage have been collected from the website Quora, including parsed out text and metadata from user posts. This data was scraped using a PhantomJS headless browser and processed with Python. General statistics were calculated on the dataset and lexical comparison between it and Twitter was performed so as to provide a better overview of the content of the dataset.

A Comprehensive Analysis of Adena Burial Practices and Rituals

Luc Renaux

Mentor: Stephanie Sperling
Institution: Lost Towns Project

The purpose of this project was to provide a comprehensive summary and description of Adena burial sites, and ritual. Various pieces of literature regarding Adena culture and burial were sourced from reviews of literature and colleagues. Each piece of literature pulled was analyzed in order to find key aspects of Adena burial and ritual in order to compile a "checklist" of characteristics of Adena burial sites. Through this process, descriptions of Adena burial

sites, Adena mortuary rituals, and of Adena artifacts were created. Distinct characteristics that seemed unique to Adena culture here noted. Some examples of these noted characteristics are the presence of stone-tube pipes and the use of clay in burial ritual. This unique list of characteristics can then be used to help determine whether or not a certain burial site from the Adena culture. In the future this project could be used to facilitate a cross cultural comparison of burial practices.

Design and Creation of a Research-oriented EMG Electrode Cuff

Eterick Stonely

Mentor: Megan Hodgson
Institution: Infinite Biomedical Technology

Creation of a spandex EMG electrode cuff, using methods of trial and error to find the most effective use of single swatches of material. Of two designs created, the simpler of the two was chosen to take advantage of its use of one materials only, and the simple means of using said material. The spandex carries qualities of extreme stretchiness, and high durability. Utilizing these traits, the cuff was made with the minimum specifications, to maximize the tautness of the cuff in all situations. Electrode containment involved creating and sewing over folds, forming small pockets into which each end of the electrode could be inserted and held. But as a result of its high stretch ratio, the cuff design could not contain the electrodes effectively through the patient putting on or repositioning the cuff, and the edges of the fabric would stretch and curl away from the electrode surface, drastically decreasing the friction force that was keeping the electrodes in place.

CT reconstruction of Ediacaran trace fossils

Humza Yaqoob

Mentors: Dr. Linda Hinnov, Johns Hopkins University;
Dr. Mike Meyer, Penn State Harrisburg
Institution: Johns Hopkins Department of Earth and Planetary Sciences

The transition between the Ediacaran and Cambrian geological periods coincided with an increase in the diversity and complexity of bioturbation. Most trace fossils from the Ediacaran period representing burrows are relatively simple, whereas the Cambrian period has yielded burrows which represent more complex behaviors. *Lamonte trevallis* is an ichnospecies found in the Shibantan Member of the upper Ediacaran Dengying Formation, in the Yangtze Gorges region of South China. Most other trace fossils from the Shibantan Member are relatively simple in comparison to *L. trevallis*, which makes it a subject of interest when studying the changes in the trace fossil record that occurred as the Ediacaran period came to a close. In order to more thoroughly investigate the behaviors of the *L. trevallis* trace maker, the ichnofossil's internal morphology will be rendered using 3D computer software. Through the use of X-ray Micro-CT technology, a specimen of *L. trevallis* will be scanned as a stack of digital images from which a three-dimensional model can be constructed. This model will allow a more in depth study of the burrow's shape and structure by providing a visualization of the internal features of the fossil.

Sophomore Statements of Interest

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

From Left: Branden Etienne, Nick Eusman, Stephen Grabowski, Anisa Hofert, Amy Zhang, Aishwarya Shettigar, Sam Smith, Sydney Worsham, Robin Graham-Hayes, Samantha Niziolek, Lauren Fink, Emma Eklund, Yoav Kargon, Ben Bjarnsson, Olivia Birkel, Julianna Lucas.

Not Pictured: Andrew Frock, Jasmine Long, Sydney Rosebrough, Jacob Smith,

Sophomore Abstracts

Cultural Anthropology
Olivia Birkel

Cultural anthropology defines the field that studies the development of human cultures based on factors such as ethnography, linguistics, politics, religion etc. In order to connect the cultures together, scientists analyze behaviors and customs. As of now, I only have one specific mentor candidate. However, there are a few places that I'm looking at as potential places to work on research. The mentor candidate I currently have in mind is Clara Han. She is an assistant professor at JHU and studies violence, death, and illness in many South American/ Asian countries. The second place I'm looking at is the Walters Art Museum. Since they keep large collections of artifacts, they have restoration and research groups working there. Since some of their work revolves around taking care of the artifacts and researching all about them, this is definitely a good place to research artifact relationships (with each other and other societies) as well as doing hands-on work (like my original topic of archeology was all about).

