CONNECTICUT SCIENCE & ENGINEERING FAIR www.ctsciencefair.org

Meet Our 2020 Top High School Winners

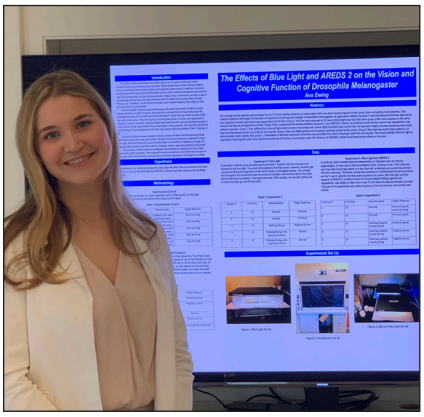
Who would have competed at

CORONA VIRUS CANCELLED FOR 2020!

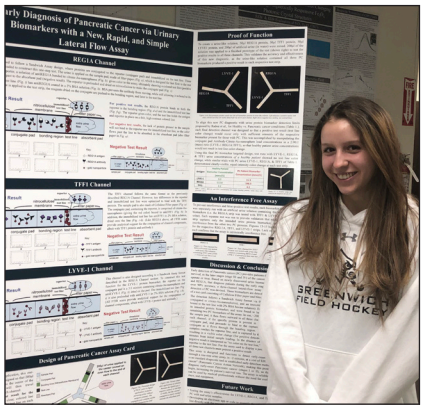
Christopher Reed

Trevor Brunette

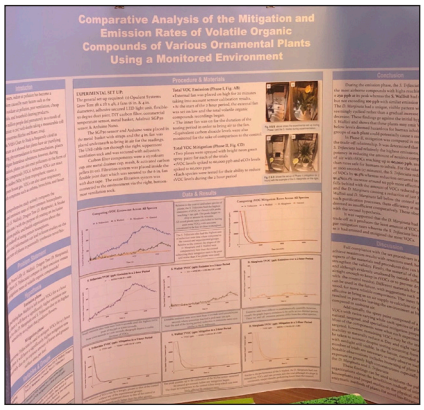
Trevor Brunette, Junior, & Christopher Reed, Junior
Academy of Aerospace and Engineering, Windsor
1st Place Team- Lockheed Martin Physical Sciences



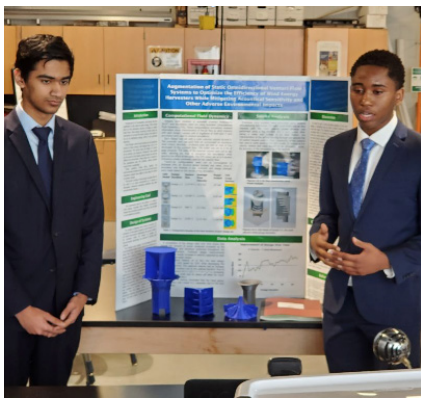
Ava Ewing, Junior
Greens Farms Academy, Westport
2nd Place - Pesico / Pfizer Life Sciences



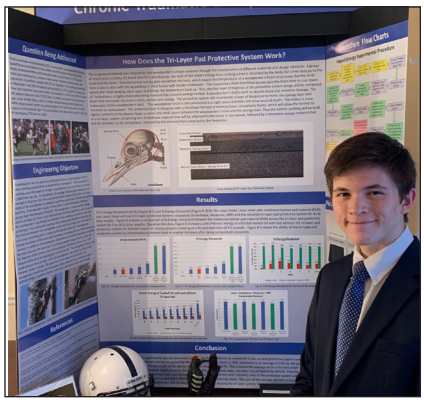
Ana-Florina Galic, Sophomore
Greenwich High School
1st Place - Collins Aerospace Engineering
3rd Place - Alexion Biotechnology



