A Novel Approach to Environmental Biosensors Using a Two-Step Genetic Circuit

Dhillon, Jakar (School: Bloomfield Hills High School)

By utilizing the principles of electrical engineering, biologists are pioneering new ways to construct logic circuits inside of cells in order to perform a variety of useful functions. In conventional environmental monitoring, samples collected from the environment are subjected to arduous chemical and physical analyses to determine the presence of toxic chemicals. Using genetic circuits, scientists are able to create logic systems to transform bacterium into sensors that can accurately report the toxicity and even type of contaminant in an environment. I predicted that the creation of an environmental biosensor using a two-step genetic circuit would be drastically more effective at sensing and even eliminating harmful chemicals such as arsenic and mercury. I proposed the use of a genetic circuit with the integration of OR and AND Boolean logic that is able to analyze input signals from the ArsR operon (for arsenic) and the MerR operon (for mercury) and result in a quantitative fluorescent output. The next step of the circuit is able to analyze the concentration of arsenic present and result in a sufficient production of S-adenosylmethionine, which is known to detoxify arsenic through biomethylation pathways. In order to design the circuit, programs such as CelloCAD and Visual DSD were used to computationally build the circuit and obtain the corresponding DNA plasmid sequence. These programs were also utilized to simulate the results of both steps of the circuit. The first step of the circuit was able to produce a sufficient amount of fluorescent protein in the presence of either arsenic or mercury in simulations, as expected. The second step was able to produce S-adenosylmethionine in the presence of both arsenic and fluorescent protein in simulations, as expected.