Fifty-Ninth Connecticut

JUNIOR SCIENCE and HUMANITIES SYMPOSIUM

Sponsored by UConn Health, Farmington, Connecticut
Held Virtually
March 5, 2022

THE NATIONAL SCIENCE TEACHING ASSOCIATION
under contract with
THE U.S. ARMY, NAVY, AIR FORCE and
UCONN HEALTH/CT AREA HEALTH EDUCATION CENTER

OBJECTIVES

...To promote research and experimentation in the sciences, mathematics, and engineering at the high school level;

...To recognize the significance of research in human affairs, the importance of humane and ethical principles in the application of research results;

...To search out talented youth and their teachers, recognize their accomplishments at symposia, and encourage their continued interest and participation in the sciences, mathematics, and engineering;

...To expand the horizons of research-oriented students by exposing them to opportunities in the academic, industrial, and governmental communities;

...To enlarge the number of future adults capable of conducting research and development.

A part of

THE U.S. ARMY/NAVY/AIR FORCE JUNIOR SCIENCE AND HUMANITIES SYMPOSIA PROGRAM

with support from

UCONN HEALTH/CT Area Health Education Center (AHEC)

and

CONNECTICUT ACADEMY OF SCIENCE AND ENGINEERING

Webex Meeting Connection Information
Saturday, March 5, 2022, 10:00 a.m. - 3:00 p.m.

Join by clicking on the meeting link:
https://uconn-cmr.webex.com/uconn-cmr/j.php?MTID=m8326531of4b4a42e6e2c634d7a7fffce

Or from Webex application, join by meeting number:
Meeting number (access code): 2621 535 2165
Meeting password: RkTdKrGV624

If all else fails, join by phone:
1-415-655-0002 US Toll

Program Summary

Online February 27 – March 4	**Pre-week Events & Activities**
February 27	● Online judging of oral and competitive poster presenters. (Live oral competition presentations recorded 2/27 and poster competition PDFs will be available for viewing during the week prior to Saturday, March 5, 2022.)
Self-guided through March 4	● Exhibit Quest: View the STEM Poster Exhibition videos and participate in the raffle entry. ● Prepare your questions for the oral and poster competitors by viewing their videos and poster PDFs, respectively.
Saturday, March 5	**Symposium**
10:00 – 10:30 AM	Welcome & Keynote Address—everyone attends.
BLOCKS #1 – 3 (25-minute blocks) 10:35 AM – Noon	Each 25-minute block includes: Oral Presentation Session Competitive Poster Presentation Session Research Panel Humanities Activity Alumni-led Workshop
Noon – 1:00 PM	**LUNCH BREAK** including optional "Lunch & Chat" Rooms, 12:15 – 12:45 PM, 4 rooms to explore: Biomedical Engineering; Engineering & Data Science; Health Sciences; Physical Sciences.
BLOCKS #4 – 6 (25-minute blocks) 1:00 – 2:25 PM	Each 25-minute block includes: Oral Presentation Session Competitive Poster Presentation Session Research Panel Humanities Activity Alumni-led Workshop
2:30 – 2:40 PM	Evaluation and Raffle Prizes—everyone attends.
2:40 – 3:00 PM	Awards Ceremony—everyone attends.

Winners and runners-up who make up the Connecticut Delegation to the National JSHS will stay to learn details.

Fifty-Ninth Connecticut
JUNIOR SCIENCE and HUMANITIES SYMPOSIUM

HELD VIRTUALLY SATURDAY, MARCH 5, 2022

Briefing

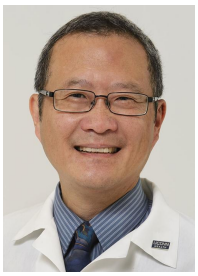
Pre-recorded, available here
Brittany Knight, PhD
Director, CT-JSHS
Program Coordinator, United States Association for the Study of Pain
And special guests: CT-JSHS alumni

OPENING SESSION
10:00 – 10:30 a.m. Webex Main Room (Click for the link.)

Welcome

Bruce Gould, MD, FACP
Associate Dean for Primary Care
Professor, Department of Medicine
Director, CT AHEC Program
UConn School of Medicine

Bruce Liang, MD, FACC
Dean, UConn School of Medicine
Director, Pat and Jim Calhoun Cardiology Center
Ray Neag Distinguished Professor of Cardiovascular Biology and Medicine



Keynote Address

Kelly Benoit-Bird, PhD
Senior Scientist & Science Chair
Monterey Bay Research Institute
CT-JSHS and Francis T. Maloney High School (Meriden) Alumna
"Echoes from the Deep"

At the conclusion of the Opening Session, you will move from the Webex Main Room to your assigned group's breakout room for Block 1, which can be found in the email with this subject line: CT-JSHS: Your Personalized Schedule, 3/5/22.

2022 HUMANITIES ACTIVITY: *World Hunger*
Developed by Heather Biancheri, MS, Brookfield High School

BLOCK #1
10:35 – 11:00 a.m.

Activity	Group A: 1st Oral Session	Group B: Research Panel	Groups C & D: Humanities Activity Part 1	Group E: Alumni-led Workshop	Group F: 1st Poster Session

Please promptly enter your assigned group's breakout room for Block #1, which can be found in the email with this subject line: CT-JSHS: Your Personalized Schedule, 3/5/22.

There will be a 5-minute transition period between each block of activities.

Block #1 Oral Presenters

Ryan Kim
Choate Rosemary Hall, Wallingford, CT
Mentor: Dr. Hyung Gi Min, Namseoul University
JARVITS: A Novel Deep Learning IoT Traffic Control System for Real-Time Detection and Signal Optimization

Avni Kabra
East Lyme High School, East Lyme, CT
Mentor: Mr. Samuel Harfenist, East Lyme High School
Investigating the Interplay between APP and MAPT and its Contribution to Neuroinflammation in Alzheimer's Disease Progression

Snigtha Mohanraj
Engineering and Science University Magnet School, West Haven, CT
Mentor: Anne Gold, 3M, Personal Safety Division
Ferro-Sponge: An Investigation into the Usage of Metal Oxides for the Removal of Microplastics and Oil from Water

Block #1 Poster Presenters

Melinda Lu
Amity Regional High School, Woodbridge, CT
Mentor: Dr. Adam Mecca, Yale School of Medicine
In Vivo Imaging of Structural Connectivity and Synaptic Density in Alzheimer's Disease

Deborah Luo
Amity Regional High School, Woodbridge, CT
Mentor: Arijit Chakravarty, Fractal Therapeutics
Determining the Most Effective Countermeasures for Protection from COVID in a High Population, Large Setting Using Mathematical Modeling

Aadya Wijesekera
Amity Regional High School, Woodbridge, CT
Mentor: Mrs. Rachel Powell, New England Food Allergy Treatment Center
Modifying an Application to Help Oral Immunotherapy Users Track Symptoms, Incidence of Allergic Reaction, and Progress

BLOCK #2

11:05 – 11:30 a.m.

Activity	Group A: Research Panel	Group B: 2nd Oral Session	Groups C & D: Humanities Activity Part 2	Group E: 2nd Poster ession	Group F: Alumni-led Workshop

Please promptly enter your assigned group's breakout room for Block #2, which can be found in the email with this subject line: CT-JSHS: Your Personalized Schedule, 3/5/22.

There will be a 5-minute transition period between each block of activities.

Block #2 Oral Presenters

Lily Donzeiser
Darien High School, Darien, CT
Mentor: Dr. Maggie MacPherson, Louisiana State University Museum of Natural Science
Evolutionary Responses to Climate Change in a Long-Distance Migratory Songbird: the Scarlet Tanager

Alison Enters
Darien High School; Darien, CT
Mentor: Carolyn Keogh, Emory University and Shoals Marine Laboratory
The Effect of Microplastic Ingestion on the Health of Parasites (Cryptocotyle lingua) in Periwinkles (Littorina littorea)

Sebastian Mengwall
Darien High School, Darien, CT
Mentor: Scott D. Guzewich, NASA Goddard Space Flight Center
Cloud Identification in Mars Daily Global Maps with Deep Learning

Block #2 Poster Presenters

Angela Ferraro
Bridgeport Regional Aquaculture Science and Technology Education Center, Bridgeport, CT
Mentor: Kirk Shadle, Bridgeport Regional Aquaculture Science and Technology Education Center
Developing a Fully Plant-Based Sustainable and Renewable Replacement for a Polychloroprene Fabrication

Adeethyia Shankar
Brookfield High School, Brookfield, CT
Mentor: Xiaodi Wang, Western Connecticut State University
Co-researcher: Stephanie Chang, Greenwich High School, Greenwich, CT
Wavelet Based Machine Learning Approaches Toward Precision Medicine in Diabetes Mellitus

Daniel Vash
Hamden Hall Country Day School, Hamden, CT
Mentor: Dr. Frank Gasparro, Hamden Hall Country Day School
The Formulation and Testing of a Skin-Friendly Sunscreen Encapsulated in Hydroxyapatite

BLOCK #3
11:35 a.m. – Noon

Activity	Group A: Alumni-led Workshop	Group B: 3rd Poster Session	Group C: 3rd Oral Session	Group D: Research Panel	Groups E & F: Humanities Activity Part 1

Please promptly enter your assigned group's breakout room for Block #3, which can be found in the email with this subject line: CT-JSHS: Your Personalized Schedule, 3/5/22.

There will be a 5-minute transition period between each block of activities.

Block #3 Oral Presenters

Audrey Lin
Greenwich High School, Greenwich, CT
Mentor: Andrew Bramante, Greenwich High School
Eco-friendly Remediation of Polycyclic Aromatic Hydrocarbons in Stormwater via Magnesium-Infused Calcite Crystal, Supramolecular Hydrogel Scaffolding

Naomi Park
Greenwich High School, Greenwich, CT
Mentor: Andrew Bramante, Greenwich High School
Biomimetic Removal of Microspheres Water Contaminants, via Calcite-Infused, Coral-Like Melamine Sponges

Elizabeth Wallace
Greenwich High School, Greenwich, CT
Mentor: Andrew Bramante, Greenwich High School
Controlled Delivery of Sulfoxaflor Pesticide via Cinnamaldehyde-Infused Hydrogels to Reduce Toxicity to Honey and Wild Bee Pollinators

Block #3 Poster Presenters

Shealeigh Crombie
Greens Farms Academy, Westport, CT
Mentor: Dr. Mathieu J. Freeman, Greens Farms Academy
The Comparative Effects of Fuhc Immunosuppressants and Allotransplanted Blood Plasma Transfusion on Allotransplant Acceptance in Botryllus schlosseri

Jason Li
Guilford High School, Guilford, CT
Mentor: Mrs. Mary Mooradian, Guilford High School
Did the Vaccination Quell COVID-19 Surge after Holidays: An Analysis of Real-World Data

Lauren Marze
Canton High School, Canton, CT
Mentor: Jeffrey Aureli, Canton High School
Impact of Climate Change on the Timing and Intensity of Precipitation in the Northeastern United States

Olivia Pistone
Darien High School, Darien, CT
Mentor: Dr. Silvia De Rubeis, Icahn School of Medicine at Mount Sinai
Comparing Dendritic Development in Embryonic Neurons Harvested from DDX3X Mutant Mice and Wild Type Mice

LUNCH BREAK

Noon - 1:00 p.m.