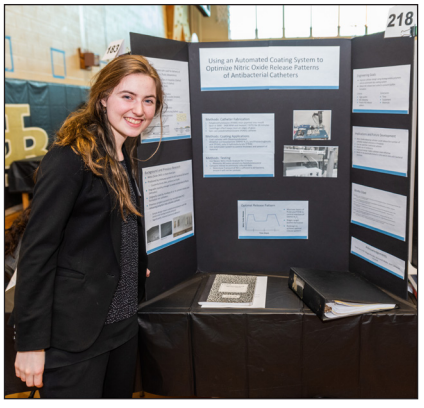
Patrica Joseph
Greenwich High School
1st Place - PesiCo / Pfizer Life Sciences



Devesh Kakkar and Johnathan Bell, Seniors
Academy of Aerospace and Engineering, Windsor
1st Place - Connecticut Academy of Science & Engineering /The Jackson Laboratory
Urban School Challenge Awards with IBM



John Oei, Junior
East Catholic High School, Manchester
1st Place Alexion Biotechnology



Abigail Slanski, Senior
Amity Regional High School, Woodbridge
1st Place - Lockheed Martin Physical Sciences

Trevor Brunette & Christopher Reed

Junior

Academy of Aerospace and Engineering, Windsor

ISEF Category- Systems Software

Christopher Reed is a senior at the Academy of Aerospace and Engineering in Windsor. This is the first year that Chris would be attending the International Science and Engineering Fair. Chris has a passion for Mathematics, Computer Science, and Aviation. He plans on majoring in Computer Science in college. Chris hopes to go into Software Engineering, Cyber Security, or potentially aviation. He is a member of Boy Scouts and the Civil Air Patrol in which he has held many leadership positions. Chris enjoys programming and flying in his free time.

Trevor Brunette is a senior at the Academy of Aerospace and Engineering in Windsor. This is the first year that Trevor participated in the Connecticut Science and Engineering fair and would also be his first year going to the International Science and Engineering Fair. Trevor has passion for computer science, mathematics, and electrical engineering. He intends to major in computer science and possibly minor in electrical engineering. Trevor is quite passionate about computer science, cybersecurity, and mathematics, participating in many competitions pertaining to those fields throughout highschool. Trevor is also intent on educating more people in the emerging field of computer science. Trevor is also an Eagle Scout in Boy Scouts Troop 156. In his free time, he relaxes by playing video games, programming, and learning on YouTube.

Cyber Attack Identification in the Electric Power Grid by Anomaly Detection

Power grids are subject to physical and cyber security attacks. A way to help mitigate this threat is to reduce response time by analyzing data reported to detect inconsistencies which could represent a breach or malfunction within the grid. These potential failures would be reported and then inspected by a cybersecurity technician who would enact a response.

To design such a system, a digital model of the power grid was created by programming a configuration structure with the reported values. That data is analyzed for indications of an outage, malfunction, or potential breach. A graphical data structure representing the power grid equipment and each of its measurements was made. A program was created to analyze the data from each node within the structure for inconsistencies.

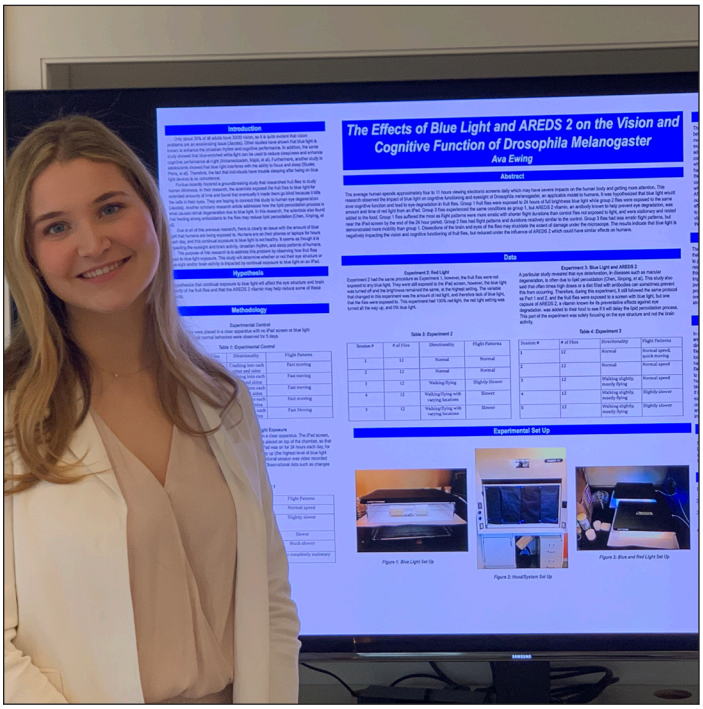
A physical model was made to test the functionality of the program. The model consists of a transmission transformer, two distribution transformers, and consumer loads. Arduino microcontrollers and Vernier current and voltage sensors were used to measure and relay data from the model to the program. This data is analyzed and displayed, showing the status of the grid.

