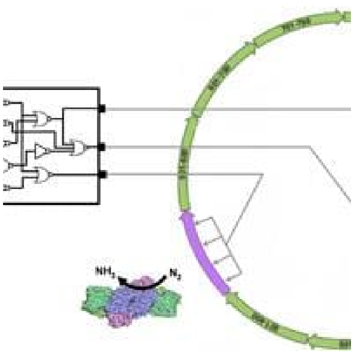
Systems Bioengineering

Analog Synthetic Biology and Systems Biology


Graphic: Christine Daniloff

Circuits in cell biology and circuits in electronics may be viewed as being highly similar with biology using molecules, ions, proteins, and DNA rather than electrons and transistors. This project exploits the astoundingly detailed similarity between the equations of chemistry and the equations of subthreshold analog electronics to attempt to create large-scale nonlinear dynamical systems that mimic the sensing, actuation, and control systems of biological cells at ultra-fast time scales including their stochastic properties. This project has applications in both systems biology, which aims at an engineering understanding of molecular networks within the cell and in synthetic biology, where it can help solve several bottlenecks in its design, analysis, robustness, and scalability via rigorous analog circuit techniques. Work in this project involves the design and testing of molecular circuits in bacteria and yeast, the design and testing of analog microelectronic chips useful for ultra-fast simulations of molecular and cellular systems, and the creation of analog circuit models of molecular networks.

Genetic Circuits



To build genetic programs, circuits need to be encoded in DNA. These so-called genetic circuits use biochemical interactions to implement functions that are analogous to electronic circuits, such as logic gates and oscillators. We are developing genetic circuits that encode new functions as well as methods to optimize their performance features. A significant challenge is the reliable connection of circuits to form programs. Computational methods based on biophysical principles are being developed to automatically tune circuits such that they can be connected to form layered programs.

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