Optional "Lunch & Chat" Rooms with CT-JSHS alumni and others, 12:15 – 12:45 p.m.

4 chat rooms to explore (visit none or stop by all 4!):

Biomedical Engineering; Engineering & Data Science; Health Sciences; Physical Sciences

BLOCK #4

1:00 – 1:25 p.m.

Activity	**Group A:** 4th Poster Session	**Group B:** Alumni-led Workshop	**Group C:** Research Panel	**Group D:** 4th Oral Session	**Groups E & F:** Humanities Activity Part 2

Please promptly enter your assigned group's breakout room for Block #4, which can be found in the email with this subject line: CT-JSHS: Your Personalized Schedule, 3/5/22.

There will be a 5-minute transition period between each block of activities.

Block #4 Oral Presenters

William Bernfeld
King School, Stamford, CT
Mentor: Dr. Simon Vecchioni, New York University, Department of Chemistry
Structural Determination of Novel Non-canonical Base Pairs and Mismatches

Gouri Krishnan
King School, Stamford, CT
Mentor: Xin Shen, Yale University, Energy and Science Institute
Electrochromism Paired with Finite Difference Time Domain Modeling Allows for the Successful Prediction of Color Change Achieved by Electrochromic Reactions

Block #4 Poster Presenters

Maya Rose Chiravuri
Choate Rosemary Hall, Wallingford, CT
Mentor: Dr. Stuart Zarich, Bridgeport Hospital/Yale New Haven Health
Development of a Home N-Terminal Pro-Brain Natriuretic Peptide Assay for Early Detection of Congestive Heart Failure

Connor Riley
Thomaston High School, Thomaston, CT
Mentor: Phillip Baker, Collins Aerospace
Is Lithium Nitrate a Good Absorbent with Ammonium Hydroxide for Absorbent/Refrigerant Pairs in Heat Loop Systems?

Zachary Stevenson
Thomaston High School, Thomaston, CT
Mentor: Dr. David Dagget, Boeing (Retired)
Investigation of Unexplained Intermediate Freeze Point Characteristics as Tested by a Newly Developed Multispectral Optical Biojet Fuel Freeze Point Analyzer

BLOCK #5
1:30 – 1:55 p.m.

Activity	Groups A & B: Humanities Activity Part 1	Group C: Alumni-led Workshop	Group D: 5th Poster Session	Group E: 5th Oral Session	Group F: Research Panel

Please promptly enter your assigned group's breakout room for Block #5, which can be found in the email with this subject line: CT-JSHS: Your Personalized Schedule, 3/5/22.

There will be a 5-minute transition period between each block of activities.

Block #5 Oral Presenters

Lucy Xu
Hamden Hall Country Day School, Hamden, CT
Mentor: Dr. Francis P. Gasparro, Hamden Hall Country Day School
Spectrophotometric Determination of the DNA Binding Constant of a Novel and Potent Psoralen Derivative

Alexandra Hamza
Manchester High School, Manchester, CT
Mentor: Blaire Steven, Connecticut Agricultural Experiment Station
The Effect of Azospirillum lipoferum Inoculation on Microbial Abundance and Diversity of the Corn Soil Microbial Population after a Moderate-Intensity Fire

Junyue Ma
Miss Porter's School, Farmington, CT
Mentor: Pingzhang Wang, Peking University
Using Single-Cell Analysis to Explore Prognostic Genes in Prostate Cancer

Block #5 Poster Presenters

Fhasal Alam
Torrington High School, Torrington, CT
Mentor: Sharon Gusky, Northwestern Connecticut Community College
Utilizing Bioanalytical Software to Examine the Genomes of Gordonia Bacteriophages Sahara and SoilAssassin

John Russell
King School, Stamford, CT
Mentors: Devan Solanki and Atsu Kludze, Yale Department of Chemical and Environmental Engineering
Biocement Bricks for Negative Emissions: Electrochemical Ocean Carbon Capture

Yuriy Sandmeier
Darien High School, Darien, CT
Mentor: Nicholas Poulton, Rockefeller University
The Essential 23S rRNA Methyltransferase rv3579c Confers Intrinsic Macrolide Resistance in Mycobacterium Tuberculosis

BLOCK #6
2:00 – 2:25 p.m.

Activity	Groups A & B: Humanities Activity Part 2	Group C: 6th Poster Session	Group D: Alumni-led Workshop	Group E: Research Panel	Group F: 6th Oral Session

Please promptly enter your assigned group's breakout room for Block #6, which can be found in the email with this subject line: CT-JSHS: Your Personalized Schedule, 3/5/22.

There will be a 5-minute transition period between each block of activities.

Block #6 Oral Presenters

Ian Murdock
Ridgefield High School, Ridgefield, CT
Mentor: Xiaodi Wang, Western Connecticut State University
A Wavelet-Based Method for Generalizing Molecular Latent Spaces for Assisted Traversal

Evia Rodriguez
Ridgefield High School, Ridgefield, CT
Mentor: Dr. Christine Rodriguez, Fairfield University, Department of Biology
Short-Term Pilot Biodegradation Study of Poly (α-Pinene Methacrylate), Poly (Myrtenyl Methacrylate), and Poly (Methyl Methacrylate) Synthesized in Supercritical Carbon Dioxide

Block #6 Poster Presenters

Aalok Bhattacharya
Staples High School, Westport, CT
Mentor: Xiangyi Chen, Texas A & M University
Classifying Alzheimer's Disease with Machine Learning via Wavelet Transform Subband Combinations

Ana-Florina Galic
Greenwich High School, Greenwich, CT
Mentor: Andrew Bramante, Greenwich High School
A Novel Drug Delivery System of Gold-Nanoparticle–Chaperone Complex to Successfully Mitigate Drug-Induced Nephrotoxicity, an Unwanted Side Effect in Organ Transplant Medications

Ambika Grover
Greenwich High School, Greenwich, CT
Mentor: Andrew Bramante, Greenwich High School
Design of a Novel, Dual-Functioning Tissue Plasminogen Activator and Anticoagulant Therapeutic for Rapid Ischemic Stroke Treatment

Prathit Kurup
Greenwich High School, Greenwich, CT
Mentor: Andrew Bramante, Greenwich High School
The Role of ICAM-1 in Facilitating Leukocyte Migration across the Blood-Brain Barrier in the Progression of Multiple Sclerosis

EVALUATION AND RAFFLE PRIZES

2:30 - 2:40 p.m. Webex Main Room

Please promptly return to the Main Room to be eligible for the raffles.

EVALUATION

- Students and teachers: Look for our CT-JSHS evaluation link in the Webex chat box now.
- A separate national JSHS evaluation will be sent to you via email later.

RAFFLES

Prizes will be mailed after shipping address confirmation via email.

CT AHEC CT-JSHS Evaluation Raffle, winner announced at end of awards:

- All students and teachers should complete the anonymous Survey Monkey evaluation--link will be posted in the Webex chat box; on the last page of the survey, click on the Google form link to add your name to the raffle drawing!
- **Several gift card and basket prizes** for students and teachers

People's Choice Award Nomination Raffle, entries due Friday, 3/4:

- Those who voted for the People's Choice Award winner (via Survey Monkey) by Friday evening (3/4/22) were entered in the raffle.
- Prize: Barnes & Noble gift card for $40

STEM Poster Exhibition "Exhibit Quest" Raffle, entries due Friday, 3/4:

- To be entered into the raffle, you must have participated in the YouTube poster video activities during the week and must be present on Webex at this time to claim the prize.
    - Those who submitted the completed Exhibit Quest entry (via Survey Monkey) by Friday evening (3/4/22) were entered in the raffle.
- Prize: Bartaco Restaurant dinner for four

STEM Poster Exhibitor Raffle:

- Students who exhibited a poster are automatically entered into the raffle but must be present on Webex at this time to claim the prize. Prizes will be mailed after email confirmation.
- Prizes:
    - Mecha Noodle Bar, 5 locations in CT, gift card for $50
    - Bridgewater Chocolate, West Hartford, Chocolates assortment

AWARDS CEREMONY

2:40 – 3:00 p.m. Webex Main Room

Acknowledgments **Brittany Knight, PhD**
Director, CT-JSHS

Awards

- Poster Presenters
- Backyard Scientist Award
- Presidential Award Nominee
- STEM Poster Exhibition:
  People's Choice Award
- Oral Presenters
- Teacher Award

Winners and runners-up who make up the Connecticut Delegation to the National JSHS: Please stay to learn details.

NATIONAL ONLINE EVALUATION

We need your feedback! You will receive a National JSHS evaluation form from CT-JSHS via email. Please take a few minutes to fill out the survey as soon as possible. Thank you.

