国外生命科学优秀教材

ESSENTIALS OF NEURAL SCIENCE AND BEHAVIOR

神经科学精要

（影印版）

Eric R. Kandel James H. Schwartz
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内 容 简 介

本书是一部有关脑科学的介绍性专著，作者之一 E. R. Kandel 曾获得2000年诺贝尔奖，主要介绍脑与行为的关系以及神经细胞与行为的关系，涉及思维过程中的基础生物学，重点讨论了行为学、脑成像、神经细胞生物学等。内容新颖，图文并茂，具有启发性和很高的学术价值，很适合从事生物学、脑科学、神经学、心理学等学科的研究人员以及相关专业的师生参考。

E. R. Kandel, J. H. Schwartz and T. M. Jessell
Essentials of Neural Science and Behavior

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Preface

The past decade has seen a great interest in the biology of mental processes. We predict that this interest will only increase. It therefore is likely that understanding the brain will be to the 21st century what the study of the gene has been to the 20th century and what understanding the cell was to the 19th century. As neural science is assuming a more central role within both biology and psychology, it is even now being taught in many undergraduate schools. In the future, an introduction to the biological basis of the mind will probably play a significant role in the core curriculum of undergraduate liberal arts institutions because neurobiology is a natural bridge between the humanities and the natural sciences.

In our larger and more detailed textbook, *Principles of Neural Science*, we outline the basic principles of brain and behavior for advanced undergraduate students, medical students, and graduate students interested in studying the biology of the brain. The increased interest in neural science among undergraduates has now encouraged us to write an introductory textbook based on the approach we used in *Principles of Neural Science*. The present book is designed to be a primary textbook for a variety of undergraduate courses, including those that require only an elementary knowledge of biology. By emphasizing the interrelationship of neurobiology and cognitive science, we have specifically sought to provide a textbook for introductory courses in the biology of behavior.

To facilitate the beginning student's use of the book, we have provided three additional teaching aids. First, a complete and detailed glossary of key terms in the book gives students a handy summary in one place of the fundamental concepts of nervous system function and behavior. Second, an interactive computer program allows the student to gain direct familiarity with electrical signaling in neurons. Finally, a workbook written by several outstanding teachers of neural science allows students to test their mastery of the material in the textbook.

When we began work on *Principles of Neural Science* in 1979, it was clear that the decade of the 1980s would see a greater integration at the

molecular level of cellular neurobiology with the rest of biology. We encouraged this unification by emphasizing the molecular aspects of neural function and by drawing the outlines of a neural science that connects molecular studies with studies of the behavioral actions of the nervous system. Less heralded during the 1980s than the advances in understanding the molecular action of the nervous system was the progress in cognitive neuroscience. But nevertheless this progress has been extremely important because, in the long run, it promises to unify psychology and neurobiology.

The most challenging aspect of this unification centers on the highest cognitive functions. We therefore believe that the task for the next several decades is to begin to understand the biological basis of consciousness and the mental processes by which we perceive, act, learn, and remember. Are these processes localized to specific regions of the brain, or do they represent a collective and emergent property of the whole brain? If various mental processes can be localized, what rules relate the anatomy and physiology of a region to its specific function? Can these rules be understood better by examining the regions as a whole or by studying its individual nerve cells? How do genes contribute to behavior, and how is gene expression in nerve cells regulated by development and learning? How does experience alter the way we perceive subsequent events?

In the present textbook we emphasize the importance of neural science for cognitive psychology in two ways. First, we believe important and surprising inroads to the logic of cognitive processes will come from molecular neurobiology, from understanding genes and proteins. We therefore think it important to introduce the beginning student to the details of the molecular mechanisms of nerve cell signaling. Because behavior is determined by the precise pattern of interconnections between neurons, the study of how these connections form during development will tell us much about the rules that relate neuronal circuits to behavioral acts. Finally, the use of genetically modified animals opens up, for the first time, a molecular approach to cognition by examining how altering one gene at a time affects behavior: learning, memory, perception, and attention.

