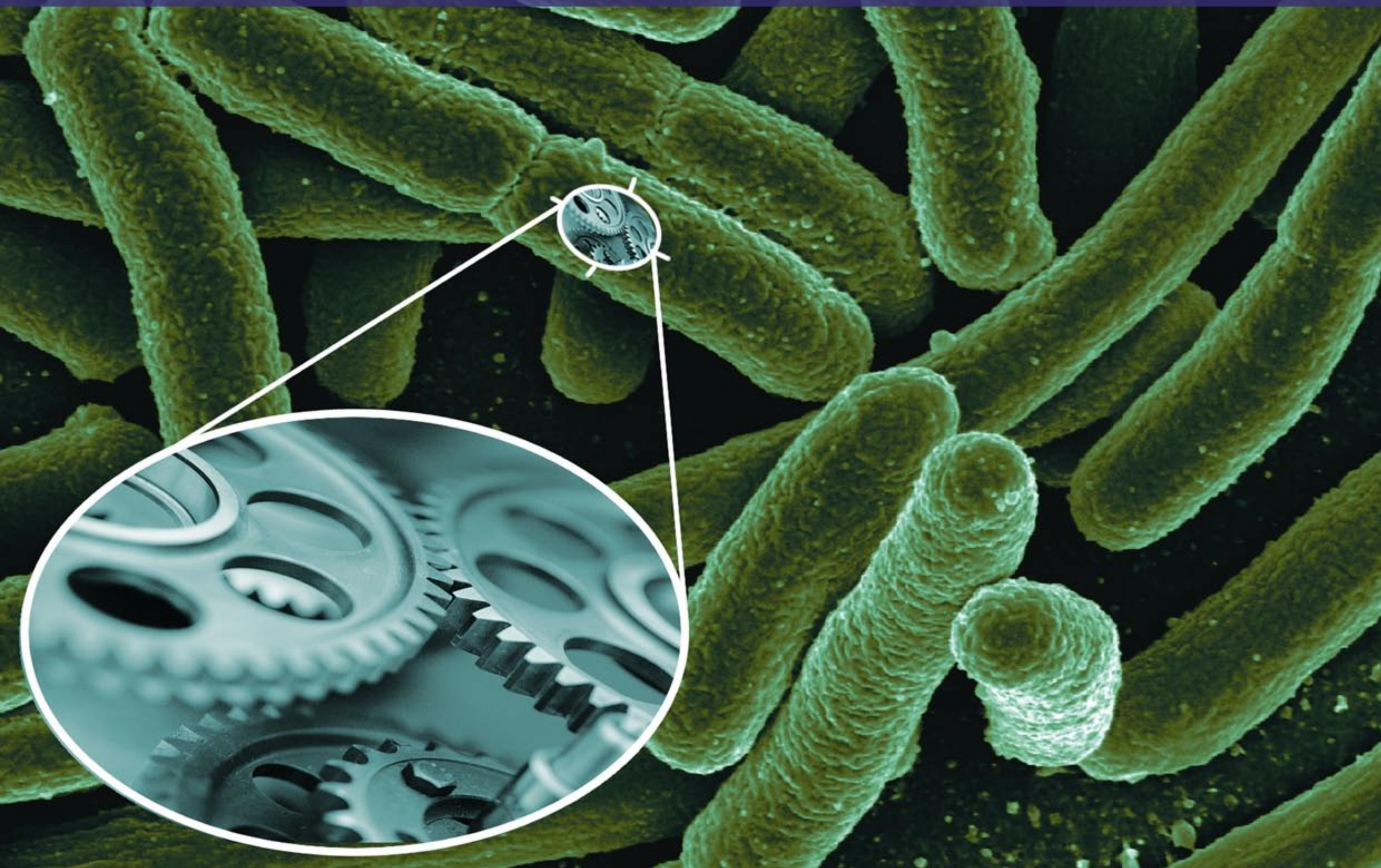
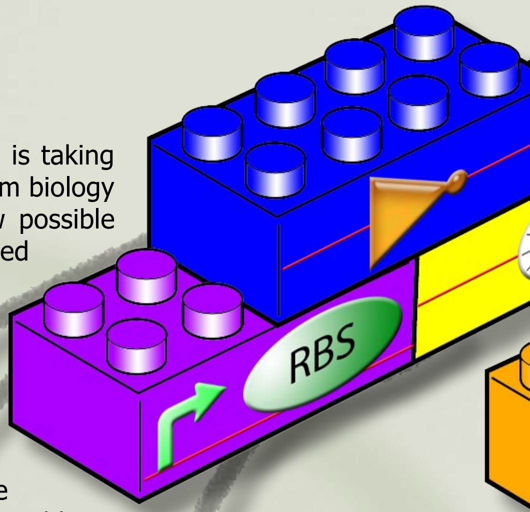
iGEM 2005

