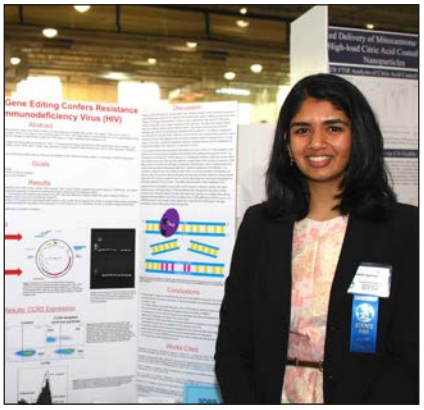
CONNECTICUT SCIENCE & ENGINEERING FAIR
at the
INTEL INTERNATIONAL SCIENCE & ENGINEERING FAIR
Phoenix Arizona, May 8 - 13, 2016

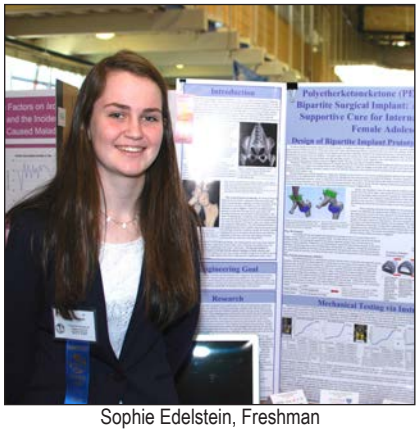
www.ctsciencefair.org

Meet the Winners

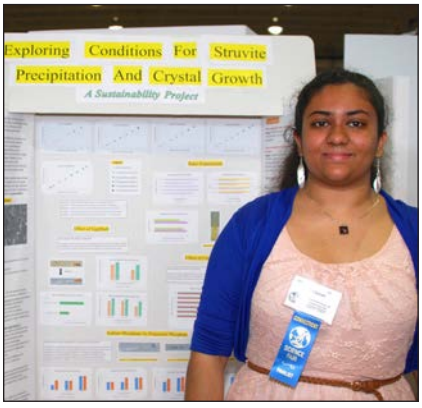
Connecticut Science & Engineering Fair ISEF Competition Participation Winners– l-to-r: William Yin, Maya Geradi, Aakshi Agarwal, Christopher Popham, and Martha Haddad, Sophie Edelstein, and Sanju Sathish



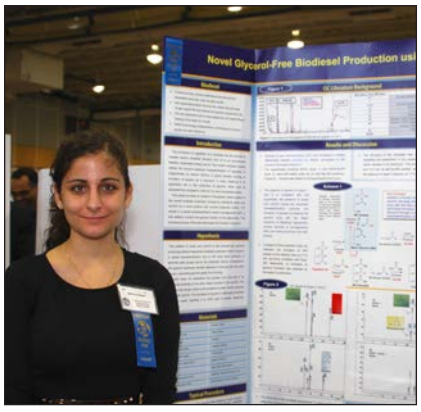
Aakshi Agarwal, Junior
Hamden High School
1st Place -Pfizer Life Sciences



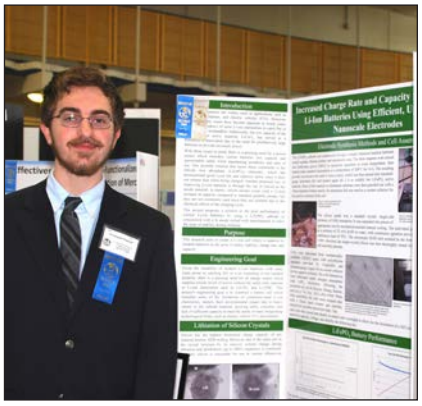
Sophie Edelstein, Freshman
Wilbur Cross High School, New Haven
Board of Directors ISEF Award



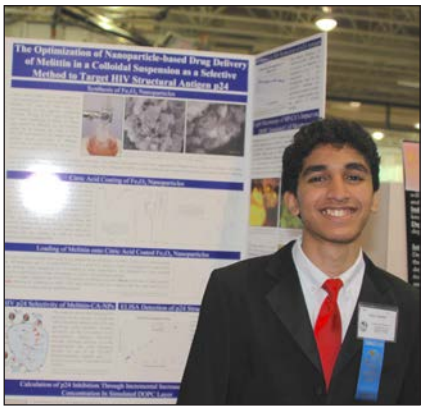
Maya Geradi, Sophomore
Wilbur Cross High School, New Haven
1st Place -CASE Urban School Challlenge



