

## SYNTHETIC BIOLOGY AND THE HIGH SCHOOL CURRICULUM: HOME

[http://openwetware.org/wiki/Synthetic\\_Biology\\_and\\_the\\_High\\_School\\_Curriculum](http://openwetware.org/wiki/Synthetic_Biology_and_the_High_School_Curriculum)



For the last decade teachers have introduced genetic engineering techniques to students. It is becoming commonplace for students in biology and AP Biology courses to conduct a standard set of "experiments" using gel electrophoresis and bacterial transformation techniques. Though they include important laboratory techniques, these experiments are limited in several ways, including the time available for students to perform the work,

non-trivial equipment needs and, most significantly, the limited range of experimental problems and teaching materials that are available. Consequently, almost all teachers conduct the same set of AP experiments every year using materials packaged by supply companies. Students who perform these experiments learn several basic techniques, but that is where the laboratory experience ends. There is little room for student inquiry or creativity. The students are more technicians than scientists.

### **What is Synthetic Biology?**

A solution to this problem comes not from biology but the relatively new field of Synthetic Biology. Synthetic biologists apply engineering principles and extend genetic engineering techniques to construct new genetic systems. The synthetic biology approach provides teachers and students with a means to learn molecular biology, genetic engineering and microbiology methods in an engineering setting. The students learn while designing, or testing designs of, engineered biological systems. In addition, this approach provides science teachers with a means of exploring numerous state and national technology standards that are hard to address in most science classes.

Like genetic engineering, synthetic biology makes use of techniques such as gel electrophoresis, polymerase chain reaction ("PCR"), restriction enzymes, and cloning. For decades now, these techniques have been used to transfer genes that exist in one organism into the genome of another, and most students are familiar with human insulin producing bacteria and genetically modified organism used for food. However, synthetic biologists are not limited to moving existing genes into existing genomes. By constructing new genetic systems, they have designed bacteria that can change color upon contacting toxins and produce a drug to fight malaria. While it would be impossible for AP Bio students to design bacteria like these, they can follow the work of the iGEM competition. This is an annual competition among synthetic biology undergraduates from around the world. Recently, MIT iGEM students have engineered bacteria that can smell like bananas and yogurt that can clean teeth. The banana-smelling bacteria are an inspiration for one of the labs in this program.

## Engineering and AP Biology

The engineering approach is based on two important principles: abstraction, and standardization, as well as numerous enabling technologies such as DNA synthesis. These principles and technologies provide biology teachers with a means to extend the teaching of molecular genetic techniques into real world, authentic applications. In the way that physics teachers can have students create functioning circuits and computer teachers can have students create 3-D animations, biology teachers can have students safely design, construct and analyze engineered biological systems. For example, teachers can order the materials and conduct bacterial transformations in which bacteria can smell like bananas or wintergreen.

Importantly, though, biology teachers can use these available materials to conduct engineering challenges with students. For example, existing devices can be altered to meet some new design criteria, and the differing designs and their results can be compared. Students gain first-hand experience with in the engineering paradigm: **Design-->Build-->Analyze**. Of course, since the engineering activities are performed in the context of living systems, the students will have to understand the underlying science. For instance, they will need to understand what a promoter and a ribosome binding site are and what a population growth curves is if they are to rationally design and measure them. Through synthetic biology, students can learn these concepts within an authentic context of engineering challenges. These tools of synthetic biology provide biology students with a means to be more than technicians; they can be engineers.

## The Synthetic Biology in AP Bio Unit



This teaching unit has been developed in conjunction with the BioBuilder website. BioBuilder.org provides educational animations for students and teachers to explore the underpinnings of synthetic biology. The curricula presented here consist of labs, an essay assignment, and links to teacher and student resources, including BioBuilder. The material is modular and can be taught completely, in any order, or as individual exercises to supplement an existing program. The pages have links at the bottom and on the side tool bar to allow for easy navigation within the unit. At the top of each page is a link to a PDF version that can be used as a handout or reading as needed.