Engineering ingenuity at iGEM

As an international competition that places a premium on creative thinking and the development of a research community of all ages, iGEM is helping synthetic biology grow.

Imagine a generic cure for viral infections, a ready supply of blood in the form of oxygenated bacteria, or cells with new organelles. Although these ideas may sound like science fiction, they represent just a few of the engineered offerings at the recent iGEM (International Genetically Engineered Machine Competition; http://www.igem.org). This international, interdisciplinary, primarily undergraduate competition utilizes synthetic biology as both a scientific goal and an educational tool. The event, which began in 2003, has grown from 16 students in a one-month design class to the recent meeting of 54 teams from 20 countries on November 3–4, 2007 at MIT in Cambridge, Massachusetts.

Like synthetic biology itself, iGEM grew out of an intersection of fields including engineering, molecular biology and computer science. Yet the problem-solving and competitive aspects of the event reflect the engineering mindset. As Randy Rettberg, a founder and current director of iGEM and the Registry of Standard Biological Parts (http://parts.mit.edu) explains, engineers do not necessarily want or need to understand something completely. Rather, he says, "Engineers like to build things, and they will build even if the story isn't quite right." This action-oriented approach is necessary for the fast-moving iGEM, where teams of undergraduates have less than one year to conceptualize, model and build a new biological system based on available biological 'parts'.

In discussing and selecting a particular project, the focus on undergraduates as team members means that "there's a lot less at risk in trying something out of the box," according to Tom Richard, a professor at Pennsylvania State University and president of the Institute of Biological Engineering. He adds, "That translates into students doing some really creative things that other people might not try." The experimental work kicks off in May, when each registered team receives the complete set of parts from the Registry. These biological units are genetic sequences encoding repressors, promoters, fluorescent proteins and other useful biological functions that can be easily mixed and matched like traditional electronic circuitry. Providing this extensive set of parts (~1,400 in 2007 and ~2,200 in 2008) brings down barriers to getting started in the lab. Rettberg suggests, "By sending the parts, the possibilities suddenly become tangible."

This entire process is documented in team wikis and culminates in a two-day 'jamboree' where students present their concepts and results, vie for prizes and, as Mingzhi Qu, who is studying ecology and evolutionary biology in Peking describes, share their passion for common scientific ideas. The emphasis on sharing, including newly made parts, is intentional; as Richard puts it, "iGEM is really trying to build a community so people can share professional support and personal contacts." Drew Endy, a biological engineering professor at MIT and one of the program founders, echoes this sentiment. In regards to a particular part that allowed the Melbourne team to create buoyant cells, he points out, "not only is that cool biology and a cool function that I can be excited about as a scientist or engineer, but because they made it a part, now everyone can go use it."

Ariel Lindner, an INSERM research scientist at Paris Descartes University's CRI, is an instructor for the team from Paris, which joined the competition for the first time this year. He reports that his team was driven to participate to "assess their capacities in an internationally competitive scale." With 22 new teams overall, the 2007 competition was organized into sessions according to focus; the Slovenian team, for example, won the prize in Health & Medicine for their project on combating viral function. The Paris project on developing multicellular bacterial systems took the prize in Foundational Research, while the Peking group, also newcomers, won both the Information Processing Prize and the Grand Prize for devising a new method for cells to count.

In addition to the potential for recognition, students from these teams emphasized that iGEM represents a unique opportunity for undergraduates in that young scientists and engineers are given significant responsibility in outlining and directing a research project. Indeed, Rok Gaber, who is studying microbiology in Slovenia, was excited to see a project from start to finish for the first time, and to find out "if an idea is just an idea or if it actually works." Students also appreciated the chance to work on all aspects of the project, even outside their primary disciplines; Lindner says of the Paris team that "in the last few weeks the *a priori* definitions melted and a coherent group emerged." Beyond the intellectual challenge of initiating a scientific project, many teams take advantage of the iGEM framework to address local environmental or health problems, such as detecting toxic metals or diagnosing infections via low-tech solutions amenable to rural applications.

"What can we do with a biological system? Or what can it do for us? When you're free to imagine, that's the exciting part about science." –Dan Lu

The importance of the program can also go beyond obvious scientific boundaries. Professor Roman Jerala, head of the biotechnology department at the National Institute of Chemistry and a faculty advisor to the team from the University of Ljubljana in Slovenia, recalls that the Ljubljana team won the Grand Prize in 2006 in the midst of concerns about the educational quality of Slovenian universities. Not only did this success provide support for the universities, but he adds, "We were pleased that science came into the focus of public attention and not just politics, sports and entertainment." However, Marko Dolinar, a professor in Chemistry and Chemical Technology at Ljubljana, cautions that attention to the field will also bring new challenges in terms of addressing ethical, legal and safety issues. Chen Daizhuo, who is studying physics in Peking, suspects these larger challenges are already at hand, given some of the difficulties the team members had in obtaining visas to travel to the jamboree.

In considering the future of synthetic biology and biotechnology, Endy highlights the importance of bringing the community together, saying "the scope of work is so much bigger than anything that one person can do." Dan Lu, who is studying theoretical biology in Peking, agrees that the potential of the field is enormous: "What can we do with a biological system? Or what can it do for us? When you're free to imagine, that's the exciting part about science." The collaboration and creativity of iGEM result in an important synergy between sharing data and sharing technical standards in the form of parts. No doubt the maturation of this communal vision, like the maturation of these emerging researchers, will bring exciting results for years to come.

Catherine Goodman, Cambridge, Massachusetts