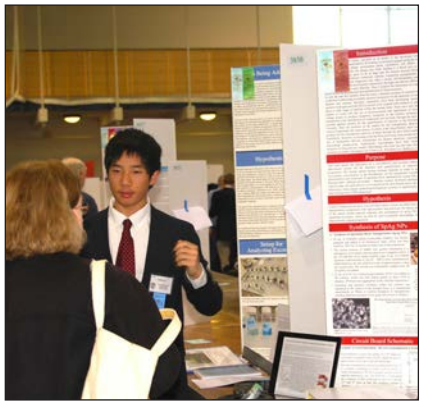
Martha Haddad, Junior
Immaculate High School, Danbury
2nd Place- Physical Sciences



Christopher Popham, Junior,
Greenwich High School
1st Place - Physical Sciences



Sanju Sathish, Junior
Greenwich High School
2rd Place - Pfizer Life Sciences



William Yin, Junior
Greenwich High School
1st Place - Alexion Biotechology Awards

Meet the Chaperones

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Ann Frattalone – ISEF Week Coordinator

Ann Frattalone retired after 31 years of teaching Special Education, the last 20 years in the Connecticut Technical High School System. An alumnus of Greenwich High School, Ann received a Bachelor's degree from Western Connecticut State University and completed her Master program in Vocational Special Education at UConn, Storrs. She has been the Regular Awards Chair of the Connecticut Science Fair for the past 26 years and is the ISEF Week Coordinator.

Ann is active in her community where for the last 17 years she has been a member of the Bridgewater Volunteer Fire Department Women's Auxiliary and currently is its President. Ann volunteers at the Senior Center and coordinates the town van that transports seniors to their appointments and activities. In her spare time she is a substitute teacher at their local elementary school and plays a little golf.

Mathieu Freeman – Greens Farms Academy

Mathieu J. Freeman is a Chemistry, Engineering, and Science Research teacher, as well as mentor and research program director for more than 50 students annually at Greens Farms Academy in Westport, CT over the last 13 years. Prior to being a faculty member at GFA, Mathieu spent two years at Stamford High School after leaving the government sector where he enjoyed a seven-year career as a research scientist and engineer for the Knolls Atomic Power Laboratory, then a division of Lockheed Martin. There, his expertise in chemistry and materials science was utilized to direct research in processing novel compound semiconductors for thermophotovoltaic applications and he assessed high temperature ceramic structural materials for nuclear reactor applications. He has authored more than 25 publications and presentations during his career. Mathieu is also an Adjunct Professor at Housatonic Community College in Bridgeport, CT, and was recently named the Goldenheim Award for Excellence in Teaching for 2015-2016. Mathieu is a native of Rochester, New York, where he completed his undergraduate and M.S. degrees in chemistry at St. John Fisher College and Rochester Institute of Technology, respectively, and received a Ph. D. in chemistry in 1995 from Rensselaer Polytechnic Institute. He is a Board Member for CSEF, and has mentored many of his students to Finalist status at the Fair. Mathieu is excited to work with the Finalists in his first trip to ISEF.

Meet the Chaperones

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Michel Leask – Fields Memorial School

Michel Leask is the Technology Director at Fields Memorial School in Bozrah, CT. As a certified teacher of secondary mathematics, she also serves as a STEM coach and technology teacher. Michel has mentored Bozrah students who participate in the CT Science and Engineering Fair for 18 years. She began her career in education in 1999 as a Technology Specialist/Trainer at LEARN in Old Lyme, CT.

Michel was previously employed by the Naval Undersea Warfare Center in New London, CT for 20 years as an electronic engineer in the area of software development for submarine sonar systems. She is an alumnus of Waterford High School, completed her undergraduate Engineering and Computer Science degree at UCONN and her graduate degree in Engineering at RPI.

Michel has a passion for introducing young students to Computer Science Education. She teaches coding classes, offers an after school computer programming club to middle school students and is the leader of a Robotics 4H club. Michel is an active community member. She is co-chair of the PTO, a member of the Board of Finance and has served as Registrar of Voters and Board of Education member. Michel is excited about her first trip to ISEF.