After analyzing how our software responded to data anomalies, we know that this program can be effective in practical scenarios. When false data was injected that didn't match what was reported elsewhere, the program would alert technicians with data about the anomaly, allowing for an expedited response. The lessened response time will decrease the likelihood of a successful cyber attack on the power grid.

Ava Ewing

Senior
Greens Farms Academy, Westport

ISEF Category- Behavioral and Social Sciences



Ava Ewing is a senior at Greens Farms Academy in Westport, CT. At the 2020 Connecticut Science and Engineering Fair, she was awarded second place in the Life Sciences category along with Special awards from the American Institute of Psychiatry and the Kathleen and David Smith award for application of lasers. Ava is interested in the impact of blue light on the eye structure and brain activity of Drosophila melanogaster, also known as fruit flies. She also tested the effect of the AREDS 2 vitamin and observed how it improved the behavior and eye degradation of the fruit flies. Ultimately, she would like to compare the results obtained to how blue light may impact humans with further testing. Ava is currently one of six students involved in GFA's Independent Research program. Ava is also a very active member of the GFA community as she plays varsity volleyball, is the captain of varsity tennis team, sings in an all-female a capella group, the Harbor Blues, and is the co-head of the Komera Club, an organization that helps Rwandan girls receive an education. Ava hopes to one day pursue a career in medicine as her passion for biology and the eye has only grown deeper over the course of this project.

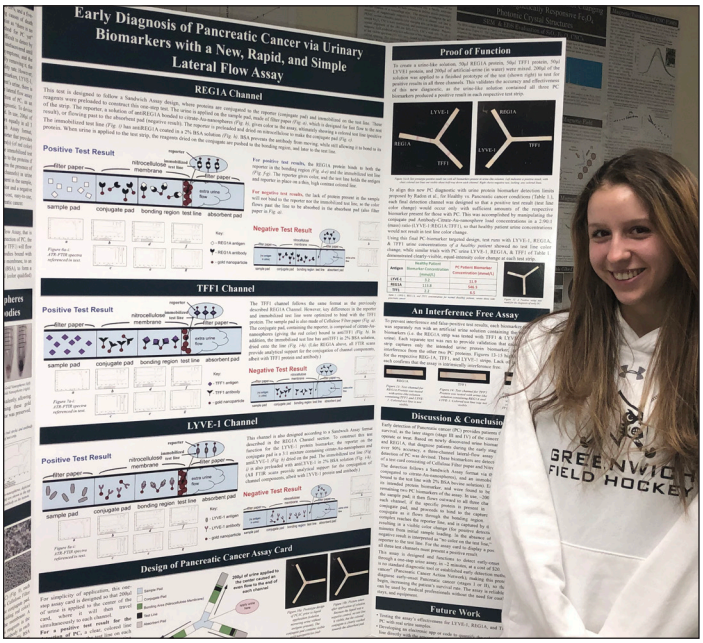
Impacts of Blue Light on the Eye Structure and Brain Activity of Drosophila Melanogaster

