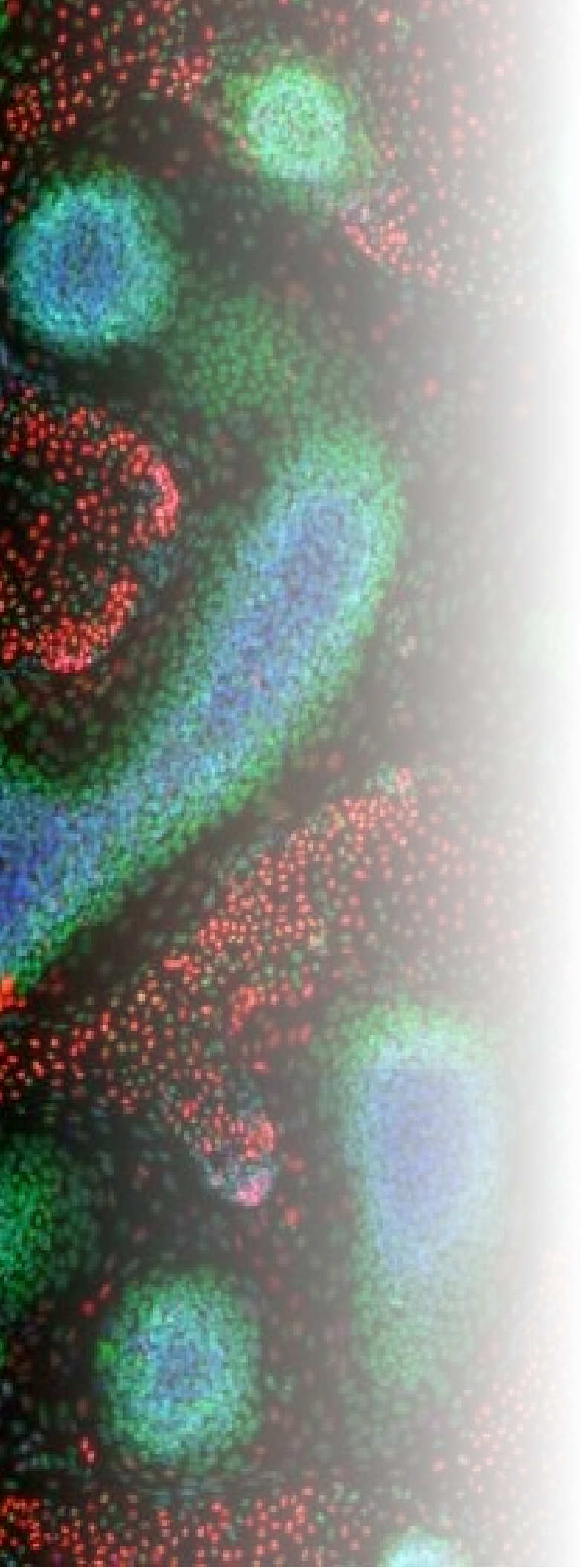


MIT

iGEM

2020

Contents

Introduction to iGEM

Overview

The International Genetically Engineered Machine (iGEM) competition is a worldwide collegiate competition focused on synthetic biology. Each year, competing teams are given a standardized kit of parts ("BioBricks") and then spend the next several months to specify, design, and test biological systems that operate in living cells, providing novel functions.

History

The iGEM competition began in January of 2003 with a month-long course at MIT to create "blinking" bacteria. From there, it expanded to a summer competition with 5 teams in 2004 and has rapidly grown annually to include over 350 teams across 40 countries and over 6500 participants in the 2019 competition. Winning projects have included synthetic pigments in bacteria for use in probiotics for diagnostics, arsenic biosensing cells, Bactoblood, and more.

Student Involvement

Each team is comprised of up to a dozen students spanning various educational backgrounds from physics to biological engineering. Teams are typically selected at each individual college by February of each calendar year and then spend the spring brainstorming on project ideas. By the start of summer, students build, test, and refine biological circuits that implement their project ideas under the guidance of professors serving as advisors and graduate students / postdoctoral scholars serving as instructors. This year, rather than cancelling the competition due to pandemic concerns, it was made entirely virtual, leveraging student minds to further synthetic biology, and for many, the current state of world health.

