New ways to study synapses and their components

Our present concept of a synapse in the central nervous system is based on electron microscopic studies of tissue fixed by chemical fixation using aldehydes. However, chemical fixation and tissue dehydration in ascending series of ethanol result in uncontrolled shrinkage of tissue components. Thus, the dimensions and precise locations of cell organelles are difficult to estimate in chemically fixed tissue. In this presentation, the advantages of high-pressure freezing (HPF) will be demonstrated. Tissue is shock-frozen in less than a second, the tissue water is substituted by methanol or acetone and, as a result, tissue components are seen in unsurpassed detail. In the results to be presented, HPF was used to study an identified central synapse, the synapse between hippocampal mossy fibers and large spines (excrescences) on pyramidal neurons in hippocampal region CA3.

The large complex spines on CA3 neurons regularly contain a spine apparatus, an enigmatic organelle located in the spine neck. We have studied this organelle by taking advantage of a mouse mutant that lacks spine apparatuses. Evidence will be provided that the spine apparatus plays a role in synaptic plasticity (long-term potentiation, LTP), and learning and memory processes. Moreover, being a Ca^{2+} store, the spine apparatus contributes substantially to calcium transients evoked by synaptic stimulation or back propagating action potentials. Together, the studies presented in this talk will contribute to our understanding of the structure and function of synapses and their components.