The average human spends approximately four to 11 hours viewing electronic screens daily which may have severe impacts on the human body and getting more attention. This research observed the impact of blue light on cognitive functioning and eyesight of Drosophila melanogaster, an applicable model to humans. It was hypothesized that blue light would slow cognitive function and lead to eye degradation in fruit flies. Group 1 fruit flies were exposed to 24 hours of full brightness blue light while group 2 flies were exposed to the same amount and time of red light from an iPad. Group 3 flies experienced the same conditions as group 1, but AREDS 2 vitamin, an antibody known to help prevent eye degradation, was added to the food. Group 1 flies suffered the most as flight patterns were more erratic with shorter flight durations than control flies not exposed to light, and were stationary and rested near the iPad screen by the end of the 24 hour period. Group 2 flies had flight patterns and durations relatively similar to the control. Group 3 flies had less erratic flight patterns, but demonstrated more mobility than group 1. Dissections of the brain and eyes of the flies may elucidate the extent of damage under the microscope. The results indicate that blue light is negatively impacting the vision and cognitive functioning of fruit flies, but reduced under the influence of AREDS 2 which could have similar effects on humans.

Ana-Florina Galic

Sophomore
Greenwich High School, Greenwich

ISEF Category- Translational Medical Science category



Already at the Elementary level I had a fascination with science, specifically medicine. When my 4th grade teacher assigned an open-ended "wonder project," I carried this mindset and kept asking myself "I wonder …". Up until my Sophomore year at Greenwich High School I rarely had an opportunity to pursue this interest further than a mere curiosity. Selected into my school's science research class with my teacher Mr. Bramante I applied my interest and creative drive towards an actual product. My research led me to develop a lateral flow assay of the early detection of Pancreatic cancer through urinary biomarkers. This device detects Pancreatic cancer in its early stages, therefore increasing patients' survival rate from 7% to up to 70%. While still a prototype, developing this assay to help patients directly is a rewarding experience. At the 2020 Connecticut Science and Engineering Fair, I received first in Collins Aerospace Engineering and third place in Alexion Biotechnology Categories, as well as winning a lunch with a patent attorney. I'm very excited to present my research at this year's ISEF. In my free time, I play field hockey and track, and enjoy fashion design and ceramics.

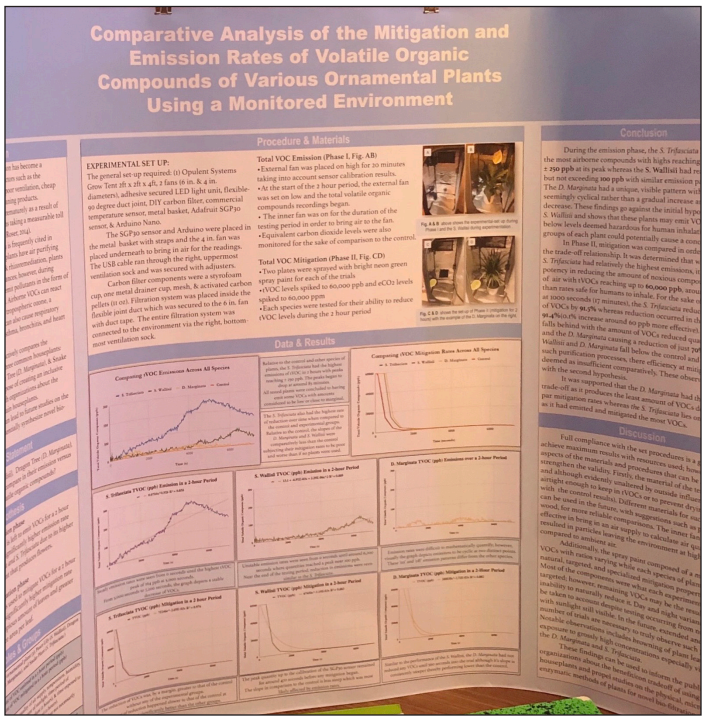
Early Diagnosis of Pancreatic Cancer via Urinary Biomarkers with a New, Rapid, and Simple Lateral Flow Assay

