# Imaging the dynamics of neuronal dendrites and synapses in vivo on times scales from seconds to days.

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Nervous systems are very dynamic. Their ability to produce adaptive behavior depends on the making and breaking of connections between neurons, which serves both to adjust those networks based on experience and to achieve target levels of excitability by broad homeostatic changes in synaptic strength. Even though the dynamics of dendrites and synapses is crucial, few studies have explored these dynamics in neurons in intact vertebrates. We set out to image the dynamics of entire dendritic trees and associated synapses on time scales of seconds to days to define the pattern of the dynamics and to use that to move toward revealing how the dynamics change with experience and with changes in behavioral state during circadian rhythms and sleep/wake cycles. We imaged dendritic arbors of identified motoneurons in intact, transparent young zebrafish, over both short and long time scales. Filopodial dynamics are rapid with extensions and retractions from dendrites occurring in seconds to minutes. The dynamics are widely distributed and occur at many locations throughout the entire arbor suggesting that these cells are engaged in a widespread search for new inputs. The pattern of dynamics varies between day and night. During the day, the ratio of extensions to retractions is highly variable. At night, the arbor is just as dynamic, however the extensions and retractions occur in about equal numbers. The day/night difference may be a consequence of lower activity dependent stabilization and removal of synapses at night. We have also monitored the dynamics of individual synapses by using fluorescently tagged synaptic markers of receptors and subsynaptic proteins. By tagging receptors with color change proteins, and laser converting receptors at individual synapses, we could monitor the turnover of receptors at particular synaptic sites for the first time in an intact vertebrate. Our observations of the kinetics of glycine receptors reveal time constants of receptor recovery after color change on the order of 4-6 hours, with early evidence suggesting that the time constant varies with cell type and increases in older neurons. In combination with earlier tools we developed to non-invasively image neuronal activity of zebrafish neurons throughout the brain and spinal cord, these approaches set the stage for tying synaptic level events to circuit and behavioral changes in an intact vertebrate. Supported by: NIH DP OD006411