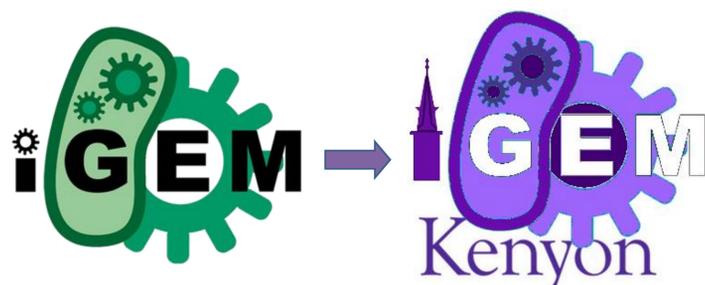


International Genetically Engineered Machine (iGEM) Competition for the Liberal Arts

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Professor Chun and Professor Elkins

INTRODUCTION



“Can simple biological systems be built from standard, interchangeable parts and operated in living cells? Or is biology simply too complicated to be engineered this way?” (*Wissenschaft*)

The iGEM foundation started in 2004 at the Massachusetts Institute of Technology. Based on a project developed by an undergraduate class in 2003, iGEM is a competition in synthetic biology for undergraduate students, and is now expanding to high schools. The independent, non-profit organization is dedicated to the advancement of an emerging discipline in the sciences called synthetic biology.

Synthetic Biology aims to redesign systems at a genetic level to solve molecular engineering-related problems. Instead of modifying the genes of an organism to discover how it works, synthetic biology removes, repackages, and reorders genes to be inserted into bacteria to create/modify functions within the organism. Although based in molecular genetics, the beauty of synthetic biology is that it encompasses many fields: physics, computer scientists, engineers, biotechnologists, mathematicians, and market scientists are all welcome and encouraged to join in on the exciting and rapidly expanding new field.

Collaboration

“Better tools, faster research.” *Benchling, iGEM 2012*

Throughout history, revolutionary science has been done predominantly by privileged individuals. From the discovery of the double helix, to individual proteins or viruses, there was a lot of emphasis on becoming the sole researcher of discipline-changing discoveries. iGEM prides itself on collaborative, open-source work between students of all disciplines and backgrounds.

iGEM provides each team with a kit of DNA *BioBricks*, and deliveries for specially requested parts. *BioBricks* are a standard of interchangeable parts such as DNA coding sequences that offer unique functionality for whatever problems the team wants to solve. Each team is also given access to an open-source Registry of Standard Biological Parts, that the team itself builds upon after the project is completed. This enables collaborative projects that allow students to work on projects that they really care about.

Entrepreneurship

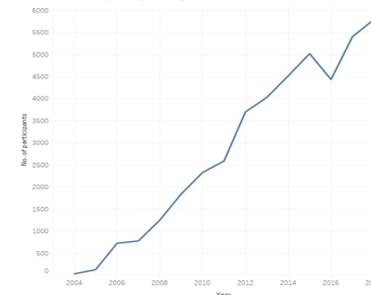
iGEM inherently promotes real-world company development, allowing bright students with revolutionary ideas to build something truly incredible. iGEM currently lists 32 start-ups created by students that have taken off since their conception during the iGEM competition. Some earning millions of dollars from grants and investors.

Ginko Bioworks, a company that originated from MIT's 2004 iGEM team and founded 2008, received a \$45,000,000 in start-up funding on top of the \$9,000,000 that the company had already received only years before. Benchling, a software company focused on life science collaborative research through cloud based software tools, received about \$5,000,000 from San Francisco venture capital firm Andreessen Horowitz, and it's completely free to use.

iGEM OVER THE YEARS

After launching in 2004, iGEM only had 5 teams, a total of 31 participants, within the United States working to engineer molecular solutions to a variety of problems. By 2017, there were 310 teams made up of 5,400 participants. The popularity of the competition is obvious, and it is not slowing down anytime soon.

Number of iGEM participants by Year



Today



For the iGEM 2019 Competition season, there are already 291 registered teams from 47 different countries, and the deadline is still a month away at the time of writing.

A Kenyon iGEM team wouldn't be an oddity. There are multiple smaller liberal arts colleges that have already participated in the competition over the years, joining the ranks of the more esteemed schools with liberal arts traditions



EASE OF USE

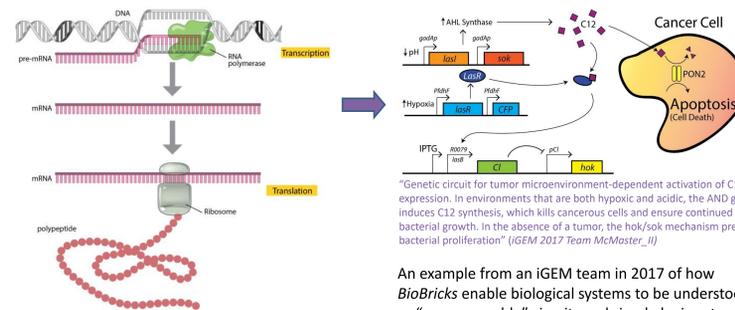
The DNA *BioBricks* included in the iGEM kit are essentially DNA Legos. *BioBricks* can be linked together which allows DNA to “programmed” using biological pieces. All of the designed parts can serve different functions, and all of these parts, including ones being made today, are available for everyone for free. Synthetic biology provides the culture and tools of traditional engineering allowing for endless biological possibilities.