Less than 20% of patients' Pancreatic Cancer (PC) is discovered before spreading to other organs, making it nearly impossible to surgically remove, and attributing to a 7% five-year survival rate. Surgery can increase a patient's survival by ten-fold; however, without an available early detection method, the cancer is rarely diagnosed in time to remove it. This research sought to devise a rapid, one-step, and inexpensive PC lateral flow assay, to be performed during routine exams, based on a current study first highlighting the presence of three protein biomarkers, LYVE-1, TFF1, and REG1A, at high concentrations in the urine of PC patients. Presence of these proteins diagnoses patients with PC at over 90% accuracy. To detect these proteins, a three-channel configuration was designed, testing for each protein separately. Following a sandwich assay format, the protein is conjugated to both a reporter (Au-nanoparticles bound to antibodies), and an immobilized test line (antibodies held in place with bovine solution). For a positive result, the protein binds to both the reporter and the immobilized test line showing a highly concentrated, colored line. If the urine protein is absent, the colored reporters don't accumulate on the test line, showing a negative result. This assay card, made from nitrocellulose and filter paper, at $20/test, requires the application of 200μl of urine on the sample pad, where it flows simultaneously outward to all channels. Three colored test lines are formed within 2 minutes, without intervention, confirming the presence of PC proteins, and therefore a positive PC diagnosis.

Patricia Joseph

Sophomore
Engineering and Science University Magnet School, West Haven

ISEF Category- Plant Science



Patricia Joseph is a sophomore at Engineering & Science University Magnet School in West Haven. This is the first year Patricia will be attending the International Science & Engineering Fair. Her first involvement in science fair took place in 8th grade, when her then science teacher, Mr. Roger Rushworth, urged her to pursue a research project. After winning first place in her category at the New Haven District Fair with her project on studying angular momentum and velocity, Patricia was determined to continue her newfound passion. This year, her research project involved studying three common houseplants during their production of air pollutants, volatile organic compounds, and comparing that to their mitigatory abilities. In order to garner accurate measurements, she created a carbon-filter using inexpensive, household materials, and programmed a small sensor via Arduino. Other than scientific research, Patricia enjoys to read voraciously, play with her four-year-old dog, practice the piano, and paint. She is one of the lead coordinators of her school's science club and guides the middle schoolers. She is also a novice debater with the New Haven Debate League and won 1st place novice speaker and 1st place team in previous local tournaments.

Comparative Analysis of the Mitigation and Emissions Rates of Volatile-Organic Compounds in Various Ornamental Plants Using a Monitored Environment

Often overlooked issues like poor ventilation and sub-par construction methods have caused (1) the proliferation of dangerous air-borne compounds inside public buildings and (2) the rise of indoor air pollution. Specifically, VOCs (volatile organic compounds) pose a great threat to human health as inhaling these particles can cause cardiovascular and respiratory diseases. Furthermore, VOCs react with nitrogen oxides (NOx) and carbon monoxide (CO) to form tropospheric ozone, a notable green-house gas.