Competition

Student teams compete in one of four regional jamborees in Asia, North America, Europe, and Latin America during the month of October. At each jamboree, teams have the potential to earn a Gold, Silver, or Bronze Medal for successfully completing lists of criteria that include accurate scientific documentation, communication, collaboration, and other essential research skills. Additionally, after being evaluated across many axes including creativity and scientific rigor, top teams are invited to the world championships (this year, held virtually) from October 29 to November 2 to compete for a variety of additional accolades.

Awards

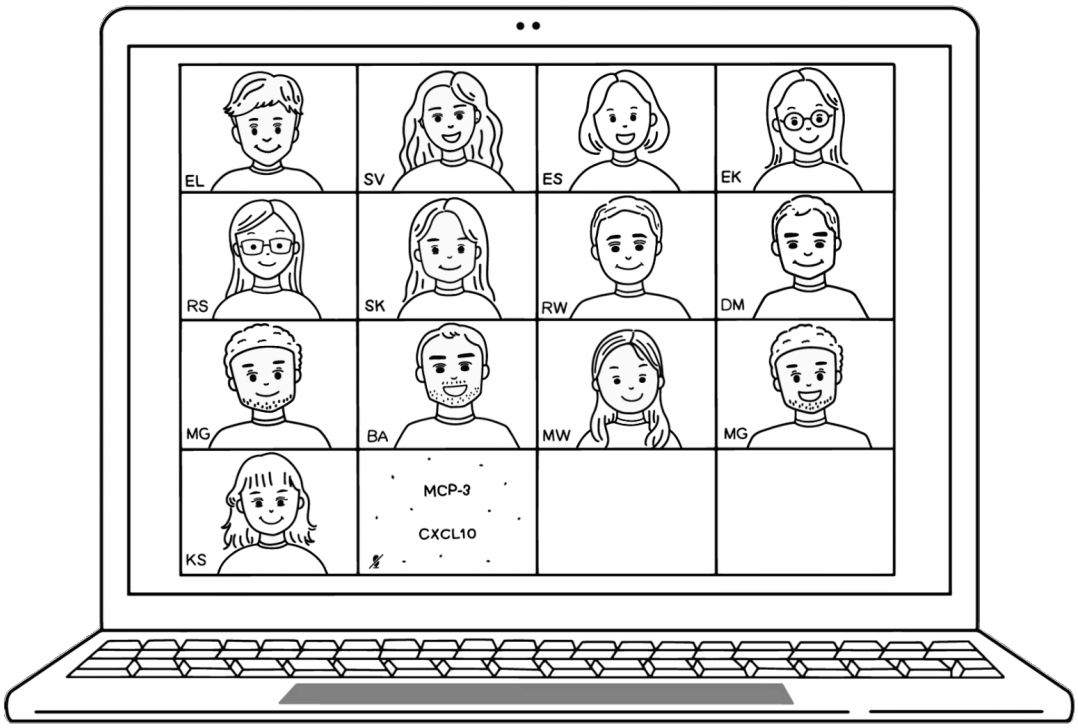
Special prizes are given out at the regional and international jamborees for:

Best New Basic Part, Best New Composite Part, Best Part Collection, Best Plant Synthetic Biology, Best Hardware, Best Education and Public Engagement, Best Software Project, Best Integrated Human Practices, Best Measurement, Best Model, Best Open Project, Best Supporting Entrepreneurship, Best Software Tool, Best Wiki, Best Poster, and Best Presentation.

Additionally, teams specify a track or area of research they concentrated in and prizes are awarded for:

Best Food and Nutrition Project, Best Environment Project, Best Energy, Best Diagnostics Project, Best Manufacturing Project, Best New Application Area, Best Foundation Advance Project, Best Information Processing Project, and Best Therapeutics.

Finally, the iGEMers prize is awarded to the groups that fellow teams believe to be the best project. In addition, a group of judges selects 3 to 10 teams will be named finalists and from that pool, a winner and two runners up will be selected.



MIT iGEM

History

The MIT iGEM team has a rich program history and one of the few teams that has participated in every iGEM competition to date. First under the faculty supervision of Drew Endy and Tom Knight (2004 – 2008) and then Narendra Maheshri (2009), MIT's iGEM teams since 2010 have been coached by Professor Ron Weiss since his arrival from Princeton after successfully managing their iGEM team for many years.

