Fifty-Eighth Connecticut

JUNIOR SCIENCE and HUMANITIES SYMPOSIUM

Sponsored by UConn Health, Farmington, Connecticut
Held Virtually
March 6, 2021

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

Join by clicking on the meeting link:
https://uconn-cmr.webex.com/uconn-cmr/j.php?MTID=me2c3b93e77332f5594527846dcb43c91

Or from Webex application, join by meeting number:
Meeting number (access code): 120 295 0319
Meeting password: K3FkSDgFe25

Or join from a video system or application:
Dial/click on 1202950319@uconn-cmr.webex.com
You can also dial 173.243.2.68 and enter your meeting number.

Or join using Microsoft Lync or Microsoft Skype for Business:
Dial/click on 1202950319.uconn-cmr@lync.webex.com

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

Program Summary

Online February 28–March 5	**Pre-week Events & Activities**
February 28	● Online judging of oral and competitive poster presenters. (Live oral presentations recorded 2/28 and pre-recorded poster presentations will be available for viewing during the week prior to Saturday, March 6, 2021.)
Self-guided through March 5	● Exhibit Quest: View the STEM Poster Exhibition videos and participate in the raffle entry. ● Oral and poster presentation video viewing: Prepare your questions for Q&A sessions.
Saturday, March 6	**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 Career Exploration
Noon – 1:00 PM	**Lunch Break**
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 Career Exploration
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-Eighth Connecticut
JUNIOR SCIENCE and HUMANITIES SYMPOSIUM

HELD VIRTUALLY SATURDAY, MARCH 6, 2021

Briefing

Pre-recorded, available here and on CT-JSHS page
Joy Erickson, MA
Director, CT-JSHS

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

Welcome

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

Andrew Agwunobi, MD, MBA
CEO, UConn Health
Executive Vice President for Health Affairs

Keynote Address

Ashley Kalinauskas, MS
Chief Executive Officer & Co-Founder
Torigen Pharmaceuticals
"Our Pets Get Cancer Too:
Veterinary Applications for Cancer Immunotherapy"

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, 3/6/21

2021 HUMANITIES ACTIVITY: *Implicit Bias in Healthcare A.I.*
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: Career Exploration	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, 3/6/21.

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

Block #1 Oral Presenters

Eesha Acharya
Amity Regional High School
Mentor: Dr. Dhanpat Jain
Determining the Effects of Gender and Age on the Severity of Nonalcoholic Steatohepatitis

Anchal Bahel
Amity Regional High School
Mentor: Daniel Wiznia
Analyzing if Racial Disparities Are Present in Medical Device Advertisements for Total Joint Replacement

Ethan Lavi
Amity Regional High School
Mentor: Z Ping Lin
The Role of Gene Expression of Non-homologous End Joining Pathways in the Progression of Ovarian Cancer

Block #1 Poster Presenters

Wafa Nomani
King School
Mentors: Elizabeth Isaac and Jan Grimm
Synergistic Effects of Feraheme® with Several ROS-inducing Drugs to Treat Pancreatic Adenocarcinoma

Joseph Winterlich
King School
Mentor: Alexandre Gouzy
Antimicrobial Peptides and Antibiotics Produce Bactericidal and Bacteriostatic Effects on Wild-Type E. coli

Danlin Luo
Ridgefield High School
Mentor: Pawel Gora
Comparing the Efficiency of Autonomous and Regular Vehicles with New Requests

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 Session	Group F: Career Exploration

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, 3/6/21.

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

Block #2 Oral Presenters

Mark Wang
Avon High School
Mentor: Dong Zhou, MD, PhD
Identification of Novel Biomarkers for Type 2 Diabetes Using Proteomic Analysis

Kavin Kathir
Cheshire Academy
Mentor: Paola Vera-Licona, PhD
Tumor Reversion in Claudin-low Triple Negative Breast Cancer

Block #2 Poster Presenters

Madeline Minichetti
Greenwich High School
Mentor: Andrew Bramante
Solar-powered Cu2O Nanowire Wastewater Microbial Algae Photosynthetic Bioreactor Hybrid for the Creation of a CO_2-free Energy

Alexander Patti
Greenwich High School
Mentor: Andrew Bramante
Plant Growth Enhancement & Fungal Disease Suppression via Copper, Zinc, and Manganese Nanoparticle Foliar Sprays

Uma Pendkar
Greenwich High School
Mentor: Andrew Bramante
Low-pressure Application of Metal Nanoparticles to Soybean Seeds to Provide Increased Resistance to Fusarium virguliforme

BLOCK #3
11:35 a.m. – noon

Activity	Group A: Career Exploration	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, 3/6/21.

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

Block #3 Oral Presenters

Abigail Bouton
Darien High School
Mentor: Eric Chang
Optical Stimulation of Genetically Modified Neurons to Noninvasively Treat Parkinson's Disease

Aditya Kabra
East Lyme High School
Mentor: Mrs. Ferryman
Examining the Relationship between Labor Cost and Firm Strategy through Mixed Methods Content Analysis on Panel Data and SEC Filings

Nadine Noaman
Glastonbury High School
Mentor: Dr. Marc F. Hansen
Analysis of Publicly Available Data to Generate Novel Ideas and Discoveries in Pathways Involving Hypoxia and Metabolism Starring RBX1 and HIF1alpha

Block #3 Poster Presenters

Sienna Matregrano
Bridgeport Regional Aquaculture Science & Technology Education Center
Mentor: Kirk Shadle
Determining the Efficacy of Zingiber officinale to Promote the Degradation of Bioplastics through Amylase Hydrolysis

Ryan Kim
Choate Rosemary Hall
Mentor: Dr. Hyung Gi Min
Development of an Autonomously Navigating Robot Capable of Conversing and Scanning Body Temperature to Help Screen for COVID-19

LUNCH BREAK
noon - 1:00 p.m.

BLOCK #4
1:00 – 1:25 p.m.

Activity	Group A: 4th Poster Session	Group B: Career Exploration	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, 3/6/21.

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

Block #4 Oral Presenters

Hannah E. MacDonald
Greens Farms Academy
Mentor: Dr. Mathieu Freeman
Using Solar Simulation to Quantify Chemical Degradation Rate of Microplastics

Alexis S. Ogrinz
Joel Barlow High School
Mentor: Dr. Katherine Nuzzo
The Use of Pleurotus ostreatus as Mycoremediation for Poly-lactic Acid Plastic in Landfills

Block #4 Poster Presenters

Ava Gross
Amity Regional High School
Mentor: Thomas G. Duplinsky, DDS
Comparing Bone Integration from One Dental Implant System to Another by Evaluating Bone Loss over Time in Healthy Patients

Shreya Hebbar
Amity Regional High School
Mentor: Jeffrey Saerys-Foy
The Effect of Different Types of Media on Empathetic Behavior

Aadya Wijesekera
Amity Regional High School
Mentor: Mrs. Rachel Powell
Creating a Mobile Application to Help Oral Immunotherapy Users Track Their Symptoms, Incidence of Allergic Reactions, and Progress

BLOCK #5
1:30 – 1:55 p.m.

Activity	Groups A & B: Humanities Activity Part 1	Group C: Career Exploration	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, 3/6/21.

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

Block #5 Oral Presenters

Ambika Grover
Greenwich High School
Mentor: Andrew Bramante
Rapid, Noninvasive, Fluorescence-based Detection for Elevated Levels of Nitric Oxide in Exhaled Breath, as a Marker for Hazardous $PM_{2.5}$ Exposure

Alexa Nakanishi
Greenwich High School
Mentor: Andrew Bramante
Multi-component Fixation Tracking in Gaze Interaction for Rapid, Non-invasive Diagnosis of Specific Learning Disorders

Sofia Pronina
Greenwich High School
Mentor: Andrew Bramante
Rapid, Low-cost, Visual Lyme Disease Diagnosis via Lab-on-Chip, Chemiluminescent Detection of Borrelia-induced Antibodies

Block #5 Poster Presenters

Lucy Nelson
Greens Farms Academy
Mentor: Dr. Mathieu Freeman
The Effect of Ocean Acidification on Chlorophyll a Concentration and the Net Primary Productivity of Tetraselmis Phytoplankton

Jackson Rassias
Greens Farms Academy
Mentor: Dr. Mathieu Freeman
The Fabrication of a Cost-effective Lithium-ion Battery with Increased Voltage and Longevity

Abby Barnett
Sacred Heart Greenwich
Mentor: Joan Fei
Designing and Testing an Activated Carbon Cloth Filter to Reduce the Prevalence of Phosphates and Nitrates in the Long Island Sound

BLOCK #6
2:00 – 2:25 p.m.

Activity	Groups A & B: Humanities Activity Part 2	Group C: 6th Poster Session	Group D: Career Exploration	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, 3/6/21.

