BIOBUILDERCLUB ABSTRACT BOOK 2026

BIOBUILDER.ORG

BioBuilderClub

FINAL ASSEMBLY ABSTRACT BOOK

2026

BioBuilder
Educational Foundation

BioBuilderClub

Table of Contents

BioBuilderClub

EMPOWERING THE NEXT GENERATION TO ADDRESS GLOBAL CHALLENGES WITH BIOSCIENCE.

Thank you to the wonderful teachers, mentors, and students who generously gave their time and energy to these projects.

FINAL ASSEMBLIES 2025-2026

- **3.12.26** at the Ragon Institute in Cambridge, MA
- **3.26.26** at the Brookhaven City Centre in Brookhaven, GA

BOSTON FINAL ASSEMBLY VIRTUAL POSTER GALLERY

Click here or scan the QR code to see the posters of teams presenting at the 3.12.26 Final Assembly in our Virtual Poster Gallery.

Abstract List

PAGE-SCHOOL AND TEAM NAME

Abstract List

PAGE-SCHOOL AND TEAM NAME

3.12.26 Poster Session I

Teams presenting virtually are italicized

Board	Team Name	School Name
1	*LEM-K Diagnostics*	*Concordia International School Shanghai*
2	Maimo BioBuilders	Maimonides School
3	*Team A5*	*Taipei American School*
4	PolyGone	Andover High School
5	Display Board	
6	Environmental Team	Oak Park and River Forest High Schol
7	*Team Topeka*	*Topeka Center for Advanced Learning and Careers*
8	SynBio South	South Forsyth High School
9		*Troy High School*
10	Green Team	Lambert High School
11	Genius Bar	Hamden Hall Country Day School
12	*Green Gene Machine*	*Western Reserve Academy*
13	Microbe Makeover	International School of Boston
14	*Agriculture Experts*	*Western Reserve Academy*
15		Oyster River High School
16	*The Locksmiths*	*Denmark High School*
17	Salty Squirmerzzz	Western Reserve Academy

Using Fluorescent Beacons for the Early Detection of the Hepatitis C Virus

Concordia International School Shanghai
Team LEM-K Diagnostics

Lucia Sostak, Ella Jin, Megan Wong, Katrina Yeung, David Doyle (Teacher), Ilkay Cisil Koksaldi (ETH Zurich-D-BSSE)

Hepatitis C is a viral disease caused by the Hepatitis C Virus (HCV) that, in its chronic form, can lead to severe liver damage, liver cancer, and in some cases death. The infection rate of HCV in China remains high, especially in rural and low-income communities, primarily among drug users and blood transfusion recipients. Current detection methods for HCV primarily include blood tests performed in labs or at hospitals and clinics. They are often inefficient and expensive, in some cases taking up to 17 days for test results to become available. Due to these issues, as well as the often asymptomatic presentation of HCV, the virus often goes undetected until damage to the liver is irreversible. Our objective is to use synthetic biology to create a cost-effective, at-home HCV detection system using HCV RNA biomarkers present in the saliva of those infected with chronic HCV. By creating an at-home detection system using a molecular beacon that binds to the target HCV RNA sequence, those living in high-risk areas would easily be able to test themselves for HCV, even in its early stages, helping prevent HCV-caused liver diseases and deaths.

Remediation of Birch Pollen Allergies: Epitope Modification of Bet v 1 for Reduced IgE Binding in Humans

Maimonides School
Team Maimo BioBuilders

Amalya Fischer, Rebecca Gold, Eliana Goldenholz, Nessa Jaffe, Jeanette Pultman, Miriam Rosenblum, Avishag Salzman, Raya Sims, Dr. Maria Lazebnik (Massasoit Community College and Bentley University), Dr. Scott Gaines (Boston University)

Pollen allergies affect a large proportion of the global population, and preexisting conditions such as asthma increase susceptibility and symptom severity. Due to its microscopic size and prevalence, pollen is difficult to avoid, particularly in spring —the primary reproductive period for many plants. Remediation is further complicated by pollen's reproductive functions. Beyond acting as a vehicle for the transfer of male genetic information, pollen proteins, or allergens, perform key, non-allergenic roles, including supporting male gamete development, facilitating pollen-stigma recognition, driving metabolic processes in pollen tube growth, and contributing to plant immune responses. Consequently, removing allergen genes risks damaging plant health and fertility. This study proposes a synthetic biology based approach to selectively reduce pollen allergenicity while maintaining its reproductive functions. We targeted a birch tree allergen, *Betula verrucosa* allergen 1 (*Bet v 1*), which binds to Immunoglobulin E (IgE) antibodies in mucosal tissues and skin, triggering histamine release. Our approach involves modifying a key IgE-recognized epitope in Bet v 1 while maintaining its physiological role in birch trees. Using *Agrobacterium*-mediated transformation, a mutated Bet v 1 gene and a CRISPR-Cas9 structure designed to silence the allergenic allele may be introduced into birch tissue cultures through deactivated tumor-inducing (Ti) plasmids in *Agrobacterium*. This approach enables the production of hypoallergenic birch trees with preserved reproductive and physiological functions. Moreover, this approach offers a model for broader remediation of other pollen-producing species.

Say No to Ice Crystal Expansion: Cloning, Purifying, and Unleashing Antifreeze Proteins for Food, Aviation, and Cryopreservation

Taipei American School
Team A5 + B5

Alivia Chen, Erika Chen, Mia Chen, Jocelyn Chiang, Conroy Chiu, Annabelle Huang, Jacquelyn Inocencio, Woojoo Jeong, Eva Lee, Adriel Leung, Tristin Wang, Myron Yu, Julie Bae, Ethan Chen, William Feung, Anya Kao, Felisha Liang, Laura Lee, Keera Tsai, Austin Wang, Florence Wu, Queenie Yeh, Dr. Hsu (Teacher)

Ice crystallization causes cellular and material damage in subzero environments, presenting challenges in medicine, food preservation, and cryopreservation. Antifreeze proteins (AFPs) are specialized polypeptides produced by cold-adapted organisms that inhibit ice growth by binding specific ice planes and inducing thermal hysteresis without altering melting points. This project aims to purify and characterize AFPs from *Zoarces americanus*, *Lycodichthys dearborni*, *Pseudopleuronectes americanus*, and *Daucus carota* recombinantly expressed in *Escherichia coli*. We will express and purify AFP proteins using immobilized metal ion affinity chromatography. We plan to evaluate the function of these AFP proteins in cryopreservation, food preservation, and anti-icing applications. We have developed preliminary assays, including freeze–thaw survival testing in *E.coli* and injections in *Eisenia fetida*, to assess tolerance for future cryopreservation studies. We utilized initial thermal hysteresis assays with glycerol as a cryoprotectant, which demonstrated reduced freezing rates. Our next steps will involve evaluating purified AFP proteins with our various frameworks targeted to control ice formation in biological and industrial systems.

SEM and HPLC Analysis of PETase and LCC Expression in BioBits for the Degradation of PET

Andover High School
Team PolyGone

Siri Jayaprakash, Ella Hu, Sanjith Kalpat, Keerthi Shome, Tommy Kruecker-Green, Dr. Lindsey L'Ecuyer (Teacher), Dr. Nathan Crook (NCSU), and Dr. Tianyu Li (NCSU)

Every year, approximately 400 million metric tons of plastic are produced globally, with polyethylene terephthalate (PET) contributing 14% to that amount. Only 5% of the PET is recycled, 15% is incinerated, and 75% is landfilled. Enzymes such as PETase, from *Ideonella sakaiensis*, and leaf compost cutinase (LCC), found in compost piles, have shown potential in addressing this long-standing issue. In addition to PETase, two different forms of LCC were tested: the original sequence and another engineered, more thermostable version. The efficiency of PETase and both LCCs on PET film (0.25 mm thickness) and PET powder (300 µm) was evaluated after expression in a cell-free system (BioBits®). Insoluble components were analyzed using a scanning electron microscope (SEM), while soluble monomers were analyzed through high-performance liquid chromatography (HPLC). In 2025, PET powder showed degradation in both LCC enzymes via SEM, while PET film did not; however, some samples dried out during the process. For 2026, buffer and mineral oil were added to stabilize enzymes and prevent evaporation. With these changes, PET film exhibited degradation with PETase and both LCC enzymes, while PET powder did not. These inconsistencies indicated the need for further experimentation, and HPLC analysis was ultimately inconclusive.

Combatting Invasive Mussels Using RNAi

Oak Park and River Forest High School
Team Environmental

Maggie Herman, Cael Walicki, Lucy Liskiewitz, Russel Frederick, Zach Schupp, Ben Chalmers, Sofia Doyle, Aria Rothman James Mattiace, Sam Morgan, Matt Kirkpatrick (Teacher), Nora Molten and Della Waldman (UChicago Genehackers)

Invasive species reduce biodiversity, disrupt habitats, and hinder infrastructure, and their growing presence is a problem for many ecosystems around the world. Our project focuses on freshwater zebra and quagga mussels, which are invasive to the Great Lakes. These species are the only freshwater mussels that use byssal threads to securely attach to a wide variety of surfaces, giving them an advantage over the native freshwater mussels that only have a foot muscle. Targeting the production of byssal threads would remove part of what allows the zebra and quagga mussels to spread so quickly, effectively giving the native mussels space to rebound in the ecosystem. We chose to target the byssus because its uniqueness to the zebra and quagga mussels would reduce the risk of harm our design could cause to native species. As well as reducing the competitive advantage, hindering byssus development and thread production would help prevent invasive mussel colonization in underground pipe systems, which has contributed to significant piping repair and replacement costs for cities near the Great Lakes, including Chicago. In order to target these byssal fibers, we are investigating the use of CRISPRi or RNAi as a tool to inhibit the production of the Dresseina bugensis foot protein 1(Dbfp1), which has been theorized to play a role either as a structural cohesive component or as a cuticle varnish. While Dbfp1 is a gene specific to quagga mussels, it is believed to be a homolog of the same foot protein in zebra mussels, suggesting that our solution would be effective against both species of invasive mussels.

Bioprospecting for Plastic-Degrading Microorganisms in Kansas Soils

Topeka Center for Advanced Learning and Careers
Team Topeka

Kenslee Young, Kaitlyn Locker, Joanna Li, Dazzani Marks, Mark Harpster, PhD (instructor), and Kissaou Tchedre, MBA PhD (Austin Community College)

The large-scale manufacturing of plastics for consumer products has contributed significantly to the pollution of our ecosystems and to a potential health crisis due to the recently reported accumulation of microplastics in the tissues of humans and animals. While select plastics exhibit biodegradation, their rates are negligible for mitigating the massive and ongoing influx of waste into the environment. To identify and isolate microorganisms that could be engineered for improved kinetics in the breakdown of a broad spectrum of plastics, we have initiated a bioprospecting approach in which soil samples from the Topeka, Kansas area are being screened for plastic-degrading capability. Preliminary studies have largely focused on developing a soil-burial assay for demonstrating degradation in unprocessed soil samples and then using degradation-positive soil samples as source material for the extraction and isolation of the causative microbe(s).

