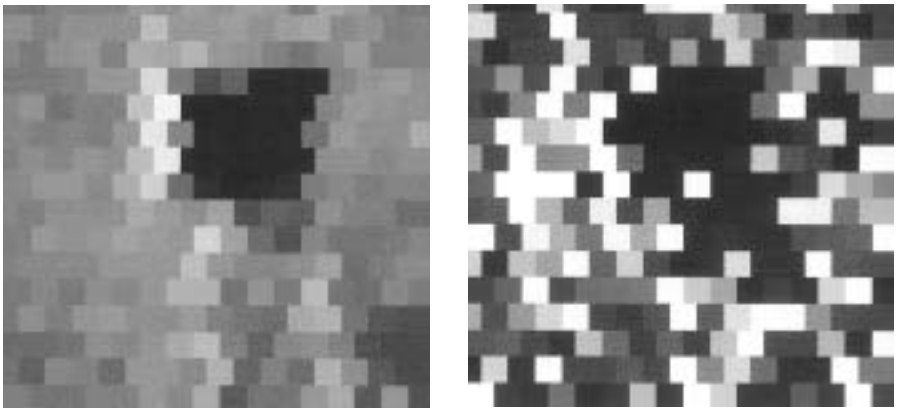
Frederick A. Dodge, Ph.D.

Processing Visual Information

"The goal of my research is to demonstrate how realistic mathematical models can be useful tools for research on signal processing in the visual system."

When light from an object enters the eye, photoreceptors convert the visual information to electrical impulses that go to the brain via the optic nerve. The brain interprets the information and forms an image that represents the object. How the brain processes visual information is the focus of Dr. Frederick A. Dodge's research. His goal is to show how mathematical models developed for the horseshoe crab can help scientists to learn how the eye and brain respond to visual stimuli. Such models are designed to represent the electrical behavior in living cells as they process visual data over time and space.



What the crab's eye tells the crab's brain. Each pixel of this 16 x 16 array represents the output of an optic nerve filter that connects the eye to the brain. Shading of each pixel signifies level of neural response. (White is high rate, black is low rate). The "neural image" of a potential mate is clear during the day (left). At night (right), a circadian clock increases the eye's sensitivity, helping the crab to find mates.

Dr. Dodge's research is funded by the National Science Foundation and National Institute of Mental Health. His work is published in *Proceedings of the National Academy of Science*, *Science*, *Journal of Physiology*, *Journal of General Physiology*, *Investigative Ophthalmology & Visual Science*, *Vision Research*, *Biological Bulletin*, *Biophysical Journal*, *Neuroscience Research Program Bulletin*, *Journal of Neurophysiology*, *Journal of Neuroscience*, *Cold Spring Harbor Symposium on Quantitative Biology*, *Behavioral Science*, *Electroencephalography and Clinical Neurophysiology*, *International Journal of Neuroscience*, *Progress in Brain Research*, and *Society for Neuroscience Abstracts*.

Dr. Dodge served as editor-in-chief of *The Biophysical Journal*, contributed chapters to two textbooks, and reviews manuscripts for several journals. He received the IBM Outstanding Innovation Award and was Honorary Research Associate at London's University College, London. He has lectured at Hebrew University and Hadassah Medical School in Jerusalem. He holds memberships in the Society for Neuroscience and the Association for Research in Vision and Ophthalmology.

In one sequence of experiments, Dr. Dodge and his colleagues recorded a natural underwater scene on video. At the same time, they recorded nerve impulses from a single photoreceptor in the eye of the horseshoe crab that viewed the scene. Later they inserted the underwater scene into a mathematical model to generate a computer representation of the simultaneous impulse activity of all the photoreceptors in the crab eye. The scientists found that the computed impulse activity of the particular photoreceptor that looked in the same direction as the one recorded on the video accurately duplicated the recorded activity, showing that the mathematical model accurately represented the electrical activities of the whole eye.

Mathematical models provide tools that enable scientists to not only understand, but to predict visual performance under a variety of conditions, furthering our understanding of vision and, in the future, eye disease.

As a research professor at both CVR and Syracuse University's Institute for Sensory Research and Department of Bioengineering & Neuroscience, Dr. Dodge collaborates with CVR's Dr. Robert Barlow, Dr. Christopher L. Passaglia of Boston University, M.D./Ph.D. candidate James Hitt of Upstate Medical University, and scientists at the Marine Biological Laboratory in Woods Hole, Mass. Dr. Dodge and CVR's Dr. Robert Barlow studied under Dr. H.K. Hartline, Nobel Prize winner for his ground-breaking description of how photons are absorbed by visual pigments and converted to nerve impulses that travel to the brain.