Along with Prof. Weiss, the MIT teams are under the leadership of Deepak Mishra, student alumni mentors, and various other Weiss Lab students. In addition, nearly a dozen other professors and scientists at MIT lend their support and advice to the team. Last year, the 2019 team designed mammalian cells to release a chemical to attract neutrophils to form the beginnings of cellular swarms. This year, the MIT iGEM team is taking computational steps toward engineering mammalian cells to detect and alleviate cytokine storms, which are a symptom in many COVID-19 patients in which patient's overreactive immune system potentially causes tissue damage and increasing disease severity.

2020 Project Goals

Overview

The COVID-19 pandemic, caused by SARS-nCoV-2, has infected millions of people [include death toll, that it has impacted normal life – talk more about the impacts beyond just infection]. One prominent feature of its pathology is the overactive immune response, or cytokine storm. COVID-19 is an inflammatory hyaline membrane disease and has inflammatory cytokine patterns.

We seek to better understand COVID-19 pathology through understanding cytokine pathways and immune homeostasis models, similar to those used to successfully study rheumatoid arthritis, another inflammatory disease. Using this information, we designed a synthetic mammalian network to modulate the immune response to COVID-19. We hope to increase the specificity of our system to sense, process, and respond to a critical immune state.

By sensing changes in concentration of two biomarkers indicative of cytokine storms, our system will compute the level at which to best respond and decrease disease severity by restoring the patient's inflammatory response to a healthy state as defined for that individual. Using synthetic

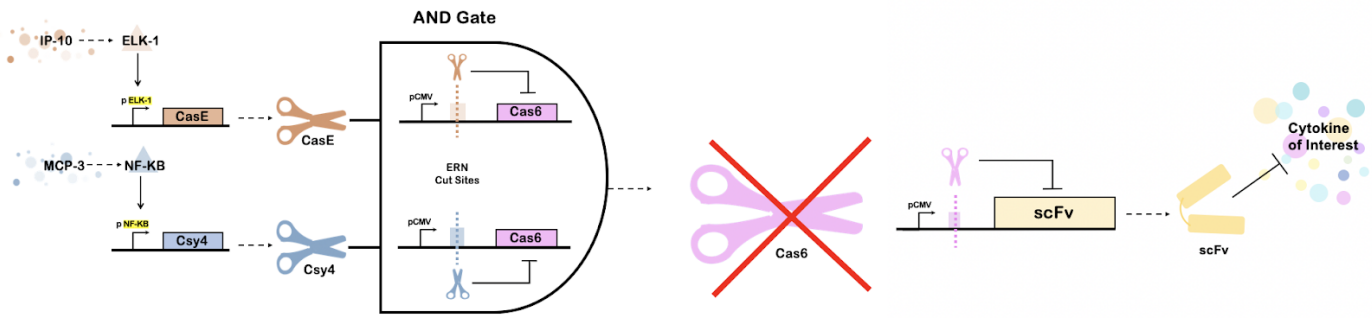
biology principles to build gene circuits, our system responds with an analog, or graded, output in order to differentially treat patients with varying levels of disease severity. Using an analog circuit allows the system to have a spectrum of responses which then can be tailored to the patient. The system can therefore sense the state of the system at a particular moment and decide on the best response.

Due to the pandemic resulting in limited laboratory access, this summer we have decided to pursue a completely computational project. We are working to realize this broad experimental system utilizing computational modeling of the immune system through a mechanistic, ODE-based model to inform the design of our sensor specifications, network topology, and tailored responses needed for treatment.

Our experimentation led to us recognizing particular targets of interest in COVID-19 immunopathology, which can inform future development of treatments.

In this project, we found ways to analyze SARS-CoV-2's unique cytokine signature, as well as pave the way to understanding other similar immune diseases. Our solution is unique in that it seeks to add complexity to solutions by changing an all-or-nothing switch-like response to a graded one that can access a broader range of situation-specific values.

Graphical Overview



With the detection of two inflammatory biomarkers in COVID-19, we have created a system that responds with the appropriate amount of anti-inflammatory protein, informed by computational analysis.