STEM Poster Exhibitors

Leila Affini, Manchester High School
Antibacterial Perfluorocarbon Emulsions: The Role Temperature Plays in the Formation and Efficacy of Integrating Perfluorocarbon (PFC) and Tobramycin

Giovanna Armetta, King School
Drosophila melanogaster Locomotion, Myonuclei Size, and Myonuclei Position Are Affected by Differential Gene Expression

Aaron Babajanyan, Amity Regional High School
Creating a More Efficient Fixation Device for Distal Femur Fractures Based on Finite Element Analysis of Different Plate and Screw Scenarios

Anchal Bahel, Amity Regional High School
Determining the Availability of Effective Online Triage Resources for Patients at Musculoskeletal Urgent Care Centers

Paris Bazemore, Manchester High School
The Design of a Microfluidic Device for the Detection of Enteric Diseases

Karishma Bulsara, Amity Regional High School
Analyzing the Effect of Sodium Levels on the Onset of Cerebral Vasospasm after Subarachnoid Hemorrhage

Albert Capodanno, Bridgeport Regional Aquaculture Science and Technology Education Center
Using Pyrethrum Extract from Chrysanthemum cinerariifolium as a Natural Insecticide

Cooper Carr, Bridgeport Regional Aquaculture Science and Technology Education Center
A Novel Mitigation Technique to Control the Spread of the Invasive Spotted Lanternfly (L. delicatula) through Cardiac Glycoside Extracts

Kennedy Carr, Bridgeport Regional Aquaculture Science and Technology Education Center
The Use of Sodium Bicarbonate as a Local Buffer to Decrease Ocean Acidity in Localized Areas to Increase the Oyster Growth

Audrey Cummings, Amity Regional High School
Utilizing Gene Set Enrichment Analysis to Identify Biological Gene Pathways for Cannabis Use

Liangtong Dong, Hamden Hall Country Day School
Research on Eye Movement Recognition of Early Childhood Autism Spectrum Disorder Based on Hybrid Timing Neural Network

Liza Dowling, Greens Farms Academy
The Effects of Pollutants, Such as Carbon Dioxide, Lead, and Scotchgard, on the Behavior of Mummichogs

Kelsey Farber, Bridgeport Regional Aquaculture Science and Technology Education Center
Absorbing High Concentrations of Nitrogen Using Biochar as a Preventative Measure to Mitigate the Dinoflagellate Karenia brevis

Michael Grant, Thomaston High School
Assessment of the Craniocervical Junction in Down Syndrome Patients

Allison Greenberg, Bridgeport Regional Aquaculture Science and Technology Education Center
An Inexpensive, Simple, and Effective Application of Off the Grid Solar Disinfection for Potable Water

Emma Greenfield, Manchester High School
The Effects of Environmental Noise Buffers on Traffic-Related Noise Pollution

Zara Haque, Greenwich High School
The Effect of Social Capital on COVID-19 Prevalence, Mortality, and Vaccine Hesitancy

Shreya Hebbar, Amity Regional High School
The Effect of Time of Day, Social Interaction, and Activity on Adolescents' Emotions within a School Day

Grace Hilton, Bridgeport Regional Aquaculture Science and Technology Education Center
The Use of Secondary Plant Metabolites to Reduce Pseudogymnoascus destructans Transmission among North American Bats

Delaney Jose, Thomaston High School
The COVID-19 Pandemic's Effect on Mothers and Infant Outcomes During Prepartum, Labor and Delivery, and Postpartum

Aidan King, Bridgeport Regional Aquaculture Science and Technology Education Center
Utilizing Rooftop Gardens as a Means of Geothermal Energy for Buildings through Ground to Air Heat Transfer Systems

Keun Hyong Kwak, Avon High School
On the Smallest (n-1)-gon Containing a Convex n-gon

Randy Liu, Amity Regional High School
Investigating the Effects of Narrowed Attentional Scope on Perceived Effort of Exercise and Performance

Yuqi Liu, Amity Regional High School
Analyzing the Effect of Toneless Language Acquisition on Tone Discrimination and Production Observed in Mandarin Chinese Native and English Nonnative Speakers

Sandra McDonald, Thomaston High School
Tracking Adolescent Hand and Arm Fatigue in Virtual Reality

Stella Meier, Darien High School
Selection of High-Affinity scFvs for HPRT by Yeast Surface Display

Madeline Minichetti, Greenwich High School
Design of a Wearable and Stretchable Hybrid Supercapacitor Biofuel Cell for Creation and Storage of Energy via Sweat

Alana Mondschein, Glastonbury High School
Helping Teachers Add Climate Justice to Their Classrooms through a Comprehensive Document of Accessible Resources

Ella Moore, Greenwich High School
Inhibition of COVID-19 Respiratory Complications via an R-954 Peptide Bradykinin 1 Receptor Antagonist

Adam Nomani, King School
Passive Thermal Energy Storage for Air Conditioning Systems Utilizing Phase Change Material

Benjamin Persily, King School
The Use of Prime Editing to Induce the CFTR-F508del Mutation in iPSCs

Charlotte Simari, Darien High School
Positive Reinforcement of Invasive Species Populations through Manipulation of Microclimate by Berberis thunbergii, Amynthas agrestis, and Lumbricus terrestris

Jack Wang, Avon High School
Proteomics Analysis Identifies Novel Therapeutic Targets and Pathways for Acute Kidney Injury

Jackson Warters, Bridgeport Regional Aquaculture Science and Technology Education Center
Optimizing Desalinization of Industrial Brine through Temperature Swing Solvent Extraction

Avery Woodworth, Greens Farms Academy
The Effects of Green Tea on Beta-Amyloid–Induced Alzheimer's Disease in Neritina reclivata

Tiffany Yin, Ridgefield High School
The Effect of Computer Light on Caenorhabditis elegans Development

Participating High Schools

Academy of Aerospace and Engineering, Windsor
Amity Regional High School, Woodbridge
Avon High School
Avon Old Farms School
Bethel High School
Bridgeport International Academy
Bridgeport Regional Aquaculture Science & Technology Education Center
Brookfield High School
Canton High School
Choate Rosemary Hall, Wallingford
Coginchaug Regional High School, Durham
Conard High School, West Hartford
Connecticut International Baccalaureate Academy, East Hartford
Cromwell High School
Darien High School
East Catholic High School, Manchester
East Hartford High School
East Lyme High School
Engineering and Science University Magnet School, West Haven
Farmington High School
Francis T. Maloney High School, Meriden
Glastonbury High School
Global Experience Magnet School, Bloomfield
Greens Farms Academy, Westport
Greenwich High School
Guilford High School
Hamden Hall Country Day School
Joel Barlow High School, Redding
King School, Stamford
Laurelton Hall, Milford
Manchester High School
Middletown High School
Miss Porter's School, Farmington
Norwich Free Academy
Orville H. Platt High School, Meriden
Parish Hill High School, Chaplin
Ridgefield High School
Sacred Heart Greenwich
Shelton High School
South Windsor High School
Southington High School

St. Paul Catholic High School, Bristol
Staples High School, Westport
The Morgan School, Clinton
Thomaston High School
Torrington High School
Trumbull High School
Westbrook High School
Weston High School
William H. Hall High School, West Hartford

SPONSORS

- Connecticut Academy of Science and Engineering
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- UConn Office of Undergraduate Admissions

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- Barnes & Noble, UConn Storrs
- Bartaco, West Hartford (and other locations)
- Blaze Pizza, Storrs
- Bridgewater Chocolate, West Hartford
- GVH Restaurants (Dog Lane Café, Storrs; Vanilla Bean Café, Pomfret; 85 Main, Putnam; Fenton River Grill, Mansfield)
- Flora Restaurant, West Hartford
- Frank Pepe Pizzeria (7 locations)
- Gansett Wraps, Storrs
- Head Husky Barber Styling Shop, Storrs
- Mecha Noodle Bar, West Hartford (and other locations)
- Play It Again Sports, West Hartford
- Price Chopper, 9 locations in CT
- Starbucks, Storrs
- TJ Maxx/Marshalls/Home Goods/Sierra/HomeSense
- Wings 'n' Pies, Willimantic
- Yono Yoga & Meditation, Willimantic

COOPERATING ORGANIZATIONS

- AmeriCorps Health*Forward* Program (CT AHEC Network)
- CT AHEC Urban Service Track/AHEC Scholars Program
- UConn Academic IT
- UConn Department of Natural Resources and the Environment, Storrs
- UConn Graduate School, Farmington
- UConn School of Engineering, Storrs
- UConn School of Medicine, Farmington

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- Jonathan Craig, Talcott Mountain Science Center, Avon
- Joy Erickson, Consultant and former Director CT-JSHS
- Robert Erickson, Pratt & Whitney, United Technologies Corporation, East Hartford (retired)
- Barbara Fischler, U.S. Army Nurse Corps (veteran)
- Sandra Justin, Connecticut Science Supervisors Association
- Brittany Knight, Director CT-JSHS, Program Coordinator U.S. Association for the Study of Pain
- Frank LaBanca, Westside Middle School Academy, Danbury
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- Richard Luddy, UConn, Hartford
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- Diane Pintavalle, Glastonbury High School
- Anu Prabhath, West Pharmaceuticals
- Jon Swanson, E.O. Smith High School, Storrs
- Ralph Yulo, Eastern Connecticut State University, Willimantic

JUDGES, REVIEWERS, MODERATORS, WEBEX HOSTS, RESEARCH PANELISTS, AMERICORPS MEMBERS, URBAN HEALTH/AHEC SCHOLARS, CT-JSHS ALUMNI AND ALL OTHER VOLUNTEERS: THANK YOU!

ABSTRACTS

Oral Presenters

Structural Determination of Novel Non-canonical Base Pairs and Mismatches
William Bernfeld
King School, Stamford, CT
Mentor: Dr. Simon Vecchioni, New York University, Department of Chemistry

With the arrival of the SARS-CoV-2 virus and its variants, humanity has suffered the destructive power of a global pandemic, the likes of which have not occurred since 1920. With over 4.5 million COVID-19-related deaths worldwide, the scientific community is rushing to find ways to slow the virus. Although viral tests and vaccines have been widely distributed, many tests yield false results and numerous breakthrough infections are being reported in vaccinated individuals. Thus, we must improve the tools by which we address the pandemic. To address this need, we synthesized a set of four novel nucleobase pairs – two from purines and pyrimidines, and two from pairs of pyrimidines mediated by transition metal ions – to expand the nucleobase language. We used the Python-based Hierarchical ENvironment for Integrated Xtallography (PHENIX), the Crystallographic Object-Oriented Toolkit (COOT), and ChimeraX to form predictive models of our pairs. We then ran simulations to predict their stability. Upon completion, we assembled the pairs *in vitro* and fitted them with sticky ends to allow for crystalline self-assembly. Through X-ray diffraction, with phasing and refinement, our findings suggest that these novel, unnatural base pairs are indeed stable. The presence of novel pairs, such as those designed herein, allows researchers to design more precise hybridization probes with fewer off-target effects to better monitor SARS-CoV-2. Moreover, with an expanded DNA/RNA language that can stably integrate into known nucleobase sequences, we could design enzymatic binding sites to encode novel amino acids into proteins, thereby developing new antiviral therapeutics.