Reducing Urban Respiratory Allergies via Seasonal Spray-Applied BioClay Pollen Suppression

South Forsyth High School
Team SynBio South

Hassan Syed, Hanssini Prekumar, Shreeya Aravind, Ridhima Bajaj, Anudeep Gadipalli, Siri Nuthalapati, Shriya Palwai, Michelle Rarasati, Pamala Seeley (Teacher), and Dr. Alberto Donayre Torres (UTEC)

Airborne pollen exposure in Atlanta increases respiratory-related ER visits by 8%, disproportionately affecting children, older adults, and individuals with asthma. Current interventions, such as pharmacological therapies, focus on treating symptoms after exposure rather than addressing pollen production at its biological source. At the biological level, pollen maturation in white oak is governed by gibberellin (GA) signaling. When GA binds to the GID1 receptor, DELLA repressors are degraded, enabling pollen development. In annual crops such as tomato, spray-applied double-stranded RNA (dsRNA) has achieved transient and reversible pollen suppression through RNA interference. In this pathway, dsRNA is processed into siRNAs
that cleave GID1 mRNA, maintaining DELLA-mediated pollen repression. However, translating this approach to perennial trees is challenging due to thick cuticles, long developmental timelines, and rapid dsRNA degradation. To address these limitations, our approach uses BioClay nanoparticles to protect dsRNA, enabling sustained uptake into plant tissues. Building on validated tomato crop applications, we aim to adapt BioClay-delivered dsRNA for white oak. Project success will be evaluated through qRT-PCR and multispecies testing, quantifying GID1 levels and validating species specificity. Ultimately, the project extends RNAi intervention from annual crops to perennial trees by enabling a scalable, seasonal, and non-transgenic method for mitigating pollen-driven health challenges.

E. coli- Based Innovating Bioremediation of Environmental Lead Contaminants

Troy High School

Ethan Wang, Nicole Li, Aarav Doshi, Angela Park, Daniel Cao, Sophia Chau, Ahmad Bokhari, Vani Bhat, Sei Park, Sara Yousufuddin, Rebecca Brewer (Teacher), and Nick Nolan (MIT)

Lead contamination in drinking water remains a major public health concern in the United States, highlighting the need for effective remediation methods. The 2014 Flint Water Crisis, with toxic lead levels over 3 times the hazardous classification, cost the city billions in clean-up costs and put hundreds of thousands at risk. This study evaluates genetically modified *Escherichia coli* engineered to express metal-binding proteins for lead removal. Three strains were tested: wild-type, metallothionein-expressing, and PbrD-expressing cells. After protein induction and lead exposure, residual lead levels were measured. We hypothesize that PbrD-expressing *E. coli* will demonstrate the greatest removal efficiency, supporting its potential as a targeted and scalable strategy for improving drinking water safety

Designing a LANCET-Based Assay to Diagnose *Burkholderia pseudomallei*-Derived Meliodosis

Lambert High School
Green Team

Saesha Abraham, Arpitha Bepeta, Tejaswi Bhimini, Sujaal Gelle, Feier (Grace) Han, Alisha Jyotiprakash, Rachita Kawale, Dheyanesh Krishnamoorthy, Sruti Lekkala, Navya Neelam, Catherine Sharer (Teacher), Nick Godzick (MIT)

Melioidosis is a tropical infectious disease spread by the gram-negative bacterial vector *Burkholderia pseudomallei*, characterized by adversities ranging from systemic lesions to even multi-organ failure. Although it affects over 165,000 individuals globally, typical diagnosis still relies on the bacterial culturing of clinical biofluids, resulting in diagnostic delays that sometimes outpace disease progression. To mitigate this, we utilize BipD, a *B. pseudomallei* virulence protein, with two high-affinity single-stranded deoxyribonucleic acid (ssDNA) aptamers to generate a detectable molecular signal prior to fulminance. Although our current predictions through AlphaFold3, RNAfold, and EZassay software show low confidence, further in silico validation is still necessary.

The Use of *Bacillus subtilis* and *Escherichia coli* as a Solution to FOG

Hamden Hall Country Day School
Team Genius Bar

Arya Chen, Kelly Du, Lan Liu, Grace Yang, Becky Liu, Fred Liu, Anand Persaud, Amy Zhou, Burt Lin, Trista Luan, Vivian Martin, Mr. Kemp (Teacher), and Dr. Hiroko Kaczmarek (BioBuilder)

Sewer systems accumulate fat, oil, and grease (FOG), which can cause blockages, overflows, and infrastructure damage if not managed properly. Current FOG management incurs high costs and adverse environmental impact, as existing methods are primarily chemical and mechanical. Bacillus subtilis is a non-pathogenic soil bacterium known for its stress tolerance, secretion capacity, and use in large-scale biotechnology. While prior sources have demonstrated microbial lipid metabolism in lab settings, the integration of extracellular lipid hydrolysis with intracellular fatty-acid processing remains underexplored. This project aims to engineer a synthetic biological system in *B. subtilis* to enable controlled conversion of sewer-derived fatty acids. Extracellularly secreted lipases derived from *Escherichia coli* will hydrolyze complex fats into free fatty acids, which are subsequently taken up by the host cell. These fatty acids are activated to fatty acyl-CoA and processed through a dedicated fatty-acid processing device to produce fatty alcohols via acyl-CoA reductase–mediated pathways. This strategy avoids energetically costly acetyl-CoA rebuilding steps, prioritizing carbon-efficient conversion. This study evaluates the feasibility, metabolic burden, and potential toxicity of aldehyde intermediates under low-exposure sewer conditions. Overall, this work proposes *B. subtilis* as a robust chassis for biologically mediated FOG degradation, offering a framework for sustainable sewer fat management.

Engineering Cyanobacteria to Enhance CO2 Fixation and Biofuel Production Efficiency

Western Reserve Academy
Team Green Gene Machine

Jaeyun Lee, Roberts Sartor, Ryo Nakano, Boran (Emily) Zang, Yirou (Rose) Huang, Vivien Marmerstein (Teacher), and Dr. Aditya Pandharinath Sarnaik (Arizona State University)

Industrial activities have driven CO2 levels to an oxygen concentration of 421 ppm, a level not seen in 4 million years of recorded history. In 2024 alone, 34 billion tonnes of CO2 were released into the atmosphere, trapping the energy equivalent of eight Hiroshima bombs per second. The resulting global warming has led to dangerous environmental hazards such as wildfires, floods, and ocean heat waves. 403 of climate change-induced disasters have cost the U.S. over $2.915 trillion since 1980. However, previous solutions like Storage and Bioenergy with Carbon and Sequestration (BECCS) and Direct Air Carbon Capture (DACC) require extremely high costs and energy devotion. Synthetic Biology provides a possible solution that bypasses all these pitfalls by utilizing Cyanobacteria's ability to capture carbon dioxide. Specifically, the overexpression of bicA, a sodium-dependent bicarbonate transporter, increases inorganic carbon availability and decreases carbon limitation. We will monitor the biosynthesis process with a biosensor that detects cellular stress and bottlenecks, ensuring efficiency and effectiveness. This single system, consisting of carbon uptake, fixation, and conservation, aims not only to reduce atmospheric CO2 by capturing it but also generates valuable biofuels, offering a dual approach to mitigate climate change.

Microbe Makeover

International School of Boston
Team Microbe Makeover

Elizabeth Hossack, Tia Makary, Camille Petit, Eva Louis, Karin Schinkmann (Teacher), and Dr. Patrick Arsenault (Triana Biomedicines)

Cutibacterium acnes naturally lives on human skin but can lead to the formation of acne. It releases lipase GehA, which hydrolyzes triglycerides in sebum into free fatty acids that contribute to inflammation. This project aims to develop a synthetic biology-based approach to inhibit GehA activity. However, because GehA lipase is not readily accessible for direct experimental testing, preliminary testing must identify suitable surrogate lipases with structural and functional similarity. Sequence alignments were performed using Clustal Omega to identify homologous enzymes. Structural and active-site comparisons were conducted to evaluate the suitability of these enzymes as experimental stand-ins. Once a surrogate enzyme has been selected, we will screen a peptide library for potential inhibitors. The current approach is to generate degenerate peptide expression constructs, which are engineered DNA sequences containing mixed codons that enable bacteria to produce many different short peptide variants at once for inhibition testing. Finally, the identified inhibitory peptide will be placed in a plasmid with a secretion sequence and inserted into *Escherichia coli* so that the peptide can be secreted and later purified and extracted for topical use. This approach uses microbiome engineering to target the root cause of acne with potentially fewer side effects, with future work focused on testing and therapeutic feasibility.

Engineering *Bacillus subtilis* for Drought Tolerance in Plants

Western Reserve Academy
Team Agriculture Experts

Jerry Hu, Justin Yin, Eason Wang, Vivien Marmerstein (Teacher), Dr. ALberto Donayre (UTEC)

Drought remains a worldwide issue, affecting regions that receive less rainfall than usual for extended periods. Drought stimulates plants' production of 1-aminocyclopropane-1-carboxylate (ACC), a precursor that signals ethylene production. Increased ethylene concentration will cause greater plant stress and reduced root elongation, which leads to serious agricultural problems such as diminished crop growth and low food production, and may even trigger the collapse of the local economy. The problem significantly impacts lower-income areas that lack proper irrigation. Although conventional methods, like rainwater harvesting and drip irrigation, can mitigate plant stress, they are often expensive and inconsistent. We use a readily inducible, cost-effective, low-maintenance system. Using *B. Subtilis* (WB800) as our chassis, our goal is to express ACC deaminase via the AcdS gene. Because ACC deaminase breaks down ACC, it reduces ethylene concentration and contributes to overall plant growth. Employing the XylR repressor, we add the inducer Xylose to trigger ACC deaminase expression as drought occurs. As both a controllable and affordable strategy, this approach alleviates drought-induced plant stress. By providing an inducible system for ACC deaminase expression, our system will become a promising method for sustainable agriculture.

The Effect of Knocking Down Ciliopathy-Associated Genes on Planaria Motility

Oyster River High School

Julianna Kun, Jessica Li, Sadhana Muppala, Lauren Pang, Anna Shuba, Drew Verweij, Cavan Wrocklage, Dawen Zhou, Dr. Kristen Johnson (mentor), Dr. Megan Thompson (Teacher)

The hair-like cilia either beat in a coordinated manner or serve as a sensory organelle. Defects in cilia cause ciliopathies, which commonly cause renal cysts. Joubert's Syndrome, Meckel-Gruber Syndrome, and Nephronophthisis (JS-MKS-NPH) are a linked group of ciliopathies sharing associated genes, most of which are located in the cilia transition zone, an area regulating movement of proteins into the cilia. Nephronophthisis 1, 4, and 5 (NPHP1, 4, and 5) and B9 Domain Containing 1 (B9D1) proteins are located in the transition zone and are mutated JS-MKS-NPH patients. Planaria, a flatworm, is a model organism for studying ciliopathies due to their similarity to humans and use of cilia for locomotion. To determine the function of NPHP1, NPHP4, NPHP5 and B9D1 in cilia, a fragment from each gene was cloned into an RNAi expression vector and fed to planaria. After a two-week feeding period, an assay was conducted to determine the effect of gene knockdowns on planaria motility. We anticipate that the knockdown planaria will move at slower velocities, indicating cilia dysfunction. By identifying how mutated genes affect cilia function, a synthetic biology approach could be used to treat the dysfunctional cilia in JS-MKS-NPH affected patients.