Past Projects and Accomplishments

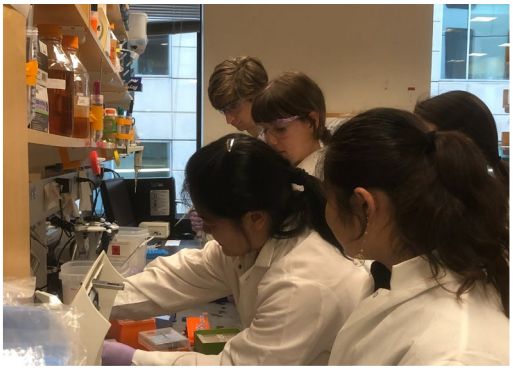
Year	Title
2019	The Perfect Swarm: Directed Migration of Neutrophil-Like Cells through Engineered Chemokine Secretion (Gold Medal)
2018	Porting the ComCDE System of *Streptococcus mutans* into HEK Cells as a Potential Caries Treatment (Bronze Medal)
2017	Splice and Dice: Artificial Control of Alternative Splicing via RNA Binding Proteins (Bronze Medal)
2016	A Genetic Circuit to Detect Endometriosis (Gold Medal, Nominated for Best Poster, Nominated for Best Part Collection)
2015	Population Control in Synthetic Microbial Co-cultures for Consolidated Bioprocessing (Bronze Medal)
2014	The Diagnosis and Treatment of Alzheimer's Disease (Gold Medal)
2013	Exosome Mediated Mammalian Cell-Cell Communication (Silver Medal)
2012	RNA Strand Displacement for Sensing, Information Processing, and Actuation in Mammalian Cells (Gold Medal)
2011	Programmable Mammalian Tissue Engineering (Best Health and Medicine Project, Gold Medal, Finalist)

In addition to a successful track record of iGEM projects, the MIT iGEM program is also proud to be distinguished by the success of its alumni. Of the dozens of MIT iGEM alumni since 2010, many of them have continued to pursue opportunities within the sciences in industrial, academic, and governmental settings.

Alumni

Alumni have researched at, interned with, and matriculated to:

- Max Planck Institute of Cell Biology and Genetics
- Broad Institute of MIT and Harvard
- MIT Dept. of Biological Engineering
- Merck Pharmaceuticals
- Alexion Pharmaceuticals
- Gingko Bioworks
- Genentech
- McKinsey and Company
- United States Senate
- Amazon Inc.
- TU Dresnen
- University of Washington
- Yale
- Stanford
- NASA
- Boston University
- TwitchTV
- Stony Brook University
- edX
- Cleveland Clinic
- Genzyme
- Massachusetts General Hospital
- Johns Hopkins University
- Harvard University
- University of Wisconsin



Many alumni graduated from MIT and are going to PhD programs, including Harvard Systems Biology and Stanford Biophysics.

Alumni have also gone on to win prestigious awards:

- Amgen Scholars
- Rhodes Summer Scholarship
- Thiel 20 Under 20 Fellows

Beyond the Competition

MIT iGEM projects have always been expanded upon after the competition ends in November. These projects have served as preliminary investigations leading to expanded research opportunities for undergraduates to work together with graduate students and post-doctoral fellows to delve into new fields.

The accomplishments of these student teams often lead to significant advances in medicine, energy, and the environment.

Examples of iGEM projects which have translated into Weiss Lab research in prior years include:

- RNAi-based cancer therapy, where viral vectors insert DNA that perform logic to determine whether a cell is cancerous by measuring mRNA levels of genes that are markers for cancer.
- Bacterial-based microbe "sense and destroy" antibiotic therapy, where bacteria can detect the quorum sensing of other virulent bacteria and release toxic proteins to kill them.
- Cell-based therapy involving the programmed differentiation of stem cells into insulin-producing pancreatic cells

All these projects were originally pioneered by iGEM teams and several have led to publications, patents, and potential therapeutic applications.