International Genetically Engineered Machine Competition

UNIVERSITY OF CAMBRIDGE

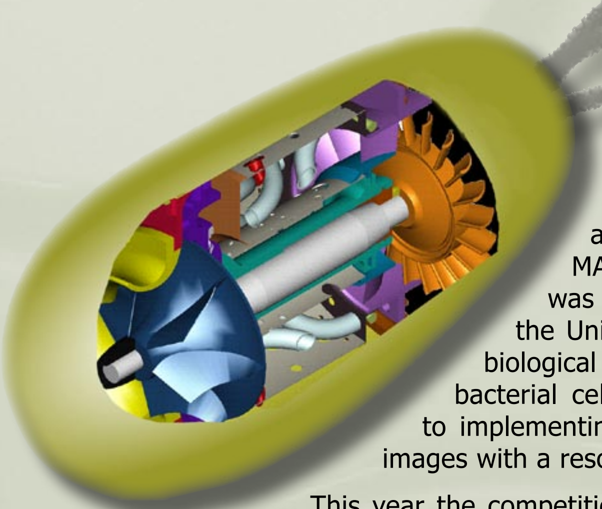


Engineering New Biological Systems

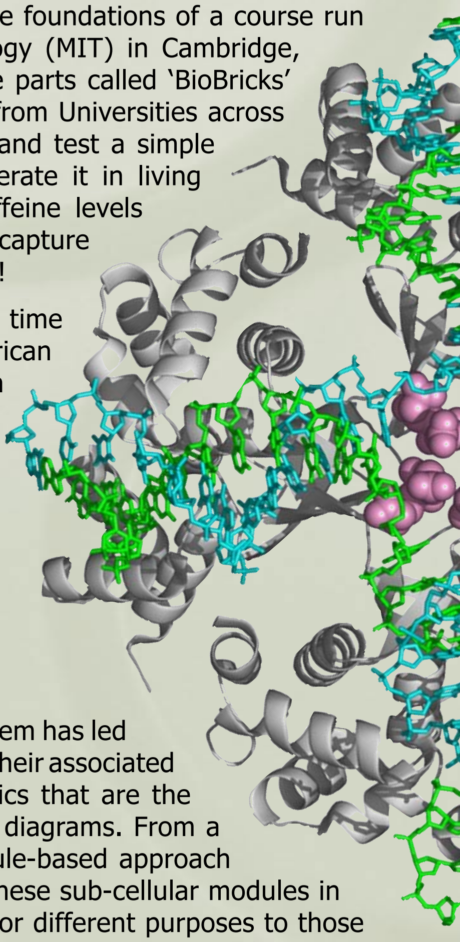


At the world's foremost centres of learning, a potentially revolutionary science is taking shape. The core idea of the field is that by drawing on knowledge developed from biology and applying principles used in engineering design and production, it is now possible to create bio-synthetic systems to achieve novel applications with unprecedented power and efficiency. This research could lead us to a greater understanding of how life functions, and how to use more effectively the very fabric from which it is created – DNA, proteins and cells. The possibilities of this technology are almost endless, and could have uses in many areas, such as health, energy, the environment or the development of new materials. This is 'Synthetic Biology'.

