CREATIVE COMMONS

Synthetic Biology, Brick by Brick

by Chris Thompson

When my AP biology teacher, Mr. Rihm, first mentioned iGEM, I actually thought he was talking about a new Apple product. Then he explained that iGEM stands for International Genetically Engineered Machines, a competition that combines engineering principles with biology. Those are my two favorite subjects, so that was all I needed to hear. Three of my friends, Austin Frazier, Brent Poling, and Lucas Ruff, and I decided to start a team.

As interested as we were in iGEM, we had no idea of what it actually involved. We started by going to an information session at our school, where our teachers tried to explain what we would have to do. Because our teachers had never participated in iGEM, either—largely because the contest has been geared to college students—their attempts at explanation just increased our confusion. Finally, they sent us out to do some research and to brainstorm possible projects. For inspiration, we looked at projects that other iGEM teams had done in the past.

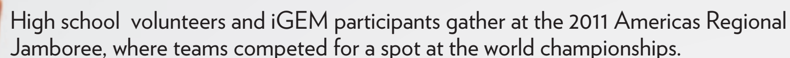
Wanted: High School Synthetic Biologists

iGEM began in 2003 as a month-long course at MIT. In 2004, it became a summer competition, and five college teams participated. The contest has grown steadily over the years, with 165 teams from around the world participating in the 2011 competition.

High school students can and do participate in the main iGEM competition. Gaston Day School in North Carolina, for example, competes with a team of all high school students; other teams, such as the one at UC San Francisco, have allowed high school students to participate.

In 2011, the iGEM High School Division started with five teams from Indiana. More than 20 teams—including teams from Turkey and Canada—will participate in this year's contest. If you'd like to start an iGEM team, visit http://igem.org/High_School_Division and http://igem.org/Start_A_Team. If you'd like to join a team, contact existing teams near you to see if there's an opportunity for you to participate: http://igem.org/Team_List?year=2011.

Learn more about iGEM at http://igem.org.



High school volunteers and iGEM participants gather at the 2011 Americas Regional Jamboree, where teams competed for a spot at the world championships.

Because of scheduling problems and a steep learning curve, it took us a few weeks to understand how iGEM works. At iGEM.org, there is a database of genetic "parts," DNA sequences that make cells do different things, such as give off light or even a scent. The goal of iGEM is to use this registry of parts to create a biological system. It's like using a tub of Lego bricks to build a car or building, but the parts have to be arranged in a certain order, much like a circuit. The sequence starts with a promoter, which controls whether genes are switched on or off. After the promoter comes the translational region, which codes for a specific protein. The terminator ends the sequence. All of these parts are inserted into a plasmid, a circular piece of DNA that can in turn be inserted into the DNA of another organism, such as *E. coli*, the most commonly used organism for iGEM.

Our Project

When we discussed what we wanted our bacterium to do, we considered creating an odor-producing bacterium, a bacterium that can test water for malaria, or one that tests water for toxic heavy metals. We did a lot of research—reading scientific papers, searching the iGEM registry, and doing old-fashioned Google searches—and learned about a promoter called CUP-1 that can detect the presence of copper and various other heavy metals. This promoter already exists naturally in yeast, so we decided to use yeast as our organism instead of *E. coli*.

Now we needed an indicator: something the yeast would produce to indicate the presence of heavy metals. Looking at projects from the previous year, we noticed that many teams used a fluorescent protein as an indicator. We found a red fluorescent protein in the iGEM registry that worked great with yeast, so we decided to use that. When we started looking for terminators, our teachers told us that we could use the terminator on the plasmid for our system, so we didn't need an extra one. We had all the parts; now we had to actually build our system.

In May, we started assembling our parts. This was the part we had signed up for—the lab work! Donning safety glasses, lab coats, and rubber gloves, we got to work. First, we extracted yeast DNA using ethanol, dish soap, and a centrifuge. This was a procedure we had heard of before but had not actually done, so it was a great learning experience. From the DNA, we then extracted the CUP-1 promoter and ran a gel electrophoresis test, which shows the base pair length of the part, so we could make sure that our part had the length identified with the CUP-1 promoter.