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

Block #6 Oral Presenters

William Bernfeld
King School
Mentor: Dr. Simon Vecchioni
Non-canonical Base Pairing in Self-assembling DNA Crystals

Kenneth Choi
Ridgefield High School
Mentor: Dean Lee
Constructing General Hamiltonian Ground States on a Quantum Computer Using the Projected Cooling Sensor Algorithm

Block #6 Poster Presenters

Sonia Ghoshal
Glastonbury High School
Mentor: Dr. Marc F. Hansen
Elucidating the Role of IRX1 in Osteosarcoma through Network Cross Analysis

Ethan Zhang
Darien High School
Mentor: Christine Leventhal
Robotic Pancreatoduodenectomy (PD) vs. Open PD: A Meta-analysis-driven Algorithm to Enhance Surgical Decision-making

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 evaluation with questions from the national office will be sent to you via email later.

RAFFLES

Prizes will be mailed after shipping address confirmation via email.

March 6th Raffles:

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

STEM Poster Exhibition "Exhibit Quest" Raffle, winner announced today:

- All students and teachers are eligible to win.
- 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 (3/5/21) were entered in the raffle.
- Grand prize for students only: Dinner for four at Barcelona Restaurant (locations throughout Connecticut)
    - Several other prizes for students and teachers!

STEM Poster Exhibitor Raffle, winner announced today:

- Students who exhibited a poster are automatically entered into the raffle but must be present on WebEx at this time to claim the prize. Prize will be mailed after email confirmation.
- Prize: Parkville Market gift card and basket

People's Choice Award Nomination Raffle, winner announced today:

- Those who voted for the People's Choice Award winner (via Survey Monkey) by Friday evening (3/5/21) were entered in the raffle.
- Prize: Barnes & Noble gift card

www.VirtualJobShadow.com (VJS) Raffle, winner to be notified March 16:

- Those of you who attended the Career Exploration session today about VJS will receive two emails around March 8:
    - VJS credentials information to access your free 11-month subscription
    - VJS user FAQ sheet and instructions to navigate to the site's COVID-19 activity.
- Complete the activity to automatically be entered into the raffle via the site's admin tools.
- **You must participate between March 8 and March 15.**
- Prize: Dinner for four at Bartaco Restaurant (locations throughout Connecticut)

AWARDS CEREMONY

2:40 – 3:00 p.m. WebEx Main Room

Acknowledgments **Joy Erickson, MA**
Director, CT-JSHS

Awards

- Poster Presenters
- Backyard Scientist Award
- Presidential Award Nominees
- 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 an evaluation form from National JSHS via email. Please take a few minutes to fill out the survey as soon as possible. Thank you.

STEM Poster Exhibitors

Anika Agrawal, Amity Regional High School
Exploring Germinal Center B Lymphocyte Transcriptional Profile Data Sets to Identify and Characterize a Novel Subset

Giovanna Armetta, King School
Mispositioned Myonuclei Likely Contribute to Muscle Fatigue

Victor Calmon Coelho, Darien High School
Use of Accelerometers to Determine Gait Irregularity

Cindy Chen, Amity Regional High School
The Effect of Cannabidiol on Metabolic Syndrome in Schizophrenia Patients

Mehr Chhatre, Sacred Heart Academy
Analysis of COVID-19 Treatment Options—Ayurvedic and Allopathic: Design Possible Combination Therapy

Reed Cooper, Joel Barlow High School
The Effect of Various Ammonium Nitrate Concentrations on Rates of Transpiration in Phaseolus lunatus

Shealeigh Crombie, Greens Farms Academy
The Effect of Fuhc Immunosuppressants and Allotransplanted Blood Plasma on Allotransplant Acceptance in Botryllus schlosseri

Audrey Cummings, Amity Regional High School
Identification of Epigenomic Biomarkers for Cannabis Use in Humans

Yuanqin Dai, Kent School
How to Use Artificial Intelligence to Automatically and Accurately Recognize Wildlife Animal Species from Camera Traps Deployed in the Wild

Matthew Duffy, Bridgeport Regional Aquaculture Science & Technology Education Center
Developing an Adhesive from a Maize-based Matrix Mixed with Chondrus crispus Carrageenan and Determining Its Solubility in Saltwater

Paige Gagnon, Manchester High School
The Effect of Dissolved Flavonoid Supplements on the Chelation of Iron (II) in a Solution

Claire Griffin and Isabel Boellmicke, Ridgefield High School
A Simple Model of Guide RNA for CRISPR-Cas9

Samuel Hillenmeyer, King School
The Electrochemical Oxidation of Methane in a Fuel Cell Utilizing Carbon Sequestration

Luke Hisiger, Ridgefield High School
Analysis of Regenerated Mouse Digit Tips following Modulation of Amphiregulin Expression

Loken Khemani, Farmington High School
Fibronectin's Role as a Biomarker for the Prognosis of Hepatocellular Carcinoma

Zoe Koskinas, Greens Farms Academy
The Effect of Essential Oils on Food Preservation and Its Economic Benefits and Nutritional Value

Nadiezhda Kucher, King School
Deep Venous Intervention Surgeries for Lower Extremities in Outpatient Offices Do Not Create Additional Complications Compared to Hospital Setting

Nicholas Levinson, Darien High School
The Landscape of Fear of Urban Versus Rural Squirrels

Alexander Lim, King School
Using an Automated Drone and Camera System to Improve the Safety of Schools and Other Populated Areas in a Cost-effective Manner

Siyi Lu, Kent School
An Exoskeleton Trying to Make Partially Paralyzed Patients' Lives a Bit Closer to Normal

Katherine May, Sacred Heart Greenwich
Uncovering Abnormalities in Asteroids Using Asteroid Occultation

Samantha McLemore, Ridgefield High School
Comparing Wood/Plastic Composite & Hemp/PLA Composite to Natural Materials to Determine the Best Moisture-resistant Bioplastic

Ethan Mills, Ridgefield High School
Effects of Climate Change and Environmental Variability on High Altitude Aspen Degradation

Shannon Nesta, Manchester High School
Tracking Changes in the Mycobiota of Feet Over the Course of Seven Months

Tiffany Nguyen, Glastonbury High School
Research on the Variety of Health Insurance Premiums throughout the States

Adam Nomani, King School
Thermoelectric Heating and Cooling of an Electric Vehicle Using Phase Change Material

Clayton Nyiri, Bridgeport Regional Aquaculture Science & Technology Education Center
Observing the Intraspecific Behavior and Reciprocal Reaction between a Trained Shark and Newly Introduced Shark

Isabel Petron, Joel Barlow High School
Unexpected UVR Mutation Burden in Melanomas – A Continuation of Research in a United States Cohort Focusing on UV Impact on Cutaneous Melanomas

Julia Puprriqi, Thomaston High School
The Effect of Limb Darkening on the Sun During Solar Flares and Coronal Mass Ejections

Yiya Qi, Cheshire Academy
Artificial Intelligence Medical Question-answering Robot

Connor Riley, Thomaston High School
Absorbent/Refrigerant Pairs Used for Heat Pumps and Heat-rejection Technology on Spacecraft

John Russell, King School
Machine Learning Accelerated Discovery of Catalytic Materials for Energy Applications

Sophie Schonberger, Hamden Hall Country Day School
Sunglasses' True Ability to Block UV Light Compared to that which Is Advertised

Christopher Shea, Greens Farms Academy
Muscular Strength and Endurance Adaptations following Resistance Training Using Higher Volume and Lower Intensity or Higher Intensity and Lower Volume

Ali Siddiqi, Joel Barlow High School
Performance Methodology of Lithium-ion Batteries

Devansi Sinha, Ridgefield High School
Exploring p53 Mutation Status and Clinical Outcome in Ovarian Cancer

Giuliana Squatrito, Manchester High School
The Cognitive Abilities of Bearded Dragons

Abby St. Jean, Darien High School
Exercise Therapy to Treat Anxiety: The Effect of Running on Anxiety Levels

Zachary Stevenson, Thomaston High School
Investigation of Unexplained Intermediate Freeze Point Characteristics as Tested by a Newly Developed Multispectral Optical Biojet Fuel Freeze Point Analyzer

Daniel Vash, Hamden Hall Country Day School
Effect of Hydroxyapatite Encapsulation on the Diffusion of Avobenzone across a Human Skin Model Membrane to Improve Sunscreen Safety

Alexander Vassallo, Bridgeport Regional Aquaculture Science & Technology Education Center
Harnessing Bio-kinetic Energy through a Wearable Non-invasive Generator

Palash Vora, Glastonbury High School
Chromosomal Instability of RB1 in Osteosarcoma

Lucy Xu, Hamden Hall Country Day School
Spectrophotometric Determination of the Binding Constant (Ka) of a Novel Psoralen to DNA