When generating a new strand of DNA, the main components for each DNA sequence require the following:

Promoters: Snippet of DNA where RNA Polymerase (RNAP) binds to start transcription.

Terminators: Sequences of DNA that signal RNAP to stop transcribing.

Ribosome binding sites (RBS): Sites on the RNA where ribosomes attach to the RNA. Once attached, the ribosomes begin to translate mRNA into the desired protein.



Clancy, S. & Brown, W. (2008) Translation: DNA to mRNA to Protein. *Nature Education* 1(1):101

An example from an iGEM team in 2017 of how *BioBricks* enable biological systems to be understood as “programmable” circuits and simple logic gates which uses similar dynamic modeling mathematics used in electrical engineering.

Part Palette Application

A mobile application called *Part Palette* allows iGEM competitors to plan genetic circuits using parts from the Registry. You can select parts, and wrap them together on the palette for a desired function. If there are any incompatible parts, or if any of the key elements above are mission, the user will receive an error that will help them figure out where they went wrong.

KENYON iGEM TO-DO LIST

Building a team

1. Team PI

Each team needs a PI to support the teams goals, resources, and responsibilities. Kenyon faculty are some of the most diverse you can find on a college campus ranging from Humanities to STEM. Included below is a list of Kenyon disciplines that would be a great fit for a place on an iGEM team.

Biochemistry	Psychology
Chemistry	Biology
Mathematics	Computational Genomics
Physics	Scientific Computing

2. Team Name

Every team has a name. Brief and descriptive, the team name should indicate the school, city, state, and country. Your team name is your team identity, and will be attached to all records of your project.

3. Team Type

As a liberal arts intuition, the team will register as a *Collegiate* team.

4. Team Information: Affiliation and Location

Includes school name, city, state, country, and school URL.

5. Shipping Information

Every team is given materials for the competition, such as the DNA distribution kit and part requests, delivered straight to their door.

6. Team Fee Payment

All teams must pay a team fee, which pays for the associated materials, support, a presentation slot at the Giant Jamboree, and one poster location. Team fees for iGEM 2019 are:

Regular registration: **\$5,000 USD**

Late registration: **\$5,500 USD**

Late registration: **\$6,000 USD**

Multiple team discount: **\$1,000 USD**

An idea to change the world

Once a team has been assembled, the next task is to brainstorm ideas for the project. Included below is a list of diverse projects that have been built from a variety of institutions.

University of Toronto, (Canada) *iGEM 2007*

This team built a bacteria neural network with two key types of cells. One cell would detect a red light, sending messages to other type which would then emit a flash of blue light with the same duration and intensity, making the start of a bacteria computer.

University of Pavia, (Italy) *iGEM 2009*

The team from University of Pavia inserted genes into bacteria that would allow it to use novel enzymes to convert lactose in milk into ethanol for use in alternative biofuels to one-day replace fossil.

Mingdao University, (Taiwan) *iGEM 2018*

My personal favorite, students at Mingdao University genetically engineered mosquitoes to fluoresce green in the presence of healthy, non HIV-infected blood. In the presence of HIV, the mosquito will fluoresce initially, but quickly. The project is designed to eliminate the need for electricity, expensive medical equipment, and professional oversight when conducting these tests in less-advantaged communities.

OUTLOOK

With the necessary preparation, Kenyon College can be apart of the iGEM Competition as early as the spring season of 2020. Kenyon already stands out as an accredited liberal arts institution, offering a higher education that is unparalleled. In a unique position, Kenyon has the ability to stand-out among smaller private schools as a technologically forward institution. With iGEM's emphasis on collaboration, Kenyon students from all seriocomic and academic backgrounds can work together to produce a project that has the potential to put Kenyon on the map of true academic innovation.

SOURCES

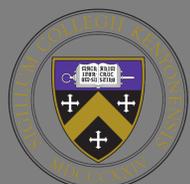
Information regarding iGEM teams and statistics come from <https://igem.org>

Figures were generated using Tableau data visualization software.

Wissenschaft. “The International Genetically Engineered Machines Competition.” *Blogspot* (blog). May 2, 2018. <http://lightsabre87.blogspot.com/2008/09/international-genetically-engineered.html>.

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Kenyon College