Getting the fluorescent protein was easier because, unlike CUP-1, another team had already extracted it and added it to the iGEM registry. All we had to do was order it. The sequence came in a standardized plasmid,

THINKSTOCK

Chris explains his team's project to a judge at the 2011 High School Division iGEM Jamboree.

called a BioBrick, which we easily cut open with restriction enzymes. Then, using a process known as the Gibson Method, in which you use primers to bind together multiple pieces of DNA, we fused the fluorescent protein and the CUP-1 promoter together. Then, using the Gibson Method again, we inserted the two parts into our plasmid.

To insert the plasmid into *E. coli* DNA, we used a method called cold shock: we set the *E. coli* into an ice bath for a period of time, then rapidly moved it into a warm water bath. The temperature shock causes *E. coli* to start a survival mechanism in which it takes up any DNA in its media—in this case, the DNA contained in our plasmid. Then, when the *E. coli* reproduced, it would create multiple copies of DNA containing our parts. Our plan was to then extract our parts from the *E. coli* and insert them into our final organism, yeast.

Now that might sound easy, but the whole process took us almost a month to complete—and we ran out of time to finish and test our biological system. Fortunately, not finishing or not creating a functional system doesn't mean you can't share your work at iGEM. So with no time to spare, we started working on our presentation and poster to compete in the iGEM competition.

The Finale

After three months of learning, researching, and working in the lab, we were ready to compete at the iGEM Jamboree, hosted at our school. The collegiate iGEM Jamboree is held at MIT, but the high school teams competed at our school because it cost less for all the teams. There are two parts to the Jamboree: a poster session and a presentation. For the former, we designed a scientific poster that outlined and explained our project. For the latter, we created a 20-minute presentation that explained our entire project from start to finish. At first this sounded like a long time, but we soon found out that fitting all of the information we learned into 20 minutes was really hard. We spent about two weeks preparing and polishing our poster and presentation, trying to make everything perfect for the competition.

As it turned out, because my team members all had scheduling conflicts, I was the only one from our team who could go to the competition. I was sweating bullets as the judges walked around during the poster session, inspecting our poster and asking me questions about how we came up with our project, how our project could be used as a consumer good, and how long we spent in the lab. The students from the other four schools looked just as nervous as I did, so I felt a little bit better. After about 30 minutes of that, the presentation session started.

As I sat through the other schools' presentations, I found it pretty exciting to learn about their projects. One team worked on sensing *Pseudomonas* in water, and another worked on an arsenic metal sensor. I realized that I would have to do a great job on my presentation if our team were to stand a chance of winning. I got up in the front of the room and gave the presentation I had rehearsed so many times. The judges seemed fairly impressed by what we did, nodding their heads in agreement and looking surprised when I explained that we did the wetlab in only three weeks. After the presentation, they asked even more questions about our project. I answered them as well as I could, but there were a few I didn't know the answer to. Regardless, they said that we did a great job.

I waited in the hallway with the other teams until the judges finished deciding the awards. When they called us back in, I was nearly shaking with anticipation as I waited for the announcement. And when it came, I couldn't believe it: Our team won Best Poster, Best Presentation, Best New Part, and Best Overall Project!

This year, the high school division has expanded, and more than 20 high schools around the world have shown interest in competing. Even here at Greenfield-Central, our team grew from four people to nineteen! We're still in the brainstorming phase of the process, but we are considering a project centered on galactosemia, a condition in which the body can't break down the sugar galactose. Whatever we choose, I know we're going to have a great year because we can build on all that we learned last year. I already can't wait until the next Jamboree! **i**

Chris Thompson is a senior at Greenfield-Central High School in Indiana, where he is captain of the tennis team and vice president of the senior class. In his free time, he likes to play video games, read, and hang out with friends. Next fall, he will attend Purdue University to study biological engineering.