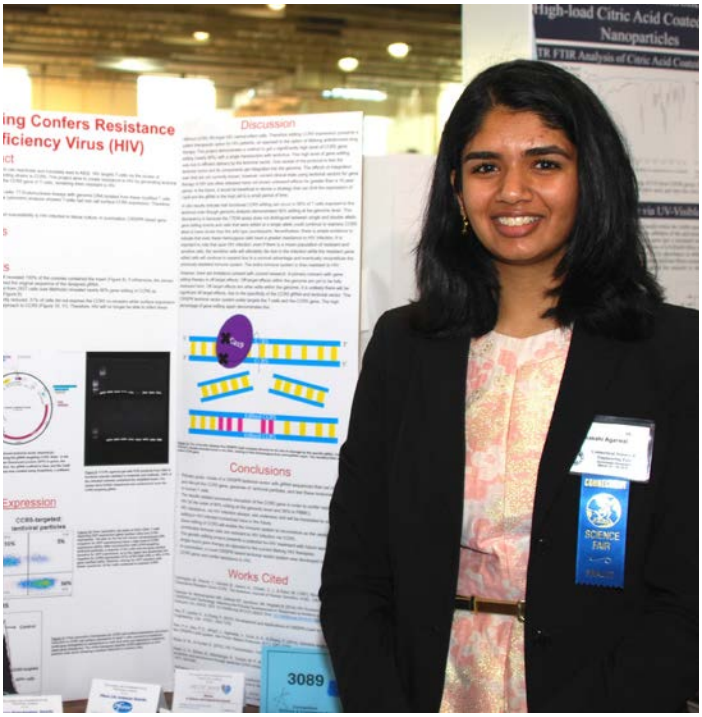
Bob Wisner – Fair Director/Chairman of the Board of Directors

Bob began his association with the Connecticut Science Fair as a 7th grader from Hartford's Kennelly School. He competed in high school making it to the National Science Fair in 1958 and 1959. In 1960 as a result of his science project work Bob was offered an internship at United Technologies Research Center. After receiving his electrical engineering degree from UConn, Bob became a full-time research engineer doing research in high-energy lasers, adaptive optics, and power electronics resulting in 15 patents. His proudest career accomplishment was leading a research team in the development of an automated clinical gait analysis system used to evaluate children with cerebral palsy. After 35 years at UT Research Center and 5 at Oits Elevator Bob retired in 1999. His science fair volunteer days began in the early seventies when his 7th grade science teacher asked him to become involved. Bob became chairman of the Fair's board in 1974 and Fair Director in 1989. Bob and his wife, Sue, have three children and five grandchildren. Bob enjoys sailing and his electronics hobby.

2015 CSEF Competitors
Pittsburgh, Pennsylvania

Aakshi Agarwal

Junior
Hamden High School



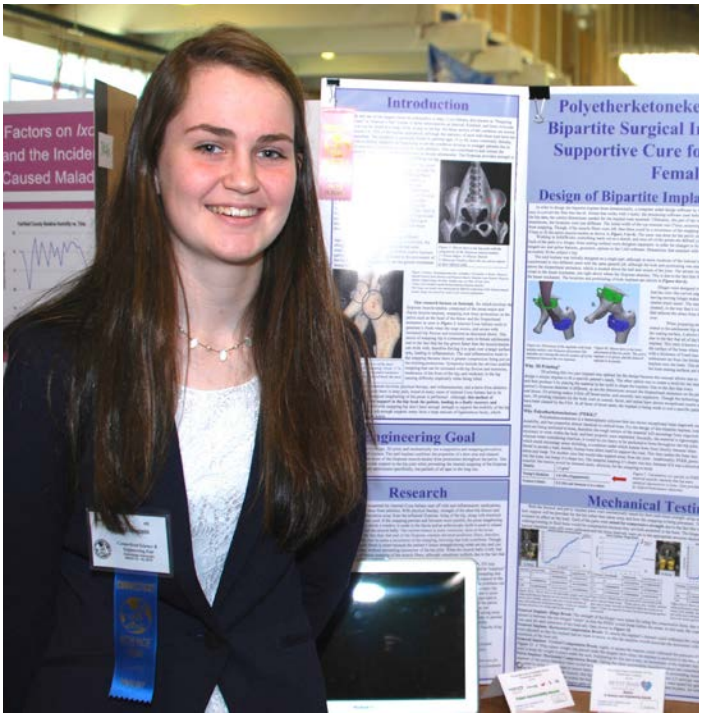
Aakshi is currently a junior at Hamden High School and has been conducting research at the Yale School of Medicine for the past three years. Her research on HIV and gene editing was inspired by the internationally recognized need for an HIV cure. She started competing in Science Fairs while in 7th grade. Her passion for research helped her in winning the Connecticut Junior Science and Humanities Symposium (JSHS) in 2016. She was also a national Broadcom MASTERS finalist in 2013. Aakshi enjoys sharing her interests in STEM through writing science articles for her school newspaper and competing with her Science Team. Aside from STEM, Aakshi is also a top state-ranked debater, Captain of the Debate Team, and enjoys performing dance at venues like MGM grand. She also takes the time to pursue her passion of helping the local community by tutoring less-privileged children, organizing blood drives, and creating programs to teach Spanish to children. In the future, Aakshi plans to combine her two passions by pursuing a future in medicine and helping patients.