Behavioral Economics
Ben Bjarnason

Popular economic theories assume that people are rational and will do things in their best interest, which is not always the case. Anomalies are events that cannot be explained by other economic theories. Behavioral economics will identify and understand those anomalies by using psychology. I have decided that I don't find behavioral economics interesting, so I will look into work more focused on economics. I am interested in doing a project that connects economics with data analytics.

Climate Change and Impacts
Emma Eklund

Climate change is the study of the changing weather patterns on Earth over time. Scientists in this field study the evidence, causes, impacts, and possible solutions to climate change. Solutions on how to lower carbon dioxide levels and temperature interests me the most. A possible mentor candidate is Dr. Ben Zaitchik who researches climate dynamics and surface hydrology. His research about the urban heat island is intriguing because the temperature is so much higher in the city than in other areas and new solutions can be made. Another possible mentor is Anand Gnanadesikan, who does research on physical circulation, biogeochemical cycling, and climate modeling. His research is interesting because he wants to see how the ocean can affect multiple things, like climate.

Robotic Locomotion
Nick Eusman

Robot locomotion is the collective name for the various methods that robots use to transport themselves from place to place. Current research involves using robotics to move over rough or unknown terrain, such as moving things to remote locations, and using the robots for disaster relief. My interests lie mainly in those research fields and in working on improving those fields and working on making things autonomous. Currently I don't have a mentor, but I am hoping to be able to work in a lab that focuses mainly on locomotion in robotics. I am looking at labs in the JHU Whiting School of Engineering.

Adolescent Psychology and Its Implications on Education
Lauren Fink

Adolescent psychology is defined as the scientific study of the adolescent mind and its functions, especially those affecting behavior. The study of how the human mind thinks and develops has been around as long as humans have, but more recent, sophisticated methods give a more in depth and scientific view of the adolescent mind. Adolescent psychological research can be conducted with brain scans and MRI machines, or by simply setting up laboratory experiments and studying behavior. These experiments can test any number of things, such as risk taking behavior and how the tendency to take risks is affected by a participant's age, and by the presence of peer groups. Research experiments at JHU CTY interest me, and I plan to work with Dr. Kinnari Atit, Postdoctoral Researcher with the CTY Baltimore Initiative, and join her research regarding spacial awareness in adolescents.

Nanomaterials: Quantum Dots
Andrew Frock

Nanomaterials are defined as particles with at least one dimension on the nano- scale, which is 1 – 1000 nanometers. These materials are studied for their special properties caused by their small size and large surface area. Properties like color and conductivity can change. Quantum Dots are a type of nanomaterial given special properties by their small size. They are semiconductor crystals with special properties because of their size. They can change light's wavelength, and also convert it into other forms of energy like electricity. Their ability to transform light makes them useful in screens, solar panels, and lighting. They are currently being researched for applications in quantum computing and lights. The author is currently looking for a mentor in the field of materials synthesis, as there is no research in the Baltimore area about quantum dots, and very limited research in nanomaterials. Possible mentors include Dr. Tyrel McQueen, a researcher of Solid State and Inorganic Chemistry at Johns Hopkins University, and Rebekka Klausen, a Synthetic and Materials Chemistry researcher also at Johns Hopkins University.

Enzyme Activity in Extremophilic Archaea
Stephen Grabowski

The bulk of current research into extremophiles is about the mechanisms which they employ to be able to survive in their environments, namely via unique enzymes. Said environments include extreme temperature or pH, high radiation, high pressure, etc. These are environments

where most biological systems fail to operate, so the enzymes used by extremophiles to perform normal cellular processes must be much sturdier than in other species. Very often, these organisms also have specialized enzymes that repair cellular damage caused by their environment. Examples include heat-shock proteins in thermophiles, or heat-loving organisms, which repair or prevent the buildup of proteins damaged due to heat when the organism is exposed to exceptionally high temperatures. My main mentor candidate is Dr. Kevin R. Sowers at IMET, and his research is focused on extremophiles which metabolize methane, which often live in hydrothermal vents at the bottom of the ocean, and the enzyme pathways they use to do so.

