

研究室紹介 I)

Learning from a small brain

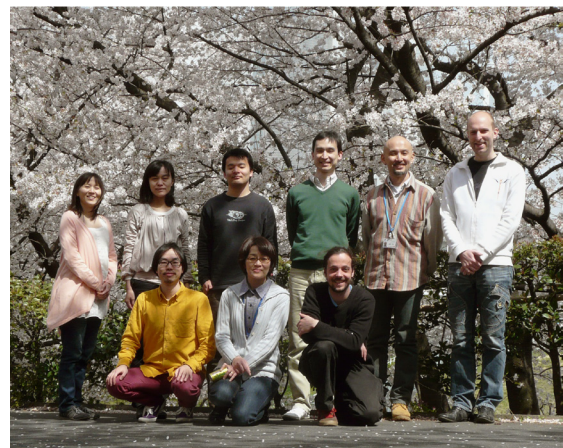
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The ray of sun, the aroma of coffee, and the cheerful voice of your family are waking you up, but the gentle breeze from the window is so relaxing that you decide to doze off again. We can appreciate such precious moments thanks to the exquisite functions of sensory systems that we take for granted. This scene also exemplifies that our emotions, decisions, and actions evolve according to the perception of environment. Sensory perception, in turn, is modulated by emotion, attention, and actions. How stimulation of sensory receptors ultimately leads to perception in the nervous system and how this processing is modulated internally are the major questions of the lab.

To address these questions at cellular, synaptic, and circuit levels, we turned to the fruit flies, *Drosophila melanogaster*. These are the tiny flies that often come along with bananas you bring home from a shop, or mysteriously appear in your kitchen out of nowhere. The flies are capable of processing environmental cues seemingly just as well as us and show complex behaviors. For instance, it is remarkable how quickly they reach the food using olfactory, visual, mechanosensory, and gustatory cues or how they perform rich courtship rituals involving many sensory modalities. These feats are accomplished despite their small brain size (650 x 350 x 300 microns) and a small number of neurons (about 100,000). Because of this numerical simplicity of the fly brain, it is often possible to identify individual neurons, synapses, and circuits. To take an olfactory system as an example, we can identify each olfactory receptor neuron and its postsynaptic partners in every information-processing module (called glomerulus) of the antennal lobe, the first olfactory processing center. Whereas there are about 2000 glomeruli in the mouse olfactory bulb, there are only about 50 glomeruli in the fly antennal lobe. The circuitry of the antennal lobe and the projection pattern of output neurons are well known. The anatomy and function of higher order processing centers where olfactory perception is thought to arise are documented to some degree. Importantly, an extensive collection of genetic tools allow us to label/manipulate specific types of neurons. Thus, we have a potential to access "all" the olfactory information encoded in successive brain regions and manipulate it at will. The techniques to read neural

information have been recently expanded: we can monitor the activity of central neurons by in vivo electrophysiology and imaging. We are routinely using whole-cell patch clamp techniques and calcium imaging based on genetically-encoded indicators. Optogenetics-mediated modulation of neural activity is also functional in this organism. On the other hand, we are probing the animal's perception by observing the behavior of individual tethered flies in response to controlled sensory stimuli. The tethered flies perform well in a virtual environment. By combining these approaches, we aim to systematically understand the relationship between ensemble neural activity and olfactory perception. Because the structure and function of the olfactory circuit are well conserved across phyla, it is likely that the insight gained in *Drosophila* can be used to better understand the fundamental aspects of olfactory computations in vertebrates. It is interesting even if we turn out to find a different form of computation in the fly – this would mean the fly's computation is superior to that in vertebrates at least in a sense that it is serving the same function with a much smaller number of neurons.

Neuroscience society has witnessed the strength of multidisciplinary approaches to brain research. Our lab houses members with expertise in neurophysiology, genetics, molecular biology, anatomy, psychophysics, systems engineering, theoretical neuroscience, and even nuclear physics. It is a joyful wonder that these individuals with diverse scientific and cultural backgrounds (four nationalities) have gathered here sharing a similar interest. I am also enjoying the interaction with labs in the institute with various research goals. Given the complexity of the brain and the effectiveness of multifaceted approaches, I feel that it wouldn't be a bad idea to construct a model of the fly brain with predictive power, before we someday do so with our own brain.



With lab members under the cherry trees (2012.4.10)