



SEGMENTAL AND INTERSEGMENTAL
MECHANISMS IN THE CONTROL
OF LOCOMOTOR PROGRAMS
ANSGAR BÜSCHGES

Born in 1961; Studies of Biology at the University of Bielefeld; 1986–1989 graduate student in the Faculty of Biology at the University of Kaiserslautern in the laboratory of Professor Ulrich Bässler; 1989–1991 postdoctoral fellow in the Medical Faculty at the University of Alberta at Edmonton, Canada, with Professor Keir Pearson; 1991–1995 postdoctoral fellow and research assistant at the Faculty of Biology at the University of Kaiserslautern; 1995 Habilitation in Zoology; 1997–1998 Heisenberg-Fellow; visiting scientist at the Nobel Institute for Neurophysiology with Professor Sten Grillner in Stockholm, Sweden; since 1998, Head of the Animal Physiology Department at the Zoological Institute at the University of Cologne; the focus of the research is in the field of neural control of locomotion in vertebrates and invertebrates, with specific emphasis on the mechanisms that contribute to the coordination of the motor output in multisegmented locomotor organs of terrestrial walking and aqueous swimming organisms. – Address: Zoologisches Institut, Universität zu Köln, Weyertal 119, 50923 Köln.

Some Information on My Field of Research

Animal movements appear so natural and automatic that we generally take them for granted. However, the underlying mechanisms are complex, with the generation of a functional locomotor movement depending on a coordinated series of interactions between the environment, body segments, muscles, and the nervous system. A multitude of experimental approaches is necessary to gain a sufficient understanding of the mechanisms controlling the execution of movements. *Behavioral and biomechanical* studies have determined

principles of stability and coordination. *Anatomical and physiological studies* determined properties of muscles and the functional properties of neuronal circuits, as well as their elements. Finally, *computational modeling* studies test the hypotheses emerging from these areas about sensory-motor transformations and neuro-mechanical principles and incorporate the findings in a functional context.

My research field is the neurobiology of locomotion. Throughout the past years, my laboratory has focused on the generation of the motor output of the insect multi-jointed limb. We have described various nervous influences and mechanisms by which sensory signals from one joint can control motoneuronal activity in the same and adjacent leg joints. These data provided a detailed insight into the interaction of sensory signals with central neuronal networks and vice versa. A level of understanding was reached at which it appeared desirable to have a platform to test the sufficiency of the mechanisms described and to identify areas of lack of knowledge. Such a platform had to be a neuro-mechanical simulation.

The Group and the Project

The Wissenschaftskolleg offered me the chance to establish a research group of scientists for this academic year. Together with Volker Dürr, Örjan Ekeberg, Sten Grillner and Keir Pearson, I formed a group on the topic of “Neural Control of Locomotion”. One main aim was the creation of 3D-dynamic neuromechanical simulations of 4-legged and 6-legged walking organisms. Based on the expert knowledge of Örjan Ekeberg on dynamic simulations, we initially created biology-based 3D-dynamic simulations of the stick insect and the cat walking system. We then started to incorporate the current knowledge of neural control in these models. It soon became clear that our group had to bridge the broad gap between biomechanical and neurobiological research. The distance between these two fields is astonishing, necessitating a more in-depth discussion of various biomechanical issues of our project. Our group took substantial advantage of the newly instituted possibility of the Wissenschaftskolleg to invite “Guests of the Fellows” to work with them for some time. Together with Ulrich Bässler, Reinhard Blickhan, Holk Cruse, Bob Full, Andreas Henze, and Felix Zajac, we had the chance to discuss issues on all relevant aspects of biomechanics and the dynamics of modeling. Substantial help was also provided by the seemingly infinite resources of the library services at the Wissenschaftskolleg. I got all publications I needed immediately.

At the end of our ten-month period, we have successfully generated 3D-dynamic neuromechanical simulations for the stick insect and the cat, in which we have implemented “state-of-knowledge” neural control for individual legs, e.g. the front and middle legs of the stick insect and the cat hind legs. All along this path, various new ideas of projects to be conducted in the home laboratory evolved, as well as a definite plan and grant application directed toward the aim of going on together on this path in our future research. Finally: *it walked!*

Living and Working at the Wissenschaftskolleg

The work on the project in the ideal environment of the Wissenschaftskolleg is the first aspect to be mentioned because of its immediate payoff for my own work. My other ongoing scientific activities also profited from this environment. During my stay I was able to prepare two major grant applications, I wrote one book chapter on “Comparative Locomotor Systems” to be published in the *Comprehensive Handbook of Psychology* (edited by M. Gallagher and R. Nelson, John Wiley & Sons), and I finished and submitted three research papers on research done in my lab. The close proximity to the Free University even allowed me to participate in an experimental project in the group of Hans-Joachim Pflüger on the role neuromodulatory neurons in the stick insect walking system. However, in a much broader sense, my stay at the Wissenschaftskolleg offered me the chance to understand the *ways-of-knowing in other disciplines* and enabled me to gain a glimpse of other fields of research, as well as develop new views on art. This happened through personal contact and conversations with Co-Fellows in a fascinating diversity of fields and from experiencing and taking part in the exceptional cultural life at the Kolleg. It was not only the regular seminars every Tuesday, in which every Fellow gave a talk on her/his field, but also the daily lunches at the Restaurant of the Kolleg that initiated interest and learning, which was then followed by more in-depth search for better understanding. Needless to say that living in Berlin itself was an exceptional experience and that all matters arising throughout our stay at the Wissenschaftskolleg were always taken care of efficiently and caringly by the staff acting in the background.

For me, being an experimental scientist, my stay at the Wissenschaftskolleg was interrupted by brief returns to my lab at my home university every once in a while, where my supervision was needed for ongoing projects of candidates, post-docs, and collaborators,

most of whom were new in the field. This duty was also generously supported by the Wissenschaftskolleg.

These more professional aspects were embedded in a living situation that allowed me to get to know the other Fellows, their partners, and their children. Specifically, living at the Villa Walther created for my family a fascinating personal atmosphere. Living virtually *around the corner* from work as well as from the school of the children made family life very spontaneous for us. This atmosphere at the Wissenschaftskolleg allowed us to make many new friends during one of the most interesting years for me and my family.