Simulation of visual processing in retinal ganglion cells

M. Watson,[1] G. Holmes,[1] T. Byrne[2] and S. Cornford,[1] [1]Department of Biological & Physical Sciences, Faculty of Sciences, [2]Faculty of Engineering and Surveying, University of Southern Queensland, Toowoomba, QLD 4350, Australia.

The retina contains photoreceptors for light detection as well as bipolar, horizontal, amacrine and ganglion cells. These form a neural network where synaptic convergence, divergence and integration take place. It serves as a simple network to simulate and thus can be used as a learning tool to demonstrate neural processing, desensitization, experimental design and protocol. The simulation is designed for students to facilitate inquiry based learning.

A given retinal ganglion cell responds to light directed to a specific area of the retina. This area is called the 'receptive field'. Ganglion cell receptive fields have a 'centre' and an antagonistic 'surround' and can be classified as 'On Centre' or 'Off Centre'. On Centre are activated by light in the centre of the receptive field and inhibited by light in the surrounding receptive field. Off Centre are inhibited by light in the centre of the receptive field and activated by light in the surrounding receptive field.

The model simulates the receptive fields of four ganglion cells. The four receptive fields are arranged into 4 arrays with each array containing 64 Light Dependent Resistors (LDR's; EG&G Vactec). These simulate the photoreceptors contained within each receptive field. The LDR's are connected *via* the Multiplexor (Temic) and through the programming of a HC12 microprocessor (Motorolla) simulate the 'On Centre' and 'Off Centre' receptive fields.

Students shine a variable point of light onto one of the four array's and will see either an increase or decrease in the clock rate output of the HC12. This represents a change in the discharge of the ganglion cell. The clock rate output of the HC12 is visualised by means of an oscilloscope. The clock rate output will vary depending on whether they are activating 'On' or 'Off' LDR's. Prolonged stimulation of the LDR's reduces the clock rate output to pre- stimulus levels to simulate desensitization.

Students are required to design an experimental protocol that determines an optimal standard stimulus, a systematic protocol for testing the different receptive fields and a protocol for gathering and analysing the data. The simulation challenges students to determine: (i) the optimum size, strength and duration of a stimulus that is sufficient to stimulate the receptive field; (ii) the receptive field characteristics of retinal ganglion cells; (iii) how such receptive fields can be formed on the basis of the cell types and connections found in the retina.