Participating High Schools/Programs

Academy of Aerospace and Engineering (CREC), Windsor
Amity Regional High School, Woodbridge
Ansonia High School
Avon High School
Bridgeport Regional Aquaculture Science & Technology Education Center
Canton High School
Cheshire Academy
Choate Rosemary Hall, Wallingford
Coginchaug Regional High School, Durham
Conard High School, West Hartford
Connecticut IB Academy, East Hartford
Darien High School
E. C. Goodwin Technical High School, New Britain
East Lyme High School
Enfield High School
Engineering and Science University Magnet School, West Haven
Farmington High School
Glastonbury High School
Global Experience Magnet School, Bloomfield
Greens Farms Academy, Westport
Greenwich High School
Hamden Hall Country Day School
Joel Barlow High School, Redding
Kent School
King School, Stamford
Manchester High School
Mercy High School, Middletown
Miss Porter's School, Farmington
New Fairfield High School
Newtown High School
Parish Hill High School, Chaplin
Portland High School
Ridgefield High School
Sacred Heart Academy, Hamden
Sacred Heart Greenwich
Sacred Heart High School, Waterbury
South Windsor High School
Thomaston High School
Waterbury Arts Magnet School
William H. Hall High School, West Hartford
Wooster School, Danbury

SPONSORS

- Connecticut Academy of Science and Engineering
- Connecticut Science Supervisors Association
- Connecticut Science Teachers Association, Inc.
- The National Science Teaching Association under contract with the U.S. Army, Navy, Air Force and UConn Health/CT Area Health Education Center (AHEC)
- UConn Office of Undergraduate Admissions

DONORS (raffle prizes)

- Barcelona, West Hartford (and other locations)
- Barnes & Noble at UConn Health, Farmington (and other locations and online)
- Bartaco, West Hartford (and other locations)
- Fork & Fire, Farmington
- J. Timothy's Taverne, Plainville
- Milkcraft, West Hartford (and other locations)
- Mecha Noodle Bar, West Hartford (and other locations)
- Naples Pizza, Farmington
- Parkville Market, Hartford
- Pink Soda Blow Dry Bar & Salon, West Hartford (and other locations)
- Sweet Frog Frozen Yogurt, West Hartford (and other locations)
- Trader Joe's, West Hartford (and other locations)

COOPERATING ORGANIZATIONS

- AmeriCorps Health*Forward* Program (CT AHEC Network)
- AmeriCorps Service to Improve Community Health (STICH) Program
- Connecticut Association of Secondary Schools
- CT AHEC Urban Service Track/AHEC Scholars Program
- National Association of Secondary School Principals
- Talcott Mountain Science Center
- UConn College of Liberal Arts and Science
- UConn Graduate School
- UConn School of Dental Medicine
- UConn School of Medicine

EXECUTIVE COMMITTEE

- Terri Clark, Connecticut Academy of Science and Engineering, Rocky Hill
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- Deborah Day, Smith College, Northampton, MA
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- Barbara Fischler, U.S. Army Nurse Corps (veteran)
- Sandra Justin, Connecticut Science Supervisors Association
- Brittany Knight, Connecticut Convergence Institute for Translation in Regenerative Engineering, UConn Health
- Frank LaBanca, Westside Middle School Academy, Danbury
- John Listorti, Killingly High School, Danielson
- Dave Lopath, Connecticut Science Teachers Association and Connecticut Science Supervisors Association
- Richard Luddy, UConn, Hartford
- Diane Pintavalle, Glastonbury High School
- Jon Swanson, E.O. Smith High School, Storrs
- Ralph Yulo, Eastern Connecticut State University, Willimantic

STUDENT PRESENTATION MODERATORS

- Terri Clark, Executive Director, Connecticut Academy of Science and Engineering, Rocky Hill
- Robert Erickson, Pratt & Whitney, United Technologies Corporation, East Hartford (retired)

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

ABSTRACTS

Oral Presenters

Determining the Effects of Gender and Age on the Severity of Nonalcoholic Steatohepatitis
Eesha Acharya
Amity Regional High School, Woodbridge, CT
Mentor: Dr. Dhanpat Jain, Yale School of Medicine

Nonalcoholic fatty liver disease (NAFLD), characterized by fat accumulation in the liver, is the leading cause of chronic liver disease amongst obese people worldwide. Its severe form, nonalcoholic steatohepatitis (NASH) eventually causes liver failure. Research indicates that men and postmenopausal women have a higher risk of developing NASH than premenopausal women. Estrogen has been speculated to play a role in protecting the liver. However, the impact of gender and age on NASH remains poorly studied. It is hypothesized that men have a higher severity of NASH compared to women of similar age and Body Mass Index (BMI), and NASH is more severe in older people of similar BMI irrespective of gender. Liver biopsies of NASH patients were evaluated for severity based on the presence of steatosis, fibrosis, inflammation, and ballooning degeneration. BMI was obtained from the patient's charts. Disease severity was correlated with NAFLD activity scores (NAS) and fibrosis scores. Our results show that overall, men have a higher fibrosis score than women, and people older than 50 have a higher fibrosis score than younger people, supporting the idea that estrogen may have a protective role in NAFLD. However, estrogen's protective effect may decrease when BMI is >30. This research will expand our understanding of NASH/ NAFLD by understanding the roles gender and age play in disease pathogenesis. Currently, weight loss is the only treatment for these conditions. If estrogen does play a role in preventing NASH, then other treatment modalities such as hormonal therapy need to be further studied.

Analyzing if Racial Disparities Are Present in Medical Device Advertisements for Total Joint Replacement
Anchal Bahel
Amity Regional High School, Woodbridge, CT
Mentor: Daniel Wiznia, Yale School of Medicine

Annually one million patients undergo total joint arthroplasty (TJA). Minority and obese patients are severely prone to osteoarthritis, but many are not undergoing TJA. This project aims to determine how medical device companies who produce the implants target their advertisements to specific patient populations. It is hypothesized that in various mediums of advertisements, the target audience will not be minority groups. The independent variable is the advertisement medium, and the dependent variable is the focus and target group of the advertisement. Data was collected from pamphlets, websites, website banners, and videos of the top medical device companies in TJA (Smith + Nephew, Johnson & Johnson: DePuy Synthes, Stryker Orthopedics, and Zimmer Biomet). Information on race, sex, age, and weight of the model portrayed in the advertisement was collected. Pearson likelihood tests were used to compare categorical variables, including advertisement attributes and advertisement type. Of all advertisements collected, there was a lack of overweight patients and a lack of non-white patients in the advertisements, which are two groups more prone to TJA. Overwhelmingly, models were white, male, and of normal BMI, which is not the demographic of those in need of TJA. Despite having high rates of osteoarthritis, TJA remains underutilized in minority communities. It is shown that direct-to-consumer advertising from US medical device companies does not accurately reflect the population in need of this surgery. This study will facilitate changes in medical companies to target groups more prone to these treatments while also motivating them to undergo TJA.

Non-canonical Base Pairing in Self-assembling DNA Crystals
William Bernfeld
King School, Stamford, CT
Mentor: Dr. Simon Vecchioni, New York University

The scientific community has long recognized the four naturally-occurring nucleobases as the universal genetic language. However, this four-base model has recently been turned on its head with the development of "hachimoji" nucleic acids, which use up to eight bases. Four new synthetic components have been incorporated into a variety of sequences. These sequences, in turn, have been used to encode basic information and to construct a wide variety of crystals and nanocages. In this investigation, we furthered our understanding of hachimoji DNA by using the Python-based Hierarchical ENvironment for Integrated Xtallography (PHENIX), the Crystallographic Object-Oriented Toolkit (COOT), and ChimeraX to simulate a base pair between cytosine and

5-methyl isocytosine. This virtual base pair is situated at the center of a DNA strand derived from a previously-designed sequence, developed roughly 11 years prior. This pairing is considered degenerate because its components do not normally form hydrogen bonds. However, it shows coherence within the digitized sequence, and therefore suggests that the pair can exist in the real world. Should future research reveal further evidence of its existence, this development has tremendous implications for the biochemical sciences, e.g., molecular computing, genetics, and immunology. Because the new base pair may be capable of encoding peptides using non-proteinogenic amino acids, our findings may be used for the development of new, unique proteins. These molecules, encoded using hachimoji nucleic acids containing the cytosine-5-methyl-isocytosine base pair, may prove effective in the treatment of genetic and/or metabolic illnesses such as diabetes, anemia, and cancer.