Kinase Reactions in Signal Transduction

Anisa Hofert

A signal transduction pathways are the steps a stimulus from outside the cell takes, in order to create a change inside the cell. They are very important because they regulate the entire body and define what each cell does. Kinase reactions are a major part of signal transduction pathways. These reactions release the energy stored in ATP molecules. Kinase proteins do this by breaking the bond of the third prosperous in ATP, releasing the energy stored in that bond. Studying these reactions is an integral part of understanding signal transduction pathways because they are present in almost all pathways. There are also many proteins that regulate the use of kinases. One example is the scaffold protein. These hold the kinases close to each other to expedite the reaction. Problems with scaffold proteins can slow down a reaction or cause different reactions to intertwine and become mixed up. Signal transduction pathways are important to study because they could help cure diseases such as cancer and diabetes which occur largely due to mutations in key pathways. Dr. Paul Shapiro is studying the ras pathway which is very likely to result in cancer if mutated.

Synthetic Biology

Yoav Kargon

The field of synthetic biology involves the application of engineering principles to the creation of custom biological systems. Custom biological pathways can be used to create desired products in living organisms such as medicine or biofuels. Synthetic Biologists often base work off of already existing organisms and can use known genetic pieces called “parts” (accumulated from the work of previous scientists) to create novel systems. There are a wide variety of possibilities involving work with synthetic organisms. A recent development was the creation of the antimalarial drug artimesinin in yeast. The pathway in yeast could produce artimesinin at a fast-

er and more reliable rate than the herb that had previously been the only source for the potent antimalarial. Other workers focus on more commercial possibilities: the company Evolva has created yeast that can produce vanillin, the main ingredient in vanilla flavoring. This summer, I will be working with Dr. Takanari Inoue in the Department of Cell Biology at Johns Hopkins Medicine.

Medical Genetics
Jasmine Long

My topic is cancer and genetics and over time my research has narrowed in the beginning my research was the basics on what cancer is and what's genetics is. Medical genetics is the study of genetics in direct correlation with medicine and for medical purposes. There are series of mutations in key regulatory genes that cause cancer; the abnormal behaviors demonstrated by cancers cells are a result of those regulatory gene mutations. Breast cancer cells have an expression of the estrogen receptor (ERa) and tend to be treated with hormone therapy using the receptor antagonist tamoxifen; however, in 30-40 percent of the patients the cancer comes back. The HOX genes are transcription factors that would normally regulate "temporospatial development of the extremities and organs." Patients with a higher level of expression in HOXB13 seem to show a resistance to tamoxifen, so the question ends up being why that is so. My mentor will be Dr. Saraswati Sukumar. She works in the cancer program with John Hopkins. She has most recently been working on the reasoning behind why minority ethnical groups have a higher breast cancer rate. After discussing the current work with her it seems as though the main hypothesis in the reasoning behind the gap in her eyes was by far diet.

Neural Circuits Relating to Memory
Samantha Niziolek

My research throughout the year has been geared towards understanding memory circuits. Memory circuits are divided into sections: Long-term, Short-term, Short-term sensory and working memory. I am most interested in Long-term memory and its connection with working memory. To date the most accepted model of memory involves three main processes, rehearsal, encoding and retrieval, but other processes, like consolidation, modify memories over time. I am very interested in investigating subsections of long-term memory (episodic, semantic and procedural) and how overlapping, or connected circuits perform specialized tasks, depending on what two circuits are overlapping . For example, a team of researchers is investigating the overlap of neurons in the medial entorhinal cortex, which process spatial memories, and neurons in the lateral entorhinal cortex, which process sensory memories; they believe where these circuits connect is crucial for autobiographical memories, or episodic memories. This summer, I will begin work in the lab of Dr. Kristina Nielsen at the Zanvyl Krieger Mind/Brain Institute ,

focusing on the visual processes in the brain concerning curvature and recognition.