As the birthplace of molecular biology, and with one of the most respected and innovative engineering schools in the world, the University of Cambridge is one of the first centres to look at this new subject. We are host to several hundred world-class biologists, and recent developments have led to the establishment of the Cambridge Computational Biology Institute and the Engineering for the Life Sciences group in the Department of Engineering. There are very few environments more suited for such a subject.



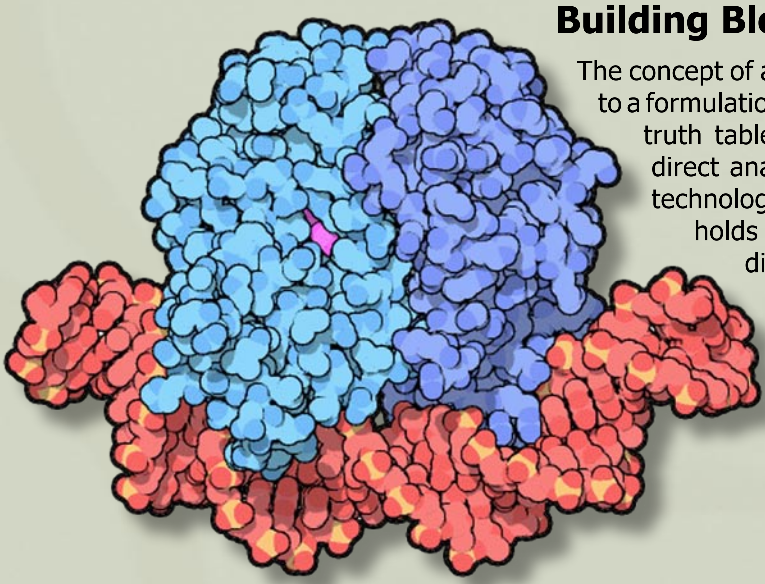
An International Competition for Bio-Engineering



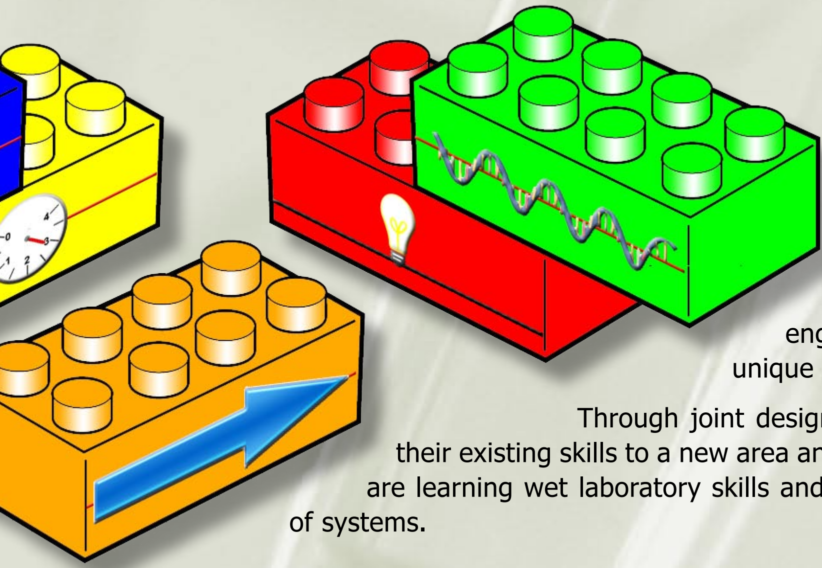
The intercollegiate Genetically Engineered Machine (iGEM) competition was introduced in 2004, and built upon the foundations of a course run at the Massachusetts Institute of Technology (MIT) in Cambridge, MA. A collection of standard interchangeable parts called 'BioBricks' was made available to five teams of students from Universities across the United States. The challenge was to design and test a simple biological system from these BioBricks, and to operate it in living bacterial cells. Designs ranged from detection of caffeine levels to implementing bacterial photographic film that could capture images with a resolution of up to 1 gigapixel per square inch!