Optical Stimulation of Genetically Modified Neurons to Noninvasively Treat Parkinson's Disease

Abigail Bouton
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Mentor: Eric Chang, Feinstein Institute for Medical Research

An estimated 60,000 Americans are diagnosed with Parkinson's Disease (PD) each year and 10 million people suffer from the disease worldwide. The root cause of PD is the degeneration of dopaminergic neurons in the substantia nigra (SN), causing tremors and slowed movement in PD. A current treatment for PD is deep brain stimulation (DBS) of the subthalamic nucleus, where a large hole must be drilled into the skull so electrodes can be implanted into the brain. Due to the invasive nature of DBS, it prevents many patients with PD, who are typically older, from receiving this treatment. In addition, another treatment, Levodopa, can cause negative side effects. Optogenetics is a method where DNA coded for a light sensitive opsin is injected into the brain. When transfected neurons are illuminated with light, they are either hyperpolarized or depolarized. It was hypothesized that optogenetics can be used to stimulate genetically-modified dorsal root ganglia (DRGs), therefore modulating their activity levels, and the MICROS device (Microelectrode Instrument that Captures Response to Optical Stimulation) can record these changes. In addition, increasing the pulse rate of the light source will directly correlate with activity levels of the neurons. Due to optogenetic's use of light and genetic methods, it is more precise than other methods and does not damage tissue, making it an ideal treatment for PD.

Constructing General Hamiltonian Ground States on a Quantum Computer Using the Projected Cooling Sensor Algorithm

Kenneth Choi
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Mentor: Dean Lee, Facility for Rare Isotope Beams and Department of Physics and Astronomy, Michigan State University

With accurate algorithms, quantum computers have the potential to find the properties of complex many-body systems that classical methods simply cannot examine. One such property is the ground state, which is a system's lowest energy configuration. In 2002, Alexei Kitaev proved that all quantum circuits can be modeled using only ground states, making them extremely important to reconstruct and put into use. However, current quantum algorithms that attempt to reconstruct ground state wave functions have low fidelity and are not robust against noise. To this end, we introduce the projected cooling sensor algorithm, which accurately reconstructs the ground state of any general Hamiltonian (the energy operator of a system) to solve the quantum ground state preparation problem. For low-dimension Hamiltonians, the projected cooling sensor algorithm reconstructs the ground state with a relative error of 0.0001 or less. For high-dimension Hamiltonians, multiple iterations of the projected cooling sensor algorithm exponentially decrease the error of the reconstructed ground state. We find that on a quantum computer, the reconstructed ground state has nearly 100% overlap with the exact ground state. The projected cooling sensor algorithm can be applied to a wide range of general many-body systems, including nuclei, bulk materials, superconductors, Ising models, and protein folding. When simulated on a quantum computer, the projected cooling sensor algorithm has the potential to achieve quantum supremacy over classical computations for any quantum Hamiltonian.

Rapid, Noninvasive, Fluorescence-based Detection for Elevated Levels of Nitric Oxide in Exhaled Breath, as a Marker for Hazardous $PM_{2.5}$ Exposure

Ambika Grover
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Mentor: Andrew Bramante, Greenwich High School

There is a clear correlation between prolonged exposure to ambient fine particulate matter ($PM_{2.5}$) and the development of lethal disease. Today, there exists no personalized, quantifiable measure to gauge an individual's exposure to $PM_{2.5}$ other than generalized tools. $PM_{2.5}$-induced constriction of lung airways leads to elevated NO levels produced in the lungs to fight inflammation. Accordingly, excess concentration of NO (40+ ppb in adults, 25+ ppb in children) can be a viable breath biomarker

for the indication of $PM_{2.5}$-induced lung inflammation. Herein, an inexpensive, portable, rapid, and temperature-independent breath detection kit for $PM_{2.5}$ exposure was developed, based on smartphone-detection of NO-induced luminescence of DAF-2 (diaminofluorescein-2). Upon exposure to NO, DAF-2 is converted to highly luminescent DAF-2T (exc/em 485/550nm), which acts as a positive indicator for elevated breath NO levels due to $PM_{2.5}$ exposure. To begin, 8 µl of 50µg/ml DAF-2 was embedded onto a filter-paper based detection card, which was found to be stable when stored at room temperature (via repeated FTIR analyses). A linear relationship between 60ml of 0-1000ppb NO breath concentrations and DAF-2T detector illumination was established, first via surface-luminescence spectroscopy, and later with smartphone images, taken with 490/560nm bandpass filters, for the flash and camera, respectively. A Smartphone application rapidly converts the detection card images (DAF-2 blank versus breath, NO-induced DAF-2T image) to green-color values, with a written algorithm determining the NO-breath concentration down to 10ppb. These results are time-stamped and shared, along with GPS coordinates, to build live $PM_{2.5}$ exposure trends, at a per-test cost of ~$5.

Examining the Relationship between Labor Cost and Firm Strategy through Mixed Methods Content Analysis on Panel Data and SEC Filings

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Mentor: Mrs. Ferryman, East Lyme High School

With a desire for growth and longevity, corporations have looked to analyze labor cost, a proven indicator for capital success, to recognize which components of firms ensure maximal revenue. Interpreting such indicators help make vital managerial decisions regarding production cost adjustment and workforce investment. In recent years, it has been hypothesized that firm strategy also impacts corporate success but could not be evaluated due to the data's qualitative nature. In this study, I analyzed labor cost and its variability in relation to five prominent firm strategies through the creation of a novel mixed-methods methodology using tokenization and root-word identification. I examined a cross-sectional dataset spanning over 30 years with 3300 observations, performing content analyses on qualitative SEC 10-K filings and multivariate regression analyses for quantitatively extracted frequencies. Multivariable statistical models were analyzed via R and SPSS and organizational control variables, such as capital expenditure, were selected due to their high correlation with labor cost, acting as a way to avoid multicollinearity. Results showed that innovation, human resources, and consumer-focused strategies had a strong association with labor cost while growth, restructuring, and human resources shared strong correlations with labor cost variability ($p<0.01$). Such results led to conclusions on the implementation, advantages, and drawbacks of each strategy and their magnitude of significance in relation to capital success. Firms can use this novel mixed-methods approach to draw conclusions and make critical organizational decisions referring to cost allocation and strategy identification. Future studies should include content analysis using multi-layered analytical techniques and big data.

Tumor Reversion in Claudin-low Triple Negative Breast Cancer

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Mentor: Paola Vera-Licona, PhD, UConn Health Center

Triple negative breast cancer (TNBC) is a clinically challenging disease that makes up approximately 12% of all breast cancers. TNBC is characterized by a lack of expression of the oestrogen and progesterone receptors as well as a lack of human epidermal growth factor receptor 2 (HER2) amplification. Expression in these receptors are commonly utilized in targeted and hormone therapies, but are ineffective for TNBC, limiting treatment options to aggressive chemotherapy and surgery. Within this group, claudin-low (CL) TNBC lacks basal markers and expresses low levels of claudin proteins and E-cadherin. CL TNBC has one of the worst prognoses of all subtypes due to its high chemoresistance and metastatic abilities. Tumor reversion, the process in which the cancerous cells lose their malignant phenotype, is often overlooked in cancer treatment. The objective of this project is to derive the genes that potentially control this reversion process to fuel a better treatment option in CL TNBC. Using RNA-Seq data in TNBC and normal cell lines, such genes were investigated. By utilizing bioinformatics tools to find the functionally enriched differentially expressed genes, their transcription factors, and upstream master regulators, a static core TNBC intracellular network was constructed. Further analysis through a systems control approach identified the genes driving the long-term behavior of the cells and genes that can potentially induce tumor reversion. These results not only show the appropriate genes for potential tumor reversion, but display how this type of structural analysis can yield promising candidates for targets in future cancer therapies.

The Role of Gene Expression of Non-homologous End Joining Pathways in the Progression of Ovarian Cancer
Ethan Lavi
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Mentor: Z Ping Lin, Yale School of Medicine

One way the cells repair DNA damage is with error-prone Non-Homologous End Joining (NHEJ). Causing a high level of mutations, this process serves as a double-edge sword in cancer therapy, being used as a target for treatment or also causing resistance to develop. The purpose of this project was to determine if the genes involved in NHEJ have an impact on the survival of ovarian cancer. A list of NHEJ genes were determined through literature search. It was hypothesized that expression levels of these genes have a significant impact on the progression of ovarian cancer. First, data from ovarian and breast cancer patients was extracted from the TCGA database. A multiple linear regression analysis of the ovarian cancer data showed a weak correlation (R^2=0.1196) between gene expression and survival time. Then a neural network was programmed to analyze any complex data patterns, with the goal of predicting prognosis. The model was trained on a combination of 606 ovarian and breast cancer patients, but was tested only on 45 ovarian cancer patients. Breast cancer patients were added to augment the model's learning. This approach yielded 18% higher relative accuracy compared to random predictions. This finding supports the hypothesis, indicating that the NHEJ expression in cancer cells is a possible biomarker of tumor aggressiveness. For future research, the accuracy of a predictive model could be increased by including other variables such as demographics. Further inquiry is required to identify each gene's contribution to the prediction.