Detecting Malaria Through De Novo LOCKR Design

Denmark High School
The Locksmiths Team

Nishna Chippa, Tanvi Cholleti, Ram Choppa, Ranvitha Devarasetty, Sahana Ramiya, Vishnu Tadipatri, Atharva Somyajula, Mary Caretenuto (Teacher), Shajesh Sharma (University of Washington)

In Sub-Saharan Africa, the World Health Organization reported the prevalence of ~95% positive malaria cases–-76% within children under the age of five. Currently, malaria tests for the P. falciparum strain have provided an abundance of false negatives, due to a gene deletion occurring on the HRP2 protein gene. Our solution to this issue is the detection of the Plasmodium falciparum lactate dehydrogenase (PfLDH) protein prevalence using Bim-Bcl2 LOCKR proteins. We plan to use luminescence as a biomarker to identify the abundance of PfLDH proteins present in malaria. This will be completed through modifying LOCKR to bind to PfLDH and “open.” A sandwich assay structure will form where a primary capture agent binds to the PfLDH biomarker. When the aptamer binds to the PfLDH, the nanoclusters conformationally change, emitting fluorescence. In essence, this LOCKR system will be developed through a multistep framework. Paired alongside a coffee-ring amplification mechanism, this engineered test is portable and provides results within 15 to 30 minutes, requiring no highly-skilled personnel. This allows our LOCKR diagnostic to be used in underdeveloped countries, mainly in Sub-Saharan Africa. The use of small blood samples (below 5 µL) allows this innovation to be cost-effective and globally accessible.

Engineering *E. coli* to Produce *Tenebrio molitor* and *Lolium perenne* Antifreeze Proteins

Western Reserve Academy
Team Salty Squirmerzzz

James Vacca, Yunwoo Choi, Vivien Marmerstein (Teacher), and Dr. Becky Meyer (MIT)

Annual U.S. vehicle crashes on snowy and icy roads result in more than 1,300 deaths and 116,800 injuries. However, using chemical road salt to prevent accidents has negative consequences, including corrosion and nearby water contamination. Our more eco-friendly design utilizes naturally occurring antifreeze proteins (AFPs) to prevent ice formation on road surfaces. This project aimed to construct two plasmids, one expressing an AFP from *Lolium perenne* (perennial ryegrass) and one from *Tenebrio molitor* (mealworm). Both genes are controlled by inducible promoters in the *Escherichia coli* chassis. Proteins will be extracted from the transformed *E. coli* using cell lysis, centrifugation, and solubilization to release the inclusion bodies containing the proteins. AFPs will then be purified through affinity chromatography to ensure high purity for functionality and stability tests. In preliminary transformations, robust colony growth was observed for the *T. molitor* AFP construct, whereas no colonies formed for the *L. perenne* construct, indicating differential cloning or selection efficiency that will guide our next optimization steps. The application of these AFPs offers a sustainable and eco-friendly alternative to traditional road salt, mitigating environmental damage while preventing risks of icy roads.

3.12.26 Poster Session II

Teams presenting virtually are italicized

Board	Team Name	School Name
1	*Shanghai Crocodiles*	*Concordia International School Shanghai*
2		Xaverian Brothers High School
3	*Team B5*	*Taipei American School*
4	Gut Guardian	Andover High School
5	*Moodbiome*	*Western Reserve Academy*
6	Neuronavigators	Oak Park and River Forest High Schol
7		*John P Stevens High School*
8	South BioMakers	South Forsyth High School
9		*Dublin High School*
10	Yellow Team	Lambert High School
11		*Athens Drive Magnet High School*
12		*Weston High School*
13	Lead Sense	International School of Boston
14	*Dermatitis Dinosaurs*	*Western Reserve Academy*
15	Wolverines	Westwood High School
16	*The Brewers*	*Denmark High School*
17	Heavy Metal Heroes	Western Reserve Academy

Overexpressing *pgm* and *galU* to Boost *E. coli* Bacterial Cellulose Production

Concordia International School Shanghai
Team Shanghai Crocodiles

Carrie Wang, Claire Jeong, Hanwoon Kim, Sophie Xu, Richard Roy, PhD (Genome Surfer, Inc.), and David Doyle (Teacher)

Bacterial cellulose (BC) is a high-performance, sustainable biomaterial whose exceptional purity, crystallinity, and water-retention make it attractive for biomedical devices and flexible electronics. Native producers such as *Komagataeibacter* spp. are limited by slow growth, genetic instability, and poor scalability, restricting large-scale BC manufacture. *Escherichia coli* offers a well-characterized, rapid growth chassis, yet recombinant BC yields are constrained by insufficient intracellular UDP-glucose, the direct precursor for cellulose synthase. Our design addresses this bottleneck by co-expressing native *E. coli* phosphoglucomutase and UDP-glucose pyrophosphorylase, enzymes that together convert glucose-6-phosphate to UDP-glucose, thereby raising the intracellular pool of the essential substrate and enabling higher cellulose synthase activity. Our design screens three inducible promoters, T7 lac, arabinose-responsive araBAD, and cold-shock inducible pCspA, in the C41(DE3) strain to achieve high yet balanced expression while limiting metabolic load. By systematically varying inducer concentration and incubation temperature (25˚C vs 30˚C), we assay growth, fluorescence, and UGPase activity to pinpoint conditions that maximize UDP-glucose pools without compromising cell viability. These optimal promoter-inducer-temperature regimes give our platform a robust metabolic foundation for subsequent incorporation of the full bcsABCD operon, paving the way toward scalable, recombinant BC production in *E. coli* and broader industrial adoption of this sustainable biomaterial.

Expression of the Flv3 Gene in Spirulina to Enhance Photosynthetic Efficiency

Xaverian Brothers High School

Evan Campbell, Liam Curry, Anthony Issa, Maddox Lund, Shubh Mehrotra, Zach Parlon, Gabe Perez, Max Richards, Heather Osborne (Teacher), and Dr. Jason Boock (Syracuse University)

We have designed a plasmid based on the pDV044 backbone to contain the Flv3 gene from *Synechocystis*. We identified the gene using NCBI BLAST. We then used the Benchling program to incorporate the gene into our plasmid and design primers for gene amplification.

To measure the rate of photosynthesis, our procedure uses changes in water pH to detect the efficiency of the photosystems. This method ensures the system remains open, with oxygen readily available to spirulina without risking damage or death. It uses the principle that removing CO2 from water raises the pH because fewer hydrogen ions are present, making the water more basic, allowing the photosystems to work efficiently. The hope is that, as the plasmid-containing spirulina removes CO2 faster than spirulina without the plasmid, the pH will rise faster.

We selected spirulina for our study because of its global abundance and its potential for use in bioengineering efforts to reduce atmospheric CO2. Future work will focus on optimizing Flv3 expression and testing additional environmental conditions to directly assess whether this engineered spirulina is viable for improved photosynthetic efficiency and CO2 reduction.

The Gut Guardian: A “Sense-and-Respond” Probiotic for Localized Celiac Relief

Andover High School
Team Gut Guardian

Shreya Soni, Lindsey L’Ecuyer (Teacher), Jackie Thompson (Takeda Pharmaceuticals)

Celiac disease (CD) is a serious autoimmune disorder that damages the small intestine in response to gluten. Despite affecting an estimated 1 in 100 people worldwide, current therapies rely exclusively on dietary restriction, something that is difficult to maintain and fails to prevent inadvertent exposure. To address this therapeutic gap, this project proposes a synthetically engineered *Escherichia coli* Nissle 1917 (EcN) probiotic pill designed to reduce gluten-induced inflammation in individuals with CD. The engineered EcN functions as an autonomous “sense-and-respond” system by detecting Nitric Oxide (NO), a key biomarker of gluten-induced intestinal inflammation, through a synthetic gene circuit. Upon NO detection via the PnorV promoter, the circuit triggers the localized secretion of interleukin-10 (IL-10), a potent anti-inflammatory cytokine, directly in the intestinal lumen. Above all, the strain is engineered with a biocontainment “kill switch" to ensure safety and precision for individuals. By modulating the mucosal immune response directly at the site of inflammation, this pill aims to suppress T-cell-mediated damage, preventing subsequent villous atrophy. This synthetic biology solution offers a proactive alternative to strict dietary management, potentially mitigating the long-term stress and damage caused by accidental gluten consumption and significantly improving the quality of life for individuals with CD.

Targeting the Gut-Brain Axis: A Multi-Pathway Engineered Yogurt for Mild Depressive Symptoms

Western Reserve Academy
Team Moodbiome

Elisabetta Huff, Mitchell Hooten, Josephine Lo, Ben Ross, Evan Sun, Vivien Marmerstein (Teacher), and Dr. Becky Meyer (MIT)

Depression affects an estimated 332 million people globally, yet current treatments like Selective Serotonin Reuptake Inhibitors (SSRIs) offer limited efficacy by failing to address underlying physiological factors such as gut inflammation and microbiome imbalances. This project proposes a functional yogurt containing an engineered probiotic to mitigate mild, subclinical depressive symptoms via the gut-brain axis. Yogurt provides a nutrient-dense matrix that supports gut health and reduces inflammation. The probiotic *Bacillus subtilis* (BS50) will be genetically modified to produce bile salt hydrolase (bsh). By inserting the bsh1 gene from *Lactobacillus plantarum* RK21, the engineered BS50 will decrease gut inflammation through interruption of interleukin-6 (IL-6), an inflammatory cytokine elevated in depression. Additionally, native BS50 contains the trp operon for tryptophan synthesis, providing the essential precursor to serotonin, a neurotransmitter whose dysregulation is linked to mood disorders. Following successful modification, the engineered BS50 will be incorporated into a yogurt culture for fermentation, ensuring delivery within a familiar and accessible food matrix. This food-based intervention integrates synthetic biology, nutrition, and microbiome science to offer a promising, sustainable alternative to traditional pharmacotherapies for managing milder depressive symptoms.

Multiple Sclerosis Point of Care with miRNA-145

Oak Park and River Forest High School
Team Neuronavigators

Ireolukunmi Osikanlu, Lincoln Lundak, Dylan Lavery, Sara Holzer, Aidan Sjoblom, Henry Brown, Gabe Ardell, Lily Zort, Jeanette Zort, Matt Kirkpatrick (Teacher), and Mark Cherepashensky (Life Science Strategic Consulting)

Multiple sclerosis affects 2.8 million people worldwide, with diagnosis often delayed due to the high costs of MRI scans and invasive procedures. MicroRNA-145-5p has emerged as a promising MS biomarker, showing 79% sensitivity and 87% specificity in distinguishing patients from healthy controls. However, current detection methods require costly qRT-PCR equipment and trained personnel. We propose a plasmid-based fluorescent biosensor using engineered *E. coli* to detect miR-145 at point-of-care. Our design employs a toehold switch — an RNA hairpin complementary to miR-145 that blocks the ribosome binding site, preventing GFP translation. Upon miR-145 binding, the hairpin unfolds and activates GFP expression, producing measurable green fluorescence. If validated, this affordable biosensor could enable MS screening in resource-limited settings where MRI is unavailable, significantly improving diagnosis in underserved populations.