Evolutionary Responses to Climate Change in a Long-Distance Migratory Songbird: the Scarlet Tanager
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Mentor: Dr. Maggie MacPherson, Louisiana State University Museum of Natural Science

In the 21st century, as the climate changes rapidly, many species are left with the uncertainty that their evolutionary processes may not keep pace. Profound consequences will result from the human population's heavy reliance on the environment, so it is vital to protect species. In this study, a migratory bird species known as the Scarlet Tanager *(Piranga olivacea)*'s vulnerability to climate change was assessed in terms of its breeding range and morphology. *P. olivacea's* geographical dispersion was projected and analyzed using the Species Distribution Model "Maxent." Locality data for models was obtained from the Global Biodiversity Information Facility (GBIF) from 2000–2020, and April–October in North America. The WorldClim database was used for environmental data to assess *P. olivacea's* relationships with minimum and maximum temperature and precipitation, factors impacted by climate change. WorldClim's future climate data (under RCP 8.5) until 2070 was used to evaluate the Tanager's future vulnerability. Morphological data from LSU's Museum of Natural Science was utilized to examine *P. olivacea's* morphological evolutionary development. It was hypothesized that *Piranga olivacea* will attempt to shift its breeding range and morphologically adapt to changing climatic conditions, but ultimately the species' ability to do so will prove limited. Yet, the findings suggest that minimum temperature is the largest limiting factor in *P. olivacea's* breeding range, and thus *P. olivacea* has the potential to expand its range past historical northern limits as temperatures rise. Findings additionally suggest that *P. olivacea* may be increasing its tail length to accommodate for longer migrational distances.

The Effect of Microplastic Ingestion on the Health of Parasites (Cryptocotyle lingua) in Periwinkles (Littorina littorea)
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Mentor: Carolyn Keogh, Emory University and Shoals Marine Laboratory

Microplastics, plastics smaller than 5 mm, threaten marine life as they are hard to distinguish from food sources and are easily ingestible. Parasites also threaten marine organisms as they make their way between hosts through the food web. For trematodes specifically, it is important that the entire ecosystem is healthy so the parasite can complete its life cycle; if microplastics make their way into the food web of a specific ecosystem and impair the health of the organisms in that ecosystem, it may become more difficult for parasites to thrive with a lack of viable hosts. Microplastics have been shown to impair the health of marine organisms,

and may prevent parasites from completing their life cycles if there are no healthy hosts to inhabit. Limited research has been done on the interactions between parasites and microplastics. The purpose of this experiment was to determine if microplastic ingestion impacts the health of parasites, *Cryptocotyle lingua,* in periwinkles, *Littorina littorea.* To test this, *L. littorea* infected with the parasite *C. lingua* were fed microplastics adhered to seaweed *(Ulva lactuca),* and the cercarial output of each snail was quantified. This value was compared to the control cercarial output of each snail. The soft body tissues of all *L. littorea* were digested in KOH to confirm microplastic ingestion. No correlation between microplastic ingestion and cercarial output was found after statistical analyses. These inconclusive results suggest the need for further research on the microplastic-parasite relationship and the need for revised methods of testing this relationship.

The Effect of Azospirillum lipoferum Inoculation on Microbial Abundance and Diversity of the Corn Soil Microbial Population after a Moderate-Intensity Fire

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Mentor: Blaire Steven, Connecticut Agricultural Experiment Station

High-intensity forest fires can negatively affect the soil rhizosphere by decreasing microbial populations and limiting ecological processes. After a high-intensity fire, the soil microbiome can take months or years to completely recover and resemble pre-fire conditions. However, both plant growth and an increase in microbial diversity can aid in the recovery process over time. Inoculation of the soil rhizosphere has induced positive effects in the soil microbiome in some studies with unburned soil. Studies have demonstrated that *Azospirillum lipoferum* inoculation significantly increases corn soil nitrogen and osmotic potential of corn plants in water-stressed environments. However, whether *Azospirillum lipoferum* also has a positive effect on the soil rhizosphere during fire recovery has not yet been studied. The goal of this study is to explore the possibilities of *Azospirillum lipoferum* inoculation in aiding corn growth and rhizosphere recovery after a high-intensity fire. Soil taken from the roots of corn plants was burned for six hours at temperatures above 800°C. After burning, both the unburned and burned soil were cultured. The burned soil had no culturable bacteria on any of the 10-4 dilution plates immediately post-fire. The post-burn greenhouse study found that soil inoculation with *A. lipoferum* led to an increase in microbial diversity and plant growth when compared to unburned soil.

Investigating the Interplay between APP and MAPT and its Contribution to Neuroinflammation in Alzheimer's Disease Progression

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Mentor: Mr. Samuel Harfenist, East Lyme High School

Alzheimer's disease is classified as the most common neurodegenerative disease that triggers and furthers the onset of neuronal cell death as a consequence of hallmark pathological changes. Since there is yet no cure for dementias such as Alzheimer's disease, there is a perpetual cognitive function and development decline in diseased patients. The hallmarks of Alzheimer's disease include abnormal amyloid beta plaques, neurofibrillary tangles, and neuroinflammation. While these neuronal processes are interlinked, it is not entirely understood how they are related or regulate each other. I will focus on the relation of neuronal processes and Alzheimer's disease pathology, more specifically the influence of amyloid beta peptide aggregation on tau protein, dysregulated inflammation, and defective degradation mechanisms. In this paper, I analyzed the interaction between amyloid beta and tau tangles and how this leads to proinflammatory patterns, which results in neuroinflammation observed in Alzheimer's disease. In context, I observed evidence for induction and progression of Tau hyperphosphorylation and neuroinflammation through analysis of RNA-seq data. In examining and correlating the pathological hallmarks for Alzheimer's disease, neuronal abnormalities and dysfunctions have been analyzed with the intent to uncover new potential therapeutic approaches.

JARVITS: A Novel Deep Learning IoT Traffic Control System for Real-Time Detection and Signal Optimization

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Mentor: Dr. Hyung Gi Min, Namseoul University

In the status quo, traffic signal control systems operate on predetermined patterns and instructions devised from past data. While this conventional method functions effectively for traffic under normal conditions, it becomes heavily congested and inefficient during rush hour. Furthermore, the constant presence of unexpected emergencies renders predetermined systems ineffectual. By combining traditional traffic controllers with modern technological advancements like Internet of Things (IoT) devices and computer vision, traffic control systems can be greatly improved, and traffic optimized for greater efficiency. Yet there are currently no systems that can affordably fulfill this task. By optimizing traffic signal duration, this can allow for not only a reduction in delay

time for vehicles, but also a reduction of greenhouse gasses emitted while the vehicle is stationary. Considering the Intergovernmental Panel on Climate Change (IPCC)'s August 2021 report on the current dramatically worsening state of the climate crisis, there is a powerful, compelling need for such a traffic control system to optimize throughput and thus greatly reduce vehicles' greenhouse gas emissions. This research presents a novel deep learning traffic control system, called JARVITS (Just A Rather Very Intelligent Traffic System) that can be used for accurate real-time vehicle detection and signal control. Compared to previous methods, JARVITS offers a complete solution, with a physical vehicle detection algorithm and traffic signal optimization using an evolutionary algorithm. This study can largely be divided into two subsections: (1) the IoT traffic control system and (2) traffic control optimization. Lastly, a realistic virtual simulation created using Pygame is used to model traffic conditions and demonstrate that this research effectively improves traffic flow for an intersection.

Electrochromism Paired with Finite Difference Time Domain Modeling Allows for the Successful Prediction of Color Change Achieved by Electrochromic Reactions

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Mentor: Xin Shen, Yale University, Energy and Science Institute

With more than 60% of energy used for energy generation lost, the issue of how to save energy has come to the forefront of research in recent years, particularly as greenhouse gas emissions from wasted energy continue to increase the effects of global warming and climate change. New and innovative approaches are needed to solve this problem; energy saving electrochromic windows fulfill this need. We aimed to improve existing electrochromic windows by designing a more efficient electrochromic coating that can undergo a reversible color change when exposed to smaller magnitudes of positive and negative applied potentials. We ran simulations with varied parameters using the Lumerical modeling software to achieve the best fit between reflectance spectrums generated by simulations and reflectance spectrums obtained from in-person experimentation. Furthermore, additional software was used to acquire an RGB color value from the simulation-generated reflectance spectrums, providing insight into the ideal thicknesses and material combinations necessary to achieve the desired color change. We found that a two-layer model with a top layer of $TiCrO_x$ with a thickness of 176 nm and a bottom layer of fluorine-doped SnOx with a thickness of 600 nm allowed for the best fit with the experimental results. Collectively, these novel conditions identified herein lay the groundwork for designing an efficient electrochromic coating and window, a promising solution to a problem that has eluded researchers for years. This, in turn, will allow for an increase in energy savings worldwide, and, most importantly, a decrease in carbon emissions, thereby mitigating climate change.

Eco-friendly Remediation of Polycyclic Aromatic Hydrocarbons in Stormwater via Magnesium-Infused Calcite Crystal, Supramolecular Hydrogel Scaffolding

Audrey Lin
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Mentor: Andrew Bramante, Greenwich High School

Polycyclic aromatic hydrocarbons (PAHs) are commonly found in stormwater runoff due to motor vehicle usage, oil spillage, and asphalt road material, causing numerous environmental issues like immunotoxicity when transported throughout ecosystems and marine organisms. High absorption abilities of calcite filter PAHs from water; additionally, research supports that magnesium reduces PAH removal time. As the incorporation of magnesium during calcite crystallization optimizes PAH capture, Mg-calcite will be embedded in an amorphous calcium carbonate - polyacrylic acid hydrogel to fabricate Mg-APH. Mg-APH is then housed in a water-permeable pouch, creating a system that can remove PAHs from running water, in real time. In typical usage, the structure will be stretched across a flowing stream or shoreline. As water flows through the filtration device, the hydrogel expands, allowing for enhanced interaction between Mg-calcite and PAHs. In a static, airtight experiment, Mg-APH began remediation of phenanthrene and naphthalene in 30 minutes, at rates of 5.5µg/140µg per gram of Mg-APH with 82%/92% effectiveness rates, respectively, relative to direct placement of active components. In a simulated mid-river arrangement, with saturated concentrations of phenanthrene and naphthalene, 0.12mg and 4.6mg were remediated per gram of Mg-APH, respectively, in 5 hours against river flow of 1.4L/minute. Increased remediation efficiencies of 16x and 11x, respectively, highlight improvements provided by the scaffold design. Mg-APH is stable with no ingredient degradation into running water sources. Once saturated with contaminants, Mg-APH can simply be removed from the water-permeable pouch and disposed of at an appropriate waste station.

