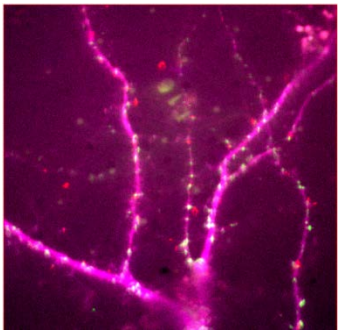
THEME 3: NEUROBIOLOGY

Students will participate in the following 3 modules:

MODULE 1: SUPER-RESOLUTION IMAGING OF NEURONAL SYNAPSE PROTEINS

Laboratory: **Paul Selvin** (UIUC Physics)

The process of learning and forgetting has much to do with how certain receptors, called ionotropic Glutamate receptors, or iGluRs, move in or out of neuronal synapses. Our goal is to see this motion on fixed or live neurons taken from a rat fetus. Students will learn two techniques. First, we will use super-resolution fluorescence microscopy, commonly called PALM or STORM, along with a related technique called FIONA that can track single molecules at high time resolution. These techniques allow one to image single synapses and receptors with ~20 nm spatial resolution, and ~100 msec temporal resolution. Second, students will learn a labeling procedure that allows one to label the receptors specifically so they are bright and stable enough to stand out above the background. We will achieve this with small quantum dots ~10 nm in diameter, about half the size of the "usual" 20 nm quantum dots.

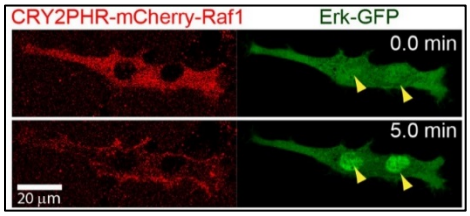


Selvin Lab (unpublished)

MODULE 2: OPTOGENETIC ACTIVATION OF NEURONAL CELL DIFFERENTIATION

Laboratory: **Kai Zhang** (UIUC Biochemistry)

The recent development of optogenetics allows dissection of intracellular signaling transduction in living cells. Compared to pharmacological and genetic approaches, optogenetic methods interrogate intracellular signaling with superior spatial and temporal resolution. In this module, students will have the opportunity to use optogenetic tools to control the activation of growth factor-mediated signal transduction. We will demonstrate light-mediated activation of the mitogen-activated protein kinase (MAPK) signaling pathway in living cells. We will use a fluorescent reporter system to track the activation kinetics of the MAPK signaling. We will use this optogenetic system to demonstrate light-induced PC12 cell differentiation. By varying the temporal pattern of light illumination, we will analyze how regulation of the MAPK activation kinetics affects cell differentiation.

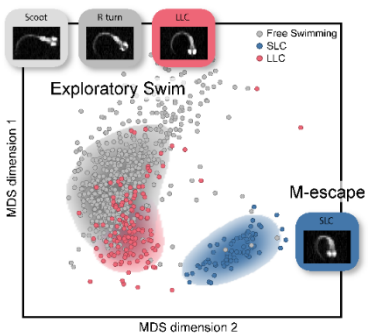


Zhang et al., PLOS ONE (2014)

MODULE 3: NEURAL NETWORK MODELING OF ZEBRAFISH LOCOMOTION

Laboratories: **Martin Gruebele** (UIUC Chemistry & Physics) & **Yann Chemla** (UIUC Physics)

Vertebrate locomotion has been modeled in the past by discrete types, such as "J-turns" or "C-turns" in zebrafish. Recent work has shown that the behavioral patterns are more continuously distributed than such categories suggest, and that they can be classified automatically in a behavioral space by a combination of singular value decomposition (SVD) and clustering analyses applied to videography of swimming trajectories. In this module, students will apply neural network modeling to simulate actual fish swimming data collected in a 2-D or 3-D swimming tank, and establish the effect of various parameters in the neural network on the behavior of the simulated vertebrate organism. A swimming repertoire ranging from free swimming to escape responses stimulated by sound will be studied.



Feng et al (unpublished)