Engineering a Bacterium to Restore CFTR Function in Cystic Fibrosis

John P Stevens High School

Neel Bhosale, Sandra Sanchez, Anderson Portillo, Ambika Bhosale (Teacher), Amanda Ferrante (Northeastern University)

Cystic Fibrosis is a rare genetic disease caused by mutations in the CFTR. This disrupts the transport of chloride and water, leading to thick mucus accumulation and lung infections. Current forms of treatment reduce the symptoms of Cystic Fibrosis, but fail to fully solve the mutation, causing lifelong treatment for patients. This project utilizes synthetic biology to create a cure for this genetic disease, which is hosted in a harmless bacterial chassis. The *Lactococcus lactis* bacteria are a common bacterium used in food and medical research, which can be used to deliver the correct genetic instructions for the CFTR gene. This information will be delivered in the form of mRNA to lung cells, allowing them to successfully produce a functional gene without high risks. This bacterium will also host parts that will help the functioning gene fold and work correctly, increasing the likelihood of it functioning accurately. Since the bacterium can be easily removed, this method could pave the way for future genetic medicine.

Optogenetic Control in C. Elegans: Engineering Blue-Light Responsive Gene Expression for Therapeutics

South Forsyth High School
Team South BioMakers

Sarvesh Sathiyamoorthi, Arush Maridu, Raghav Bajaj, Ishani Sharma, Meera Paramagurusamy, Shaun Philip Matthew, Mukul Vishwakumar, Vedanth Vivekanand, Pamala Seeley (Teacher), Dr. Peter Horanyi (UCB)

In today's day and age, constant use of digital devices has made blue light exposure unavoidable, as these technologies are essential for daily tasks. This exposure leads to oxidative stress through excessive reactive oxygen species (ROS), contributing to cellular damage in retinal tissue. Current approaches largely focus on reducing blue light exposure rather than addressing the underlying causes of oxidative stress. Excessive ROS levels are harmful as they can disrupt mitochondrial function in retinal cells, eventually leading to cell death. Our project aims to detect oxidative stress and mitigate the excess levels that are produced in response to blue light exposure. The first plasmid functions as a sensor, detecting elevated ROS levels and producing a visible GFP (green fluorescent protein) signal as an indicator of oxidative stress, while the second plasmid acts as a responder by expressing superoxide dismutase 2 (SOD2), an antioxidant enzyme that neutralizes excess ROS. This approach allows the cell to maintain normal function while reducing the harmful effects of excess ROS. The two plasmids are assembled and validated in *E. coli*, an efficient microbial chassis, and are subsequently introduced into *C. elegans* through feeding to enable organism-level oxidative stress reporting. This blue light–regulated oxidative stress sensing system links an external stimulus to a genetic response, enabling precise monitoring of cellular health and scalable biosensor applications. This innovation allows for precise monitoring of cellular health and opens the gates to biosensors that can be expanded for medicine, research, and even education.

Engineering CAR T-Cell Therapy for Rheumatoid Arthritis: Conceptual Design and Biosensor Validation

Dublin High School

Rruchir Rupkumar, Tejas Reddy Kasaram, Preethi Rupkumar (Teacher), Dr. William Chen (University of South Dakota)

Rheumatoid arthritis has no cure, with current treatments only masking symptoms rather than targeting the autoreactive B cells driving the disease. We used an IPTG-inducible GFP bacterial system to model how CAR T-cells could selectively detect these disease-specific cells, with fluorescence activating only in the presence of our target signal. This proof-of-concept demonstrates that engineered biological systems can distinguish disease-specific markers, offering a framework for precision autoimmune therapy.

Genetically Engineering the *Lactobacillus* Probiotic for Atherosclerosis Plaque Prevention

Lambert High School
Yellow Team

Aamir Motiwala, Hannah Park, Sarah Jiang, Nayesha Tamhaney, Ahaan Velaga, Esther Hong, Saniha Shankar, Akshay Chenna, Priyanka Bose, Ribhav Jha, Alikarim Mithwani, Catherine Sharer (Teacher), Kelly Teitel (MIT)

18–19 million adults in the United States have a diagnosis of atherosclerotic cardiovascular disease (ASCVD), which is the clinical disease caused by atherosclerosis. Atherosclerosis is the condition when fatty deposits build up inside the arteries, causing them to narrow and harden. This plaque development causes restriction of blood flow, increasing the risk of heart attacks, strokes, and peripheral artery disease. Current treatments focus on reducing cholesterol levels and do not address the underlying metabolic or gut-derived causes. Recent studies implicate that trimethylamine-N-oxide (TMAO)—a compound produced when gut bacteria metabolize choline into trimethylamine (TMA)—is a key factor of plaque formation. To prevent this choline-to-TMA-to-TMAO conversion, we propose a probiotic solution that engineers *Lactobacillus*, a common gut bacterium, to express the enzymes Choline Dehydrogenase (CHDH) and Betaine Aldehyde Dehydrogenase (BADH), native to *Paracoccus denitrificans* bacteria. In addition, a riboswitch or negative feedback loop will be coupled with this design to regulate gut microbiome competition and choline levels. Because the choline is redirected to be converted to betaine (a beneficial nutrient) instead of TMA/TMAO, plaque buildup will be inhibited, therefore reducing the risk for atherosclerosis.

Cost-Effective Visual Colorectal Cancer Diagnostic Via Bacterial Detection of kRAS, TP53, and APC Mutations

Athens Drive Magnet High School

Alyssa Gay, Ibrahim Abumohsen, Havish Bathina, Priyansh Shah, Madeline Boram-Rella, Isaac Pare, Ms. Calin Deleo (Teacher), Mr. Brayden Carty (Teacher), Dr. Kaitlin M. Dailey (University of Rhode Island)

Colorectal cancer (CRC) is the second most commonly diagnosed cancer, with an estimated 154,270 individuals diagnosed in 2025 alone, and 52,900 deaths. In the US, only 60% of the at-risk population will be tested. This hesitancy is in part due to current diagnostic methods (e.g., fecal immunochemical testing, colonoscopy, computed tomography colonography), which are expensive, invasive, and require both specialized medical equipment and operational expertise. Live biologic-based technologies show great promise for closing the diagnostic gap in CRC. In particular, a sensor capable of detecting genetic mutants that employs the chassis organism *Acinetobacter baylyi*. This bacterium acquires DNA from its environment - such as the gastrointestinal tract. When combined with a modified CRISPR counterselection system, this organism can detect critical mutations in the kRAS oncogene with extraordinary specificity, capable of distinguishing DNA base-pair alterations. Here, we developed a design for a novel diagnostic technology, which detects three of the most prevalent CRC-associated mutations, APC, TP53, and kRAS, while fixed within a calcium alginate hydrogelapplied on a nondigestible pill. This results in the expression of an AmilCP reporter, allowing for a colour change in the presence of said triggers. This biologic system aims to minimize the diagnostic gap of CRC by facilitating easy, at-home detection and providing patient-interpretable results.

Engineering the HSC Niche via mRNA-LNP Induced Paracrine Signaling in Microfluidic Model

Weston High School

Tanishka Singh, Kirsten Choi, Sajani Brown, Komal Jasuja, Yvonne Guo, Celia Balbale, Dr. Rachel Neurath (Teacher), Dr. Peter Horanyi (UCB Biosciences)

Hematopoietic stem cells (HSCs) are essential for bone marrow transplantation but are rare and difficult to expand in vitro due to their tendency to differentiate. As a result, patients with leukemia and other blood disorders are forced to rely on donor bone marrow transplants, which are limited by low stem cell counts, immune rejection, and invasive procedures, often requiring repeated low-dose infusions which are painful for both donors and patients. Our project proposes a bioengineered platform that models the HSC niche to preserve and expand HSCs before transplantation. By mimicking paracrine signaling to maintain stemness, our approach could generate transplant-ready HSCs from patient-derived iPSCs, reducing donor dependence, minimizing immune complications, and improving transplant outcomes.

Leadsense

International School of Boston
Team Lead Sense

Francesca Baston, Ilga Kats, Karin Schinkmann (Teacher), Dr. Scott Gaines (Boston University)

Lead ions, specifically Pb(2) are a naturally occurring substance found in small amounts in the earth's crust. However, high concentrations of lead ions, found in soil poses both environmental risks like loss of biodiversity, decreased growth in organisms, and a health risk for humans who have prolonged exposure to lead, like neurological issues, developmental behavior issues, kidney damage, and possibly death in high enough concentrations. Dangerous levels of these ions are found in many areas where mining, manufacturing, and recycling are significant industries, both locally (e.g., Somerville) and worldwide (e.g., Lagos). This project aims to develop a synthetic biology-based approach to alert users of high lead concentration in soil, by engineering a soil-compatible bacterium like *B. cereus* BPS 9, that will secrete fluorescent proteins. As proof of concept, we would first transform an *Escherichia coli* bacterium. Our genetic circuit would include a plasmid with a strong promoter, a repressor gene (PbrR), a second promoter (PpbrA), and a fluorescent color protein (mCherry). The plasmid will be introduced into *E. coli* for initial testing. If successful, the system will then be implemented in *B. cereus* BPS 9 as it is safe and compatible with soil conditions. This approach leverages synthetic biology in order to present a new approach for small-scale lead testing. It allows for cheaper, quicker, and more easily accessible testing of soil for lead. Future work will focus on furthering the system to not only detect lead, but also break it down

Enhancing PIA Production in *Staphylococcus epidermis* to Treat Atomic Dermatitis

Western Reserve Academy
Team Dermatitis Dinosaurs

Alex Lee, Alida Karsten, Alex Lee, Lydia Lockwood, Delaney Pittinger, Vivien Marmerstein (Teacher), Jackie Thompson (Takeda Pharmaceuticals)

Atopic dermatitis, or eczema, is a chronic inflammatory disease that impacts 204 million globally. It is characterized by dryness, itching, and skin irritation caused by reduced moisture retention and increased susceptibility to irritants, commonly *Staphylococcus aureus*. While some find success in treating the disease with topical corticosteroids, those treatments generally come with side effects, such as skin thinning, acne, and skin pigmentation changes. While these treatments aim to reduce inflammation and symptoms, they do little to support the skin's microbiome. *Staphylococcus epidermidis* supports skin health, but is under-represented in individuals with eczema, making it a safe and effective chassis for an engineered AD treatment. We will enhance this bacterium's synthesis of polysaccharide intercellular adhesin (PIA), a major contributor to a biofilm that helps retain moisture and create a healthy skin barrier, by inserting a plasmid with the icaADBC operon (which codes for PIA synthesis) into *S. epidermidis*. This will help restore the skin barrier by simultaneously increasing PIA synthesis, antimicrobial peptide production (which fights *S. aureus* overgrowth), and nutrient availability. The biofilm formed by PIA will allow the skin to retain these nutrients and lipids. This engineered bacteria will be formulated into a cream that heals damaged skin directly and fights underlying causes by increasing water and nutrient retention.