Using Single-Cell Analysis to Explore Prognostic Genes in Prostate Cancer

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Mentor: Pingzhang Wang, Peking University

Prostate cancer (PCa) endangers men's health and lives worldwide. It is the second most common cancer and the fifth leading cause of cancer death among men. So it is urgent to find reliable prognostic molecular biomarkers in PCa for risk stratification, personalized treatment, and prognosis improvement. This study analyzed differentially expressed genes of PCa using a microarray dataset from GEO. Then prognosis analysis was performed in UALCAN to find prognostic genes. Finally, the differential expression of the identified prognostic genes in PCa was verified in scRNA-seq data from GEO141445 using single-cell analysis with Seurat V3 (R package), and their cell expressions were explored in the tumor microenvironment. Seven differentially expressed genes were identified as prognostic genes. They were BDH1, CRACR2B, GRK6, MZT2B, NOP16, SLC25A27, and SURF6. These prognostic genes were all mainly expressed in PCa epithelial cells, but were also expressed with small amounts in other cells in the tumor microenvironment such as T-cells, mast cells, endothelial cells, monolytics, and fibroblasts. Overall, this study indicates single-cell analysis can be used for screening differential genes and exploring the role in occurrence and development of the tumor by their cell expression in the tumor microenvironment. The seven prognostic genes for PCa identified by this study have never been reported before. They are novel molecular biomarkers and may be potential therapeutic targets for prostate cancer.

Cloud Identification in Mars Daily Global Maps with Deep Learning

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Mentor: Scott D. Guzewich, NASA Goddard Space Flight Center

Cloud identification on Mars is an important tool for climatology studies, making it possible to analyze the distribution, patterns, and variability of clouds both spatially and temporally. Traditionally, cloud data on Mars has been extracted through manual or semi-automated processes, resulting in limited spatial and temporal coverage. In this paper we demonstrate the successful use of convolutional neural networks (CNNs) to extract cloud masks from Mars Daily Global Maps (MDGMs) composed from the Mars Color Imager (MARCI) on the Mars Reconnaissance Orbiter (MRO). The fully automated model reports 97% pixel-wise accuracy compared to the testing dataset, and on many occasions the model performs better at extracting the full extent of the cloud compared to the prior semi-automatic technique. We also introduce several image pre- and post-processing techniques to improve the model's performance and usability. The model is configured to provide cloud masks at 0.1° longitude by 0.1° latitude resolution. It also automatically bounds the MDGM by northern and southern polar extents depending on solar longitude. The results suggest that our deep learning model is a useful tool to automatically and quickly extract Martian water ice cloud masks and make it possible to generate cloud mask data across the complete set of MDGMs and future ones. The model and related techniques also have potential extensions to Martian dust storm identification. We will make our code, model, and data publicly available.

Ferro-Sponge: An Investigation into the Usage of Metal Oxides for the Removal of Microplastics and Oil from Water

Snigtha Mohanraj
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Mentor: Anne Gold, 3M, Personal Safety Division

Many water sources currently contain hazardous microplastics and oils, for which efficient removal methods do not yet exist. I have performed extended research over several years developing methods to address this issue, the latest of which is presented here. Current research tested the implementation of electromagnetic filtration aided by contaminant agglomeration induced by metal oxides – Fe3O4, MnO2, and NiO, of which Fe3O4 was most effective. Fe3O4 nanoparticles were consequently synthesized to increase the surface area for agglomeration, thus increasing microplastic removal. Due to their properties as sorbents, it was hypothesized that they were capable of also removing oil from water. The nanoparticles were proven to be more effective than general Fe3O4 particulate. However, aiming for an efficient implementation on larger scales, these nanoparticles were adhered to a polyurethane sponge, the original "Ferro-Sponge" model. Three other additives were tested to increase the model's effectiveness: bentonite, a clay compound with known oil removal capabilities; sorbent pads, expected to absorb oil; and mineral spirits, expected to increase Fe3O4 nanoparticle retention via adhesion promotion. Only bentonite effectively enhanced the removal of these contaminants in water. The final "Ferro-Sponge" model was created by coating a polyurethane sponge in a mixture consisting of synthesized Fe3O4 nanoparticles and bentonite. All testing was done by using home-built and laboratory spectrometers, and a microscope. To measure real-world effectiveness, contaminated water from Long Island Sound was treated

with the “Ferro-Sponge,” in which the “Ferro-Sponge” successfully removed contaminants. The “Ferro-Sponge” is currently patent-pending and in contact with industrial companies for implementation.

A Wavelet-Based Method for Generalizing Molecular Latent Spaces for Assisted Traversal
Ian Murdock
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Mentor: Xiaodi Wang, Western Connecticut State University

Auto-encoders and decoders are becoming more and more prevalent in current cheminformatics applications. In molecular modeling, molecular representations can quickly scale to a point that necessitates simplification or compression. Using a discrete wavelet transform’s approximation section, the number of basis vectors needed to represent the majority of a chemical space’s detail can be reduced, and this space can thus be more efficiently generalized. For input data, the SMILES molecular representation was used due to its relatively simple nomenclature, combined with one-hot character vectors for efficiency. Using the approximation portion of the discrete wavelet transform, the number of basis vectors needed to represent each character can be reduced by a factor of two. Wavelets allow for the simple transformation and reconstruction of the input data, even if only the approximation section is used, by utilizing a maximizing function. While this novel approach can introduce noise, it allows for simplification of a molecule’s mathematical model while preserving most of the latent space properties of a model trained without this method.

Biomimetic Removal of Microspheres Water Contaminants, via Calcite-Infused, Coral-Like Melamine Sponges
Naomi Park
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Mentor: Andrew Bramante, Greenwich High School

The detrimental threat microplastics have on the environment is well-established in literature today. However, effective and efficient microplastic remediation methods in aquatic environments have yet to be discovered. This research provides a highly efficient/practical method for the removal of microplastics through the creation of an Artificial Coral Sponge (ACS) that remains in water until it is simply removed. An accurate fluorescent detection system of green MPs was first established where white 96-wellplates were adapted as low-volume collection spheres, so that the MPs could be detected in water, regardless of settling behavior. The ACS was constructed with a 150 pore-size melamine sponge, PTFE adhesion layer, and $CaCO_3$. The cubic-shaped ACS removed an average of 0.45 mg-MPs/cm^2 in 45 hours in MP-contaminated fresh and seawater. High-load, long-term experiments were conducted to examine full capacity of the cubic ACS. In one week, where the ACS was submerged in 0.5mg/ml MPs in water, SEM analyses highlight collection of MPs throughout ACS internal structure, demonstrating that it is not a surface-only remediation device. At full capacity, the ACS can remediate 41.3kMPs/cm^2, or simply 2.1mg MPs/cm^2. To probe this limit, a “reuse-capacity” investigation was designed, where a single ACS was used, and reused twice more, in typical 0.1mg/ml MP-contaminated water. Reuse results highlight marginal declines in function over three uses. These results, in conjunction with SEM estimates for capacity, suggest that a single ACS could be reused as many as five times before reaching its capacity. Furthermore, ACS optimal shape was also investigated with ellipsoid and cubic-shaped ACS devices. Each performed similarly, once again pointing away from surface area-only adhesion, but internal MP capture. Finally, prolonged stability studies demonstrate ACS stability, thereby acting as a marine-safe, easy-to-use MP-remediation tool, costing 30¢ per tested device, or $12 for a device that mimics a typical 625cm^2 coral.

Short-Term Pilot Biodegradation Study of Poly (α-Pinene Methacrylate), Poly (Myrtenyl Methacrylate), and Poly (Methyl Methacrylate) Synthesized in Supercritical Carbon Dioxide
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Mentor: Dr. Christine Rodriguez, Fairfield University, Department of Biology

Though there has been recent progress in developing renewable plastics more suitable for commercial use, there is little emphasis on improving the biodegradation rate of these “greener” plastics. This leads to the development of plastics that are renewable but not biodegradable (or vice versa) that are marketed as “environmentally friendly,” yet produce a negative environmental impact. A pilot biodegradation analysis was performed on the plastics poly (α-pinene methacrylate), poly (myrtenyl methacrylate), and poly (methyl methacrylate), all of which were synthesized in scCO2. Samples of these plastics underwent biodegradation for 10 weeks in the presence of soil. 0.5N KOH solutions were used to absorb the carbon evolved from the plastic via microbial activity, which were then titrated to determine the amount of carbon in each solution. Interestingly, poly (myrtenyl methacrylate) samples evolved less carbon than the control sample, containing only soil, indicating poly (myrtenyl methacrylate) did not biodegrade

during the 10-week period. However, poly (α-pinene methacrylate) and poly (methyl methacrylate) samples evolved similar amounts of carbon, demonstrating similar short-term biodegradation rates. As the plastics poly (α-pinene methacrylate) and poly (myrtenyl methacrylate) are possible renewable alternatives for poly (methyl methacrylate), this pilot biodegradation analysis illustrated that poly (α-pinene methacrylate) is more readily biodegradable and thus will have a lesser impact during the end-of-life stage than poly (myrtenyl methacrylate) and poly (methyl methacrylate).

Controlled Delivery of Sulfoxaflor Pesticide via Cinnamaldehyde-Infused Hydrogels to Reduce Toxicity to Honey and Wild Bee Pollinators

Elizabeth Wallace
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Mentor: Andrew Bramante, Greenwich High School

The consequences of the wide-spread use of pesticides have negative impacts on bee pollinators, emphasizing the need for a delivery system that reduces harmful impacts on non-target insects. Previously, research has identified hydrogels as an effective controlled release mechanism for pesticides. Sulfoxaflor, a pesticide which has recently had restrictions lifted, has been shown to have significant negative effects on bee pollinators. This project utilizes the chemical compound cinnamaldehyde, a natural low-toxicity deterrent of bees, to coat a sulfoxaflor chitosan-alginate hydrogel. Experimentation on the hydrogel was designed to confirm the concurrent outgassing of cinnamaldehyde to deter bees and dissolution of sulfoxaflor to verify pesticide efficiency. To mimic field pesticide application, 2, 4, 6, 8, and 10 SC-Hgels were separately placed into 10ml containers with .5 g sawdust and heated at 32^{o}C. FTIR analysis of the resulting solution indicates an 83–92% efficiency for corresponding 2–10 SC-Hgels in sawdust, with higher yields produced from greater moisture availability. The average recovery efficiency of sulfoxaflor from the sawdust method was found to be ~86%, resulting in the overall SC-Hgel sulfoxaflor release efficiency increased to ~96%. GC-FID analysis on samples similar to the previous model on sulfoxaflor, found the release rate of cinnamaldehyde to be ~20%, or 1.59 mg in 24 hours for the 8 SC-Hgels evaluated. This is well below the compared LC50 of cinnamaldehyde for pollinators (7.9 mg/24 hours). These results provide compelling evidence that SC-Hgels produce similar efficacy to delivery alone, while protecting pollinators by deterring them through cinnamaldehyde outgassing.