Immune Functions of the Intestinal Microbiota
Aishwarya Shettigar

Intestinal microbiology as a whole deals with the study of the microorganisms (collectively known as the microbiome or microbiota) that make up the gastrointestinal tract. The vast majority of these microbes are bacteria, but fungi, protists, and archaea are also present. Research conducted in the last thirty years has shown that the microbiota serves a multitude of functions, including metabolic, structural, and immune, that help the host maintain homeostasis and stability. As part of the immune system, the healthy microbiota is responsible for identifying foreign agents in the gut and notifying immune cells that are part of the intestinal epithelium (specifically paneth and goblet cells). The microbiota also provides the first line of defense against foreign agents for the host by administering a colonization resistance process. Gut microbes also help maintain the metabolic balance of the host by aiding in the production and regulation of short chain fatty acids, helping control serotonin levels and affecting T cell concentrations in the GI tract, among other indirect functions. Understanding the mechanisms and behavior of the microbiota is therefore very important in understanding the mechanisms and behavior of various diseases and infections that affect the host's digestive and immune system. This summer, I will be working with Dr. Daniel Peterson, who currently researches what effects immune responses have on the intestinal microbiota.

Signal Transduction in Cancer Research
Samuel Smith

My primary research topic is in the field of molecular biology it involves the use of signal transduction pathways to diagnose the causes of cancer and treat them once the cause is diagnosed. Currently scientists are discovering more mutant proteins that cause cancer as well as dugs that are specific to those proteins and those proteins alone. It doesn't help that signal transduction pathways themselves are still far from understood and a hot research topic themselves. This summer, I will be working with Dr. Mark Levis at the Department of Oncology at Johns Hopkins Medicine.

Vascular Dementia and other Neurologically Systemic Complications
Sydney Worsham

My interests in research lie specifically in vascular dementia, broadly in mammalian neuropathies. Vascular dementia is a branch of a collection of diseases categorized as dementia. De-

mentia primarily affects the brain and cognitive functions with various causes. Vascular dementia is caused by damage to the brain following loss of blood flow to the brain. As of yet, there hasn't been any promising research. This summer, I will be working with Dr. Betty Tyler at the Department of Neurology at Johns Hopkins Medicine.

Nanotechnology

Amy Zhang

Nanotechnology is an interdisciplinary field of research that deals with engineering at the nanoscale (1-100 nanometers). Scientists study different properties of various materials and manipulate matter at an extremely small scale to potentially discover new applications. There are different properties for many materials at this small of a scale; for example, there is greater surface area, properties are "tunable," and it is a more ideal scale to use for medical purposes. There has especially been growth in the area of "nanomedicine," where nanotechnology is applied in biological settings. This kind of research has been taking place in the lab of Dr. David Gracias (JHU). For example, his lab has researched and created tetherless single-cell microgrippers that can potentially be used in biopsies and cell encapsulation devices that can potentially be used to treat diabetes.

Student Awards & Honors

The Baltimore Science Fair

Fifteen Ingenuity students presented projects at the 2015 Baltimore Science Fair held at Towson University. For the fifth year in a row, an Ingenuity student won a grand prize award! Senior Phoebe Sandhaus won this year's Grand Prize in the physical sciences category. Phoebe won for her algorithm to detect exoplanet transits across white dwarf stars. Phoebe will go to Pittsburgh, PA in May to compete at the 2015 Intel International Science and Engineering Fair (ISEF).

Ingenuity has produced 11 Grand Prize winners in the past 13 years.
Additionally, 13 Ingenuity students received a total of 33 special awards from independent groups.

Sponsor Awards

Grand Prize, Biological Science
Phoebe Sandhaus, *"Analyzing and Placing Limits on Light Curves Generated from HST/COS White Dwarf Data"*

Honorable Mention, Biological Science
Cullen Bray, *"Role of ErbB2 and Beta 2-Adrenergic Receptor Interaction in Heart and Cardiac Progenitor Cells"*
Kathy Le, *"Activating Mutations in FGFR Leads to a Competitive Advantage in Drosophila Germline Stem Cells"*

Honorable Mention, Physical Science
Lane Easterling, *"Dynamic Fragmentation of Saturn's E-Ring Particles"*
Alex Hilger, *"Drones Equipped with LiDAR Sensors for 3D Mapping"*