Mitigation of Coral Bleaching by Targeting Reactive Oxygen Species

Westwood High School

Ethan Lee, Jacob Liu, Vincent Willits, Wilson Han, Adelyn Smith, Serena Kapur, Pragna Lal, Duanmu Jiang, YaQing Yang, John Muttiah, Shawn Mullins (Teacher), Eric Jorgenson (ETSU)

Coral reefs are vital ecosystems, contributing to marine life across the world, as they support millions of species through their creation of robust habitats and provide rich nutrients. However, climate change has caused ocean acidification and elevated water temperatures, resulting in symbiotic algae within corals to overproduce reactive oxygen species (ROS). The toxic reactive oxygen species is a harmful stressor in which the coral conducts itself to expel the toxin-producing algae, ultimately leading to coral bleaching. Peridinin-chlorophyll protein (PCP), a key light-harvesting protein in zooxanthellae, plays a central role in photosynthesis. Because the PCP is a protein that is highly expressed within the algae, the regulatory elements can be leveraged to conduct the co-expression of Iron Superoxide Dismutase (Fe-SOD), an antioxidant enzyme essential for neutralizing ROS. Through the use of CRISPR genome editing, a synthetic construct that includes the Fe-SOD gene sequence can be inserted downstream of the PCP promoter, resulting in both the preservation of PCP expression and the initiation of expression of Fe-SOD. This promoter engineering approach offers a more feasible method for overexpression due to its inherent precision and ability to efficiently utilize the high-expression regulatory elements of the PCP gene.

One Ring to Rule Them All: Visual-Assisted “Coffee Ring” Assay for Enhanced Malaria Diagnostics

Denmark High School
The Brewers

Chelsea Alonzo-Francis, Aarav Arora, Siana Biju, Riya Gupta, Aarya Thakkar, Tejas Singh Sumith, Pukhraj Sharma, Mary Cartenuto (Teacher), Dr. David Fox III (UCB), Dr. Mehdi Labaied (UCB), Ellen Wallace (UCB)

Current malaria rapid diagnostic tests, which mainly utilize HRP2 (Histidine Rich Protein 2), have been increasingly compromised by gene deletions that prevent the production of HRP2 altogether. Due to this, more than 15% of cases in Brazil, Djibouti, Eritrea, Ethiopia, Nicaragua, and Peru go undiagnosed as a result of false negatives. We aim to produce a diagnostic utilizing *Plasmodium falciparum* lactate dehydrogenase (pfLDH), a crucial enzyme for the malaria parasite's energy production, to detect *Plasmodium falciparum*. Although we’re using a modified LOCKR (Latching Orthogonal Cage-Key pRotein) to specifically recognize pfLDH, its low concentration in blood causes a need for added signal concentration. To address this, we use a coffee ring diagnostic that uses evaporation-driven capillary flow within a sessile droplet to transport suspended particles toward the droplet edge, thus concentrating the signal. This novel approach provides a low-cost method to enhance accuracy in pfLDH malaria diagnostics.

In Vitro Biosensor for Detective Heavy Metals in Cosmetics

Western Reserve Academy
Team Heavy Metal Heroes

Jungin Yoon, Maya Vaden, Vivien Marmerstein (Teacher), Dr. Hiroko Kaczmarek (BioBuilder)

Heavy metal use in cosmetics poses detrimental health risks. In the United States, 41% of consumers aged 30 to 59 use makeup daily, and over 90% of cosmetics contain one or more of the following toxic elements: mercury, lead, or cadmium. Heavy metals are often used in cosmetics to boost their function. For example, mercury in whitening creams inhibits melanin production, a substance responsible for skin pigmentation. When cosmetics are directly applied to the skin, metal ions enter the body through hair follicles and sweat pores, then reach the bloodstream, allowing them to bind to proteins, disrupt their function by accumulating in various organs, causing health issues such as dizziness, insomnia, and neurological damage. Therefore, monitoring heavy metals in cosmetic products is essential. However, current testing requires specialized laboratories, trained personnel, and complex procedures. Our project aims to develop an in vitro test solution that detects heavy metals in cosmetics. The presence of metal ions will bind to metal-responsive proteins, triggering the corresponding promoter to initiate the translation of fluorescent protein genes, revealing different colors. It will not only empower consumers to test their products at home but also enable cosmetic manufacturers to evaluate the composition of raw materials.

3.12.26 Poster Session III

Teams presenting virtually are italicized

Board	Team Name	School Name
1		Lexington High School
2	*Solar Powered Crew*	*Concordia International School Shanghai*
3	Power Rangers BioForce	Methuen High School
4	Team C	Andover High School
5	Team B	Boston University Academy
6	Plastic Pioneers	Oak Park and River Forest High Schol
7	*Biofilm Busters*	*Western Reserve Academy*
8		Montrose School
9		*Stuart Country Day School*
10	Red Team	Lambert High School
11	Mutation Nation	Hamden Hall Country Day School
12		*American School of Madrid*
13	Fur Finder	International School of Boston
14	*Synthetic Muscle Developers*	*Western Reserve Academy*
15	Team Letae	Boston Latin School
16	*Team Envisioners*	*Denmark High School*
17	Halotolerant Hackers	Western Reserve Academy

Combatting Second-Degree Burn Conversion: Bioengineered Hydrogel Bandage

Lexington High School

Tanya Jay, Annabel Volpe, Esther Kim, Tasheen Kashem, Charvi Talupuru, Aarav Phadnis, Tee Jarukulvanich, Julian Guevara Castellanos, Lakshya Kesanakurti, Nathaniel Lawrence, Reginald Hobbs (Teacher), Susana Donkor (Mirai Bio)

Whilst advancements in burn wound care have improved healing outcomes, a major unmet challenge in burn treatment is preventing burn conversion—the process by which superficial burns deepen within the first few hours of injury due to factors such as inflammation, oxidative stress, and infection. Our solution is to bioengineer a biodegradable hydrogel bandage that releases burn-stabilizing agents to prevent burn conversion during the progression period. By using a hydrogel scaffold design, we aim to regulate the delivery of burn-stabilizing agents, inflammation suppressors, and moisture-retaining components directly to the burn site. Our project will integrate a base hydrogel with an alginate-chitosan matrix, which will act as a structural and microbial barrier to retain moisture while enabling oxygen diffusion. For tissue preservation, curcumin-loaded nanoparticles will be incorporated into biodegradable microspheres that are embedded throughout the hydrogel, providing controlled, sustained release of stabilizing agents. This delivery system supports antioxidant activity, reduces inflammation, and helps preserve microvascular integrity within the zone of stasis. To maximise the beneficial properties of the hydrogel complex, we aim to replace the patch every 24-48 hours, providing a stable burn intervention solution that works alongside standard treatment and potentially obviates the need for surgical intervention for deep partial-thickness burns.

Programmable Bio-Crusts Using MICP Precipitaiton to Reduce Desertification

Concordia International School Shanghai
Solar Powered Crew

Adam Mei, Eric Du, Ethan Wu, Stephen Jing, David Doyle (Teacher), Gitanshu Bhatia (LanzaTech)

In drylands, wind-driven soil erosion is a major driver of desertification. Desertification is characterized by reduced soil stability and accelerated land degradation, both of which damage local infrastructure and ecosystems. Conventional soil stabilization methods, such as those that rely on cement, polymers, or mechanical vibration, are often energy-intensive and environmentally unfriendly. Microbially induced calcium carbonate precipitation (MICP) offers a bio-mediated alternative by binding soil particles with calcite. Unfortunately, urease-mediated MICP generates ammonia as a byproduct, conferring phytotoxic risks that limit its large-scale application. Thus, this project proposes a low-cost engineered biocrust based on carbonic-anhydrase-mediated MICP, which mitigates ammonia release. Our biocrust comprises primary cells that conduct carbonic-anhydrase- mediated MICP and helper cells that secrete exopolysaccharides (EPS). Together, the co-culture is intended to be deployed into dryland regions and independently from the biocrust in designated areas.

However, our design has limitations. Although the carbonic anhydrase in our system is highly efficient, our system can only conduct MICP under basic and calcium-rich conditions. By inducing carbonic anhydrase expression in wild soil bacteria, this system achieves regulated and enhanced calcite precipitation, forming a thin, erosion-resistant surface crust. Further development of this project may yield a carbon-sequestering, scalable, and programmable method to mitigate desertification sustainably. The initial step is to test the prmA promoter, which is known to be activated in the presence of PFAS (Young, 2021) using a reporter GFP gene to confirm PFAS sensitivity. Then, the next step would be placing PFAS-degrading enzymes DeHa 1 and DeHa 2 under the control of the prmA promoter to confirm we can eliminate PFAS in water (Harris, 2022). After PFAS is eliminated, our next step would be to determine if the bacteria can be destroyed by activating a self-destruct gene under an arabinose promoter, to ensure they cannot escape water processing facilities (Meisner, 2016). If our system successfully degrades and destroys the PFAS and bacteria, we can then integrate it into the water processing system.

Engineering a Tetrathionate-Responsive Bacterial Biosensor for Detecting Gut Inflammation

Methuen High School
Power Rangers BioForce

Alexa Buonagurio, Allie Letourneau, Valentina Carideo, Jiya Patel, Brady Nguyen, Haiquis Dominguez, Maureen Melanson (Teacher), and Dr. Racquel Sherwood (Avantor)

Gut inflammation often requires monitoring through invasive and costly procedures, creating a need for noninvasive diagnostic methods. This project focuses on designing a bacterial biosensor that detects intestinal inflammation by sensing tetrathionate, a biomarker produced during inflammatory responses in the gut. The biosensor uses the tetrathionate response promoter PttrB, regulated by the TtrS/TtrR two-component system identified in Salmonella. The membrane-bound sensor kinase TtrS detects tetrathionate and activates the response regulator TtrR through phosphorylation. Activated TtrR binds to the PttrB promoter and initiates transcription of a downstream reporter gene. The reporter gene lacZ was selected because it produces the enzyme β-galactosidase and functions without oxygen, making it suitable for anaerobic gut conditions. When lacZ is expressed in the presence of X-gal, bacterial colonies turn blue, providing a visible indicator that tetrathionate has been detected. This color change confirms detection of the inflammation marker. This project demonstrates the conceptual design of a gut-compatible bacterial biosensor capable of sensing an inflammation-associated biomarker and producing a measurable response. Such systems could support future development of noninvasive diagnostic or therapeutic engineered bacteria for monitoring and managing intestinal inflammation.