Spectrophotometric Determination of the DNA Binding Constant of a Novel and Potent Psoralen Derivative

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Mentor: Dr. Francis P. Gasparro, Hamden Hall Country Day School

Psoralens are planar molecules that intercalate with DNA. When struck with UVA rays (320–400 nm), they crosslink nucleic acids, thereby inhibiting DNA synthesis and cell division. We have designed a novel psoralen molecule, containing the acid side chain ($-C_3H_6-NH_3^+$) which can interact with the negatively charged phosphate backbone and further stabilize the psoralen-DNA interaction in a cooperative fashion. This psoralen was selected for its relatively high cytotoxicity when screened for the ability to induce cell death. Fluorescence spectroscopy and equilibrium dialysis with UV-absorbance spectroscopy have been used to experimentally determine binding constants to target DNA to see whether its high toxicity correlates with a large DNA binding constant (K_b). This will indicate whether the acid side chain increases DNA affinity and enhances psoralen intercalation. Since the DNA and psoralen UV absorbance spectra overlap, equilibrium dialysis has been performed to isolate the psoralen absorbance to analyze the variation in its absorbance upon adding increasing concentrations of DNA. The controls are 8-methoxypsoralen (8-MOP) and aminomethyltrimethylpsoralen (AMT), which have known cytotoxicities and DNA binding constants. The experimental K_b of 8-MOP, AMT, and 6E were 141, 104000, and 39300 respectively. This suggests that the acid side chain of 6E has improved psoralen binding to DNA compared to unmodified psoralen and is more effective than the methoxy group of 8-MOP in enhancing psoralen intercalation.

Poster Presenters

Utilizing Bioanalytical Software to Examine the Genomes of Gordonia Bacteriophages Sahara and SoilAssassin
Fhasal Alam
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Mentor: Sharon Gusky, Northwestern Connecticut Community College

Imagine little monsters, able to destroy anything you can think of. Perhaps they only go after one type of bacteria. In the medical world, our little monsters are viruses classified as bacteriophages. Under a national research project called SEAPhages, two students from the University of Pittsburgh discovered bacteriophages Sahara and SoilAssassin: Sahara Grinkewitz and Daniel Biery, respectively. Both Sahara and SoilAssassin are in cluster CZ and subcluster CZ2, and both attack the bacteria Gordonia. Because Gordonia is closely related to the pathogen that causes Tuberculosis (TB), conducting searches involving these phages has the potential to treat antibiotic-resistant TB. We began our analysis of the genomes of SoilAssassin and Sahara in hopes of finding common promoter regions and conserved repeats (similar sections of DNA between their genomes and the genomes of other bacteriophages). After analysis of the promoter regions, conserved repeats, and our investigation into lysins (which are involved in breaking apart the bacterial cell wall) of Sahara and SoilAssassin, conclusions suggest that genes 3, 9, 15, 18, and 28 are of particular importance to our phages. Gene 18's production of Lysin A is especially noteworthy, as lysin-producing bacteriophages have immense potential in the medical field. This may aid in the creation of medical technologies in the near future, allowing scientists to efficiently reproduce these specific weapon-like mechanisms that target certain antibiotic-resistant bacteria without having to replicate the entire bacteriophage or disrupting the patient's microbiome.

Classifying Alzheimer's Disease with Machine Learning via Wavelet Transform Subband Combinations
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Mentor: Xiangyi Chen, Texas A & M University

The 3-D wavelet transform has been used with machine learning techniques to help identify Alzheimer's disease (AD) and mild cognitive impairment (MCI) through magnetic resonance imaging (MRI). Although this approach resulted in high accuracy, a large number of subband permutations were obtained due to the usage of the 3-D wavelet transform, which causes redundancy and computational inefficiency during classification. To address this issue, this study discovers the combination with the minimum subbands giving a comparable accuracy with the original approach that used all subbands. The Alzheimer's Disease Neuroimaging Initiative (ADNI) was used to gain de-identified MRI scans for classification with 75% training and 25% test scans. The scans were standardized by pre-processing through skull stripping, segmentation, and smoothing using the MATLAB toolboxes Statistical Parametric Mapping 12 (SPM 12) and Computation Anatomy Toolbox 12 (CAT 12). Feature extraction was then completed through different 3-D wavelet transform subband combinations. Support vector machine (SVM) classification was used with radial basis function kernels (RBF) to screen patients for AD, MCI, or cognitively normal (CN) status three times per subband combination. The mean and standard deviation of the test accuracy for each combination were recorded. Among the tested combinations, the maximum mean test accuracy was 95.3%. To prevent overfitting, five-fold cross-validation was performed on the top 40% subband combinations based on the mean test accuracy. The maximum cross-validation accuracy is 97.3%. Therefore, this study shows the potential of using fewer 3-D wavelet transform subbands to help screen patients for AD or MCI in the future.

Development of a Home N-Terminal Pro-Brain Natriuretic Peptide Assay for Early Detection of Congestive Heart Failure
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Choate Rosemary Hall, Wallingford, CT
Mentor: Dr. Stuart Zarich, Bridgeport Hospital/Yale New Haven Health

Congestive heart failure (CHF) affects millions of patients and is associated with a high mortality rate. Early detection and treatment can improve outcomes and avoid hospitalization, but it is often difficult to tell if symptoms are specifically due to CHF or another cause. N-Terminal Pro-Brain Natriuretic Peptide (NT-proBNP) is an excellent biomarker for CHF. The lateral flow assay (LFA) is a technology that can be adapted for use as a home test. The hypothesis is that an LFA can qualitatively detect NT-proBNP and ultimately be used to create a home CHF testing kit. A NT-proBNP assay was created using a universal LFA kit with the appropriate capture and detection antibodies. Recombinant NT-proBNP was used to test the assay at varying concentrations. NT-proBNP was readily detectable using this system, and the visual bands on the LFA strips were quantified using an optical densitometry protocol. After optimization of the reagents, NT-proBNP levels down to 5,000 pg/mL were detectable. This puts the test in the range of NT-proBNP levels that have been described for patients hospitalized with CHF. This test was repeated with purchased human serum spiked with recombinant NT-proBNP and showed detection at similar concentrations. Ultimately the goal is to create a

simple visual test, and so the LFA strips were shown to 20 blinded volunteers confirming detection of NT-proBNP at levels of 5,000 pg/mL and higher. These results show that a home NT-proBNP test is feasible and could be used for early detection and treatment of CHF.

The Comparative Effects of Fuhc Immunosuppressants and Allotransplanted Blood Plasma Transfusion on Allotransplant Acceptance in Botryllus schlosseri

Shealeigh Crombie
Greens Farms Academy, Westport, CT
Mentor: Dr. Mathieu J. Freeman, Greens Farms Academy

When a patient requires any type of transplant, many factors determine whether the patient's body accepts the new tissue. Individuals requiring transplants are often immunocompromised and often lose partial function of vital organ systems, making the speed and completeness of the acceptance of new tissues vital to the patient's health. This study established two separate colonies of *B. schlosseri,* with peripheral ampullae testing done to determine fuhc allele variety. The growth count, oxygen respiration, and peripheral ampullae behavior of each colony were observed. The two colonies were divided and trypsinized, creating four groups which either received immunosuppressants, a blood plasma transfusion from the other colony, tissues from the other colony, or tissues from the same colony. Extent of acceptance was observed based on the visual occurrence of dark regions, implying sites of rejection. Each colony of *B. schlosseri* except the xenogeneic sample had similar growth counts, oxygen respiration trends, and peripheral ampullae behavior, but had different fuhc alleles as determined through PCR testing. Excluding the autologous group, the group given a blood plasma transfusion had the highest acceptance rate and the fastest growth count compared to the immunosuppressed group. The allogeneic group had the lowest rejection rate and highest growth count overall. Blood plasma transfusions allowed a higher acceptance rate of transplanted tissue than immunosuppressants in *B. schlosseri,* the invertebrate with closest genetic proximity to humans. This could provide insight into the effectiveness of immunosuppressants compared to blood plasma transfusions in humans.

Developing a Fully Plant-Based Sustainable and Renewable Replacement for a Polychloroprene Fabrication

Angela Ferraro
Bridgeport Regional Aquaculture Science and Technology Education Center, Bridgeport, CT
Mentor: Kirk Shadle, Bridgeport Regional Aquaculture Science and Technology Education Center

Polychloroprene produces mass amounts of pollution and emissions in the production of the material. Further research of materials led to the proposal: to develop an effaceable, renewable, and sustainable replacement for polychloroprene fabric containing all plant-based materials. The fully plant-based fabric incorporates a seaweed component, *Chondrus crispus,* as an alginate coating alternative to polychloroprene. There are certain characteristics which must be met for this proposed material, such as water absorption, durability, and the ability to be grown in mass quantities around the world. The initial prototype consisted of a blend of hemp and rice straw fiber coated with the alginate extract. To establish water absorption insulation, a water immersion test was performed. The evolved prototype consisted of hemp coated in the alginate extract that had a hydrophobic powder infused into the extract. To establish waterproofing, a water immersion test was performed. After testing the hemp and rice straw fiber blend material against polychloroprene, it was found that the hemp and rice straw blend had an average weight difference of 5.7g and polychloroprene had an average weight difference of 1.2g between both trials. This demonstrates that the hemp and rice straw blend material had a higher water intake than the polychloroprene. After testing the hemp with a lycopodium infused alginate material against polychloroprene, the polychloroprene had an average weight difference of 0.7g between the two trials, while the material with a lycopodium infused alginate had an average weight difference of 6g.