Using Solar Simulation to Quantify Chemical Degradation Rate of Microplastics
Hannah E. MacDonald
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Mentor: Dr. Mathieu Freeman, Greens Farms Academy

Microplastics are plastic fragments less than five millimeters in diameter that are sourced from both primary and secondary sources, either intentionally produced for industrial use, or created by fragmentation of larger plastic materials. Both types of microplastics densely populate Earth's oceans and have shown to be harmful to marine life and humans alike. This study examines the differences in the photodegradation of each type of microplastic, and identifies those that photodegrade most effectively. Six types of microplastic fragments were each suspended in distilled water and exposed to solar simulating UVA and UVB bulbs for seven days to replicate the effects of natural sunlight on microplastic fragments at sea. The fragments were then filtered using one micrometer filtration and measured by mass differences to determine the amount of plastic decomposed per week. The increase in vapor pressure of the container was measured at the beginning and end of each cycle to determine possible volatile products of the decomposition. This study is intended to quantify the rate of photodegradation between these microplastics, and explore the chemical decomposition of each plastic. Current findings show a rate of degradation in branched polymers between 9-12% higher than that of linear polymers, with polystyrene and polypropylene showing most rapid degradation. This research, and further studies, can aid in understanding which plastics are best to produce and consume in order to minimize their effect on water systems and coastal environments globally.

Multi-component Fixation Tracking in Gaze Interaction for Rapid, Non-invasive Diagnosis of Specific Learning Disorders
Alexa Nakanishi
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Mentor: Andrew Bramante, Greenwich High School

Specific learning disorders such as dyslexia affect 15–20% of the population worldwide. However, with no universally effective method of diagnosis for these specific learning disorders, diagnosis can be a slow and unsure process. This research devised a PC-based diagnosis tool for those with reading disorders, including dyslexia, through fixation tracking in gaze interaction, using an eye tracker. Participating middle and high school students were asked to read three read passages, while the tracker recorded their eye movements, and determined fixation numbers, durations, and progression of eye movements. The resulting data highlights measurable differences between typical and atypical readers. Atypical readers averaged 1.73 fixations/sec, while typical students averaged 2.17 fixations/second. Atypical readers exhibited an average fixation duration of 2.42sec, far more than typical readers (1.17sec). Tracking of fixation location was used to monitor the reader's eye movement, so that a best-fit regression and R^2 correlation could be determined for each line of text within the passage. Typical students' eye movement was linear across each line of text, with an R^2 correlation of >0.35. Eye movement of atypical readers, conversely, was irregular across the same text (R^2 of ~0.083). Fixation, duration, and linearity data were analyzed against each student's reported medical diagnosis, to derive selection criteria for atypical readers; fixations/sec <1.95, fixation duration >1.55 sec, and eye-movement R^2 correlation of <0.35. Blind

prediction of each participant's medical diagnosis, using these selection criteria, yielded prediction accuracies of 91%, 94%, and 99.9%, respectively, highlighting the efficacy of this simple and rapid PC-based diagnostic tool. Finally, measure of these selection criteria for new patients highlights a 100% accuracy for typical versus atypical readers.

Analysis of Publicly Available Data to Generate Novel Ideas and Discoveries in Pathways Involving Hypoxia and Metabolism Starring RBX1 and HIF1alpha

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Mentor: Dr. Marc F. Hansen, UConn Health

Osteosarcoma, a bone cancer, occurs in children and young adults. Tumors frequently become hypoxic and nutrient-limited as they grow. So, tumor cells must develop mechanisms to overcome those limitations such as altering gene expression in ways that permit the cell to continue to grow even under circumstances that are nutrient and oxygen limiting. Stimulating signaling pathways activates angiogenesis to provide both oxygen and nutrient to the growing tumor cell. My research is discovering ways to overcome hypoxia and nutrient limitation by analyzing publicly available databases to uncover novel mechanisms by which osteosarcoma induces angiogenesis. After using databases including DAVID, NCBI GEO, TF2DNA, and HuRi, I discovered that in an active Cul2-Rbx1-EloBC-VHL complex, VHL would be in use in Osteosarcoma. Active complexes occur in normal to primary tumor samples as VHL, CUL2, and RBX1 in the protein complex are all increased. Moreover, HIF1A expression is low and is unnecessary due to the tumor being relatively normoxic. As the cells become metastatic, they become hypoxic. In the transition to becoming hypoxic, VHLL, a competitor, may be used instead of VHL, inactivating the complex. This would be in primary tumor to metastasis samples as VHL expression remains the same alongside VHLL. As a result, the hypoxic tumor has HIF1A left alone to stimulate angiogenic pathways. This explains RBX1's increase and how VHLL may control the complex. Understanding what mechanisms are involved in angiogenesis can lead to therapies to block such pathways with the ultimate goal of preventing the growth of tumors.

The Use of <u>Pleurotus ostreatus</u> as Mycoremediation for Poly-lactic Acid Plastic in Landfills

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Mentor: Dr. Katherine Nuzzo, Joel Barlow High School

The accumulation of poly-lactic acid (PLA) plastic in landfills creates a dangerous environment for wildlife. The slow biodegradation of PLA plastic means that the rate of decomposition is significantly lower than the accumulation of more plastic which leads to greater leakage of toxins present in plastics. Degrading plastic will slowly leak toxic chemicals that can seep into nearby plants and water sources, poisoning both the land and animals. *Pleurotus ostreatus*, oyster mushrooms, are capable of the mycoremediation of PLA plastic in cultivated conditions. If oyster mushrooms can continue that trend in landfill conditions, *Pleurotus ostreatus* will be introduced into waste landfill material for evaluation as a viable remediation of PLA. In this experiment, oyster mushroom spores were grown inside glass mason jars. Each trial contained a 3D printed PLA plastic ring to test for the degradation of the plastic by the oyster mushrooms. The trials ran in different ratios of agar to landfill components beginning from 100%:0% and decreasing by tens until 0%:100% for a total of eleven trials. The trials were then tested for loss of plastic mass and the presence of degraded PLA in the mushroom mycelium. This demonstrates the oyster mushroom's ability to decompose PLA plastic to the same degree outside of cultivated conditions. In the future, oyster mushrooms could act as a clean source of mycoremediation for PLA plastic in landfills, effectively lowering the accumulation of plastic waste and making the area safer for both wildlife and humans.

Rapid, Low-cost, Visual Lyme Disease Diagnosis via Lab-on-Chip, Chemiluminescent Detection of <u>Borrelia</u>-induced Antibodies

Sofia Pronina
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Mentor: Andrew Bramante, Greenwich High School

Approximately 300,000 cases of *Borrelia burgdorferi (Bb)* induced Lyme disease are reported annually in the U.S. alone. Without timely diagnosis, the disease expands to Post Treatment Lyme disease syndrome (PLDS), leading to chronic delocalized symptoms such as encephalopathy, arthritis, erythema migrans, and other cognitive defects. Despite this, current diagnostic methods are costly, time-consuming, and require lab access. However, a visual point of care Lab-on-Chip (LOC) could ensure early intervention, limiting the long-term effects of PLDS. Because of their low visible absorption and large specific surface area, single walled carbon nanotubes (SWCNTs) have recently gained popularity for biosensor applications. This research applies functionalized SWCNTs to a chemiluminescent, immunological assay LOC for *Bb* IgG. The reusable LOC was CAD-designed, and laser-cut onto layers of PMMA black acrylic and polycarbonate (Yang, modified). The SWCNTs were functionalized through dispersion in H_2SO_4, HNO_3, sonication, and centrifugation in PDDA, and coated with *B. burgdorferi* antigen prior to validation through ATR-FTIR and SEM analyses. The

interchangeable immunosensor was covered with functionalized and antigen-coated SWCNT spots, then subsequently attached to the LOC. Upon exposure to *Bb* IgG (high) concentrations that are characteristic of Lyme disease, HRP-bound DuoLux substrate produced a luminescent response that is visible using a smartphone camera, with a 430nm cut-on filter. Results were validated using a fluorescence spectrometer, where fluorescent intensity correlated linearly with concentrations of *Bb* IgG. The Smartphone camera and spectral results highlight the LOC's potential in detecting IgG at varying levels that are indicative of Lyme onset, at a ~$25/test cost.