Special Awards

AFCEA Central MD Chapter- Phoebe Sandhaus
American Meteorological Society- Zach Byrd
American Psychological Association- Will Povell
American Society for Quality- Phoebe Sandhaus (2nd)
Association for Computational Machinery- Karam Lyons
ASU Walton Sustainability Award- Karam Lyons
Intel Excellence in Computer Science- Eterick Stonley
International Council on System Engineering- Phoebe Sandhaus
National Security Agency- Karam Lyons, Will Povell
National Society of Black Engineers- Karam Lyons, Lane Easterling,
Victor Ike-Amaechi, Harry Huntley, Will Povell
National Organization of Gay & Lesbian Scientist & Technical Professionals- Will Povell, Blair Smith
National Space Society- Tenee Blackett, Lane Easterling, Alex Hilger, Phoebe Sandhaus
Optical Society of America and IEEE- Alex Hilger, Phoebe Sandhaus
Society for In-Vitro Biology- Kathy Le
US Air Force- Alex Hilger, Phoebe Sandhaus
US Army- Simon Benzer, Lane Easterling, Karam Lyons
US Navy- Simon Benzer, Will Povell (3rd), Phoebe Sandhaus (2nd)
US Public Health Service- Cullen Bray (honorable mention), Kathy Le (2nd place)
Yale Science and Engineering Association- Alex Hilger

MD Junior Science & Humanities Symposium

1st Place, Humza Yaqoob, Kathy Le - 2nd Place, Will Povell – 3rd Place

Humza and Kathy earned the right to compete at the 52nd National Junior Science & Humanities Symposium on April 29-May 2, 2015.

American Mathematics Competition
Branden Etienne and Aaron Fink the two **AMC School Winners** for Ingenuity
Amy Zhang, Yoav Kargon, Morgan Hobson, and Will Povell are Team Members who also received recognition

Maryland Math League
The **best solvers for Ingenuity** were
Aaron Fink, Yoav Kargon, Yitzhak Oshry, William Povell, and Harry Huntley

Aaron Fink is a Baltimore City winner of the
2014 **University of Maryland College Park High School Mathematics Competition.**

Future Scholars Program
Aaron Fink, Will Povell, and Max Yuhas were accepted into the Future Scholars program at the Johns Hopkins University Department of Mathematics, and will be taking college math courses there next year

Ingenuity at Poly senior Nina Mendez is a **Quest Bridge Scholarship Winner**.

800 SAT and **SAT 2 scores**
Lane Easterling – Reading, World History SAT 2
Morgan Hobson – Math
Mary Kenny – Math
Darius Williams – Biology SAT 2
Aaron Fink – Biology, Physics
Max Yuhas – Math

Teams from magnet schools in the Baltimore area were invited to enter the **Northrop Grumman 2015 High School Innovative Challenge**. Ingenuity team members were: Anisa Hofert, Jakob Lucas, Martin Orellana, Aishwarya Shettigar, Craig Williams, Amy Zhang.

Carson Scholars
Carson Scholars: Lane Easterling and Diana Cayetano-Salinas

William R. King Chapter of the National Honor Society
Simon Benzer, Shoshana Brody, Jessyka Grell, Harry Huntley, Kathy Le, Emma Paglia-roli, William Povell, Luc Renaux, Max Yuhas, Jasmine Braxton, Rebecca Gearhart, Katheryn Jennings, Si Lin, Phoebe Sandhaus, Samuel Stahler

National History Day Statewide Competition

2015 Baltimore Scholars Award

Six Ingenuity seniors received four-year, full-tuition scholarships to the Johns Hopkins University:

Zach Byrd
Allen Easterling
Charlotte Fulwiler
Morgan Hobson
William Meisner
Spiros Reda

Class of 2015: College Acceptances

Benjamin Aladejebi
Bucknell University*
Clarkson University
Rensselaer Polytechnic Institute
University of Vermont

Ngozi Amanze
Morgan State University
North Carolina State University
University of Maryland, College Park*

Ma'at Ankobia
Capitol College
Howard University*
UMBC
Morgan State University
New Jersey Institute of Technology
Pace University (New York City)
Towson University
University of Maryland, College Park

Tenee Blackett
Morgan State University*
University of Tennessee, Knoxville
Howard University
UMBC
Hampton University
University of Maryland, College Park
Virginia

Jasmine Braxton
Morgan State University
Stevenson University
Temple University
UMBC
University of Maryland, College Park*
George Washington University

Julian Brown
Florida A&M University
Hampton University
Howard University
Morgan State
United States Naval Academy*

Suraju Kehinde
Drexel University

Zachary Byrd
Johns Hopkins University*
University of Maryland, College Park

Diana Cayetano-Salinas
University of Maryland, College Park
Towson University
University of Notre Dame of Maryland*
UMBC