A Novel Drug Delivery System of Gold-Nanoparticle–Chaperone Complex to Successfully Mitigate Drug-Induced Nephrotoxicity, an Unwanted Side Effect in Organ Transplant Medications

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Drug-induced nephrotoxicity is not only life-threatening but also one of the most frequent causes of drug termination during clinical trials or withdrawal from the market. Cyclosporine A (CsA), an immunosuppressant highly effective and necessary for post-transplant survival, is known to cause nephrotoxicity by initiating endoplasmic reticulum (ER) stress in renal cells. Normally, cells upregulate chaperone proteins to counter ER stress. However, prolonged ER stress leaves the organelle functionally impaired, thus signaling apoptotic cell death and causing long-term harm to the kidney. This research sought to counter these effects via a novel drug complex (gold nanoparticles, AuNPs, bound to a chaperone) administered jointly with CsA, tested with GRP78

(chaperone protein) and 4-PBA (chemical chaperone). Carboxyl-functionalized AuNPs were used to promote the covalent binding to these large, complex chaperones, facilitating trans-membrane transport. Results were quantitatively analyzed via HRPTEpC cell density studies, average cell size, and ER stress (via the Thioflavin T fluorescence marker), and qualitatively via observed morphology. As anticipated, delivery of CsA alone promoted both significant reduction in cell size (4um) and ER stress. Introduction of Variation-I (AuNP-GRP78 with CsA) showed inconclusive results, with altered morphology in some treated wells. Introduction of CsA via Variation-II (AuNP–4-PBA with CsA), however, showed 20–22um cell size and cell density comparable to that of growth-medium alone (control), with no detectable ER stress within 48 hours post administration. As such, these findings have important implications for drug-delivery systems, with the conceptual use of AuNP-complexes to mitigate medications' harsh, ER-stress–inducing side effects on the kidney.

Design of a Novel, Dual-Functioning Tissue Plasminogen Activator and Anticoagulant Therapeutic for Rapid Ischemic Stroke Treatment

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Stroke is the second leading cause of death worldwide, with 15 million people suffering from its debilitating effects each year. 87% of strokes are ischemic, where an artery narrows or becomes wholly blocked due to a thrombus. Tissue Plasminogen Activator (tPA) is a protein that activates the conversion of plasminogen to plasmin, an enzyme responsible for the breakdown of clots. While tPA is the leading emergency treatment for ischemic stroke, it possesses several shortcomings, including a non-localized nature and increased risk of hemorrhage. Similarly, no existing therapeutic candidates have both dissolved the thrombus and simultaneously deterred the coagulation cascade, the process by which a thrombus is actively built. Herein, a rapid, clot-specific, and dual-functioning microbubble and system utilizing tPA and anticoagulant dicumarol was engineered to create a more effective emergency therapeutic. To begin, fabrication of the magnetic interior nanoparticles was completed by synthesizing dicumarol-carboxylic-acid coated Fe_3O_4 nanoparticles. Next, the SiO_2-tPA component was fabricated to complete the subsequent layer encapsulating the nanoparticles. Peptides CGSSSGRGDSPA and GRGD were conjugated to adhere to platelets and fibrin and to ensure clot-specific adhesion and release. Finally, a vertical gel channel system composed of fibrinogen, thrombin, and agarose was developed to validate the system, which illustrated that the percent of the clot dissolved was twice as high compared to the area lysed by tPA. As a final verification component, *in-vitro* clots were created using the student researcher's blood, with measurements completed by a UV-Vis plate reader indicating greater absorbance and a successfully liquified and dissolved thrombus.

The Role of ICAM-1 in Facilitating Leukocyte Migration across the Blood-Brain Barrier in the Progression of Multiple Sclerosis

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Multiple sclerosis is a chronic autoimmune disorder that affects nearly one million adults in the United States. In patients living with MS, leukocytes are able to migrate into the central nervous system through the blood-brain barrier (BBB), causing damage to neuron connections. As the disease progresses, the BBB becomes weaker and thus ineffective in its function as a selective semi-permeable border between the body and the central nervous system. Recent studies suggest that cell-adhesion molecules may facilitate the migration of leukocytes through the barrier; further research is needed to identify the mechanisms by which this occurs. Accordingly, this research investigates the role that intercellular adhesion molecule 1 (ICAM-1 or CD54) plays in damaging the blood-brain barrier to allow leukocytes to enter the brain. An *in-vitro* model was developed with cultured brain microvascular endothelial cells seeded atop an extra-cellular matrix gel (the BBB model) within a Mimetas 3-lane OrganoPlate. White blood cells isolated from whole blood and stained with ICAM-1 were added to a cell culture media of 10% FBS in RPMI 1640 (with phenol red). Leukocytes with and without ICAM-1 were added to the 3-lane OrganoPlate, and profusion through the BBB was studied. After only one day, significant BBB damage and subsequent leukocyte profusion was observed in more than 70% of trials where ICAM-1 was attached, compared to trials in which ICAM-1 was not present. These findings provide compelling evidence that ICAM-1 plays a significant role in damaging the BBB and facilitating leukocyte migration into the central nervous system.

Did the Vaccination Quell COVID-19 Surge after Holidays: An Analysis of Real-World Data
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Last year, I analyzed how holidays affected COVID-19 spread. This year, I wanted to further study the following: how vaccination impacted COVID-19; how the post-holiday spike differed from 2020; and how vaccination impacted the post-holiday surge. Data was retrieved from CDC and Johns Hopkins databases. I studied Independence Day, Halloween, Thanksgiving, and 1/15–2/1/2022. Analysis was done using Excel pivot tables, linear regression, and Pearson correlation. I compared the post holiday spike of 2021 to 2020 and examined correlation between vaccination rate and the spikes. I also correlated vaccination rate with cases/deaths when Omicron was dominant. Next, I compared northeast and southeast states to see the impact of weather/temperature. I found that in 2021, every additional 100 full vaccinations prevented 8 infections. Every 1% increase in full vaccinations prevented 35 deaths per million people. Partial vaccination was less effective. In 2021, higher vaccination rates correlated with a greater surge after Halloween and Thanksgiving. Cold temperatures could have contributed to the greater surge in the Northeast than the Southeast during Halloween. There was a possibility that a false sense of security caused Northeast states that had more vaccination to have a greater spike after Thanksgiving, which is suggested by a positive correlation between fold change and vaccination rate. Results show that, overall, the vaccination is effective in decreasing infection and death but less effective for Omicron. However, high vaccination correlated with greater surge after Halloween and Thanksgiving, which could be due to a difference in weather or a false sense of security.

In Vivo Imaging of Structural Connectivity and Synaptic Density in Alzheimer's Disease
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Mentor: Dr. Adam Mecca, Yale School of Medicine

Alzheimer’s disease (AD) has been considered a pathology of the gray matter (GM) with both hallmarks of the disease, amyloid-beta and tau buildup, contributing to neurodegeneration, or GM loss. However, recent studies have indicated that white matter (WM) damage found in early stages of AD may contribute to disease progression. This study aimed to bridge the gap between WM tract damage and corresponding synaptic damage in GM regions in AD. It was hypothesized that WM tract damage is associated with synaptic loss in GM of the precuneus and entorhinal cortex regions, and that this relationship would be strongest in WM tracts connected to the medial temporal lobes that are affected early in AD. The IV was WM tract integrity, which was measured using diffusion tensor imaging (DTI). The DV was synaptic density, measured using positron emission tomography (PET) to quantify synaptic tracer, [11C]UCB-J, binding to synaptic markers, synaptic vesicles glycoprotein 2A (SV2A). Analysis was performed in a group of AD individuals with early dementia and mild cognitive impairment. All imaging data came from studies done at Yale’s Alzheimer's Disease Research Unit. The DTI images were run through FreeSurfer, DSI Studio, and 3D Slicer software to create diffusion tensor models. The relationship between the WM integrity and synaptic density was analyzed using linear models which showed a significant correlation between WM DTI measures of axial and mean diffusivity in the entorhinal cortex and precuneus regions as well as the cingulum frontal parietal WM tract. These findings provide new insights on how WM integrity changes affect AD neurobiology.

Determining the Most Effective Countermeasures for Protection from COVID in a High Population, Large Setting Using Mathematical Modeling
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Finding protective countermeasures for COVID-19 has become imperative. I previously collaborated with my mentor in a mathematical modeling project concerning how specific countermeasures (masks, ionizers, air filtration/exchange) impact the concentration of viral particles in air over time in a one-room setting with a single emitter. The purpose of this project is to build upon the existing model to have multiple rooms, with air flowing from the room of the infected. The independent variables are the different countermeasures of mask efficacy, air filtration and air exchange rates, ionizer efficacy, and their various combinations. The dependent variable was viral particles over time, and the steady state particle concentration. There was no control, as this was a comparative study. The model was coded in Python. My hypothesis was that the most effective lone countermeasure would be an effective ionizer, while the most effective combination would be using all of them. The data gathered supports this hypothesis, with a decently effective ionizer being able to significantly decrease the steady state concentration. Meanwhile, filtration efficiency and air exchange rates were found to be dependent on each other, where both had to be effective in order to see any decrease in

steady state concentrations. I also found mask-wearing effective in greatly reducing particle concentrations in a room. My mentor assisted me by providing general guidance. By determining the effectiveness of these countermeasures, we hope to provide practical guidance around how to better limit spread of COVID in a high-population, larger setting.

Impact of Climate Change on the Timing and Intensity of Precipitation in the Northeastern United States

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In the present study, precipitation trends recorded by the National Weather Service (NWS) during a 20-year time period are analyzed and the NWS data is evaluated as an effective indicator of climate change. Five NWS Forecast Offices with 300 locations total—Boston, New York, Philadelphia, Binghamton, and Albany—represented the Northeastern United States. A random number generator was used to select from the NWS locations while accounting for incomplete data (an average of 15% of NWS locations). Two-tailed matched pair t-tests with an alpha value of 0.05 were conducted on a random sample of 20 locations for each month of the year. The August, November, and February t-tests were not found to be statistically significant, while the other nine months were found to have statistically significant changes in total precipitation. The researcher can be 90% confident that the true mean differences of the 20 locations for each month are within positive values greater than 2 inches of precipitation. Also, a positive increase of 22.37% in yearly precipitation was calculated from a random sample of 25 NWS locations. These findings suggest that precipitation is significantly increasing in the Northeastern U.S. on a rapid timescale, and that the precipitation of each of the months are being affected at variable rates. In the researcher's local community, this increase in precipitation has resulted in damage to infrastructure, negative impact to the local economy, and loss of life, which can be extrapolated to communities throughout the greater U.S.

Comparing Dendritic Development in Embryonic Neurons Harvested from DDX3X Mutant Mice and Wild Type Mice

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DDX3X syndrome is a rare neurological disorder that affects 3% of females around the world. The syndrome was discovered in 2015, so the molecular functions remain unclear. It occurs when one of the two copies of the DDX3X gene has lost its normal function, due to a mutation. The study will compare neurons harvested from wild-type mice and mice with the mutated DDX3X gene. The neurons from the mutated DDX3X mice will have an altered and simplified structure. In this study, flox P sites were inserted into the mice and the flox heterozygous female mice and wild-type cre mice were bred. The cre will recognize the flox and will remove part of the DDX3X gene after breeding, creating haploinsufficient mice. After 15 days, the mice were sacrificed and the embryonic neurons were harvested, and cultured for 14 days. The neurons were then transfected with fluorescent dye, and images were taken of the neurons. The neurons were analyzed by tracing the dendrites to observe the difference of complexity between wild-type and mutated neurons. It was expected that the structure of the mutated neuron would be smaller and less complex than the wild-type neurons. This is because the DDX3X gene controls neuron development by regulating the branching of dendrites, so if there is a mutation in the gene, then developmental setbacks will occur. After analysis, the hypothesis that the structure of a mutated neuron will be altered and less developed was supported.