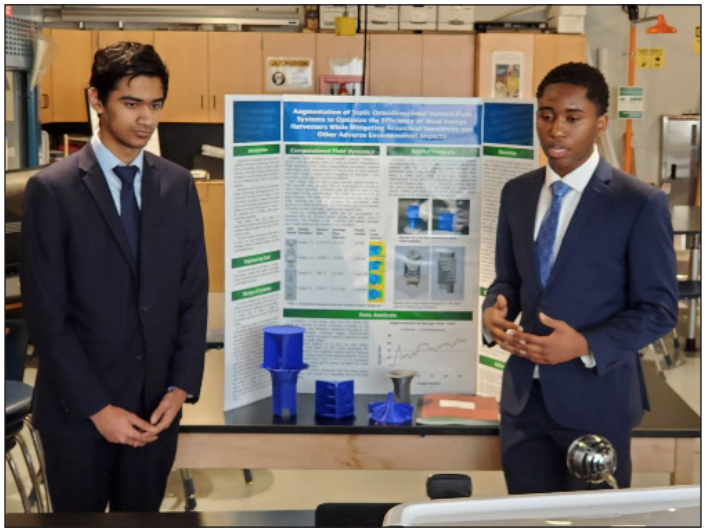
This project aims to create a comprehensive study comparing the mitigation and emission rates of the Peace Lily, D. Marginata, and S. Trifasciata. It was hypothesized that the S. Wallisii would emit more VOCs during the emission phase, whereas the S. Trifasciata would mitigate a substantial amount relative to the other experimental groups due to having a larger surface area per leaf.

A repurposed grow tent was used along with an Arduino-programmed SGP30 sensor and DIY carbon filter to measure the total VOC and equivalent CO_2 levels. Additionally, an aerosol paint with high concentrations of acetone, xylene, and ethylbenzene was sprayed during the mitigation phase. The emission results showed that the S. Trifasciata produced the most TVOCs contrary to the given hypothesis with peaks reaching ± 200 ppb, which is a marginally low concentration. The S. Wallisii constantly emitted <100 ppb and the D. Marginata emitted < 40 ppb with 'on-off' cyclical rates. On the other hand, S. Wallisii had the highest mitigation rates and reduced the amount of TVOC in 16 ft³ of air in 5 minutes.

Devesh Kakkar & Johnathan Bell

Seniors
Academy of Aerospace & Engineering, Windsor

ISEF Category- Energy: Physical



Devesh Kakkar is a Senior at the Academy of Aerospace & Engineering in Windsor, CT. Devesh has a passion for Math, Biology, and Computer Science. He wishes to major in computational biophysics. He is interested in computational analysis of cellular interactions. In addition to pursuing scientific opportunities, he holds key leadership positions as co-captain of his school's math and robotics team. Devesh's interests in programming led him to be one of the only coders on the team. Under his leadership, the team placed third in state competition. For the past three years, Devesh has also qualified for the Connecticut State American Regional Math League team. He likes to play soccer and ultimate frisbee in his free time.

Johnathan Bell is a Senior at the Academy of Aerospace & Engineering in Windsor, CT. This is his second year competing successfully at the CT Science and Engineering Fair. He enjoys engineering and has a strong passion for aviation and space. Johnathan had the honor of receiving congressional nominations to the Air Force Academy, West Point, Naval Academy, and Merchant Marine Academy. He is interested in majoring in Astronautical Engineering to further pursue his lifelong dream of becoming a fighter pilot and an astronaut. As such, he accepted an appointment to the U.S. Air Force Academy. He has completed a NASA internship, pursued a private pilot's license, and led a team in building the RV-12, a home built experimental aircraft. Apart from science, Johnathan loves to be involved in his community. He holds multiple leadership positions as the Cadet Commander of the Civil Air Patrol's Royal Charter Composite Squadron in Hartford CT, Co-Captain of his Debate/Model United Nations Team, and Vice President of his school's National Honor Society chapter.

Augmentation of Static Omnidirectional Venturi Flow Systems to Optimize the Efficiency of Wind Energy Harvesters While Mitigating Acoustical Sensitivity and Other Adverse Environmental Impacts

The conventional wind turbine has Federal, State, and Local siting regulations that restrict its ubiquity due to environmental concerns. These stem from a high number of avian collisions and the negative effects of infrasound produced by the turbines that disrupt ecosystems and physically hurt people in neighboring communities.

By creating a novel wind system that accelerates and concentrates wind (using Bernoulli's principle by progressively restricting airflow) into a turbine enclosed from the sides, the problems caused by an open blade design and acoustic disruption are mitigated.

To create the most energy-efficient model, multiple designs were created using Computer-Aided-Design (CAD) to test variables like intake size, venturi narrow diameter, fin count, and stripe geometry.