Identification of Novel Biomarkers for Type 2 Diabetes Using Proteomic Analysis
Mark Wang, Avon High School, Avon, CT
Sponsor: Dong Zhou, MD, PhD, UConn Health School of Medicine

Diabetes is a chronic metabolic disease associated with metabolic disturbances of carbohydrates, proteins, and lipids. Robust efforts have been made to strengthen the healthcare systems for the diagnosis and management of diabetes. However, it remains a medical dilemma; how to effectively monitor and manage diabetes. At present, blood glucose and hemoglobin A1C are gold standard biomarkers for the diagnosis and management of diabetes. The values of blood proteins in monitoring the occurrence and progression of diabetes have not been well explored. To fully understand the biological changes in the blood of diabetic patients, we recruited 60 participants including 30 healthy adults and 30 patients diagnosed with type 2 diabetes. By performing deep profiling of proteomes in the blood, we identified a total of 42 proteins that are differentially expressed in the blood of diabetic patients compared with healthy controls. Of the differentially expressed proteins, α2-macroglobulin, L-selectin, APOA1 and APOD displayed considerably high expression levels in diabetic patients, which could serve as a more sensitive combinational biomarker in distinguishing diabetic patients from healthy people and may predict the progression of diabetes. Furthermore, through analyses of gene ontology and Kyoto Encyclopedia of Genes and Genomes pathways associated with the differentially expressed proteins, we discovered that the activation of liver X receptors/retinoid X receptors in diabetic patients was a key biological event that can trigger the dysregulation of cholesterol, lipid, and glucose metabolism. Collectively, our study provides a rich and open-access resource to shed lights on personalized strategies for optimal management of diabetes.

Poster Presenters

Designing and Testing an Activated Carbon Cloth Filter to Reduce the Prevalence of Phosphates and Nitrates in the Long Island Sound
Abby Barnett
Sacred Heart Greenwich, Greenwich, CT
Mentor: Joan Fei, Sacred Heart Greenwich

Excess amounts of nutrient pollutants enter storm drains and are ultimately directly deposited into the Long Island Sound. These pollutants carry harmful levels of nitrates and phosphates, which cause eutrophication and lead to lower dissolved oxygen levels, also known as hypoxia, which kills fish populations and even entire ecosystems. My previous research has indicated that the carbon cloth filter uniquely decreases both phosphate and nitrate, rather than one of the factors of nutrient pollution, as seen in other filtering materials. The purpose of this year's study is to test the new design of the activated carbon cloth filter in order to replicate previous research as well as quantify the percent decrease. It is hypothesized that with the introduction of an activated carbon cloth filter nitrate and phosphate levels will be reduced significantly. The effectiveness of the filter was determined by measuring the concentration of these pollutants in the stormwater run-off before and after the use of the carbon cloth filter. A reduction of 100% of nitrates was seen in one trial, and the average decrease of nitrate was 62%. The phosphate levels also decreased by an average of 73%. Based on these results it is expected that by using this carbon cloth filter, strategically placed in storm drains, nutrient pollution will be reduced significantly by a factor of approximately 5%. Nutrient pollution affects thousands of bodies of water across the world, and finding a solution to combat nitrate and phosphate overflow will create healthier water for all marine life.

Elucidating the Role of IRX1 in Osteosarcoma through Network Cross Analysis
Sonia Ghoshal
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Mentor: Dr. Marc F. Hansen, University of Connecticut School of Medicine

Osteosarcoma unfortunately has not seen significant improvements in treatment for the past few decades, partially due to limited knowledge on the prevention of metastasis. Recent studies have increasingly turned to investigating alternative splicing, the

natural process where multiple mRNAs are created from the same gene, in order to better understand if and how it could affect tumorigenesis. These studies have indicated that mutations in alternative splicing correlate to cancerous traits, such as angiogenesis, cell proliferation, and the inability to undergo apoptosis (Climente-González, 2017). This virtual project aims to further elucidate the connection between alternative splicing and osteosarcoma through cross analysis of data obtained through public databases. This project is centered around IRX1, which is heavily overexpressed in metastatic osteosarcoma. By cross referencing datasets from GEO, KEGG, STRING, TF2DNA, and Enrichr, we created a novel network of proteins involved with IRX1 in metastatic osteosarcoma, including DLX2, SOX9, SHH, FOXJ1, SMAD3, CXCL14, SRC, AKT, PIK3CA, HEY2, SOX2, IKBKB, NF-KB, and AKT. Through data from MOTIF, BLAST, and UCSC Genome Browser, we are further looking into how differences in IRX1's two transcripts could affect the protein network identified. Although the transcripts of IRX1 are very similar, there are alterations on the 3' and 5' end of the sequences as well as an exon skip, highlighting the differences of the two variants. These alterations may help us understand how the two transcripts differ in their role in leading to metastatic osteosarcoma. These results would need to be further validated through physical laboratory research. By analyzing which splicing isoforms are more active in the tumorigenic process, we can uncover the connection between alternative splicing and osteosarcoma, paving the way for new splicing correction treatments- advancements much needed for cancer patients (Lee, 2016).

Comparing Bone Integration from One Dental Implant System to Another by Evaluating Bone Loss over Time in Healthy Patients

Ava Gross
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Mentor: Thomas G. Duplinsky, DDS, Yale School of Medicine

When a patient loses a tooth, a dental implant, a titanium screw, is needed to replace it and retain the shape of the mouth. The implant osseointegrates with the bone in the mouth. The purpose was evaluating the bone loss over time in two types of implants, 3i and Astra, in healthy patients. Healthy patients do not smoke, have diabetes, or peri-implantitis. Anyone with these conditions was excluded to not skew the data. This is a second year project, so the data from last year was used too. The x-rays were provided by the student's mentor, Dr. Thomas Duplinsky, resident advisor and general dentist at the Yale Dental Residency program. It was hypothesized that the implant brand with the least amount of bone loss in healthy patients was Astra. The independent variable was the implant brand and the dependent variable was the amount of bone loss over time. The constant was the program used to assess the bone loss. To evaluate it, the program Eaglesoft was used and measured by the measuring tool. The tool was calibrated to the length of the implant, specified in the patient's file. The amount of bone loss was divided by the total length of the implant to calculate the percentage of bone loss. The percentage of bone loss over time was compared across both types of implant brands. The data was also run through a Z-test for analysis. The data enables dentists to pick the most effective implant for their patients.

The Effect of Different Types of Media on Empathetic Behavior

Shreya Hebbar
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Mentor: Jeffrey Saerys-Foy, Quinnipiac University

Elements in narrative fiction can foster empathetic development through transportation into a story. Transportation occurs when an individual experiences high imagery, and is emotionally impacted. Components of empathy include affective empathy (capacity to respond with the correct emotion), concern for others, emotional contagion, and perspective taking. The purpose of this experiment is to identify whether viewing a narrative fiction film or reading a short story lead to a greater level of empathy. The film and reading was based on the same story: "The Man Who Planted Trees" by Jean Giono. One group of college students received the reading while the other viewed the 30-minute film. Each participant answered some simple comprehension questions to confirm their understanding, and then assessed their empathy using four different questionnaires. They played a round of dictator game to assess their prosocial life, completed a narrative engagement scale, a character identification scale, and finally the interpersonal reactivity index which has four subscales, each measuring a separate aspect of empathy. So far data has shown that the fiction reading led to a higher measure of prosocial life, participants were more engaged with the film, and nonfiction scored higher in overall empathy. In today's day and age with more online interactions, it is important for students to be able to connect with others and grow healthy relationships. Filmmakers and storywriters can also continue to develop their characters to encourage empathy through transportation, which can translate into real life behavior.

Development of an Autonomously Navigating Robot Capable of Conversing and Scanning Body Temperature to Help Screen for COVID-19

Ryan Kim
Choate Rosemary Hall, Wallingford, CT
Mentor: Dr. Hyung Gi Min, Adjunct Professor, Namseoul University

Throughout the COVID-19 pandemic, the most common symptom displayed by patients has been a fever, leading to the use of temperature scanning as a preemptive measure to detect and isolate potential carriers of the virus. Human employees with handheld thermometers have been used to fulfill this task, however this puts them at risk as they cannot be physically distanced when taking forehead temperature readings and the sequential nature of this method leads to great inconveniences and inefficiency. The proposed solution is an autonomously navigating robot capable of conversing and scanning people's temperature to detect fevers and help screen for COVID-19. To satisfy this objective, the robot must be able to (1) navigate autonomously, (2) detect and track people, and (3) get individuals' temperature reading and converse with them if it exceeds 38ºC / 100.4ºF. An autonomously navigating mobile robot is used with a manipulator controlled using a face tracking algorithm, and an end effector consisting of a thermal camera, smartphone, and chatbot. The goal of this project is to develop a functioning solution that performs the above tasks. In addition, technical challenges encountered and their engineering solutions will be presented, and recommendations will be made for enhancements that could be incorporated when approaching commercialization.

