Synaptic connections between nerve cells establish the neural circuits that underlie behavior. An important feature of synapses is their modifiability by experience. In fact, it appears that the effect of experience on brain development and plasticity occurs largely at synapses. Specifically, synapses can be strengthened by increased use and this activity-dependent synapse strengthening plays an important role in the development of the brain, and in learning and memory in the adult. A major goal of Neuroscience is to understand the mechanisms of these synaptic changes. The complexity of the mammalian brain makes it difficult to study individual synapses. Thus, we have chosen to use the fruit fly (Drosophila) where single synapses can be studied and the activity and molecular components of these synapses can be altered using genetic techniques. We use imaging and electrophysiological techniques to examine changes in synaptic structure and function. A particular focus of our research is the role of intracellular calcium in synapse strengthening.

Synapses can be studied in Drosophila larvae. The synapses between neurons and muscle fibers in Drosophila larvae are ideal for these studies since these synapses are identifiable (the same synapse can be found in different animals), accessible and amenable to genetic manipulations. Dissection of a Drosophila larva (bottom) reveals the body-wall muscles (middle) where the identified synaptic terminals (top) are located.

Top: A nerve and its synapses are loaded with a fluorescent calcium indicator (OGB-1).
Right: Changes in intracellular calcium during synaptic transmission are detected by measuring the change in fluorescence. The change in fluorescence/initial fluorescence (ΔF/F₀) along a synaptic terminal during a
single action potential was mapped using pseudo-color. Images of the terminal were acquired at 50 Hz (20 msec exposure) beginning at the top and spanning 300 msec. The images show a rapid increase in $\Delta F/F_0$ followed by a slower decline. Pseudo-color calibration shows $\Delta F/F_0$. (From Lnenicka et al., 2006)

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