Second, in addition to molecular neuroscience other approaches will, however, be required to decipher the special computational power of the brain. We therefore also emphasize in the textbook behavioral and clinical approaches from systems and computational neuroscience, neurology, psychiatry, and neuropsychology. To give but one example, recent developments in brain imaging have made it possible for psychologists to study the internal representation of mental processes directly, often in living human subjects. As a result, higher mental functions need no longer be inferred from behavioral observations, and the

study of cognition can be carried out noninvasively in human subjects and in parallel with comparable studies in experimental animals.

From this convergence of molecular neural science and cognitive psychology, we are gaining a new perspective on behavior. We have also seen that the concept of mentation does not suffer by discussing issues in terms of neural science. Contrary to some expectations, biological analysis is unlikely to diminish our fascination with mentation or to make mentation trivial by reduction. Rather, as we try to show in this text, neurobiology expands our vision by allowing us to perceive previously unanticipated relationships between biological and psychological phenomena.

Acknowledgments

Many colleagues read portions of the manuscript critically. We are particularly indebted to Ronald Calabrese of Emory University, one of the premier teachers of neural science to undergraduates, who read and critically commented upon the entire book. In addition, the following colleagues have made constructive comments on specific chapters: David Amaral; Elizabeth Bates; Michael Brownstein; Maxwell Cowan; Antonio Damasio; Hanna Damasio; Michael Davis; Howard Eichenbaum; Richard S. Frackowick; Christopher Frith; Michela Gallagher; Apostolos Georgopoulos; Amiram Grinvald; Miles Herkenham; Larry Katz; Joseph LeDoux; Keir Pearson; Michael Posner; Donald Reis; Paul Sawchenko; Arthur Shimamura; Gerald Smith; Larry Squire; Larry Swanson; and Semir Zeki. Lise Eliot, Ted Abel, and Mark Barad read and commented on the Glossary.

We are again indebted to Seta Izmirly who single-handedly, and with great thoughtfulness and intelligence, coordinated all aspects of the production of this book at Columbia. Howard Beckman edited the manuscript with his usual high standards for style of presentation and clarity of content, and brought to this book a level of enthusiasm that inspired all of us. We also were extremely fortunate to recruit for this book Sarah Mack, who assumed responsibility for the art program. Our colleague Jane Dodd assessed the art for scientific accuracy and, together with Sarah Mack, developed a consistent and didactic approach to the use of color in the figures. In these tasks they were ably assisted by Charles Lam. Finally, Andy Krawetz organized and oversaw the typing of the many versions of the manuscript, and together with Harriet Ayers typed the final draft.

How to Use This Book

This book is designed to be used as a comprehensive textbook for a variety of introductory college courses in neurobiology, physiology, psychology, and cognitive neural sciences. The book can be used for either a two-semester or one-semester course. A student manual is available to facilitate students' mastering of the material.

For a two-semester course, Chapters 1 through 17 should be covered in the first semester. These chapters describe the signaling properties of nerve cells. Chapters 18 through 36, which are concerned with systems and cognitive neural science, should be covered in the second semester.

For a one-semester course, we would recommend one of two approaches. For courses emphasizing the cellular biology of neurons, students should read Chapters 1 through 17; and Chapters 18, 25 and 36. For courses emphasizing behavior and cognitive psychology, the students should read Chapters 1 and 2, 5, 6, 10 and 11, and Chapters 18 through 36.