CRISPR Based Gene Editing Confers Resistance to Human Immunodeficiency Virus (HIV)

Current HIV therapies lead to drug resistance and fail to address the latent viral reservoir which reactivates and inevitably leads to AIDS and mortality. Commonly infectious HIV targets T-cells via the cluster of differentiation glycoprotein (CD4) receptor and a highly conserved chemokine co-receptor, CCR5. This project aims to create resistance to HIV by generating lentiviral particles that will use CRISPR (clustered regularly interspaced short palindromic repeats) to specifically edit the CCR5 gene in T-cells, rendering them resistant to HIV. First, novel CRISPR lentiviral particles were created to effectively and specifically deliver the gene editing complex into T-cells. These lentiviral particles were then transduced into T-cells and resultant genomic DNA was isolated. Subsequently, gene editing efficiency was determined by subjecting genomic DNA isolated from these modified T-cells to T7 Endonuclease Assays. Results indicated that approximately 90% of the cells had undergone gene editing at the CCR5 gene. Further, flow cytometric analysis showed T-cells had lost cell surface CCR5 expression. Therefore, they will be resistant to HIV infection. In future, resistance will be confirmed by measuring the reduced susceptibility to HIV infection in the CCR5 geneedited cells. Such HIV resistance will also be tested in vivo. In summation, CRISPR based gene editing confers resistance to HIV. This project presents a potential single round gene therapy that confers resistance to HIV as opposed to current lifelong HIV therapies that are associated with comorbidities.

Sophie Edelstein

Freshman
Wilbur Cross High School



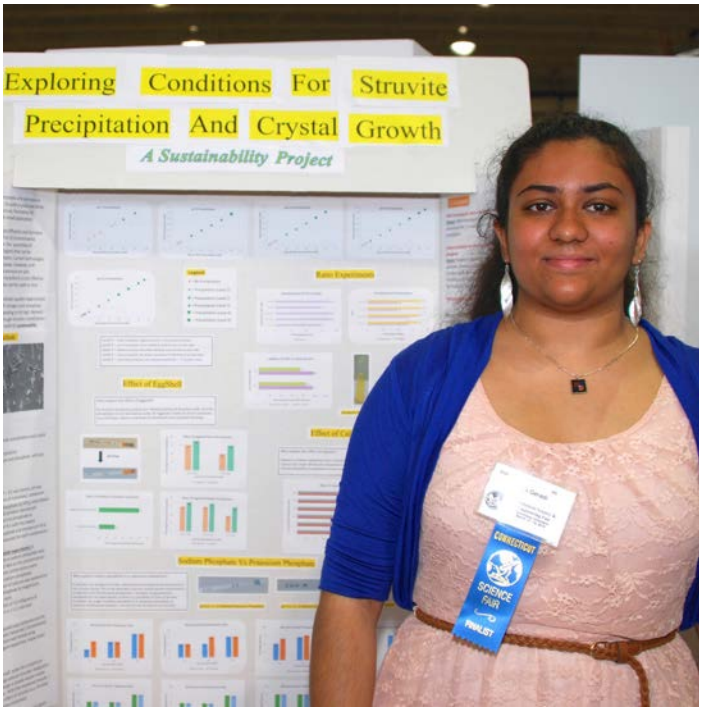
Sophie Edelstein is a freshman at Wilbur Cross High School in New Haven, Connecticut, and a two-time medalist at the Connecticut Science and Engineering Fair. She decided to focus her project on the development of a two-part implant as an alternative approach to cure Internal Coxa Saltans in female adolescents after growing up with hip issues herself. Sophie has the condition and is reminded of it during most daily tasks when her hip catches and locks or an audible, piercing snap is heard. Female adolescents tend to have hip and knee issues during puberty and following due to the rapid growth of their hips, for which the surrounding bodies can't always accommodate. The current surgical treatment is a release of the iliopsoas muscle-tendon, though that treatment is not suitable for Sophie and many others because it has a tendency to diminish support of the hip joint. Sophie has developed a bipartite implant that is anchored to the pelvis and femur in order to lift the muscle-tendon off of the eminences it is snapping over, therefore preventing it. The implants require no removal of stability and can be installed via an arthroscopically assisted procedure.Sophie hopes to become a pediatric orthopedic surgeon so she can help young children just like herself. In addition to her school and science fair work, Sophie is a member of the Yale Model UN program, a mentor for other students in her school's science research club, and a rower for the Great River Rowing Club.