Student Team Members

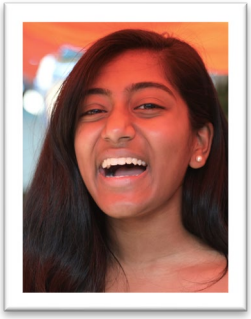
Erin Kim is a rising sophomore at Phillips Academy interested in biological engineering. While researching several treatments for burn patients last summer, she became fascinated by synthetic biology. This year, she joined iGEM to meet others who are equally passionate about synbio, and she looks forward to collaborating with her team and honing her research skills. Erin is currently a volunteer at the Massachusetts General Hospital and the founder of the Phillips Academy branch of Team HBV, a non-profit organization striving to end Hepatitis B and liver cancer. She is also actively involved as the board member of her school's science club and is a writer and illustrator for her school newspaper. Some of her other passions include classics, singing, the climate movement, volleyball, and women's empowerment.

Stuti Khandwala is a rising sophomore at MIT. She was born and brought up in India and competed in the International Biology Olympiad, her interest in biological and medical sciences stemming from that. She finds synthetic biology extremely powerful in its potential to cure diseases, and hence the interest in this year's iGEM. On campus she is a part of some teaching communities, and also works on traditional RNA structure research alongside being a part of MIT's Model United Nation chapter, MIT's newspaper the Tech, the BioMakerSpace and MIT BrainTrust for brain injury buddies.

Ethan Levy is an incoming freshman at Johns Hopkins University studying biomedical engineering. After years of science fair experiments on heart disease treatments, he joined iGEM as an opportunity to learn and contribute more to the medical field in the future. Interested in bioengineering and synthetic biology, he hopes to explore the unanswered questions of biology. Inspired by medical drawings, he enjoys combining bioengineering with graphic design. Outside of research he is usually found taking long walks (often on the beach) or playing strategy video games. Lastly, he enjoys volunteering at his local nursing home, where he does pet therapy for the residents with his dog, Choco.

Rachel Shen is a rising junior at MIT majoring in biology and minoring in Earth and Planetary Sciences. At MIT, she helped research 3-D printing of live plant cells in the Velasquez-Garcia lab and how oxygen gradients affect gene expression on ocean bacteria in the Babbin Lab. She is an officer of the Huang-Hobbs Biomakerspace and is working on a group project to create a microfluidic chip to study how salt gradients affect the rhizosphere. She joined iGEM motivated to learn how to use synthetic biology as an even more powerful tool to understand biological systems. Outside of science, she is the vice president of her dorm, Random Hall, where she spends a lot of time playing D&D with her friends.

Erin Shin is a 2023, majoring in Course 6-9 Computer Science & Brain and Cognitive Science. She is interested in computational and interdisciplinary approaches to biology, and she joined the MIT iGEM 2020 Team to further explore the field of synthetic biology. In other spheres at MIT, Erin is involved in music as an Emerson Scholar for private study in cello, a member of MIT's Chamber Music Society, and the Reading Director of MIT's first cello club, CelloWorld. She is also a part of the Sport Taekwondo Team, Concourse Learning Community, and serves on the exec board of the MIT BioMakerSpace.



Sangita Vasikaran is a member of the MIT Class of 2023 majoring in Bioengineering and minoring in Design. Originally a science fair kid from Dallas, Sangita joined iGEM to be a part a global community of doers, as well as to ideate freely with students like herself. She is intrigued by the intersection of biotech and the human experience–be it through nature-inspired materials and art, the future of food, or bioethics. Sangita is an EMT with MIT EMS, helps organize the Huang-Hobbs BioMakerSpace student group, works on the Infinite Fashion Magazine, and loves to cook (currently pursuing breads from across the world!).

*Former Members: Diani Jones, Dana Osei

Instructors and Advisors

Ron Weiss is one of the pioneers of synthetic biology. He has been engaged in synthetic biology research since 1996 when he was a graduate student at MIT and where he helped set up a wet-lab in the Electrical Engineering and Computer Science Department. After completion of his PhD, Weiss joined the faculty at Princeton University, and recently returned to MIT to take on a tenured faculty position in the Department of Biological Engineering and the Department of Electrical Engineering and Computer Science.

Deepak Mishra is a NSF Graduate Fellow in MIT Biological Engineering and a Ph.D. student in Ron Weiss' Synthetic Biology Group. Prior to MIT, Deepak earned a B.Sc. in chemical engineering with a biomolecular engineering emphasis at Caltech. Deepak enjoys teaching immensely and has been involved in teaching 3 undergraduate/graduate academic courses, mentored 46 students across 3 iGEM teams to date, and directly supervised several master's thesis students and undergraduate researchers. His research interests lie in the use of protein-protein interactions within synthetic biology both alone and in concert with other regulatory modalities for sophisticated circuit design.