Contents

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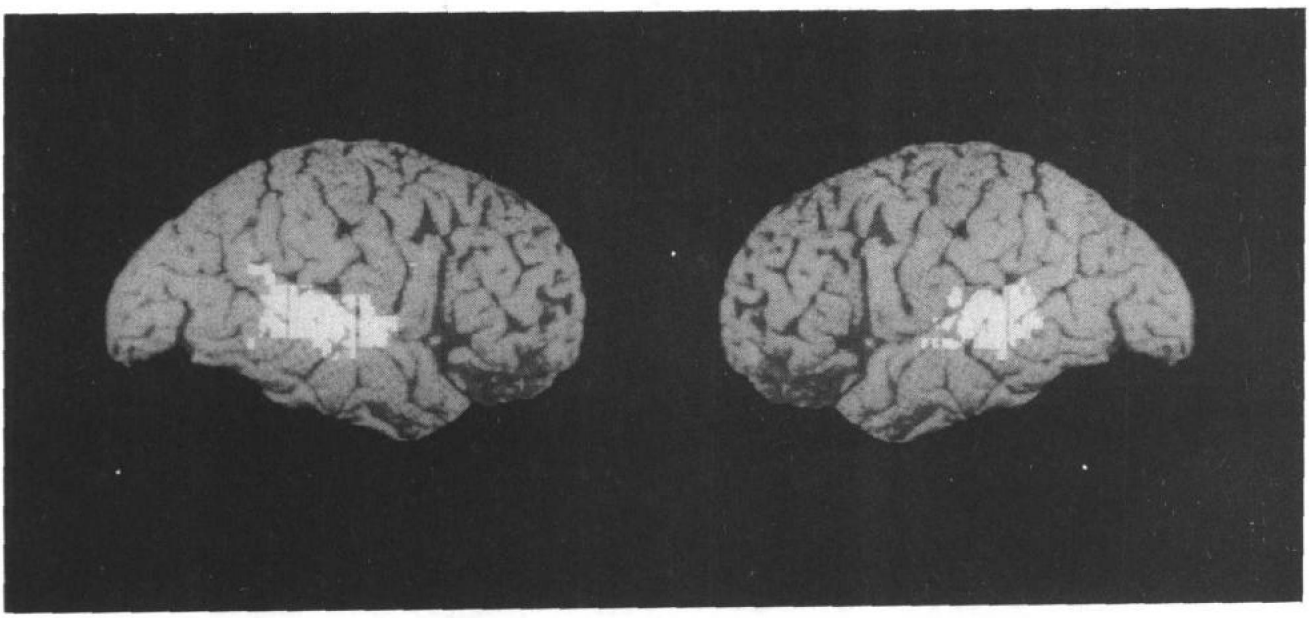
AN OVERALL VIEW



About the image on the preceding page:

A computer image of a living human brain while it listens to sentences. As the subject listens, the primary auditory and association cortices (including Wernicke's area) in both cerebral hemispheres are activated. This activation is detected by increases in blood flow that correlate significantly with the listening test. Blood flow is measured quantitatively using three-dimensional positron emission tomography (PET) after injection of water containing the unstable isotope ^{15}O. The areas of the brain activated are projected on computer images of the lateral aspects of the cortex obtained by magnetic resonance imaging (MRI). The right hemisphere is here depicted on the left and the left hemisphere on the right. (Courtesy of Drs. David Silbersweig and Emily Stern and colleagues at the MRC Cyclotron Unit, Hammersmith Hospital, London, and New York Hospital.)

About the hieroglyphs on the next page:

The ancient Egyptian hieroglyphics for the word "brain"  (*ỉyś*) first appeared in a Seventeenth Century B.C. papyrus (the Edwin Smith Surgical Papyrus) describing the symptoms, diagnosis, and prognosis of two patients wounded in the head. This writing is the earliest known reference to the brain anywhere in the human record.

Introduction

> The microscope and telescope opened vast domains of unexpected scientific discovery. Now that new imaging methods can visualize the brain systems . . . a similar opportunity may be available for human cognition. . . .
>
> MICHAEL POSNER
> *Seeing the Mind*

The primary challenge of neural science is to understand how the brain produces the remarkable individuality of human action. This book illustrates how the neurobiological study of behavior spans the distance between molecules and mind—how the molecules responsible for the activities of nerve cells relate to the complexity of the mental processes.

The brain is a precise network of more than 100 billion discrete nerve cells, interconnected in systems that produce our perception of the external world, fix our attention, and control the machinery of action. Our first step in understanding the mind, therefore, is to understand how neurons become organized into signaling pathways and how individual nerve cells of the brain talk with one another by means of synaptic transmission. In later chapters we shall see how alterations in individual genes affect signaling between nerve cells, and how alterations in signaling affect behavior.

Neural science has emerged over the last century from studies of the nervous system in a variety of classical disciplines. Today, new techniques provide the means of directly linking the molecular dynamics of individual nerve cells with representations of perceptual and motor acts in the brain, and relating these internal mechanisms to observable behavior. New imaging techniques, for example, allow us to observe the human brain in action—to identify specific regions associated with thinking and feeling. In its ability to bridge molecular biology and cognitive studies, neural science makes it possible to begin to explore the biology of human potential, to understand what makes us what we are.