Development of a Scalable qPCR Chip for Early Genetic Screening of Rare Diseases

Andover High School
Team C

Kaveri Dole, Anika Abbott, Dr. Lindsey L'Ecuyer (Teacher), Dr. Peter Horanyi (UCB)

With over 10,000 known rare diseases, nearly 4% of newborns are estimated to have one, creating a growing diagnostic challenge. Rare disease diagnoses are often delayed until symptoms become apparent, further debilitating patients. Screening for all rare diseases is unfeasible due to financial constraints and limited resources. Current diagnostic strategies rely on symptom-driven genetic testing, which is costly, time-consuming, and impractical for broad screening. To improve early detection, we propose a real-time quantitative polymerase chain reaction (qPCR) chip utilizing TaqMan technology. This approach employs specific primers and fluorescent probes that bind to the DNA and are cleaved during amplification, enabling rapid and accurate screening. Although full-scale multiplex screening is our long-term goal, our initial prototype targets PHOX2B to diagnose Congenital Central Hypoventilation Syndrome (CCHS). It also targets SHANK3 and MECP2, mutations associated with Autism Spectrum Disorder (ASD) and Rett's Syndrome. A single blood sample can be scaled to screen for hundreds of genetic disorders within one qPCR run, provided the causative genes and mutations are known. Limiting initial screening to three genes allows us to validate assay performance and optimize the system before expansion. By converting rare disease diagnostics from symptomatic testing to proactive screening, earlier intervention is enabled.

Using *B. breve* MCC1274 to Combat Alzheimer's Disease

Boston University Academy
Team B

Harjas Grover, Daniel Shaer, Ida Sanaktekin, Bella Horta, Eliana Kofman, Vaani Malla, Thea Wu, Camila Horta, Leo Thorati, Olivia Waring (Teacher), Dr. Sitaram Meena (UCB)

Alzheimer's Disease (AD), responsible for up to 80% of dementia-related diagnoses, currently impacts more than seven million Americans and fifty-five million individuals worldwide. Characterized by the accumulation of beta-amyloid (Aβ) plaques in the brain, AD's hallmark symptoms include memory loss and a functional decline of the central nervous system. While no cure exists, there are many intervention strategies, such direct Aβ depleting antibodies, but many of these strategies invite a wide array of side effects. Recent research demonstrates the promise of utilizing the microbiota-gut-brain axis as a safe, indirect pathway for therapeutic intervention. Bifidobacterium breve MCC1274 is one probiotic strain that has demonstrated significant clinical potential through its ability to promote anti-inflammatory cytokines and reduce Aβ deposition in the CNS of APP/PS1 mice. To bolster these functions, our project focuses on increasing the short- chain fatty acid (SCFA) output of B. breve, namely acetate, to upregulate the ERK pathways that produce HIF-α, hypoxia-inducible factor-alpha, a regulator that helps induce many of *B. breve's* beneficial effects.

PV-See: A Novel E. coli-based Biosensor for PVC Detection

Oak Park and River Forest High School
Plastic Pioneers Team

Keaton Roberts, Ava Lebovitz, Gayatri Gadhvi, Ben Boyd, Holden Benbrook, Isadora Conour, Audrey Latham, Nathan Kralik, Matthew Kirkpatrick (Teacher), Dr. Eric Young (936-Technologies)

Polyvinyl chloride (PVC) is one of the most widely used plastics, accounting for 10% of global plastic production1. PVC can invade the human body, damaging gut structure and promoting carcinogenesis. Despite these risks, the lack of medically relevant PVC detection methods limits the ability to correlate exposure with health effects. Current detection methods rely on physical and/or chemical characterization techniques that are costly, time-consuming, and poorly suited for assessing biological impact. In this project, we implement a proposal from students at Brookline High School to genetically engineer an *Escherichia coli*-based biosensor that produces luminescence in response to PVC exposure. The design stems from the hypothesis that PVC exposure induces oxidative stress in *E. coli*, leading to the upregulation of the protein OxyR. Once activated, OxyR drives transcription of the KatG gene, which is coupled to a NanoLuc® luciferase reporter to produce luminescence. By linking PVC exposure to a cellular stress response, this biosensor framework offers a novel approach for assessing biologically relevant plastic exposure. If validated, this system can provide a basis for future studies to monitor plastic presence in medical samples and support investigations into the health impacts of plastic exposure.

Beyond Antibiotics: Coating Sutures in Depolymerase to Combat Surgical Site Infections

Western Reserve Academy
Team Biofilm Busters

Anna Barger, Madison Glass, Colin Si, Lauren Smeltzer, Vivien Marmerstein (Teacher), İlkay Çisil Köksaldı (ETH Zurich-D-BSSE)

A primary risk associated with surgery comes not from the operation itself, but the risk of infection afterwards. The sutures left in place give pathogens easy access to the wound, often forming shells that are very difficult to remove known as biofilms. To combat this, many sutures are coated in antibiotics like Triclosan. While Triclosan may reduce pathogenic colonization for a short time, biofilms can form, limiting their effectiveness, leading to them having no impact on pre-established biofilms. Beyond the financial burden placed on healthcare systems, surgical site infections, or SSIs, negatively impact patients' quality of life, extending hospital stays, delaying recovery time, and increasing morbidity rates. Biofilms are not entirely impervious to attack though. In nature, bacteriophages use an enzyme called depolymerase to kill bacteria by breaking down the biofilms that protect them. Our project proposes transforming the genetic code for a phage derived depolymerase, DpoMK34, into *Escherichia coli* for protein production. The product would then be purified using histidine tagging before being used to coat the sutures, preventing biofilms from forming. By targeting the mechanisms underlying biofilm formation, rather than relying on traditional antibiotics, enzyme based antimicrobial sutures can reduce SSIs while minimizing cost and health risks.

Patch Perfect: Guiding Collagen Deposition with an RsaA Protein Mesh

Montrose School

Ruby Quintiliani, Aneesa Maity, Tvesha Patel, Siena Eliffe, Elena Schuster, Leah Vaz, Sophia Hoffman, Chloe Dias, Paola Favaretto (Teacher), Sarah Hanna (Teacher), Dr. Kelly Doering (KSBD, LLC)

Second-degree burns damage the epidermis and part of the dermis, resulting in scar formation during wound healing. During the proliferative phase, activation of TGF-β1 causes fibroblasts to differentiate into myofibroblasts, which rapidly deposit type III collagen, often poorly aligned and contributing to thick scar tissue. In early remodeling, type III collagen is gradually replaced by type I collagen, and fiber organization remains modifiable. Unlike post-scar treatments that cannot influence collagen alignment, our approach targets scar formation while it is actively occurring. We will use *Escherichia coli*, a non-pathogenic bacterial chassis, to produce RsaA S-layer proteins, which self-assemble into rigid hexagonal lattices and form a temporary, two-dimensional mesh. The proteins are then harvested and applied in an external patch. This mesh delivers nanoscale mechanical cues that provide contact guidance. By mimicking the structural features of the extracellular matrix, the lattice directs cell alignment, ensuring that as type III collagen is replaced by type I, the resulting fibers are organized. Successful protein production will be verified using a GFP reporter, and lattice formation will be confirmed through imaging techniques such as electron microscopy. This project presents a safe, preventative strategy to reduce scar formation following second-degree burns.

Probiotic-Based Oxidating Stress Sensor for Modeling Gut Inflammation

Stuart Country Day School

Ryka Iyer, Ganeev Kaur, Zhiyu Wang, Melissa Bressia (Teacher), and Dr. Tu Nguyen (MIT)

Gut inflammation is linked to microbiome imbalance, elevated oxidative stress, and increased inflammatory signaling. Research on the gut–brain axis shows that dysbiosis contributes to increased cytokine production, reduced short-chain fatty acid (SCFA) levels, and immune dysregulation. Reactive oxygen species (ROS), produced during immune activation, serve as measurable indicators of oxidative stress within the intestinal environment.

This project presents a design-only probiotic biosensor that detects oxidative stress as a proxy for gut inflammation. The system uses nonpathogenic *Escherichia coli* engineered with an OxyR-responsive promoter linked to green fluorescent protein (GFP). Under elevated ROS conditions, OxyR activates GFP expression, generating a visible fluorescence signal. The project emphasizes biological feasibility and modular circuit design rather than experimental validation.

Degradation of Viral NS5 Polymerase from Mosquito-borne Disease Engineered with RNAi

Lambert High School
Red Team

Rochan Saireddy, Raghavan Swaminathan, Nila Prabhu, Smyan Reddy, Sanel Lathiya, Sarah Manoj, Anish Anumakonda, Andrew Jiang, Chethas Chittipiralla, Catherine Sharer (Teacher), Dr. Alyssa Morrow (Immunai)

Mosquitos are such small things, and yet, they can cause much harm and damage. They often carry potent diseases and transfer them to humans when they bite. Roughly 390 million people are affected by Dengue each year, with hundreds of thousands more being affected by Zika. Our project targets the viral NS5 polymerase (the enzyme that causes viral RNA to be replicated) of these viruses, attacking the source of the problem rather than treating it. Our design originally involved infusing Wolbachia pipientis with a custom-designed RNAi strand. However, due to the unavailability of *W. pipientis*, we created a proof-of-concept, using yeast as a medium to prove the likelihood of *W. pipientis* being a suitable host to our plasmid. Using Clustal, we matched up three genomes coding for NS5 polymerase from Zika, Dengue, and Yellow Fever to identify a set of common strands to target, and converted those to complementary RNA antisense strands. With ViennaRNA, we modeled the folding of each strand into a complex structure to find the most optimal to insert into our plasmid, which in turn will be propagated through *Escherichia coli* and transferred into yeast. Following this transfer, the yeast cell will express our RNA antisense strand and bind with the viral NS5 polymerase mRNA. Finally, the Dicer-2 protein cleaves our combined strand and prevents translation of NS5 mRNA.

Antifreeze *Bacillus subtilis* in *Saccharum officinarum*, Sugarcane

Hamden Hall Country Day School
Mutation Nation Team

Andrew Aldo, Kinan Harb, Yifan Xiang, Austin Zhou, Johan Wang, Eli Davis, Jiayu Shao, Madelon Parke, Daniel Kemp (Teacher), Dr. Jamie Gregory (Arvinas)

This experiment will examine the growth of sugarcane in colder climates and whether symbiotic *Bacillus subtilis* will affect sugarcane growth under such conditions. Sugarcane is a tropical plant that grows best at temperatures ranging from 21 to 31 degrees Celsius. If we insert a Bacillus colony that possesses an antifreeze protein coding gene into sugarcane, then it will grow better in colder climates because of both the endophyte (nitrogen-fixing) relationship between the *Bacillus* and the sugarcane, and because of the antifreeze protein protecting the plant from sub-freezing temperatures.

Producing G-CSF via *E. coli* for accelerating wound healing processes

American School of Madrid

Valentina Wang, Miryam Frost, Sung Tae Hwang, Katharina Birkmann, Edith Mcaab, Roque Lavin Delgado, Fay S, Alexis Papageorgiou, Meghan Perks (Teacher), Dr. Michael Sheets (Sunflower Therapeutics)

Our research aims to suggest one of the possible ways to treat neutropenia by producing Human Granulocyte Colony-Stimulating Factor (G-CSF), a hematopoietic cytokine that stimulates neutrophil production and hematopoietic stem cell (HSC) mobilization (Hamid et al., 2011). We are using a pET-based plasmid system (pelB/6×His/TEV) from VectorBuilder containing the G-CSF gene driven by a T7 promoter and an Ampicillin resistance marker. Currently, the plasmid is being used in NEB 5-alpha *Escherichia coli* derived from the K-12 strain. While this strain ensures efficient plasmid cloning and stability, we acknowledge that it lacks the necessary T7 RNA Polymerase to activate the T7 promoter system. Therefore, to induce protein expression, we must transfer the plasmid into a DE3 lysogen *E. coli* strain (such as BL21). This strain will then be able to produce the T7 RNA polymerase gene under the control of the IPTG-inducible lacUV5 promoter, triggering transcription of G-CSF. The cells with designated plasmids will then be screened on the ampicillin agar plate, whose solution will then be filtered to extract native G-CSF protein after cell rupture.