Ben Allsup is a first-year graduate student studying Biological Engineering at MIT. He completed his undergraduate studying Biomedical Engineering and Biology at the University of Texas at Dallas (UTD). There, he worked as an undergraduate researcher and Green Fellow investigating potential gene-based therapeutics for autoimmune disorders and characterizing novel immune checkpoint blockade inhibitors for use in cancer treatments. At UTD, Ben was involved in several educational outreach initiatives through his roles as the president of the university's Biomedical Engineering Society chapter, a peer tutor, and a volunteer with Engineering World Health.

Malik George is a rising junior at MIT majoring in Biological Engineering and planning to minor in Africa and African Diaspora Studies. In high school, he worked with and bred zebrafish, fruit flies, and mice in to learn about conditioning and its effect on behavior. He is interested in the relationship between an organism's genetic makeup and its resulting phenotype. Malik was eager to be a part of the 2019 iGEM team and is excited to mentor the 2020 iGEM team, where he can both learn and teach molecular and synthetic biology and communication skills. Besides iGEM, he is a member of The Standard, the Black Student's Union, and Nu Delta fraternity. He enjoys playing a wide variety of games with his friends as well as discussing superhero movies and lore.

Miles George is a rising junior at MIT studying Biological Engineering and minoring in African and African Diaspora Studies. He was enrolled in his high school science research course for 3 years, focusing on a different biological model organism each year. His junior year mouse study was an extensive epigenetic and behavioral study. Doing research contributed much to his dream of being a biological engineer in a research lab. One of his goals is to spread scientific awareness to the world. He joined the iGEM team as a freshman to learn more about the field of synthetic biology. His hobbies include deceitful board games, trivia, and tennis. He is also a part of the Nu Delta fraternity, The Black Students' Union, and The Standard.

Kristina Stoyanova is a sophomore at Caltech studying computer science and biology. She joined iGEM fascinated by synthetic biology, the wet lab, and cloning. After she discovered biological simulations, she became interested in working on computational biology models. Outside of the lab, you can find her watching Avatar the Last Airbender with friends or voice acting in animations.

Melody Wu is a rising junior majoring in Biological Engineering and minoring in design at MIT. In 2016, she participated in iGEM as project manager of her high school team, Alverno, researching methods to reduce the effects of supercoiling in multi-genetic bacterial circuits. At MIT, she works in the Housman lab identifying genetic modifiers for Huntington's. She joined MIT's 2019 iGEM team because it was a valuable learning experience in 2016. She now is an After iGEM 2020 North America Ambassador. Outside of the lab, she enjoys creating art to visually explain the jargon of science (but also just for fun) and trying new foods from around the world. She loves thinking about global sustainability and development as part of MIT's living-learning community iHouse.

Finance Information

Basic Needs

We would benefit greatly from your sponsorship! Sponsoring the MIT iGEM team will benefit the educational experience of the students on the team. With proper resources, the team's research can directly lead to a wide variety of useful industrial applications, such as future medical therapies or drug discoveries. Sponsorship may include direct funding, discounts, or products.

Sponsor Benefits (work it more so it parallels first section)

Sponsors would also benefit from supporting us! The benefits of sponsorship are numerous. Sponsors will have a chance to support one of the most successful teams in the iGEM competition and receive attention at the world's largest synthetic biology competition. Sponsors will be able to access undergraduate talent and receive exposure through the MIT iGEM team's social media, website, and t-shirts. In addition, sponsors will receive a private project presentation and present themselves to our team since many of our alumni go on to work for biotechnology companies or in health-related fields after iGEM. This also puts sponsors in a prime position to evaluate and recruit top undergraduates after graduation.

Estimated Budget (itemize this more and talk about each item)

Item	Cost
Registration Fees	$5,000
Undergraduate Summer Stipends (4 unpaid students * $6240)	$24,960
Total	**$29,960**

Prior Partners

Social Media

The general iGEM website can be found at:
https://igem.org

Our public team website can be found at:
https://2020.igem.org/Team:MIT

https://www.instagram.com/igem_mit/

mitigem2020@gmail.com