Polyetherketoneketone (PEKK), 3D Printed, Bipartite Surgical Implant: An Alternative and Supportive Cure for Internal Coxa Saltans in Female Adolescents

Coxa Saltans, a condition of the hip, comes in three forms that manipulate a snap, but the contributing factors vary. Internal Coxa Saltans, on which this research focuses, occurs when the iliopsoas muscle-tendon snaps over bony protrusions on the front of the pelvis. The condition is commonly seen in female adolescents due to the hips growing faster than the muscle-tendon can accommodate. The muscle-tendon cannot span such a large area without complications. This results in a tight, inflamed iliopsoas that is prone to snapping. Basic treatment is administered and if the snapping persists and becomes increasingly painful, lengthening of the tendinous fibers of the iliopsoas muscle-tendon is performed. Research has shown that this method removes valuable support from the patient's hip joint. This research seeks to design, 3D print, and mechanically test a bipartite surgical implant that prevents the snapping and provides support for the patient. Using Solidworks, the two parts of the implant were designed, combining the properties of a doorstop and channel like mechanisms. The bipartite implant was 3D printed and then tested mechanically via an Instron machine. The implants were tested for compressive strength in different orientations. When tested mechanically, the femoral implant failed at a load of approximately 1,240 N and the pelvic implant failed at a load of approximately 720 N. Taking the general anatomy of the hip and the strength of the implants into account, it can be concluded that the implant design can provide required support to the hip, while also preventing the snapping.

Maya Geradi

Sophomore
Wilbur Cross High School, New Haven



Maya Geradi is a sophomore at Wilbur Cross High School in New Haven, CT and has been competing at the CSEF for 4 years. Maya is very interested in chemistry and environmental engineering.

This year, her research focuses on recovering ammonium and phosphate from municipal sewage and farmland effluent as struvite crystals. The method her project explores has implication for sustainability as the produced struvite can be recycled as a slow-release fertilizer. Maya aspires to be an environmental engineer, conducting research on water management systems.

Maya is also interested in the history of environmental awareness. She has participated in history day competitions for 4 years, competing at nationals last year. She is a peer tutor for mathematics and is in the Spanish Honor Society. Maya is an avid musician. She plays flute and is part of the leadership team for her school and all-city wind ensembles and mentors younger musicians in a greater youth band. She also volunteers at the Yale Peabody Museum teaching kids about science and interpreting exhibits to visitors. She enjoys spending her free time swimming and binge reading the Harry Potter series.

Maya is very excited to be competing at I-SWEEEP and Intel ISEF this year!

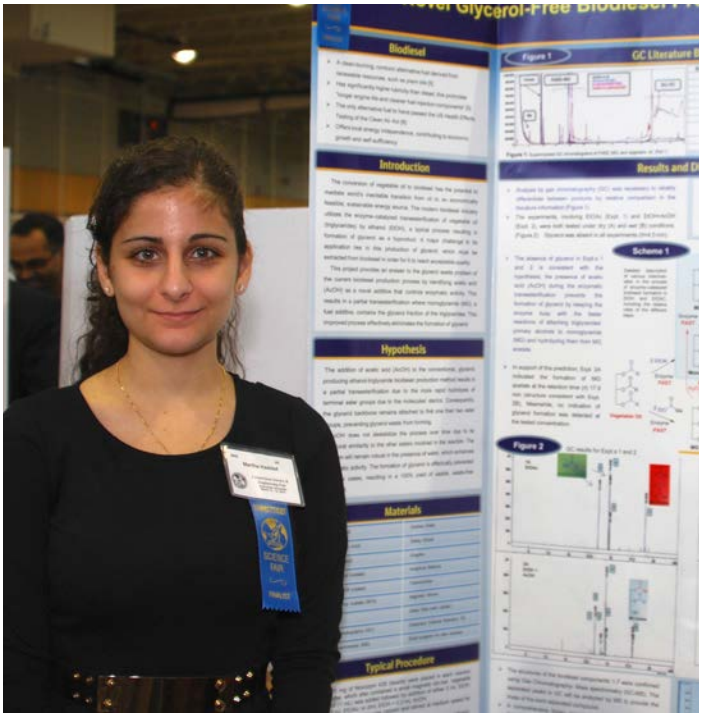
Exploring Conditions for Struvite Precipitation with Sustainable Goals in Wastewater Management