Allen "Lane" Easterling
Columbia University/Sciences Po Dual BA Program
Johns Hopkins University
King's College London
George Washington University
Georgetown University*

Chidi Ede
George Mason University
UMBC*
Youngstown State University

Charlotte Fulwiler
Johns Hopkins University*
University of Maryland, College Park

Eryn Hickson-Carrington
Drexel University
North Carolina A&T State University
St. Joseph's University
Temple University*
University of Tampa

Morgan Hobson
Johns Hopkins University*

Envioha Ike-Amaechi
Drake University
Hampton University
Howard University*
Morgan State University
Mount Saint Mary's College
St. Francis University
Temple University
UMBC

UMBC
University of Maryland, College Park*

Mary Kenny
Frostburg State University
University of Pittsburgh*

Karam Lyons
Fordham University
Hunter College
Northeastern University*
Rochester Institute of Technology
University of Pittsburgh

Jared MacKinnon
Drexel University
UMBC*

Omar Mahmoud
McDaniel University
Rochester Institute of Technology
Rensselaer Polytechnic Institute
Stevenson University
UMBC*
West Virginia University

William "Gus" Meisner
Johns Hopkins University*
UMBC

Nina Mendez
Juniata College
Spellman College
University of Chicago*
UMBC

Keimonte Mims
Florida Agricultural & Mechanical University
Morgan State University
UMBC
University of Maryland, Eastern Shore
Widener University*
York College

Jaelyn Moses
Drexel University
Howard University*
Lycoming College
University of Maryland, College Park
Bucknell University
Towson University

Sara Nabulsi
UMBC*
University of Maryland, College Park

Chikaodi Maryann Nwanegwo
Bowie State University
University of Maryland, College Park
UMBC
Morgan State University*
Mount Saint Mary's University

Savannah Price
McDaniel College
Towson University
University of Maryland, College Park*

Tula Ragahavan
Imperial College of London
New York University
University of Edinburgh
University of York
University of Maryland, College Park*
Royal Conservatory of Music

Ina Rastegar
McGill University
Carnegie Mellon University*
Temple University
UMBC

Spiros Reda
Johns Hopkins University*
Towson University
University of Maryland, College Park

Russel Reyes
Morgan State University
Towson University
UMBC*

Phoebe Sandhaus
Goucher College
Pennsylvania State University – University Park
UMBC*
University of Maryland, College Park

Blair Smith
Bucknell University
Morgan State University
UMBC
University of Maryland, College Park*

Brooke Smith
UMBC
University of Maryland, College Park*
Morgan State University

Olivia Stadelmaier
Fordham University
Temple University*
UMBC
University of Massachusetts, Amherst
Stevenson University
Boston University
Hunter College

Marquise Stewart
Frostburg State University
Hampton University
Coast Guard Academy Prep Academy*

Kashay Webb
Notre Dame University of Maryland*
McDaniel College
Temple University
Stevenson University
Goucher College
Howard University
Loyola University of Maryland
Salisbury University
UMBC

Enza Williams
Pepperdine University
University of Maryland – College Park
University of Miami
University of Southern California*

Nicolette Williams
Towson University*
UMBC

(* indicates selection)


Aladegebi, Ben


Amanze, Ngozi


Ankobia, Maat


Blackett, Tenee


Braxton, Jasmine


Brown, Julian


Byrd, Zachary


Cayetano-S, Diana


Easterling, Allen


Ede, Chidi


Fulwiler, Charlotte


H- Carrington, Eryn


Hobson, Morgan


Ike-Amaechi, Victor


Kehinde, Suraju

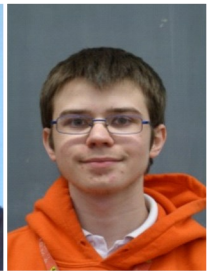

Kenny, Mary


Kitwala, Abubakari


Lyons, Karam


MacKinnon, Jared


Mahmoud, Omar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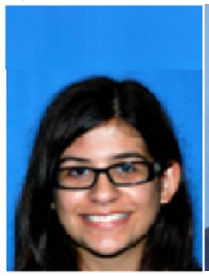
Mendez, Nina


