

## Department of Anatomy (Gross Anatomy and Neuroanatomy)

---

Yoshinori Kawai, *Professor*

Tohru Hashimoto, *Assistant Professor*

### General Summary

Our department research activities have focused on neuroanatomy and gross anatomy. In neuroanatomical research, organizations of neuronal networks and the development are investigated to elucidate brain function and diseases using immunocytochemistry, electron microscopy, in situ hybridization histochemistry, single cell tracer injection and patch-clamp electrophysiology. Our primary interest is focused on quantitative architecture and dynamics of microcircuit and their relationship. In gross anatomical researches, functional importance is explored on variations of organ systems using cadavers and animals.

### Research Activities

#### *Pattern differentiation of excitatory and inhibitory synaptic inputs on distinct neuronal types in the rat caudal nucleus of the tractus solitarius*

Region- and size-specific neuronal organizations of the caudal nucleus of the tractus solitarius (cNTS) were investigated, followed by analyses of excitatory and inhibitory synaptic input patterns onto specific cell types by patch clamp recordings and immunoelectron microscopy. Cell size distribution and numerical density of cNTS neurons were examined in subregions at levels of the area postrema. In the subpostremal and dorsomedial subnuclei, characterized by the presence of dense glutamatergic and sparse GABAergic somata, small calbindin neurons constituted 42% of the total cells. The medial subnucleus contained large numbers of glutamatergic, GABAergic, and catecholaminergic somata and large tyrosine hydroxylase-containing cells constituted 13% in this region. In total, small neurons ( $< 150 \mu\text{m}^2$ ) represented about 80% of the cell population in the cNTS. Predominant excitatory postsynaptic currents were observed in the adult small neurons, while inhibitory postsynaptic currents were more evident in larger neurons, irrespective of subnuclear location. This distinct differentiation of postsynaptic current patterns was not evident in neonates. GABAergic synapses were more frequently associated with dendrites of large catecholaminergic cells (73%) than with those of small calbindin-containing cells (10%) in adults. These results indicate that differential synaptic input patterns were developmentally established in distinct small and large neurons.

#### *Geometric and functional architecture of visceral sensory microcircuitry*

Is microcircuit wiring designed deterministically or probabilistically? Does geometric architecture predict functional dynamics of a given neuronal microcircuit? These questions were addressed in the visceral sensory microcircuit of the caudal nucleus of the tractus solitarius (NTS), which is generally thought to be homogeneous rather than laminar in cytoarchitecture. Using in situ hybridization histochemistry and whole-cell patch clamp

recordings followed by neuronal reconstruction with biocytin filling, anatomical and functional organization of NTS microcircuitry was quantified to determine associative relationships. Morphologic and chemical features of NTS neurons displayed different patterns of process arborization and sub-nuclear localization according to neuronal types: smaller cells featured presynaptic local axons and GABAergic cells were aggregated specifically within the ventral NTS. The results suggested both a laminar organization and a spatial heterogeneity of NTS microcircuit connectivity. Geometric analysis of pre- and postsynaptic axodendritic arbor overlap of reconstructed neurons (according to parent somal distance) confirmed a heterogeneity of microcircuit connectivity that could underlie differential functional dynamics along the dorsoventral axis. Functional dynamics in terms of spontaneous and evoked postsynaptic current patterns behaved in a strongly location-specific manner according to the geometric dimension, suggesting a spatial laminar segregation of neuronal populations: a dorsal group of high excitation and a ventral group of balanced excitation and inhibition. Recurrent polysynaptic activity was also noted in a subpopulation of the ventral group. Such geometric and functional laminar organization seems to provide the NTS microcircuit with both reverberation capability and a differentiated projection system for appropriate computation of visceral sensory information.