Municipal and farmland effluent and CAFO produced wastes contain high phosphate and ammonium levels, which must be brought to EPA mandated standards. Current treatments are relatively expensive and remove ammonium and phosphates separately. Production of struvite, crystals consisting of magnesium, ammonium and phosphate (MAP) in 1:1:1 ratio, is a potential effective, low-cost method to recover ammonium and phosphate together. This process has implication for environmental management and sustainability since struvite is an excellent slow-release, eco-friendly fertilizer, which allows for the recycling of MAP. This project aims to optimize conditions for recovery through struvite precipitation. Towards this goal, solutions of ammonium acetate, magnesium chloride and potassium phosphate were mixed at varying concentrations over ranging pH (7-9.5). Crystal morphology was observed. Ammonium and phosphate recovery was measured using reagent-based tests and test strips, respectively. The ratio of the three ions was varied and compared with solutions compounded in 1:1:1 ratio. Possibility of K-Struvite formation was tested by comparing usage of potassium phosphate with sodium phosphate. Effect of eggshell and sodium carbonate was later explored. Crystal formation increases with increasing initial pH. Precipitation was accompanied by drop in pH of supernatant and reduction of AP concentrations. Recovery increases with higher ratios of phosphate, addition of phosphate as a base and addition of eggshell. The KStruvite hypothesis was supported. My results significantly show that neutralization of pH drop is vital to maximum recovery. Eggshell proves to be a promising, novel approach to neutralization as it is a cheap, abundant waste and effectively increases struvite production.

Martha Haddad

Junior

Immaculate High School, Danbury



Martha Haddad is a junior at Immaculate High School in Danbury, Connecticut. Her interest in developing a low-cost, sustainable source of alternative energy grew as she experimented with naturally pigmented dye-sensitized solar cells in the seventh grade and invented the multiple-anode microbial fuel cell in the eighth grade. This year, Martha has focused her project on creating an inexpensive, one-phase biodiesel production method based on the addition of acetic acid to the reaction, resulting in partial enzymatic transesterification and completely preventing the formation of crude glycerol waste, which is in global oversupply. Easily implemented, the unprecedented process is able to increase biodiesel output while eliminating the need for waste disposal or refinement, offering to transform the current biodiesel industry. Martha is a silver medalist at the 2015 GENIUS Science Olympiad, has placed six times at CSEF, and has been nominated to apply for the 2017 Sustainability Solutions Festival. She is also a school newspaper editor, a religious education teacher, a member of her Diocesan Choir, a leading cantor in her local parish choir, and an elected officer of the National Association of Melkite Youth, for which she is currently designing a website. Martha has performed over 300 community service hours in the past three years. A classical pianist for ten years and a singer for eight, Martha plans to study music in addition to biotechnology, for which she has a passion.

Novel Glycerol-Free Biodiesel Production using Enzyme Catalysis

Biodiesel production from vegetable oil and ethanol (EtOH) has become a demonstrated alternative energy source. Current processes convert triglycerides to biodiesel, from which 90 million pounds of crude glycerol, a waste product, is extracted per annum in the US. Last year, a new method of production was formulated to avoid glycerol formation using selective partial transesterification; preliminary data required additional research to verify early findings and support the method reliably. This project investigates the effectiveness of the addition of acetic acid (AcOH) to the enzymatic process to prevent the formation of glycerol by inducing faster transesterification of the terminal alcohols. Gas chromatography and mass spectrometry (GC/MS) analyses were applied in order to identify intermediate compounds' structures dependably. Using GC/MS and dodecane, an internal standard (IS), to track formation of the new products, the reaction's stability was demonstrated. Glycerol was continually absent from the invented EtOH+AcOH reaction, supporting the hypothesis that stopping the process at the monoacylglycerol (MG) stage results in a 100% yield of good-quality biodiesel. Furthermore, the reaction of MG acetate, formed under anhydrous conditions, was tracked after the addition of water, experimentally verifying its structure. In the EtOH+AcOH experiment, 8% MG acetate was formed; its complete hydrolysis in the presence of water resulted in a 10% increase in biodiesel and 0.12% increase in MG. These results indicate that the EtOH+AcOH method for biodiesel production is a sound, efficient, and applicable process to prevent waste glycerol formation at minimal cost.