Mims, Keimonte


Moses, Jaelyn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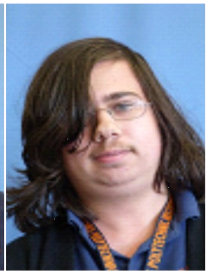
Nwanegwo, Chikaodi


Price, Savannah


Raghavan, Tula


Rastegar, Ina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Reyes, Russel

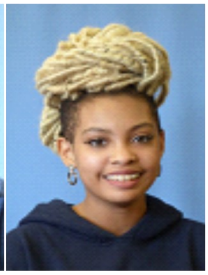

Sandhaus, Phoebe


Smith, Blair


Smith, Brooke


Stadelmaier, Olivia


Stewart, Marquise

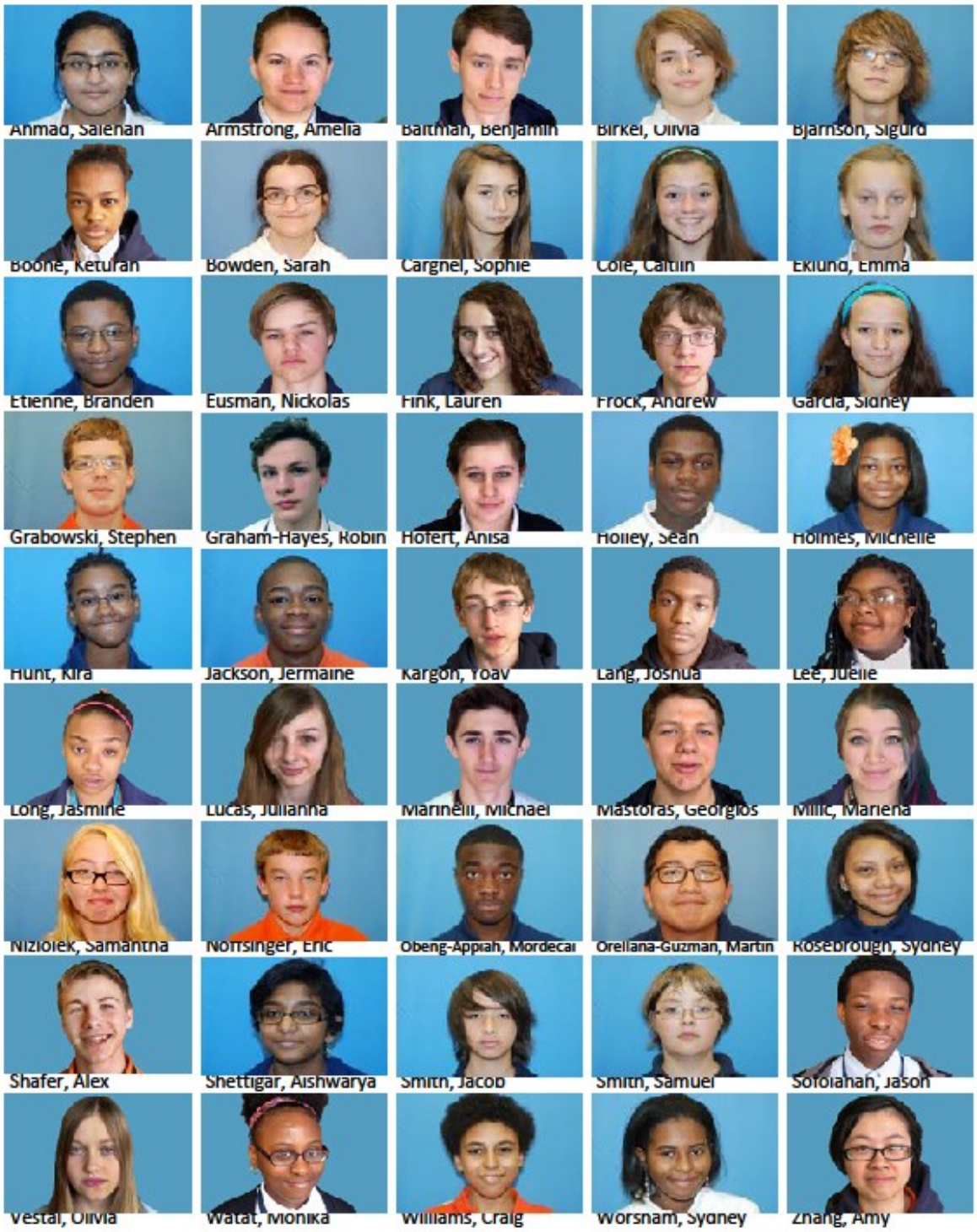

Webb, Kashay


Williams, Enza

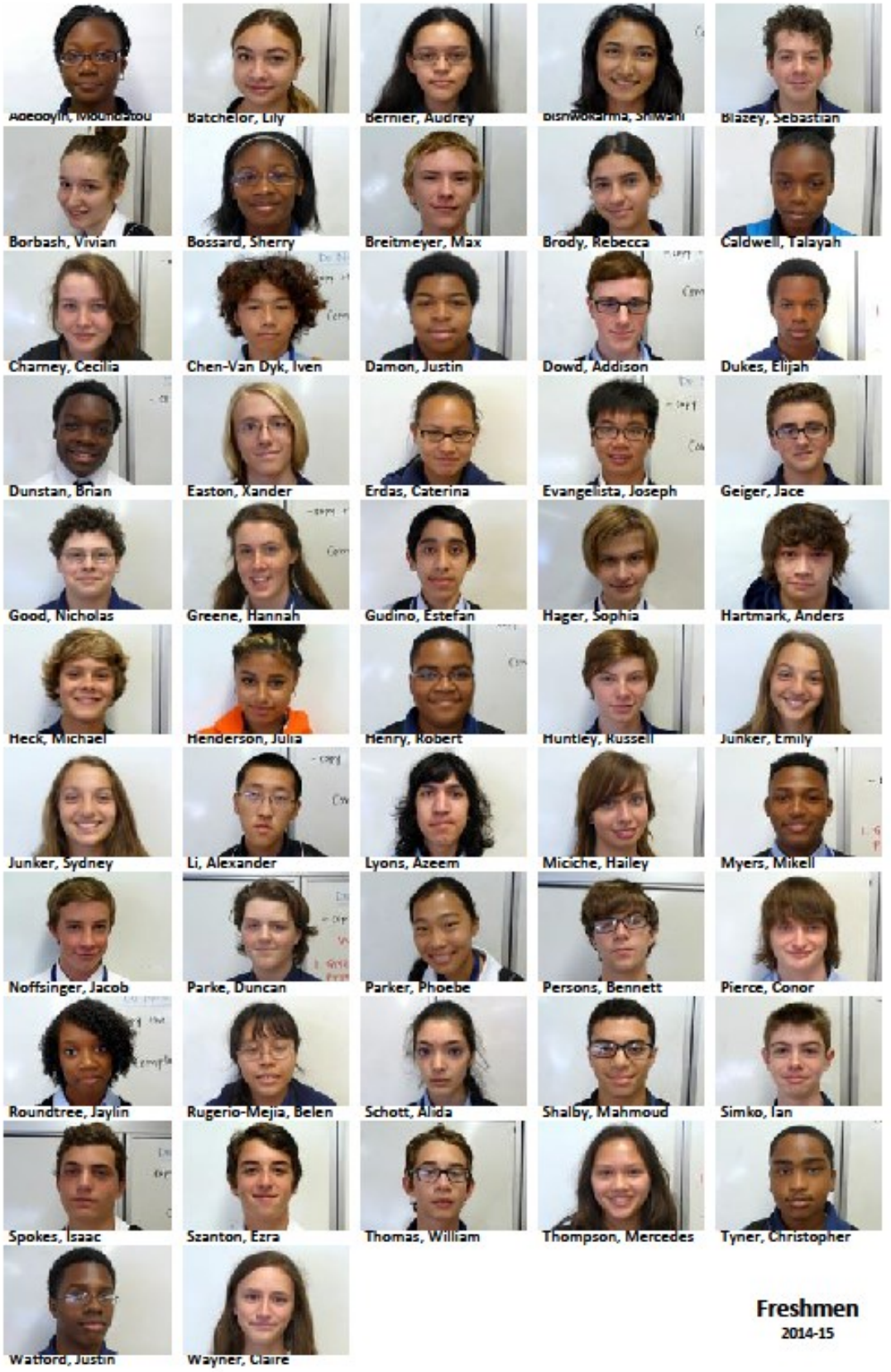

Williams, Nicolette

Seniors
2014-15

Juniors
2014-15



Sophomores
2014-15



Freshmen
2014-15

Thank You

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