This year the competition has greatly expanded and for the first time there are two teams from Europe, as well as a much wider range of American universities. The expansion of the competition is providing a focus on the sharing of experience and knowledge between institutes, as well as linking undergraduate and postgraduate studies. The culmination of the competition is the November jamboree at MIT, which is a unique opportunity for the students and supervisors to interact and present their results to the other competitors.

Building Blocks for Biology



The concept of an engineered BioBrick system has led to a formulation based on logic gates and their associated truth tables, with resulting schematics that are the direct analogue of electronic circuit diagrams. From a technological perspective, the module-based approach holds out the promise of using these sub-cellular modules in different combinations and for different purposes to those of natural systems. It suggests the long-term vision of developing a new area in which engineered components will be used as versatile building blocks (BioBricks) with standardised functionality and interface, to form technological systems not unlike those of VLSI electronics today.

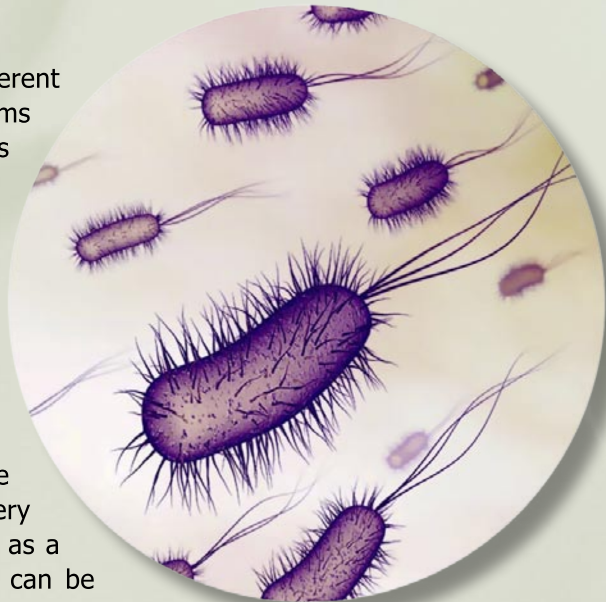


Unique Educational Opportunity

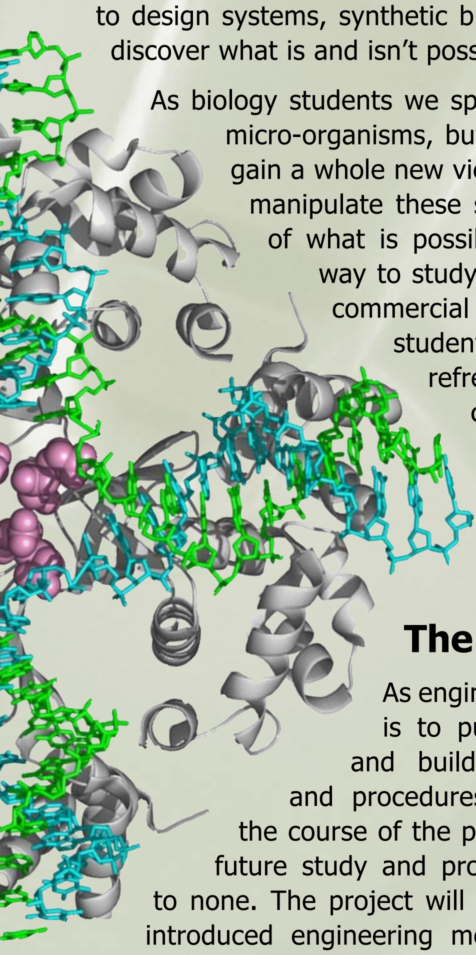
The distinctions between mathematicians, physicists, computer scientists and engineers are blurring all the time. Now biologists are entering into the equation too. This project, unusally, brings together talented students and supervisors from the life-sciences and engineering departments within the university, creating a unique learning environment for all involved.

Through joint design, model and build projects the students are applying their existing skills to a new area and also learning rapidly about other fields: the engineers are learning wet laboratory skills and the biologists are learning about numerical modelling of systems.

