

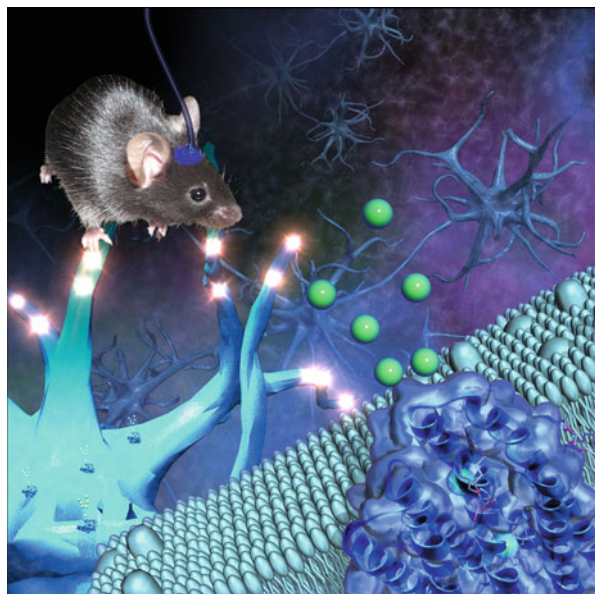
Preface

Neuroscience is one of the most multidisciplinary research fields, employing a great variety of research approaches. To conduct investigation in neuroscience, researchers need to understand a wide variety of experimental and analytical methods and to make full use of a broad range of techniques. In addition, they have to use peculiar techniques such as electrophysiology that are unfamiliar in other fields of life science studies. In some instances, at least modest computational skill for mathematical analysis and modeling is required. Researchers, including ourselves, tend to persist in familiar methods and to have reservations about the introduction of novel approaches. However, manifold methods are strongly required for attaining a higher level of research products in this field. Further, because technological progress is much faster now, researchers must work to obtain information not only on the specific field of their own study but also on methodology, and must continue to renew their research techniques to keep them up-to-date.

Actually, it is impossible for a single researcher to be familiar with all of the methods. In many cases, collaborative work between specialists with different techniques reduces the strain on each other. Even in this case, it goes without saying that we should have a fundamental knowledge of the techniques used for our own research work. Now, we can get a large number of cookbooks on various techniques, recipes, and protocols used for neuroscience. However, most of these books provide a special technique or detail of individual methods in specific model animals, while there are very few books reviewing overall methodology used for neuroscience research. For that reason, we came up with a book plan that provided a good starting point for neuroscience students, newcomers, and young researchers to consider the introduction of new experimental strategies, especially for neuroethology.

The genesis of this book plan was in our organization of a symposium entitled “Strategy for the New Generation of Neuroethology” at the annual meeting of the Japan Neuroscience Society in 2007. Neuroethology is a branch of neuroscience that seeks to understand the neural basis of *natural* animal behavior. Neuroethological studies have covered various types of behaviors in a wide diversity of animals including locusts, crickets, honeybees, electric fish, toads, sea turtles, barn owls,

Fig. 1 Behavioral control with optogenetic tools. See also Chap. 8



bats, and others. In addition to these classic subjects, so-called model animals such as *Caenorhabditis elegans*, *Drosophila*, and zebrafish are generally used for specimens in neuroethological studies because they provide a major advantage for molecular genetic techniques, of which application and variation has expanded rapidly. In 2007, neuroethological research using model animals was not yet very popular. However, we predicted that optical imaging with genetic probes and genetic manipulation of neural activity would become important tools in the next 10 years if they were combined with conventional methods such as electrical physiology and behavior observation. We therefore dared to select topics investigating model animals in the organization of the symposium. This symposium with its new initiative acquired a good reputation, and Springer Japan suggested to us the creation of a book plan related to the symposium. Every reader knows that a number of studies focused on model animals have had great impacts on the neuroscience field in the past several years.

The aim of this book is to introduce novel experimental and analytical techniques useful for present and upcoming neuroethological study to students and young researchers. Therefore, we did not list traditional approaches but, rather, methods unfamiliar in neuroethology with selected applications for *C. elegans* (Chap. 1), *Drosophila* (Chap. 7), and mice (Chap. 8). In particular, optical imaging using the genetic probe and optogenetics that have still been adopted only in the model animals would also become a powerful tool for other animals used in neuroethology (Fig. 1). On the other hand, we also took up applications of the new technology to conventional neuroethological materials such as honeybees (Chaps. 2 and 10), crickets (Chap. 5), and earthworms (Chap. 6). These cases show the possibility that

advanced approaches could provide new findings even in unpopular, non-model animals that have disadvantages in molecular genetics.

Furthermore, these chapters will serve as useful references encouraging ingenuity or providing know-how in applying the new techniques to specific animals with unique behavior. Electrophysiology, which directly records neural activities, although conventional, remains an important method in neuroethology. Recent advanced analytical methods derived from electrophysiological data can clarify complex spatio-temporal pattern encoding environmental information to build a simulation model of neural processing (Chaps. 3 and 4). Especially, the MATLAB toolbox is very powerful for on- and offline analysis of electrophysiological data recorded in various species of animals. Finally, spatial analysis of the expression pattern of the immediate early gene is widely used for the monitoring of neural activity. For example, this method has provided important results on the neural system underlying song learning in songbirds (Chap. 9). Recent molecular-biological approaches demonstrate that the gene expression induced by learning and experience is epigenetically regulated in vertebrates and invertebrates (Chap. 10).

Most of the chapters in this book focus not on original innovation of novel techniques but on how to apply those methods to a particular research theme or experimental animal. In fact, it is more common for researchers not to develop their own original methods independently but to use ingenuity and innovation in employing established methods for their studies. This application is not such an easy process for researchers who investigate the unique natural behavior of non-model animals in neuroethology. A great effort is required for modification of methodology to adjust it to different animals and research themes if reliable and significant results are to be obtained. The young researchers we asked to write each chapter of this book have tried to create novel methods of their own and to obtain noteworthy progress in their research. We hope that this book will encourage many students and postdocs in neuroethological research to try new approaches. We will be greatly pleased if this book can support their research work.

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