Comparing the Efficiency of Autonomous and Regular Vehicles with New Requests

Danlin Luo
Ridgefield High School, Ridgefield, CT
Mentor: Pawel Gora, University of Warsaw

Autonomous vehicles will become prevalent among the public within a few years, aiding in the reduction of traffic through communication between vehicles. However, properly planning the routes of these vehicles and testing their efficiency has been recently subjected to research. This experiment compares the efficiency of autonomous and regular vehicles with the appearance of new requests. Using Python, a computer model records the total time a regular and autonomous vehicle needs to pick up every location and fulfill new requests. The autonomous vehicle can change its route with the appearance of the new requests while the regular vehicle must make a second trip. An 8x8 grid is used for simplicity. This experiment comparing the efficiency of autonomous cars and exploring the potential of rerouting can inspire scientists to pursue the development of a smarter car. The results will help the public understand the potential increase in efficiency of autonomous vehicles.

Determining the Efficacy of <u>Zingiber officinale</u> to Promote the Degradation of Bioplastics through Amylase Hydrolysis

Sienna Matregrano
Bridgeport Regional Aquaculture Science & Technology Education Center, Bridgeport, CT
Mentor: Kirk Shadle, Bridgeport Regional Aquaculture Science & Technology Education Center

As the expansion of the bioplastics industry continues to grow there is a new stress to mitigate the long and short-term effects of starch-based bioplastics on environmental parameters. This research proposes that *Zingiber officinale* (ginger) can be used to promote amylase hydrolysis of starches in *Crassostrea virginica* (eastern oyster), the model filter feeding organism, allowing for less excess starch to remain in the marine environment. The goal of this experiment is to determine the water quality mitigation requirements and the efficacy of the eastern oyster ginger/amylase systemic bioremediation process. Multiple trials were conducted to evaluate water quality parameters over a twenty-four-hour period with the addition of starch bioplastics to saltwater. Starch absorbances of tanks with oysters and different concentrations of ginger were compared to measure the starch concentration over time. All research was independently designed and executed unless otherwise noted. Hardness, salinity, and temperature were not affected by the bioplastics while the turbidity, dissolved oxygen, and pH data indicated that there was a statistically significant change over time due to the bioplastics. Data concluded that oysters treated with a .055M concentration of ginger could hydrolyze 38% of the initial starch, double the amount of starch in five hours compared to the untreated oysters. Oysters treated with .1M ginger salt water hydrolyzed 20% of the initial starch. Future applications include the treatment of oyster beds for bioremediation of microplastics and other materials in ocean water and the addition of powdered ginger to the starch matrix of the biodegradable plastics prior to dehydration.

Solar-powered Cu2O Nanowire Wastewater Microbial Algae Photosynthetic Bioreactor Hybrid for the Creation of a CO_2-free Energy

Madeline Minichetti
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Mentor: Andrew Bramante, Greenwich High School

The continuous use of fossil fuels persists to release harmful carbon dioxide into the atmosphere; hence, global warming remains a pressing issue. A renewable energy resource that has less adverse effects on our environment, as well as scalability, is needed. Microbial fuel cells have proven efficient in creating energy from bacteria decomposition of wastewater, however, the process produces CO_2. Conversely, algae photosynthetic fuel cells require CO_2-inputs to increase the technology's efficacy of energy. While these cells are efficient in addressing the environmental footprint of renewable energy, they lack convenient scalability to be an effective solution. Conventionally they have to be massive in size to produce sufficient energy. In this research, a proposed algae-microbial hybrid energy cell (AMHEC) was developed that combines the energy productions of algae photosynthesis and microbial decomposition, in a self-CO_2-scrubbing AMHEC that employs a fabricated, increased surface area Cu2O nanowire cathode. In use, CO_2that is produced by anodic wastewater degradation is actively recycled into the cathode chamber, for reuse during algae photosynthesis. Recycled-AMHEC performance increased by ~133% relative to a closed-chamber system, from (5-day) sustained output of 0.15V (closed) to 0.35V. Versus literature attempts at wastewater-algae hybrid cells, the increased energy efficiency of the self-CO_2-scrubbing AMHEC is clear; polarization response is 50% higher, and the maximum power achieved (202μW) is 55% higher than previously reported data (130μW). Increased performance is directly attributed to algae longevity within the recycled system. For the closed system, 83% algae loss in 5days results in 74% output loss; for the recycled system, only 50% loss in viable algae results in 49% reduction in performance. When compared to power densities of typical microbial cells (26mW/m2), the self-CO_2-scrubbing AMHEC produces 78mW/m2.

The Effect of Ocean Acidification on Chlorophyll a Concentration and the Net Primary Productivity of <u>Tetraselmis</u> Phytoplankton

Lucy Nelson
Greens Farms Academy, Westport, CT
Mentor: Dr. Mathieu Freeman, Greens Farms Academy

Carbon sequestration by phytoplankton is a natural process with potential to mitigate the effects of excess atmospheric and oceanic carbon dioxide as the climate crisis progresses. The purpose of this investigation was to evaluate the effect of reduced pH on the net primary productivity (NPP) of phytoplankton as indicated by chlorophyll a concentration in order to determine phytoplankton's ability to absorb carbon dioxide under increasingly acidic conditions. Unlike prior studies, this research occurred *in vitro,* used chlorophyll a as an indicator of productivity, and focused on a range of pH values specific to local ocean acidification projections. In the lab, phytoplankton were grown using a live *Tetraselmis* culture, divided into five samples, and subjected to different pH values ranging from 8.1 to 7.7. Every 24 hours for a week, chlorophyll was extracted from each sample via vacuum filtration methods and measured using spectrophotometry at two wavelengths: 645 and 665 nm. Chlorophyll a concentrations could then be calculated from absorbance ratings. The data collected during this experiment demonstrates a decrease in average chlorophyll a concentration as pH decreases, therefore indicating a simultaneous decrease in NPP. Since depth was controlled in this experiment, the production per unit chlorophyll concentration was constant, and NPP and chlorophyll a concentration are directly related. These results reveal that lower oceanic pH will affect phytoplankton's rate of photosynthesis and ability to absorb carbon dioxide as ocean acidification continues. Understanding phytoplankton's future productivity provides context for climate change projections and the future health of marine ecosystems.

Synergistic Effects of Feraheme® with Several ROS-inducing Drugs to Treat Pancreatic Adenocarcinoma

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The five-year survival rate of pancreatic cancer is approximately 3%, making it an unmistakably fatal condition. Since most pancreatic cancers are diagnosed at metastatic stages, they become challenging to treat. Traditional chemotherapies are associated with many adverse effects on healthy cells such as an increased chance of infection, easy bleeding or bruising, and shortness of breath. However, iron-oxide nanoparticles present as promising drug delivery agents to mitigate issues with free chemotherapy drugs as well as act as a generator for reactive oxygen species (ROS). Since active iron can generate ROS in cells leading to cell damage, iron-oxide nanoparticles (e.g. Feraheme®) should work similarly. In this study, we explored the potential of Feraheme® as an ROS generator. We non-covalently loaded several ROS-inducing drugs (i.e. Brusatol, Erastin, Parthenolide) onto Feraheme® to treat pancreatic cancer cell lines and measured corresponding cancer cell viability via MTS assays and lipid

peroxidation (an indicator of ROS) via flow cytometry. We found that cells treated with both Feraheme® and drugs had a synergistic effect that increased lipid peroxidation and decreased viability; thus, they showed promise as a targeted cytotoxic combination. We are also currently functionalizing Feraheme® with an amine-based coating and an O-PEG coating to optimize cellular entry of Feraheme®. Although this data is only preliminary, it shows promise that nanoparticle therapies are more desirable than traditional chemotherapies for fatal cancers like pancreatic cancer because they can effectively target and kill cancer cells with minimal damage to healthy neighboring cells.

Plant Growth Enhancement & Fungal Disease Suppression via Copper, Zinc, and Manganese Nanoparticle Foliar Sprays
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Mentor: Andrew Bramante, Greenwich High School

Sensitive crop regions are constantly under environmental stresses that foster plentiful plant disease. Basil plants, for instance, have been victims of *Fusarium oxysporum (F.o.)* wilt for decades, where growth conditions have stimulated progression of this disease, and subsequent crop destruction. A simple and effective treatment that would eradicate *F.o* wilt, while promoting overall plant growth, is needed. Metallic nanoparticles (NPs) have shown to improve plant health and overall crop yield, due to systemic movement through the plant's root system, where the nutritional value of metallic nanoparticles is fully realized. This research investigates whether the "foliar-spray" application of NPs of copper, manganese, and zinc (as oxides) increases the growth rate and crop efficiency of healthy *O. basilicum* plants, and inhibits the adverse effects of *F.o.,* to ultimately devise an easily-applied, simple, and effective treatment to promote increased crop growth. Pre-grown (3") basil plants were first transferred to ~0.8L pots using ProMix-BX soil, which was pre-inoculated with 1-2ml of 1g/L-*F.o* in water. Each plant was then treated with ~2ml foliar spray of the respective nanoparticles. After six weeks' growth, all three MO-NP treatments produced significant increases (>120%) in biomass, relative to diseased plants; ZnNPs were the most favorable, at 180% increase in biomass relative to untreated, diseased plants. Combined Cu-Zn NP treatment enhanced diseased plants' biomass by 29% and provided a 40% increase in height. Most importantly, diseased-plants outgrew healthy controls by 21%, highlighting the treatment's ability to fully suppress *F.o.,* so that infected plants grow beyond normal, healthy conditions.