Christopher Popham

Junior
Greenwich High School

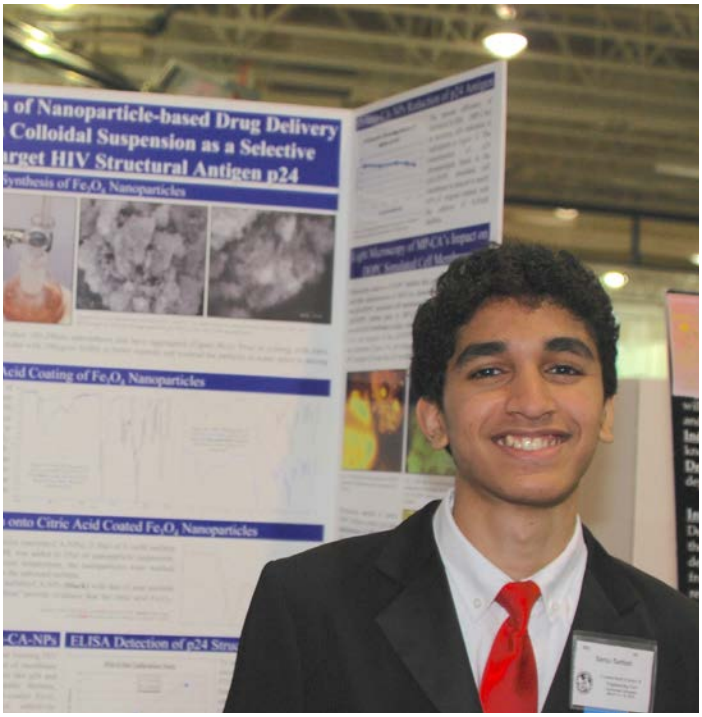
Christopher Popham is a junior currently attending Greenwich High School in Greenwich, CT. This is his first year participating in the school's Independent Science Research program, as well as the Connecticut Science and Engineering Fair. For his research project, he explored the viability of an alternate internal chemistry for lithium-ion batteries, which demonstrated great durability and cycle life as well as being easier and less expensive to produce. The most significant upside of this new formulation is its safety and stability. In contrast to the volatility of many current lithium-ion cells, batteries made according to the new formula will not catch fire or explode when mishandled or overcharged. Christopher has also been active in extracurricular activities, and was recently elected captain of the Greenwich HS Science Team, ranked #2 in the New England region. He is a second-degree black belt in Isshinryu Karate, and currently works as an assistant instructor at a local karate dojo. He is also interested in music, having been accepted to the Connecticut All-State chorus for 3 years in a row, and enjoys playing the guitar and composing music in his free time.

Increased Charge Rate and Capacity for Olivine Li-Ion Batteries via Efficient, Upcycled Nanoscale Electrodes

Lithium-ion batteries are used as the power source for a myriad of devices, from smartphones to electric vehicles. The main issues preventing further growth and development of these batteries are safety and capacity - both of these must be addressed in order to secure the future of the Li-ion energy market. A possible solution to these limitations may lie in adaptation of silicon anodes; Si's specific capacity can reach 4.2 Ah g-1, 12x that of the most commonly used anode, graphite. To date, however, Si anode technology remains untapped due to its massive volume change and instability during Li cycling. Concurrently, Li-ion electrode technology can be improved using lithium iron phosphate (LiFePO4) in place of LiCoO2. LiFePO4 possesses increased thermal and chemical stability, charge stability for over 2000 cycles, and decreased environmental impact when discarded. In this research, Si-anode and LiFePO4 technologies were simultaneously adapted to design an improved Li-ion battery. To prepare silicon for use as an anode material, Si wafers were first (metalassisted) chemically etched, to create nanoscale channels on the surface. These channels provide space for the crystal to safely expand and contract without damage to its structure. Lithium-ion batteries, including etched, nanostructured Si-anodes, were assembled, and compared to a standard CR2032 cell at low-load conditions (10 ohm resistance). The new Si-LiFePO4 design demonstrated 48% higher specific capacity, and exhibited 250X improvement in consistent output, suggesting that they are better suited than the CR2032 for long-term applications such as pacemakers, emergency lighting, and devices which require consistent power.

Sanjeev-kumar Mamalapuram Sathish

Junior
Greenwich High School



Sanju is a junior at Greenwich High School. He developed a biocompatible injection that functions through selectively targeting HIV surface proteins without affecting the blood or cells within. It accounts for cost and effectivity through the use of simulations of blood and cells in order to create the treatment. The project was inspired by drastic changes of late in the pharmaceutical industry especially with respect to standard HIV treatment. His research addressed the common feature of most modern HIV treatment methods which address the cause of HIV rather than the root replication process. The project was inspired by his experiences in the plight of Third World countries as he has focused his time on community service to an irrigation farmer in Nigeria. In his free time, Sanju is a lover of music. He has participated in the Western Regional Chorus of Connecticut and its All State Choir. He also participates as a leader in his school's chapter of the Tri-M Music Honor Society. He hosts a gaming youtube channel and is an entertainer to thousands of people from across the world. When Sanju grows up, he hopes to pursue being a doctor and working in an international help organization like Doctors Without Borders. He grew up in a tightly-knit community in India where his grandfather would treat hundreds of patients a week in his own hospital. Having grown up in this environment, it is something he wishes to get involved in when he is older.

