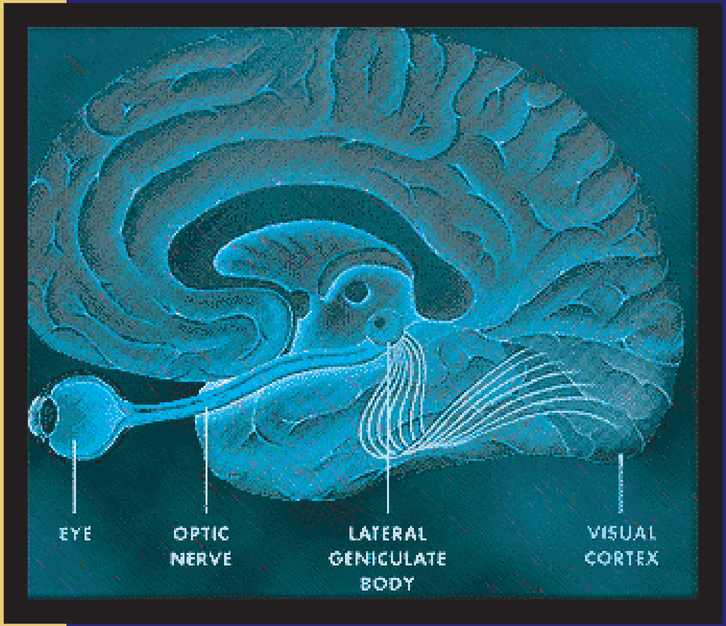
Parallel Pathways and Local Circuits in Visual Cortex

We have studied the organization of local circuits within the primary visual cortex (V1) to better understand how neural circuits give rise to the visual response properties of cortical neurons and to cortical function in general. Intracellular labeling and reconstruction of axonal and dendritic arbors of individual neurons has revealed the cell types present within the various layers of V1 and how they might be interconnected. Relating the axonal projection patterns to the laminar and columnar functional architecture of V1 provides insight into the functional influence of the various connections. We have used "photostimulation" to identify which of the possible connections, inferred from anatomical overlap of dendritic and axonal arbors, in fact exist. In these experiments, light is used to release caged glutamate and thus "photostimulate" small populations of neurons while recording from a single cell. This results in the identification of the locations of neurons presynaptic to the recorded cell. Analysis of functional input to individual neurons reveals that anatomically and physiologically distinct types of inhibitory and excitatory neurons typically receive input from distinctly different sources, even amongst neurons located in the same cortical layer. Thus, functional connectivity can not be predicted from the spatial overlap of axons and dendrites. Cell type specificity confers an even finer level of organization of functional microcircuits than the laminar and columnar cortical organization. This specificity implies that studies of relationships between circuits and function should match this level of organization. For example, because differences in functional input are correlated with morphological differences, this provides the possibility of correlating circuits with single cell receptive fields. We have exploited differences in the laminar projections within V1 of different types lateral geniculate nucleus (LGN) neurons to correlate these cell types with their functional properties. We find that red-green and blue-yellow color opponent LGN neurons comprise parallel pathways that project to different layers of V1. In addition LGN neurons with blue-on versus blue-off receptive fields project to distinct zones within V1. In order to test hypotheses about how specific cell types contribute to visual responses of single neurons and to perception, we are developing methods using viruses and cell type specific promoters to allow reversible inactivation of selected cell types in primates. We find that expression of an insect neuropeptide receptor which couples to GIRK channels can be used to selectively, quickly, and reversibly eliminate the spontaneous activity and visual responses of LGN neurons in vivo. Future application of these methods will allow in vivo tests of the role of particular cell types within the functioning cortical network.



Ed Callaway, Ph.D

Systems Neurobiology Laboratories
Salk Institute for Biological Studies

Vision Research Seminar Series

Monday, March 1, 2004
4:00 p.m. • 115 Wilson Hall
(Refreshments prior to seminar)

Sponsored by the Vanderbilt Vision Research Center
For more information contact Gale Fox at
(615) 343-7620 or e-mail vvrc@vanderbilt.edu