The Biologists' View

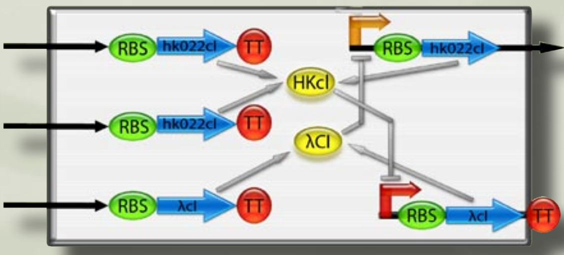


This field is extremely exciting for biologists as it is a completely different approach to normal research methods. By treating biological systems as a series of interlocking parts and using higher level approaches to design systems, synthetic biology presents a very quick way to discover what is and isn't possible in biological systems.

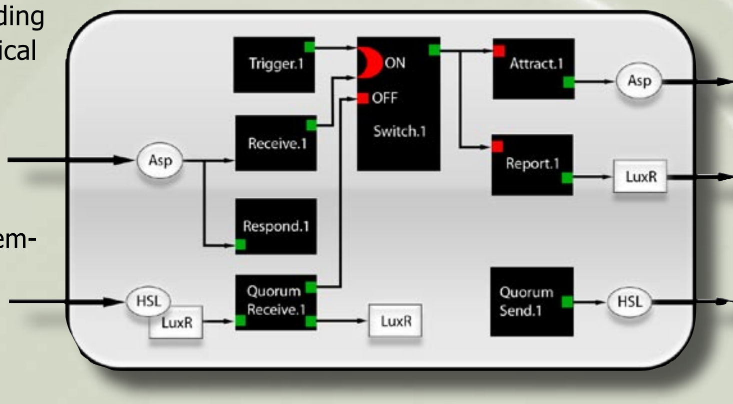


As biology students we spend a great deal of time studying micro-organisms, but by taking part in this project we gain a whole new viewpoint. By looking at how we can manipulate these systems, and by testing the limits of what is possible we can see a completely new way to study biology, and one with very obvious commercial applications. Working alongside students from a range of disciplines is very refreshing, the engineers view the 'bug' as a circuit, and anything we manipulate can be defined by its actions; inputs and outputs on a circuit diagram.

The Engineers' View



As engineers, the best way to learn about biology is to pursue our natural inclination to design and build; the biological wet-work techniques and procedures we'll familiarise ourselves with over the course of the project will no doubt prove invaluable for future study and provide practical experience that is second to none. The project will also build and expand on recently introduced engineering modules in bioscience, providing us with a wealth of information relevant to future biological engineering initiatives.



The opportunity to investigate design ideas, as well as model and test the team's entry will be really exciting and give us a chance to properly explore biology for, what is to many of us, the first time. Hopefully, our ability to problem-solve, analyse data and our mathematical and computing skills will lend many useful tools to the team.

Cambridge Team

The competition raised a great deal of interest from undergraduates and places on the team were substantially over-subscribed. A balanced number of engineers and life-scientists were selected and each team member is spending ten weeks of the summer on the project which will involve designing, testing and developing new parts and systems for the team's competition entry. The first two weeks consist of intensive seminars to prepare all team members with the necessary background knowledge.

The project is being housed in the teaching laboratory at the Department of Plant Sciences, which provides a large space for experiments, access to computers and appropriate equipment. There has been much interest in the competition from around the University, and we have an extended network of support for more specialised aspects of the work.

The team members are from the Departments of Engineering, Pathology, Plant Sciences, Genetics and the Cambridge Computational Biology Institute.

Undergraduates: James Brown, Russell Brown, Eva Cheng, Chris Field, James Godman, Alice Young

Post-doctoral Advisors: Dr. Eric Kerrigan, Dr. Duncan Rowe, Dr. Tony Southall

Faculty: Dr. Jim Ajioka, Dr. Jorge Goncalves, Dr. Jim Haseloff, Dr. Gos Micklem, Dr. Glenn Vinnicombe

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