2 Summary

Form and function are mutually interacting characteristics of neural systems. In recent years, new approaches for visualization and analysis of structures have been developed, whose accuracy opens the possibility to detect structural differences and peculiarities and allow important conclusions about the function of a structural characteristics.

The present study focuses on three different topics – action of a messenger molecule, development of filopodia and synaptic wiring. By exploring morphological properties of mechanosensory systems in locusts and moths, predictions are made about functional consequences of the morphological traits, such as regulatory mechanisms and sensory information processing.

Chapter I Most sensory systems need to cope with stimuli over a broad range of intensities or stimuli with highly diverse temporal characteristics. A case in point are systems that monitor airflow around the body. In the locust, an animal which may in succession roost jump, walk and fly, the wind-sensitve system must encode airflow over a broad range of parameters. In many systems nitric oxide (NO) has been shown to modulate responses to sensory stimuli and since NO is synthesized in mechonsensory neuropils of *Locusta migratoria*, it has been suggested that NO could act as a messenger. However, up to now there was no information about which neurons might receive the NO signal, due to the lack of knowledge about the distribution of NO-synthase in the vicinity of the identified mechanosensory neurons.

The mechanosensory projection interneuron A4I1 receives input from more than 150 wind sensitive receptor neurons. To determine whether the anatomy is permissive of a direct role for NO in modulating the receptor/A4I1 synapse I analyzed in detail the spatial relationship between the A4I1 and NO-synthase immunoreactivity (NOS-IR). High resolution confocal microscopy and an automated surface reconstruction algorithm permit mapping NOS-IR in defined volumes around the arborizations of the A4I1. NOS-IR occurred in low densities in the vicinity of the axonal aborizations of the A4I1. However, it appeared in high densities in those areas where the A4I1 dendrites and receptor cell axons were co-localized. Estimates in the literature of the effective signaling range of NO vary between synapse-specificity to more than 100 _m. I therefore used different mapping distances. I found NOS-IR within sub micrometer distance from the dendritic surface. However marked differences occurred when

mapping the NOS-IR onto the dendritic surface using distances ranging from only 0,5-5 µm. These results have implications for the ongoing debate about the signaling distance of the diffusible messenger NO.

In pharmacological experiments I showed that NO modulates the spiking response of the A4I1 interneuron and causes a depolarization of its membrane potential. The complex temporal action during bath application of a NO donor suggests NO effects to be mediated by two different signaling cascades. Inhibition of only one specific pathway by blocking the NO dependent guanylyl cyclase led to an increase in habituation. Endogenous NO may therefore counteract habituation and thus maintain a high response level during phases of high activity load, e.g. during flight.

Chapter II During metamorphosis of the hawkmoth *Manduca sexta* many neurons undergo striking structural and functional changes. An identified Motorneuron (MN5) retracts its dendrites, beginning at the end of larval life and re-growths during pupal stages. Only during early pupal development the dendrite is densely equipped with growth cones and filopodia. This study aims to reveal possible structural changes of dendritic filopodia in their natural cellular assembly.

During three subsequent stages filopodia underwent a morphogenic reduction in length and branching complexity. Filopodia at dendritic shaft segments and those at the tip of the outgrowing dendrite differed significantly in length, density and underwent a different stage dependent growth. Filopodia shape on tips varied in a broader range compared to shaft areas suggesting differences of regulatory mechanisms acting in different dendritic areas.

Chapter III Until now, the A4I1 was the only identified interneuron within the central nervous system belonging to the prothoracic wind sensitive network of the locust. Here I give first evidence that the information about airflow is processed by a complex network of interneurons that bear unique morphological characteristics and show different response properties.

Three new types of wind sensitive interneurons were identified. All of these branch within the projection area of prosternal receptor cells. Particular branching patterns might enable processing information of different classes of receptor neurons in different dendritic compartments. In contrast to the A4I1, one type of interneuron (ProWIn2) branches bilaterally within the prothoracic ganglion and resembles characteristics known for other neurons that process information on stimulus direction. Structural asymmetries suggest that information from both hemispheres is processed in a different way.

During postembryonic development the projections of prosternal receptor neurons undergo striking structural changes. However the emerging projection pattern could not be explained by the wind response of the A4I1 interneuron. On the basis of the ProWIn2 response characteristics a wiring scheme is proposed that explains how postembryonic changes might enhance the contrast of the directional response.