Fur Finder

International School of Boston
Team Fur Finder

Leonor Mory, Elisa Miras, Stella Ulfers, Reia Chahin, Gerda Eilers, Josephine Ekendahl, Karin Schinkmann (Teacher), Adrien Binet (Teacher), Dr. Alexander Graewe (Leibniz Institute for Natural Product Research and Infection Biology)

The current tools available on the market for iron detection are very expensive and use a lot of heavy machinery. Not everyone who could benefit from these machines has access to them.

The goal of our project is to create a test strip similar to a pH test strip to detect iron levels in the blood. Our product would work by changing colors depending on the concentration.

The protein we plan on using is called CoBiSe and switches between two different colors depending on the concentration of blood present in the sample.

Engineering an IL-6 Responsive Probiotic for Dynamic Follistatin Secretion and Myostatin Inhibition

Western Reserve Academy
Synthetic Muscle Developers

Lydia Stropki, Adelaide Baran, Arya Shirsat, Colton Waters, Sanam Mody, Vivien Marmerstein (Teacher), Dr. Kosuke Seki (University of California, San Francisco)

Duchenne Muscular Dystrophy (DMD) is the most common form of muscular dystrophy, affecting 20,000 children worldwide yearly. Muscle degenerative conditions, including the genetic disorder DMD and age-related sarcopenia, share pathological mechanisms such as progressive muscle wasting and elevated myostatin signaling. Existing therapies rely on systemic drug administration or gene-based approaches, which can take years to develop. They also raise safety concerns, costs, and a lack of a long-term solution. We propose using the chassis *Limosilactobacillus reuteri* (formerly *Lactobacillus reuteri*) as a gut-safe probiotic. Elevated interleukin-6 (IL-6), a cytokine released during inflammation and muscle stress, signals disease activity. Our system uses an IL-6-responsive promoter to detect this state and drive FST-344 (specific follistatin protein used) expression. The resulting follistatin protein suppresses myostatin signaling by preventing receptor binding, thereby promoting muscle preservation. To ensure homeostatic control and prevent overproduction, the circuit incorporates a TetR-regulated repression loop. For additional biosafety and regulatory control, the design incorporates a mazF-based kill switch and a feedback mechanism to limit expression and trigger cell termination. This oral, sensor-regulated delivery system offers a potentially scalable, noninvasive, and adaptable alternative to traditional gene therapies and systemic drug regimens.

Glyphosphate Removal from Agricultural Grounds by C-P Lyase Pathway

Boston Latin School
Team Letae

William Yu, David Wang, Aditya Tangella, Jared Acevedo, Chelsea Bateman, Sapna Malhotra, Silas Rosenberger, Julianne Jang, Kathleen Bateman (Teacher), Joe Switzer (BioBuilder)

Around three million metric tons of pesticides are used worldwide annually. However, only 1% of these pesticides effectively protects plants; the vast majority enters the environment. This pesticide contamination poses a significant threat to soil health, harming non-target organisms and leaching into surrounding water systems. Conventional approaches to removing pesticides, such as soil excavation, solvent flushing, and chemical oxidation, are costly, non-selective, and often impractical. Our project presents a biological solution: engineering a bacterial chassis to detect glyphosate in soil and produce a targeted degradation enzyme. Glyphosate is an optimal target: the most widely used herbicide in the world, it accounts for 44% of the active ingredient volume in global herbicide use and thus a significant portion of the residual pesticide in the soil. To address this challenge, we utilize the carbon-phosphorus (C-P) lyase pathway to degrade glyphosate into the ecologically harmless compounds that are inorganic phosphate and sarcosine. The *E. coli* chassis is the optimal choice, containing the phn operon essential for the C-P lyase pathway. This system would reduce persistent pesticide pollution, restore soil and ecosystem health, prevent water contamination, and promote more sustainable agricultural practices worldwide.

Exploring the Methods of Detecting Diabetic Retinopathy

Denmark High School
Team Envisioners

Ismail Farid Allauddin Khan Ghori, Parisha Goyal, Saanvi Moota, Victoria Semanduyeva, Jahnavi Singh, Vivek Venigalla, Mary Cartenuto (Teacher), Dr. Kissaou Tchedre (Austin Community College)

Diabetes is a leading cause of death and carries several serious complications, one of the most critical being diabetic retinopathy, a chronic condition that damages the retina and can result in irreversible blindness if left unaddressed. Diabetic retinopathy is highly prevalent, with an estimated number of affected Americans of 16 million by 2050, as predicted by the American Diabetes Association. Despite the growing concern, many cases go undiagnosed until the disease reaches advanced stages, limiting treatment options. Early detection remains a clinical challenge, as the condition silently worsens without visible symptoms. The design we implemented addresses this issue by using biochemical detection and AI-based image analysis to increase detection accuracy. An AI image recognition model was trained via machine learning and images derived from a retina bank to accurately identify signs of the condition. The lateral flow assay utilizes the color produced by gold nanoparticles, alongside a Wheatstone bridge circuit that allows for precise differential measurements via an ammeter to determine the degree of diabetic retinopathy. The AI model demonstrated 96% accuracy in identifying diabetic retinopathy, suggesting that the method of combined biochemical detection and image analysis holds strong potential for improving early detection outcomes.

Aerobic Bioremediation of Perchlorate Contamination via a Novel *Pseudomonas stutzeri* Construct

Western Reserve Academy
Team Halotolerant Hackers

Stephanie Qin, Anna Barger, Alex Wang, Joe Yang, Vivien Marmerstein (Teacher), Dr. Eric Young (936-Technologies)

Perchlorates (ClO4-) are harmful chemicals commonly found in arid and semi-arid regions worldwide. While they are naturally occurring, perchlorate concentrations have increased drastically due to anthropogenic activities. This presents a major challenge to agriculture in arid regions and risks contaminating groundwater drinking supplies. Even at microgram levels, perchlorate is toxic—for example, when present in the soil, they interfere with plant growth by competitively inhibiting nutrient uptake. Current treatments are often expensive and ineffective, and potential bioremediation strategies rely on anaerobic pathways that are unachievable in nature. This paper aims to engineer a three-step degradation pathway in *Pseudomonas stutzeri*, a bacterium capable of withstanding harsh, arid environments. Enzymes expressed from a plasmid operon will first reduce perchlorate, after which the resulting intermediates will be processed by the chassis' endogenous chlorate reduction and dismutation pathways to finally produce chloride and oxygen. A Flavodiiron protein module will also be introduced to prevent intracellular oxygen accumulation, ensuring perchlorate will not be outcompeted as the terminal electron acceptor and thereby allowing the system to function in aerobic conditions. If successful, this chassis could be deployed directly to contaminated soil and water sources, providing a cost-effective approach to perchlorate pollution without the need for additional infrastructure.

Abstracts of Teams Presenting at the Southeast Final Assembly

3.26.26
Brookhaven City Centre
Brookhaven, GA

Radiation Detection Through Melanized Fungal Cells

Alliance Academy for Innovation
Gold Team

Anushka Dingare, Shaurya Kulakarni, Shreyansh Waghole, Siri Chivukula, Mohnish Naga Satya Sai Chintalapudi, Tejshree Ratnakar, Dev Gupta, Sanvi Sadangi, Arjun Nomula, Aprameya Beigam, Caroline Matarrese (Teacher), Dr. Anna Li (Versatope Therapeutics)

High levels of radiation exposure are an increasingly relevant problem, yet there is a clear lack of low-cost methods for detecting this issue. In nature, many species of fungi are shielded from otherwise harmful levels of radiation thanks to the presence of melanin. The pigment acts as a biological semiconductor, utilizing its unique structure to enhance its electron-transferring capabilities when it comes in contact with high levels of radiation. Previous studies have noted the effects of radiation on melanized fungi, such as enhanced cell growth and even measurable levels of electrical output. This experiment aims to apply those observations in a low-cost setting in an attempt to utilize a melanized fungal bioelectrochemical system as a marker for surrounding radiation while using UV radiation as a safe substitute with the same effects.

Engineering Plant-Compatible Bacteria to Enhance Nutrient Availability

Alliance Academy for Innovation
Silver Team

Manya Gulati, Tejas Bachu, Shriyans Nomula, Dananh Dang, Hansika Sahukari, Vrishank Regonda, Hayaan Dangra, Nived Syam, Suhali Tirumareddi, Caroline Matarrese (Teacher), Dr. Anne Anderson (Aims Community College)

More than half of global agricultural soils lack the macronutrients potassium, phosphorus, and nitrogen required for full plant productivity and health. Deficient plant nutrition increases plant susceptibility to climate instability, including drought and temperature extremes. Agriculture contributes over $70 billion annually to Georgia's economy, highlighting the importance of sustainable soil productivity. Currently, fertilizers used to supply essential nutrients entail significant purchasing costs, investments in application equipment, and environmental risks from misuse and nutrient runoff. However, many soil microbes naturally possess the ability to fix atmospheric nitrogen via the nif operon, while others can solubilize phosphate and potassium ions from soil minerals via characterized gene clusters. Nonpathogenic *Pseudomonad* isolates exhibit some of these beneficial traits. We propose to determine whether a plant-associated bacterium, *Pseudomonas putida*, can be engineered to express a combination of these functions. Growth studies would assess whether such an engineered strain enhances plant development under nutrient-deficient soil conditions. The use of plant-beneficial microbes represents a sustainable and ecologically sound approach to improving plant nutrition in poor soils. Implementation of this synthetic biology strategy could reduce reliance on chemical fertilizers and contribute to improved food security worldwide.

Early Detection of KRAS G12D Mutation Using CRISPR-Cas12a and REA-RPA to Increase Survival Rates of Pancreatic Cancer Patients

Alpharetta High School
Team 1

Aarna Ravikanth, Rachel Weitz, Aleena Rasheed, Swetha Anand, Bhargavi Ladekar, Nitya Shool, Hyowon Kim, Shreeansh Bommoju, Sai Jaggannagari, Letitiah Etheridge (Teacher), Eric Lu (MIT) and Katherine Gell (Vanderbilt Univeristy)

More than half of global agricultural soils lack the macronutrients potassium, phosphorus, and nitrogen required for full plant productivity and health. Deficient plant nutrition increases plant susceptibility to climate instability, including drought and temperature extremes. Agriculture contributes over $70 billion annually to Georgia's economy, highlighting the importance of sustainable soil productivity. Currently, fertilizers used to supply essential nutrients entail significant purchasing costs, investments in application equipment, and environmental risks from misuse and nutrient runoff. However, many soil microbes naturally possess the ability to fix atmospheric nitrogen via the nif operon, while others can solubilize phosphate and potassium ions from soil minerals via characterized gene clusters. Nonpathogenic *Pseudomonad* isolates exhibit some of these beneficial traits. We propose to determine whether a plant-associated bacterium, *Pseudomonas putida*, can be engineered to express a combination of these functions. Growth studies would assess whether such an engineered strain enhances plant development under nutrient-deficient soil conditions. The use of plant-beneficial microbes represents a sustainable and ecologically sound approach to improving plant nutrition in poor soils. Implementation of this synthetic biology strategy could reduce reliance on chemical fertilizers and contribute to improved food security worldwide.

