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University of Cambridge team wins iGEM synthetic biology competition

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The team of undergraduates won the competition by engineering two biological parts that overcome limitations of current biosensor designs.

Seven undergraduates from the University of Cambridge have taken gold at the 2009 International Genetically Engineered Machine (iGEM) competition. The student team designed two biosensor parts to create a tunable biosensor that uses color as its output.

iGEM is a global synthetic biology competition that challenges undergraduates worldwide to build simple biological systems from a supplied kit of standard, interchangeable parts.

The Cambridge team focused on building a biosensor from their materials, since it recognized two limitations in current designs that they could address: the sensitivity of their promoters and the way they report their output. A biosensor is any integrated device capable of detecting a biological reaction or analyte and converting it into a signal that can be processed. A common example of a biosensor is the glucose monitoring device used by diabetes patients. Team Cambridge developed a signal transduction system that picks out a particular input, amplifies that signal internally to the cell using an input-sensitive promoter, and then produces a pigment output that is easy to see by eye or with a spectrometer.

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The team developed a way to tune a biosensor's sensitivity, allowing it to report meaningful concentrations of the inducer. The group also engineered pigment-producing operons into *E. coli* to enhance the output. Thesetwo parts would improve current biosensor designs by providing user-friendly output within a variable range suitable to the application.

If a biosensor only has an input-sensitive promoter, its output generally varies linearly with input. The Cambridge team placed different sensitivity tuners downstream of varying promoters, resulting in sigmoidal output with distinctive thresholds.

"The team characterized a set of amplifiers of varying sensitivities and gains," said Robert Carlson, an iGEM judge and Principal of a Seattle-based engineering and consulting firm, and "added a whole range of new colors to the palette available for future projects."

The color generators for output were created by mining bacterial genomes for pigment-producing operons, selecting the strongest candidates, and transforming them into *E. coli*. The resulting bacterial strains could produce red, orange, brown, violet, and green pigments. The team employed three different pigment systems: carotenoids for red and orange, melanin for brown, and violacein for violet and green. The team believes that this technology could be used at the bench, where the presence of a pollutant in a well, for example, would trigger a pigment change in bacteria. Beyond bacterial biosensors, the team imagined future applications including a multicolored biosensor for detecting changes in human GI tract microflora.

Color output of the Cambridge team's biosensor part.

iGEM has become the premier international undergraduate synthetic biology competition. Thirteen teams competed in 2005, 54 teams in 2007, and 112 teams this year. The competition began in 2003 when two MIT-based groups worked towards improving biological oscillators during their Independent Activity Periods. At the beginning of the summer, each team receives a kit of biological building blocks from MIT's Registry of Standard Biological Parts. Under the supervision of several advisors, each team of students build biological systems that operate in living cells from the biological parts that they received from the registry and that they design themselves.

This year, the National Science Foundation (NSF), Invitrogen, and the Federal Bureau of Investigation (FBI) were among those sponsoring over 1700 participants. Laboratory space, equipment, and expertise came from each team's institution and faculty members. The summer-long competition is organized by MIT and concludes with a weekend jamboree where the entries are judged and winners announced. This year's event was held between Oct. 31 and Nov. 2 on the MIT campus.

The research conducted by these undergraduates offers potential benefits for the future of biotechnology. Runners-up included a team from Valencia, Spain that demonstrated a circuit in yeast that converts external electrical systems into light. "We can't expect them to generate Nobel-quality projects," Carlson told *BioTechniques*, but results like these will "certainly be reused in both academia and industry."

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