

## About the lab

We focus on three areas: dendritic integration in neural circuits, brain architecture and evolution, and the cerebellum, with an emphasis on multiphoton optical methods. Research interests are represented both by published papers and by more recent work. In vitro, the laboratory studies how single-neuron function is modified by dynamic changes in neural activity such as complex input patterns of neurotransmitters and neuromodulators. Rapid barrages of dendritic input activation may alter function in a fraction of a second, thus altering circuit function and driving synaptic plasticity. These questions are being pursued using uncaging methods, which allow neurotransmitters such as glutamate to be generated in femtoliter (1 cubic micron) volumes within a millisecond. With rapid beamsteering technology we can uncage at tens of thousands of locations per second. Projects focus on large neurons such as cerebellar Purkinje neurons and pyramidal neurons of the neocortex and hippocampus, all of which receive a large convergence of synaptic input. A recent area of expansion for the laboratory is the study of in vivo function using two-photon microscopy. We are imaging synthetic fluorescent dyes loaded into cell populations and protein-based fluorescent probes of neural activity expressed under viral control. So far, biological signals in the brains of living mice and rats have been detected from dozens of Purkinje cells or Bergmann glia at once. Recent experiments show that both of these major cell types generate synchronized activity patterns. In the case of Bergmann glia the finding of synchrony is surprising and opens the possibility that glia can act in the moment-to-moment functioning of the cerebellum. Finally, we use comparative biophysical principles to infer functional principles of brain architecture. For example, the mammalian neocortex (also known as cerebral cortex) shows regularities of structure that suggest that brain structure may be subject to universal design constraints. From shrews to whales, mammalian brains vary over 100,000-fold in volume. Over this range large brains are more folded than small brains: the surface area of the cerebral cortex follows a power law relative to cortical volume greater than simple geometry would predict. We want to understand how these power laws are constructed from the cellular architecture of the cortex. Using electron microscopy, we find that on average, axons are wider in large brains than in small brains. The space demanded by these axons is sufficient to account for the increased folding seen in large brains. This widening of axons may be driven by an evolutionary need to preserve the time it takes for a nerve impulse to cross the brain.

### The Wang Lab

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Back row: Xiaonan (Richard) Sun, Megan Lee, Eve Schneider, Gene Civillico, Sam Wang, Tycho Hoogland, Ilker Ozden  
Front row: Bernd Kuhn, Christoph Kuhn, Vita Ching-Mei Moss Wang, Kyra Mori Hoogland