Low-pressure Application of Metal Nanoparticles to Soybean Seeds to Provide Increased Resistance to <u>Fusarium virguliforme</u>
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Mentor: Andrew Bramante, Greenwich High School

Fusarium virguliforme is a major pathogenic fungus that affects ~30% of global food crops annually, resulting in plant yellowing, wilting, stunting, and death. While current treatments for crop disease offer varying levels of effectiveness, the most promise lies in pre-treatment methods that would bolster the plant's immune system. Recent research has suggested that metal oxide nanoparticles may provide immune boosting effects for healthy plants against Fusarium wilt, however methods for their inclusion onto and into the plant remain unclear. In this research, copper nanoparticles (CuNPs, 10-40nm) were introduced to (model) soybean seeds via an innovative 10-minute, reduced pressure (0.1atm) soaking within a 500ppm CuNP solution in deionized water. SEM and EDS analyses confirm the successful integration of the CuNPs below the seed coat, into the radicle and endosperm. Three-week growth experiments with these CuNP seeds, as well as normal/dry, and low-pressure (in water) seeds, were conducted for healthy and Fusarium inoculated plants. While all seed types germinated in 10 days, introduction of Fusarium to normal-seed plants caused wilting, with 25.4% and 50% decline in plant growth and biomass, respectively. Conversely, low-pressure-infused CuNP seeded plants produced ~3.5% increase in plant growth relative to normal, healthy plantings, and as much as 39% and 106% increases in growth height and plant biomass respectively, relative to normally-seeded plants suffering from Fusarium wilt. These collective results highlight the efficacy of the newly-developed, low-pressure application of 500ppm CuNPs into seeds to promote increased crop biomass, while acting as a pre-emergent to inhibit the effects of *Fusarium virguliforme.*

The Fabrication of a Cost-effective Lithium-ion Battery with Increased Voltage and Longevity
Jackson Rassias
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Mentor: Dr. Mathieu Freeman, Greens Farms Academy

The world is in an ever-expanding digital age and revolving around the need for batteries, specifically lithium-ion batteries (LIB) due to their lightweight, small size, and high voltage. However, modern-day LIBs have crucial limitations such as their price, rigid structure, and relatively small range of operative temperatures. The motivation of this investigation is to create an improved, cost-effective, paper LIB while maintaining reasonable power output. This project consists of fabricating a flexible paper LIB with

the optimized cathode, anode, and multi-walled carbon nanotube materials. Methods for this study consist of applying a slurry of carbon nanotubes and lithium manganese oxide to a cellulose-based paper. This adhered film acts as the cathode. The same method is applied with lithium titanate oxide for the anode on the opposite side. Voltage, current, and resistance will be measured with a multimeter as well as changes within the battery during charge and discharge. Current voltages are measuring near 0.3 Volts and improving. Also, multiple batteries can be connected in series to achieve an increased voltage. Implications for this study are the larger range of operative temperatures and the low price (currently under five dollars). Also, the battery is more flexible (due to the paper separator), which allows for a variety of uses such as wearable electronics and medical applications..

Creating a Mobile Application to Help Oral Immunotherapy Users Track Their Symptoms, Incidence of Allergic Reactions, and Progress

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As food allergies become a more prominent issue around the globe, a form of treatment called Oral Immunotherapy (OIT) has emerged. In this type of treatment, the patient consumes doses of their allergen, which gradually increase from a very small dose, in order to increase the threshold for allergic reactions. This will continue until the patient reaches a maintenance dose. An important part of this process is monitoring patient progress and symptoms after dosing. The purpose of this project is to create a personalized allergy application to allow oral immunotherapy users to track their symptoms after taking a dose, the overall incidence of allergic reactions, and overall progress. In this experiment, I created a mobile application that allows the user to log their symptoms after taking a dose and personalize the app to fit their allergy. The application was developed using Xcode. Phase 1 of testing was proof of concept, which showed that the app worked correctly and met the criteria. In Phase 2, a survey was given in order to receive feedback and an overall rating out of 10 using a Google form. In the future, this app could be used to help a user confirm that they are having an allergic reaction before administering epinephrine. It could also be geared towards other diseases, such as asthma.

Antimicrobial Peptides and Antibiotics Produce Bactericidal and Bacteriostatic Effects on Wild-Type E. coli

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Mentor: Alexandre Gouzy, Weill Cornell Medicine

In 2012, there were approximately 12 million global cases of tuberculosis, including 1.3 million fatal cases. Additionally, in 2016 there were 10.4 million new cases of infection, 600,000 of which displayed resistance to Rifampicin, one of the most powerful first-line drugs in use. Bacteria are becoming increasingly resistant to widely-used multidrug treatments; thus, the need for new antibacterial treatments is imperative for treating bacterial infections effectively. One promising solution to this problem is the use of antimicrobial peptides (AMPs), which are part of the innate immune system response to bacterial infection. However, little is known regarding the mechanism of action employed by the human cathelicidin LL-37 and the murine cathelicidin mCRAMP. We investigated the efficacy of AMPs against *E. coli*, a model for tuberculosis infection, and their potential synergism with commonly-prescribed antibiotics. We aimed to develop a minimal combination of an antibiotic and AMP that effectively kills wild-type *E. coli* strains. We sought to identify the minimum inhibitory concentration (MIC) at which LL-37, mCRAMP, and various antibiotics, namely Gentamicin, Ampicillin, and Ciprofloxacin, each kill bacteria. LL-37 displayed a significantly lower MIC than mCRAMP and demonstrated bacterial membrane permeabilization. We then combined LL-37 with several concentrations of each antibiotic and discovered promising synergism between LL-37 and Ciprofloxacin. Collectively, these data reveal that LL-37 is more potent than mCRAMP and that LL-37 and Ciprofloxacin cooperate synergistically. With further investigation into this synergism, the likelihood of identifying a cure for tuberculosis and reducing fatalities from infection will increase.

Robotic Pancreatoduodenectomy (PD) vs. Open PD: A Meta-analysis-driven Algorithm to Enhance Surgical Decision-making

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The Centers for Medicare & Medicaid Services estimates that health care expenditures will account for 19.7% of the GDP by 2028; therefore, medical resources must be prudently managed. Besides the $3000-6000 difference between robotic and open surgery, past studies have shown the inferiority of robotic pancreaticoduodenectomy (PD) as compared to open PD. However, given the rarity of operable pancreatic tumors, a study with an adequate sample size and a sufficient assessment of bias/heterogeneity remains unperformed. To accomplish this, a meta-analysis was conducted. The present study seeks to fulfill two objectives: (1) to

determine if the efficacy and feasibility of robotic PD are comparable to those of open PD, and if so, (2) to provide surgeons and patients with a data-driven algorithm to facilitate the selection of optimal PD approach in a clinical setting.

Five databases were systematically searched for studies. 24 studies totaling 12,579 patients were included in the final quantitative analysis. Six primary endpoints and four secondary endpoints were selected. The Mantel-Haenszel-Cochrane odds ratio and the Inverse Variance weighted average for categorical and continuous variables, respectively, were utilized. This meta-analysis concluded that robotic PD is at least comparable to its open counterpart: Five primary endpoints favored robotic PD and one favored open PD. The second conclusion comes in the form of an algorithm that offers insight into the favorable PD approach on a case-by-case basis. These findings will improve postoperative qualities of life for patients undergoing PDs and identify situations in which expensive robotic equipment is unnecessary.

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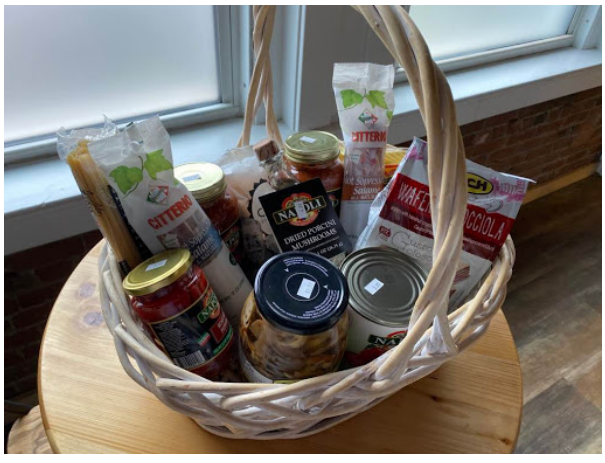

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