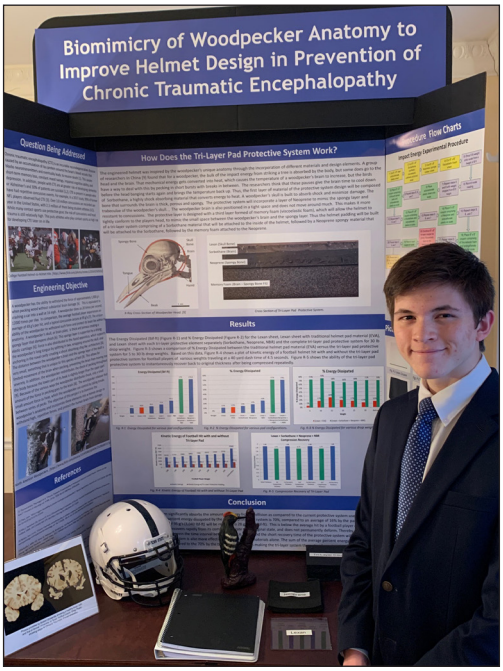
Over 26 different design iterations were modeled in CAD and simulated in Computational Fluid Dynamics (CFD). Multiple 3D-printed model prototypes were also tested in the wind tunnel to verify flow models. Through CFD, we obtained the rotational speed, torque, and power production to discover the most power-efficient design. Project development saw the wind system decrease in size tenfold from the initial to optimal design. Captured air velocity increased by 473% from the initial to optimal design. The best design increases the initial airflow velocity by 53% before reaching the turbines. This results in a 157ft^3 system generating between 10,786 and 12,864 kWh annually. This is enough to fully power the average American household. This system is intended to generate power in backyards, rooftops, and other residential locations because of its eco-friendly, sound-dampening design.

John Oei

Junior

East Catholic High School, Manchester

ISEF Category- Biomedical Engineering



John is a junior at East Catholic High School. He was inducted into the Honor Society this year. At the 2020 CSEF, John won first place in the Alexion Biotechnology category. He also won an award from the Yale Science and Engineering Organization as well as an $80,000 scholarship from University of New Haven. John grew up with the Science Fair watching his sisters compete and go to three ISEF competitions. He is excited to get to go himself this year. John is a member of East Catholic's cross-country and track teams. He ran the first leg of the 4x800 team that recently won the CIAC division state championship. John is an internationally ranked Irish dancer having performed throughout Connecticut with the Griffith Academy Irish Dance Company. He is a national and world qualifier and will be competing in Dublin, Ireland. John is a pianist for East Catholic's concert and jazz bands which won the 2018 Berklee College of Music Jazz Festival and he was awarded best pianist at the Greenwich Essentially Ellington Jazz Festival. He likes to stretch his vocal cord as a member of East Catholic's male acapella group. John is a black belt in Taekwondo and loves to surf during the summer.

Biomimicry of Woodpecker Anatomy to Improve Helmet Design in Prevention of Chronic Traumatic Encephalopathy

Chronic traumatic encephalopathy (CTE) is an incurable neurodegenerative disease affecting people who have had repetitive concussive events. In a 2017 study, 99% of former NFL players observed had CTE. Over 3.8 million concussions are recorded per year in the United States, with 2.5 million of them being student athletes.

A woodpecker has the ability to withstand the force of approximately 1,000 g's when pecking wood without substantial brain damage. A woodpecker does so 20 times per second, 12000 times per day. In comparison, a football player experiences a typical concussion at 95 g's.

The tri-layer padding system designed was inspired by the woodpecker's unique anatomy. This included a combination of sorbothane, a shock absorbing material that converts energy to heat, to mimic the ability of a woodpecker's brain to convert energy to heat; Neoprene to mimic the spongy layer of the woodpecker's skull; and viscoelastic memory foam, which will keep the helmet close to the skull, to mimic the small space between the woodpecker's brain and the spongy layer.

