Specified Differentiation of Neurons and Neuronal Learning

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Introduction:

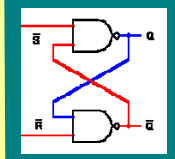
The iGEM (international Genetically Engineered Machines) competition is an annual friendly competition held by MIT in which teams of undergraduates from across the country compete by creating biological devices.

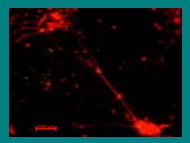
This year our team from Princeton had the desire to work with neurons. We developed two main projects: one of which being a bistable switch made of neurons, and the other is an *in vitro* neural network that can learn to recognize patterns.

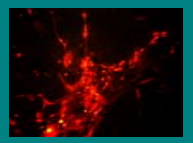
We have experimented with two different ways of patterning the neuronal growth. The first uses an optical tweezer setup that uses the power of a YAG laser to trap the cells and keep them in a specified location. Our other option includes patterning adhesion proteins on gold plating using shadow masks and electron beam vaporization.

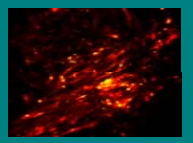
The Latch:

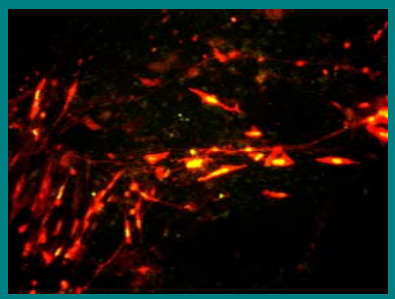
The latch designs consists of two mechanisms. The first are the pacemaker cells which we make using a combination of over-expressed genes (*HCN2, CAV3.1).* These pacemaker cells will constantly be activating the inhibitory neurons which in turn will inhibit the other set of inhibitory neurons. An inhibitory input will act as R' and S' and inhibit the activity of either inhibitory group causing a bistable output.

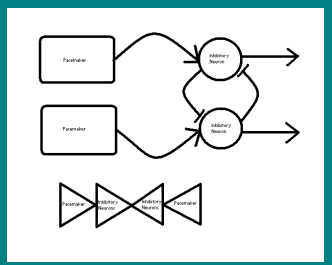




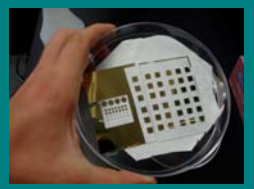








The above pictures show the plasmid we inserted into our Embryonic Stem Cells (*above)* and pictures of the cells after differentiation into neurons and marked with EYFP. Below are our optical tweezer setup and patterned gold ready for adhesion protein



Learning Circuit:

Our learning circuit consists of two inputs, a computation area and an output area. When given the correct signal we will reinforce the selection by inducing long-term potentiation. Otherwise, on an incorrect input we inhibit long-term potentiation and induce long term depression.

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