The Optimization of Nanoparticle-Based Drug Delivery of Melittin in a Colloidal Suspension as a Selective Method to Target HIV Structural Antigen p24

The HIV-1 strand of the human immunodeficiency virus is an evasive retrovirus due to its ability to invade a cell and use the outer membrane to multiply and invade other cells. The p24 capsid protein that protects the RNA plays an important structural role in transporting the multiplied virus as it leaves the phospholipid bilayer. Previous studies have shown that melittin, a peptide found in bee venom, has the ability to selectively target p24 and other primary structural components of HIV that are found on the cell surface during replication. This research will investigate if melittin, introduced via a Fe3O4-Citric acid nanocarrier (CA-NP), will act to target HIV p24, thus inhibiting replication of the virus. First, CA-NPs were synthesized according to Racuciu, et al., with minor modification. Following confirmation of CA coating and NP size via FTIR and SEM, 130mg CA-NPs were immersed in 250µl of 2-10μM melittin (in 0.1M KCl) for 12 hours peptide loading. Following centrifugation, the solid melittin-CA-NPs were resuspended in di-water for use on simulated HIV-cell phospholipid bilayers (cpbs), created using an electroformation chamber (3Hz, 2Vp-p). To simulate HIV-cell targeting, 5μl melittin-CA-NPs were introduced to cpbs composed of 1,2-dioleoyl-sn-glycero-3- phosphocholine (DOPC) and p24. Using p24 selective ELISA at 450nm, results demonstrate that the introduction of 0.05µM melittin caused a 20% decline in p24 expression (8.51ng/ml to 6.89ng/ml), while "normal" cpbs containing only DOPC were unaffected. These results highlight the success of CA-NP as a nanocarrier for melittin, which in turn was selective in disrupting HIV replication.

William Yin

Junior

Greenwich High School

William Yin is a junior at Greenwich High School and a member of the GHS Science Research program. He competed at CSEF last year, placing 3rd in the Pfizer Life Sciences category, and then went on to win a 2nd Place Grand Prize in Material Sciences at the Intel ISEF. William's project describes the development of a tattoo-based biosensor for the cost-effective and accessible detection and quantification of atherosclerotic plaque progression. As heart disease or strokes remain the leading cause of death worldwide, William was surprised to discover that there existed no easily-accessible, reliable, and cost-effective test for the detection and quantification of plaque buildup in the arteries, and so set out to create one. This summer, William will be attending the prestigious Research Science Institute at MIT. At Greenwich High School, William is currently the President of the Math Honor Society and Secretary of the Science National Honor Society. He is the founder and President of the Science and Technology Club at the Huaxia Chinese School of Greater New York. He currently serves as the Production Editor for the school newspaper, The Beak. William has played multiple classical piano performances at Carnegie Hall and Steinway Hall, as well as around the world. He is currently a member of the GHS JV tennis team.

Development of a Portable, Tattoo-Based Biosensor for the Non-Invasive, Low-Cost Diagnosis of Atherosclerosis via Iontophoresis of Macrophage-Targeting Silver Nanoparticles

Atherosclerosis and subsequent cardiovascular disease causes nearly one-third of all deaths in the world. Unfortunately, atherosclerosis commonly remains asymptomatic fordecades, and is properly diagnosed only after a severe, life-threatening cardiac event. A simple, portable, and inexpensive method for early detection of atherosclerosis is highly desirable. This research details the fabrication of a cost-effective and portable tattoobased system for the detection and quantification of atherosclerosis progression. The system is contained within a screen-printed biosensor which utilizes human immune response in order to quantify macrophage concentration in the bloodstream via the transdermal iontophoretic administration of spermine-silver nanoparticles (spAg-NPs). In clinical usage, the patch is placed on the skin directly above the carotid bifurcation, where plaque quantification/diagnostic accuracy is especially high. The patch utilizes an iontophoretic circuit to introduce spAg-NPs into the interstitial fluid matrix. The patient then waits for macrophages to enter into the matrix and engulf a portion of the spAg- NPs. Remaining spAg-NPs are then extracted via a reversed current, which then react with amine oxidase to produce H_2O_2, which in turn electrochemically reduces Prussian- Blue 'artificial peroxidase'. Current produced is measured to determine concentration of spAg-NPs, and thus the concentration of macrophages in the bloodstream, which correlates directly with progression of the atherosclerotic plaque. The biosensor demonstrated a limit of detection of 3.26x10-5M spAg-NPs, with a sensitivity of 5.07 A/M-cm^2, allowing for the precise, cost-effective detection of as little as 0.059% arterial cross-sectional plaque buildup within the carotid bifurcation.