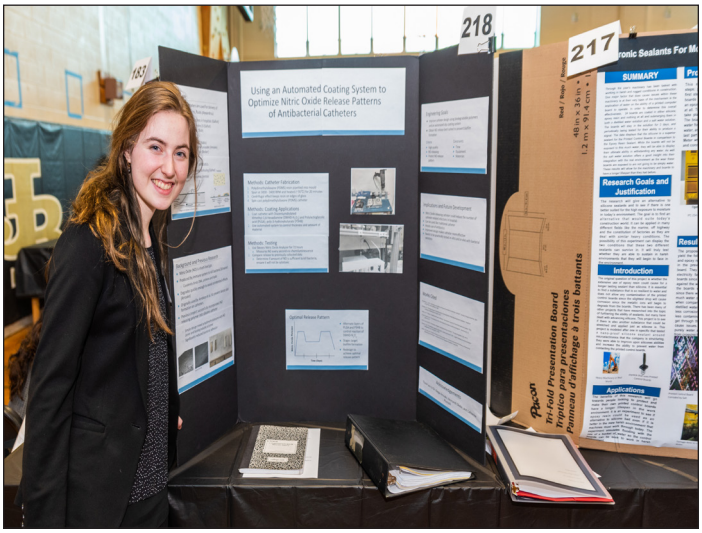
The average percent energy dissipated by the tri-layer protective system is 70%, compared to an average of 16% by the padding currently used. Thereby, a hit of 95 g's (3,040 lbf-ft) will be reduced to 28 g's (900 lbf-ft). This is below the average hit by a football player of 49 g's (1600 lbf-ft). The tri-layer protective system significantly absorbs the amount of energy from a collision as compared to the current protective system used by standard football helmets.

Abigail Slanski

Senior

Amity Regional High School, Woodbridge

ISEF Category- Biomedical Engineering



Abigail Slanski is a senior at Amity Regional High School. She has been conducting research through her school's program for the past four years. Her project, "Using an Automated Coating System to Optimize Nitric Oxide Release Patterns of Antibacterial Catheters" won the first place Lockheed Martin Physical Sciences award at the 2020 Connecticut Science and Engineering Fair. She intends to major in public health. She has always loved science and hopes to use an interdisciplinary approach to solving health care problems. Outside of science, Abigail volunteers with the Connecticut chapter of National Youth Leadership Training and is involved with her school's theater program.

Using an Automated Coating System to Optimize Nitric Oxide Release Patterns of Antibacterial Catheters

Intravascular (IV) catheters are essential medical devices used for monitoring, the deliverance of medications, and more. IV catheters are also one of the leading causes of hospital infection, due largely to biofilm formation. These infections lead to longer hospital stays and increased costs. While infections can be treated with antibiotics, increased resistance and the ineffectiveness of antibiotic locking at clearing biofilms. An antiseptic catheter, however, could circumvent these issues entirely. This project will create an antibiotic catheter by functionalizing polydimethylsiloxane (PDMS) catheters with nitric oxide (NO). Catheters were spin-cast and NO-releasing coatings were added using a dip coating system. One coating is composed of diazeniumdiolated dimethyl-1,6- hexadiamine (DMHD-N2O2) and polylacticglycolic acid, and the other is composed of DMHD-N2O2 and the polymer poly-3-hydroxybutyrate. The amount of coating and order of layers will be changed to achieve optimal release. NO release will be measured using a sievers Nitric Oxide Analyser. The NO release data will reveal quantity was released over time and will be compared to previous data of bactericidal NO release. The final prototype will ideally have a release pattern with rising levels for 72 hours and maintain a high level for another 24. The release should then drop off to a lesser level, releasing for 24 more hours. If successful, this catheter will use a natural compound created within the body's immune system to prevent

catheter infections. The release pattern of this catheter is optimized to prevent biofilm formation, the primary cause of catheter infections and chronic infections.