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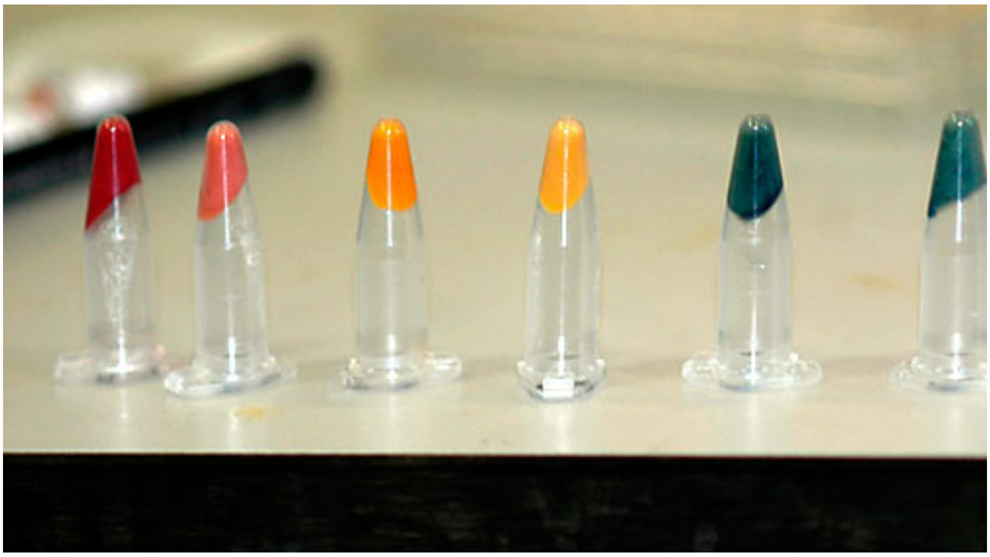
Building new life forms at the iGEM Jamboree

By Alexandra Daisy Ginsberg | 09 November 2009 | Categories: Technology



When you're faced with the entire living kingdom as a materials library, what do you design?

With this question in mind, I walked into the 2009 International Genetically Engineered Machines (iGEM) Jamboree, equipped with an aluminium briefcase full of multi-coloured poo. I was with fellow designer James King and the Cambridge University iGEM team: seven rainbow-haired undergraduates who spent their summer engineering a new kind of E.coli that secretes a palette of seven colours, christened E. chromi after a tense online vote.

Three days and 112 presentations of synthetic biological machines later, we found ourselves on stage, electrified, in front of 1,500 people in MIT's largest auditorium as we were presented with the grand prize, a giant milled-aluminium Lego block – the BioBrick – by the founders of synthetic biology.

iGEM, in its sixth year, is growing exponentially. Five teams took part in the first open competition in 2004, and this year 1,700 undergraduates in 112 teams from 26 different countries entered.

"This science is as good or better than at conferences," Tom Knight, one of synthetic biology's founders, told me over supper after the first day, as we swapped science fiction recommendations with the Cambridge professors (Knight's favourite, *The Space Merchants*, was in my suitcase). "There's an 11-year old entrant this year, but he's sick so can't make it," Knight said. In the end, the 11-year-old sent a video submission of his solo project, the BioBrick-A-Bot, "a Lego robot for automated BioBrick DNA assembly." While I was certainly using Lego at 11, I certainly wasn't using video, let alone persuading university authorities to let me enter genetic engineering competitions. How did we get here, and so fast?

The aim of the competition is to add to the Parts Registry, a squat, mundane-looking freezer quietly humming away upstairs in Knight's lab in the Gehry-designed Stata Centre. This is the only tangible artefact of all the invisible molecular science that happens during the three days of iGEM. The "parts" are interchangeable components of DNA – BioBricks – which the students use to design novel biological systems, inventing new BioBricks as necessary along the way. While the competition is an effective way of filling the freezer's drawers, it is also introducing more students (and universities) to this bright new field, a rebranding of genetic engineering that embraces the engineer's dream of simplicity. At Cambridge University, synthetic biology isn't even on the syllabus yet. And that's how I ended up in Knight's lab, having the door of the ice-filled Registry opened for me by Knight himself.

I first met plant scientist Jim Haseloff in April when I went to ask him about his work for a design project I was working on at the Royal College of Art. Jim – hugely open and innovative – runs iGEM at Cambridge and invited me and three other designers, to join the pre-iGEM crash course in synthetic biology. He was intrigued to see what might happen. I was picked on within the first few minutes: "So, who can define a gene? Daisy, can you?" Um... Since the team comprised two engineers, a physicist, three biochemists and one geneticist, we were all new to synthetic biology.

The first slide channelled engineer Theodore von Karman: "Scientists discover the world that exists; Engineers create the world that never was," setting the tone for two intense weeks of lectures and lab practicals to learn the key biology and tools. We ended with a Friday afternoon Dragon's Den of hastily-invented ideas presented to a panel loaded with Synbio Dollars. Back in the lab on Monday, the team's first question was, of course, "What should we design?" Soon, they leapt into designing an entirely new two-part system comprising a sensitivity tuner and seven pigments all derived from the natural kingdoms, an environmental sensor with easy-to-read visual output. Green fluorescent protein eat your heart out.