Is Lithium Nitrate a Good Absorbent with Ammonium Hydroxide for Absorbent/Refrigerant Pairs in Heat Loop Systems?

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Mentor: Phillip Baker, Collins Aerospace

Heat is a major problem for spacecraft, as the other two ways currently known for transporting heat, combustion and convection, do not work in space, as they need a molecule-to-molecule connection, which would not work in a vacuum environment like space because of the low amount of molecules. This means the only way to transport heat away from spacecraft is through radiation, or the process of turning heat into electromagnetic (EM) waves, and emitting through a radiator. This process is often achieved by using some transportation device that can absorb the heat and transfer it to the radiator. A heat loop system is a common apparatus used for this task. Heat pumps have a fluid inside of them, in this paper's case, an absorbent/refrigerant, which can take in the heat from one location, and then eject the heat when at the designated destination. This paper will show a specific refrigerant, ammonium hydroxide (14.5 M), mixed with a common absorbent to see its ability to hold and transport heat. This will be done by measuring the vapor pressures of the refrigerant at specific temperatures. The results will indicate if the absorbent is

able to absorb the refrigerant, consequently reducing the vapor pressure, which should result in higher performance in a heat loop system.

Biocement Bricks for Negative Emissions: Electrochemical Ocean Carbon Capture
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Mentors: Devan Solanki and Atsu Kludze, Yale Department of Chemical and Environmental Engineering

Atmospheric concentrations of carbon have increased by more than 10% in the past two decades, contributing to the warming effect, which has made 2020 the warmest year on record. Along with reducing anthropogenic emissions, negative emissions technologies must be implemented in order to mitigate existing carbon. The ocean is the world's biggest carbon sink, having concentrations 120 times higher than the atmosphere. Additionally, ocean acidification caused by carbon dioxide reacting with water endangers the organisms that produce the majority of the world's oxygen. Here, we designed a flow cell for the removal of carbon from the ocean. We flow in ocean water and separate it into two streams, one acidified and one basified, through the use of bipolar membrane electrodialysis, transferring ions from solutions using ion exchange membranes. This model is thermodynamically efficient, leveraging pH and temperature relationships to turn harmful dissolved inorganic carbon into something beneficial: biocement bricks made of insoluble compounds, such as $CaCO_3$. By using a redox couple, such as ferricyanide and ferrocyanide, the cell runs with minimal inputs and minimal voltage losses. Costs and corrosion can be additionally minimized by the use of protective thin-film materials such as TiO_2. Machine learning analysis allowed us to rapidly analyze material candidates and their best preparation methods, an additional precaution to ensuring flow cell stability and efficient operation. This project provides both an opportunity for companies that cannot abandon fossil fuels to be carbon-neutral, and an opportunity for the world to become carbon negative and reduce the damages already done.

The Essential 23S rRna Methyltransferase Rv3579c Confers Intrinsic Macrolide Resistance in Mycobacterium Tuberculosis
Yuriy Sandmeier
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Mentor: Nicholas Poulton, Rockefeller University

According to the Centers for Disease Control and Prevention (CDC), in 2018, roughly 1.7 billion people were infected with Mycobacterium tuberculosis (Mtb). To treat tuberculosis (TB) infections, there has been a long-standing interest in using macrolides, a family of drugs that include clarithromycin and azithromycin (Z-pack), due to the fact that they are exceedingly safe and well-tolerated by most individuals. However, Mtb has intrinsic resistance to macrolides, generally rendering macrolide drugs ineffective at treating TB infections. The mechanistic basis for this resistance is only partially understood; thus, we aimed to determine whether there were additional factors responsible for this phenotype. A CRISPR interference (CRISPRi) screen performed in our lab identified *rv3579c,* a predicted 23S rRNA methyltransferase, to be a novel macrolide-resistance factor in Mtb. Using homology-based methods, we ascertained that *rv3579c* was closely related to the *rlmB* family of methyltransferases found in *E. coli.* We then demonstrated the essentiality of *rv3579c* in *M. smegmatis* (a surrogate of Mtb) and later showed that, with genetic knockdown of *rv3579c,* Mtb becomes more susceptible to clarithromycin, thereby highlighting a mechanism that will most likely facilitate successful treatment and elimination of TB in affected individuals. With these pivotal findings, we have laid the groundwork for further research to determine whether or not *rv3579c* can be targeted by chemical compounds to both inhibit Mtb growth and render the bacteria sensitive to macrolides. In the future, we aspire to use our findings to prevent the deaths and hospitalizations of countless millions of people.

Wavelet Based Machine Learning Approaches Toward Precision Medicine in Diabetes Mellitus
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Mentor: Xiaodi Wang, Western Connecticut State University
Co-researcher: Stephanie Chang, Greenwich High School, Greenwich, CT

It is estimated that 422 million people around the world have diabetes mellitus (DM)—a devastating, complex, and highly heterogeneous disease requiring better interventions based on disease subtyping. In this research, we utilize the discrete wavelet transform (DWT) to decompose and denoise DM data. Using DWT, we enhance heart rate variability (HRV) based DM diagnosis, data visualization of the disparities with Human Microbiome Project (HMP) data (gut bacteria, metabolomics, proteomics, RNA sequencing, targeted proteomics, and transcriptomics data) for demographic features, and insulin resistance prediction. We achieve 91.9% diagnosis accuracy for Type 1 DM using random forest with data transformed by DWT, holding the potential for usage in clinics. In addition, our DWT-based t-SNE and UMAP explorative analysis of HMP data support subtypes of prediabetic

patients stratified on sex, race, and age. Moreover, DWT-based transformations provide multiview clustering that any other methods would not provide on metabolomics, proteomics, RNA sequencing, targeted proteomics, and transcriptomics data, and outperform those without DWT. Taken together, DWT based machine learning approaches enable a fine resolution of subtyping DM towards precision medicine.

Investigation of Unexplained Intermediate Freeze Point Characteristics as Tested by a Newly Developed Multispectral Optical Biojet Fuel Freeze Point Analyzer

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Mentor: Dr. David Dagget, Boeing (Retired)

The aviation sector contributes approximately 5% of America's total anthropogenic radiative forcing through toxic emissions such as CO_2. Fatty acid methyl ester (FAME) biofuels are a promising solution to this issue, although they are very limited in freeze point and cannot withstand the extremely cold conditions of an airplane at cruise altitude. To test the freeze point characteristics of FAME fuel, a multispectral optical biojet fuel freeze point analyzer (comprised of 3 different wavelength emitting LEDs, a multi-spectral photodetector, a PT1000 RTD temperature sensor, and an Arduino Uno microprocessor) has been developed. Throughout preliminary tests, unexplained variations of the light wavelength intensity were observed with different fuel mix ratios. The goal of this research is to better understand the intermediate freeze point characteristics of FAME biofuels and determine the origin of these unexplained variations. To accomplish this, various biofuels will be tested by the optical fuel freeze point analyzer for 3 hours in an auxiliary household freezer. Diesel fuel will also be tested and serve as the control variable. The conclusions drawn from this research may lead to the development of a new optical freeze point device testing standard.

The Formulation and Testing of a Skin-Friendly Sunscreen Encapsulated in Hydroxyapatite

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Mentor: Dr. Frank Gasparro, Hamden Hall Country Day School

The purpose of this study was to investigate the effect of using n-hexadecane as a solvent for a study of how hydroxyapatite encapsulation of avobenzone reduces the transdermal diffusion rate of avobenzone. Studies have shown that avobenzone and other organic UV filters in sunscreens can undesirably diffuse into the bloodstream, potentially causing endocrine disruption. Structurally, n-hexadecane is similar to isohexadecane, a common sunscreen emollient with no side effects, making this study more realistic than a previous study that used dimethyl sulfoxide (DMSO). The MilliporeSigma Strat-M Membrane was used because of its artificial similarity to human skin. It was hypothesized that encapsulation would result in a lower diffusion rate. Control trials used unencapsulated avobenzone dissolved in n-hexadecane while the experimental trials used encapsulated avobenzone suspended in n-hexadecane. All trials used 0.14 g/L avobenzone. The membrane was placed in a Franz cell between a donor chamber with the sample and a receptor chamber with pure n-hexadecane. The increasing avobenzone concentration was measured spectrophotometrically. The efficacy of encapsulation was supported with an unpaired t test ($p=0.0002$) that compared both n-hexadecane trials, confirming an extremely significant lower rate of encapsulated avobenzone diffusion. After 3 hours, the final value of the unencapsulated trial was 0.00926 mg/cm^2 while the encapsulated value was consistently 0. Furthermore, the significantly lower overall n-hexadecane trial diffusion compared to the DMSO trial diffusion showed how the highly polar DMSO accelerated the diffusion because it dissolved the membrane. This is unlike n-hexadecane, a nonpolar, skin-friendly solvent.

Modifying an Application to Help Oral Immunotherapy Users Track Symptoms, Incidence of Allergic Reaction, and Progress

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Food allergies are on the rise around the world, posing life-threatening consequences, with the only treatments being allergen avoidance and emergency administration of epinephrine. Oral immunotherapy or OIT provides a new alternative, where patients are introduced to increased doses of their allergen to increase tolerance. The treatment plan is very personalized, making logging patient symptoms very important. The purpose of this project is to modify the application's user interface from last year's project and make the application HIPAA compliant. The app was further developed using the integrated development environment Xcode to modify the user interface and make it more user-friendly and visually appealing. Figma was used to further develop the different components of the application, making them more visually appealing. Amazon Web Services was used as the database, with a Business Associate Addendum (BAA) signed to ensure that AWS would do its part to safeguard sensitive information. Phase 1 of testing was proof of concept that the app works and meets all the criteria, while Phase 2 involved human participants reviewing

the app, voting whether they prefer the app or the paper diary, and giving additional feedback. In the future, this app could be used daily to help OIT patients manage their symptoms and reactions after taking a dose. It could also be used by doctors to keep more detailed logs of their patients' symptoms in order to provide better care.

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