Enhancing Root Growth in Georgia Red Clay Soils Through ALMT Gene Editing

Alpharetta High School
Team 2

Sai Kundanika Bobba, Derek Kim, Megha Ganesan, Teresa Walker, Aaliya Panda, Tanvi Palan, Sudeep Gandra, Nandita Mannepalli, Letitiah Etheridge (Teacher), Sean Pascoe (MIT)

Approximately 50% of the world's arable land is affected by aluminum toxicity, which reduces root growth and limits nutrient and water uptake, ultimately decreasing crop productivity. We aim to address this issue specifically in Georgia's red clay soils, exploring how we can enhance root development and crop performance at the genetic level. We focused on improving plant tolerance to aluminum stress by leveraging the Aluminum-Activated Malate Transporter (ALMT), a protein that releases malate from roots to chelate and neutralize Al^{3+} ions in acidic soil. Using CRISPR-Cas9 gene editing, we plan to enhance the expression of the plant's native ALMT gene to promote root growth, improve nutrient uptake, and reduce susceptibility to aluminum damage. We also investigated grafting techniques to strengthen root systems and support plant growth in nutrient-poor, acidic soils. We expect enhanced ALMT activity to increase root length and thickness, improve water and nutrient absorption, and provide greater resistance to aluminum toxicity. This offers a sustainable alternative to chemical soil treatments, allowing crops to thrive in Georgia's red clay soils. By creating stronger and longer roots, farmers can cultivate a wider variety of crops, expand usable farmland, lower production costs, and adopt more environmentally responsible agricultural practices.

A Molecular Approach to Extend Life in Carnations

Cross Keys High School
BioBloom Team

Michelle Barron, Anthony Marin, Eva Gomez, Nhan Phan, Hazel Uribe, Ana White (Teacher), Dr. Michael Sheets (Sunflower Therapeutics)

Ethylene is a central hormone regulating ripening and senescence in horticultural and floricultural products, contributing to significant postharvest losses in ethylene-sensitive species such as *Dianthus caryophyllus* (carnations). This project develops a synthetic biology proof-of-concept using *Escherichia coli* to model ethylene pathway suppression. A custom IPTG-inducible plasmid was designed to express ethylene-modulating genes and incorporate RNA interference elements (siRNA/shRNA) to silence targets analogous to plant ethylene-response genes. Blue-white screening is used to validate successful plasmid transformation, and gene expression outcomes demonstrate controllable activation and repression within the model. This system provides a foundational framework for future adaptation to plants and highlights the potential of engineered biological circuits to extend shelf life and reduce waste across floricultural and agricultural supply chains.

BioFlavor Synthesis: The Next Generation Yogurt

Cross Keys High School
Elemental Alliance Team

Mahabubul Hasan Sowrav, Nafisha Karim, Marta Reyes-Gaitan, Yamileth Manzano-Ortiz, Warren Oliver, Lisbet Ortiz-Arreaga, Ana White (Teacher), Gitanshu Bhatia (LanzaTech)

Yogurt is a widely consumed probiotic dairy product known for its nutritional benefits and diverse flavor profiles. However, industrial yogurt production often faces challenges that lead to inconsistent flavor and texture. To address these issues, we engineered a probiotic yogurt strain capable of biosynthesizing natural fruity esters, alongside a purple pigment for visual verification.

Building on last year's theoretical design, we developed a functional biological system using *Lactobacillus paracasei* as the chassis. We introduced the ATF1 gene to generate banana-like aromas, specifically isoamyl acetate. Plasmid components were amplified via PCR, assembled using NEBuilder, and initially validated in Escherichia coli using tsPurple as a visual reporter [6,8]. Functional expression was assessed through IPTG induction at varying concentrations and confirmed via SDS-PAGE analysis.

While the final transformation into *Lactobacillus* remains a future step due to time constraints, this work highlights a practical synthetic biology approach to improving flavor consistency. This project lays the groundwork for a sustainable, self-flavoring probiotic yogurt that reduces reliance on synthetic additives.

Detecting Urushiol Contact on Human Skin with a DMPR-based Biosensor

Marietta High School

Alwyn Cortez, Savannah Miles, Tessa Chalfant, Harrison Pacin, Ellen Gbolade, Cooper Murdock, Thenulya Jayasinghe, Kennedy Brock, Aarav Tandel, Amanda Barrett (Teacher), Dr. Ilenne Del Valle Kessra (Oak Ridge National Laboratory)

The majority of people are allergic to members of the toxicodendron genus, most notably poison ivy. Adverse reactions from urushiol, an oil in members of the genus, occur due to an immune response caused by its binding to skin cells, yet no rapid detection method exists to prevent exposure before it penetrates the skin. Although visual methods of identifying the toxicodendron genus and post-exposure treatments exist, there is a critical gap of time between urushiol contact and treatment. To address this issue, our biosensor was designed to produce a colored response on human skin to alert the user of contact. *Escherichia coli* was employed as a proof-of-concept chassis in order to ensure future safety when used in a bacteria of the human skin microbiome. Our construct uses a catechol-responsive transcription factor, the DMPR wild-type gene, paired with the lacZ gene, which produces β-galactosidase that cleaves the X-gal to generate a visible blue coloration for urushiol detection on various skin tones. This plasmid-based system integrates a chloramphenicol resistance for selection in experimentation. In the future, this biosensor could be applied in preventative dermatology through integration into topical products that provide immediate visual alerts after urushiol exposure to allow for rapid treatment.

Combatting Carbon Dioxide Output via an Innovative Approach to Biofuel Production

North Forsyth High School

Prabha K., Alana J., Hrithiik R., Mateusz S., Sahasra T., Sahasra D., Nidhi D., Khaila C., Yue Z., Shahzoda S., Stephen Nelson (Teacher), Dr. Ryan Tappel (LanzaTech)

Invasive plant species threaten ecosystems and agriculture by reducing biodiversity and disrupting natural systems, while climate change continues to worsen due to fossil fuel use and rising greenhouse gas emissions. This project proposes converting invasive plant biomass into renewable energy as a sustainable solution. An engineered BL21 *E. coli* strain produces lipase to break down plant biomass into biodiesel precursors through physical processing followed by enzymatic hydrolysis and transesterification. Microalgae such as *Schizochytrium*, known for high lipid content, further enhances fuel production. Overall, the system aims to control invasive species, lower carbon emissions, strengthen energy security, and support sustainable biofuel development.

Reverse Engineering Rapid Meliodosis Immunochromatography Test to Diagnose other Synthetic Tropical Diseases Using Synthetic Biology

Rabun Gap-Nacoochee School
GFP Eagles

BuGwon Seok, Clare Hwang, Hitomi Nakamura, Margot Caffery-Draa, Irmak Bilici, Jackson Tyers, Elizabeth Sweeney, Chioma Nwanze, Maria Clara Coutinho, David Chen, Tanea Hibler (Teacher), Dr. Irene Reizman (Rose-Hulman Institute of Technology)

Melioidosis (Whitmore's disease) is a potentially fatal infectious disease caused by the bacteria *Burkholderia Pseudomallei. B. pseudomallei* is a bacteria found in the soil and water of tropical regions such as South-East Asia and Northern Australia. This disease is often hard to detect because its symptoms vary by site of infection and are often misdiagnosed as pneumonia, influenza, and sepsis, hence the alias "The Mimicker". People with immune-suppressing conditions as well as chronic diseases such as diabetes, liver, or lung disease are more susceptible to contracting Whitmore's disease.

Whitmore's disease is contracted through environmental contact with broken skin, ingestion, and/or inhalation. The bacteria works by invading the host cells, escaping phagosomes using Type 3 Secretion systems (T3SS3), and using actin polymerization (mediated through BimA) in order to move between cells. The bacteria induce the fusion of infected cells, leading to multinucleated giant cells. The pathogen survives within macrophages and subverts host immune responses, facilitating systemic dissemination. The development of rapid detection methods for melioidosis has demonstrated how diagnostics can save lives, and this approach can be reverse-engineered through synthetic biology to create rapid diagnostic tools for other emerging or synthetic tropical diseases.

Reimagining Cancer Diagnostics: A Cell-Free Biosensor for Early Detection of HER2 Positive Breast Cancer

South Cobb High School

Abigail Sanchez Chavez, Chloe Martin, Bria Washington, Daniella Rico, Zion Jatta, Abigail Ejoga, Temitayo Fakunle, Dr. Tiffany Jones (Teacher), Laura Guerrero (Stanford University)

Breast cancer is known to be one of the most aggressive types of cancer in women, with an alarming estimate of 300,000 cases being diagnosed every year. Early detection of an aggressive and malignant cancer is imperative for receiving targeted therapy and treatment. Detecting the overexpression of the HER-2 protein, a major contributor to breast cancer, can be utilized in early stages to reduce the risk of the cancer spreading and fatal outcomes. This project aims to design a cell-free biosensor that detects HER-2 overexpression using a DNA aptamer with high specificity for the protein. Once the HER-2 aptamer and the protein bind, a toehold switch is then activated, producing a reporter signal that indicates HER-2 overexpression. With further experimental verification, the final design for the cell-free biosensor and research suggests that this approach offers a low-cost alternative for detecting HER-2 overexpression and improving the accessibility of cancer detection methods.

Reducing Ladder Fires

Druid Hills High School

Cameron Hopkins, Aahil Chagani, Kyle Cordon, Daniel Botello, Poornima Amarapu (Teacher), and Dr. Tianhu Sun (ETSU)

The environmental issue our team wanted to tackle was the spread of wildfires. We have discovered that current methods of putting out fires are both costly and ineffective, and we feel that a genetic solution would resolve those issues soundly. By implementing a dual promoter gene circuit that utilizes pATHb2 and pBRC1, we will develop engineered trees that are capable of producing the enzyme ACS8 when the system detects that low red to far red light ratios are present. ACS8 produces Ethylene, a hormone which drives self pruning in many plant species. We hope that our solution will naturally prune lower branches, increasing the crown base height of trees and preventing ladder fuel fires.

THANK YOU

BioBuilder gratefully acknowledges our partners for their support of the BioBuilderClub. Together we're growing the future through life science education.

britebound

CAROLINA®

ucb

NEW ENGLAND BioLabs Inc.

GINKGO BIOWORKS

WPI

Ragon Institute
MASS GENERAL | MIT | HARVARD

BioBuilder
Educational Foundation

Email: info@biobuilder.org

Help us grow the future. Support BioBuilder today!