We visited at intervals during the summer, amazed at how comfortable the team had become in the wetlab, guided by the faculty and iGEM veteran, PhD candidate James Brown. And that's what's so extraordinary about the whole process. In ten weeks, the students have made a serious contribution to cutting-edge science, with the faculty embracing and enabling the imaginations of the next generation of scientists. These students, unaware of the implications when they applied to join, are helping to build the field. Minutes after presenting at the Jamboree, scientists from leading labs were requesting the colour parts the undergrads had designed, Jim proudly told us.

The Cambridge team (from top): Shuna Gould, Siming Ma, Alan Walbridge, Megan Stanley, Mike Davies, Crispian Wilson, James Brown (principal advisor) and Vivian Mullin

Over the first two days of the Jamboree, mixed teams of engineers, physicists, mathematicians and computer science undergrads (with the occasional biologist) stand up in front of huge audiences and panels of judges to present their inventions, designed and built over the summer, some fully working, many not, but still mind-blowing in concept. In the breaks, they nibble Halloween-themed iced cookies and mingle with world-famous scientists, the FBI (this year's sponsors), a nice chap from the UN handing out badges but probably keeping an eye out for the next generation of synthetic biologists, chief executives of biotech companies, the 50 judges from around the world, social scientists and DIYbio groupies.

As I sit through sessions as diverse as terraforming Mars (Tokyo Tech, engineering iron-oxidising bacteria, adding melanin to tan them and darken the planet, initiating the melting of Martian ice caps while inserting protective antifreeze proteins) or Berkeley's robot-powered generation of more than 800 new parts for their alternative registry, I'm in awe. Valencia designed a bio-screen of electrically light-activated bacteria (the world's first biological 'LCD' screen), Harvard managed inter-species communication between bacteria and yeast using light and Slovenia proved Drew Endy right: synthetic biology is nanotechnology that works.

There are niggles, too, which makes it all the more juicy, as we get glimpses of the hidden agendas in a new field of science. The spirit of the competition is open source, so the overflowing auditorium gasps when the Slovenia team, last year's grand-prize winners, reveal that they have filed three patents. The commercial aspect can't be ignored: entering iGEM is an expensive undertaking, and sponsorship drives the process. Support ranges from promotional T-shirts at the Jamboree to big biotech firms providing free gene synthesis and loans of high-end equipment. And then there's the difficulty of separating the work of the labs from the work of the students, which several judges tell me is one of their most difficult tasks.

Questions aside, iGEM is changing science. Students, whether or not they continue in synbio, are learning completely new ways of working. These multi-disciplinary, fast-paced projects that move from design to realisation over a summer are often their first taste of self-directed research. Design is an integral part of synthetic biology, which is why it was so exciting to see design and art making their first iGEM appearance. Teams built their own DIY equipment – the MIT team couldn't afford two $6,000 LED boxes, so "we made them ourselves".

ArtScience Bangalore, winners of best presentation and my iGEM highlight, are a truly ground-breaking team of art students led by artist/designer Yashas Shetty. The team learnt biology with the help of India's National Centre For Biological Science, producing E. coli that smell of rain. They took synthetic biology to new groups, running workshops to teach designers to build working DIY microscopes using webcams and ran creative workshops at a school for the urban poor. This idea of "human practices" – that is, exploring the ethical and social implications of the technology – was a new focus this year, with Imperial College London and Paris sharing a prize for their substantial surveys.

As for the suitcase full of poo, that was our contribution to the Cambridge project. We infiltrated the competition as designers, helping the team to think outside the petri dish. Through a series of workshops, we considered human-scale applications for their molecular circuits and the long-term implications of their work. The poo – also known as the Scatalog – is one of our proposals inspired by the team's E. chromi: cheap personalised disease monitoring. After our guerrilla activity, we suspect that many teams will have designers in tow next year.

E.chromi was a popular win, truly in the spirit of iGEM. As Jim Haseloff reiterated as we recovered afterwards, eating burritos, "We just want to teach the students about synthetic biology." It is a beautiful, simple and elegantly designed system, thought up by the students and producing visible results, while adding useful new parts to the registry.

So how do the Cambridge team feel now, as they return to normal undergraduate life having presented scientific discoveries to the world? Shuna tells me, "I'd never thought of making biological systems before, of using genes in pathways for my own benefit, and the very 'engineer' way of looking at the devices and models. The experience was the most frustrating, exhausting, draining and amazing thing I've ever done."

I ask Mike if he would continue with synthetic biology, he thought about it and says, with absolute sincerity, "I hadn't considered it, but now, I have a responsibility to continue". I can't help but agree with them both. These students have been given a gift, the potential to design world-changing innovations. It has been amazing to be part of it.

Alexandra Daisy Ginsberg is a designer and researcher