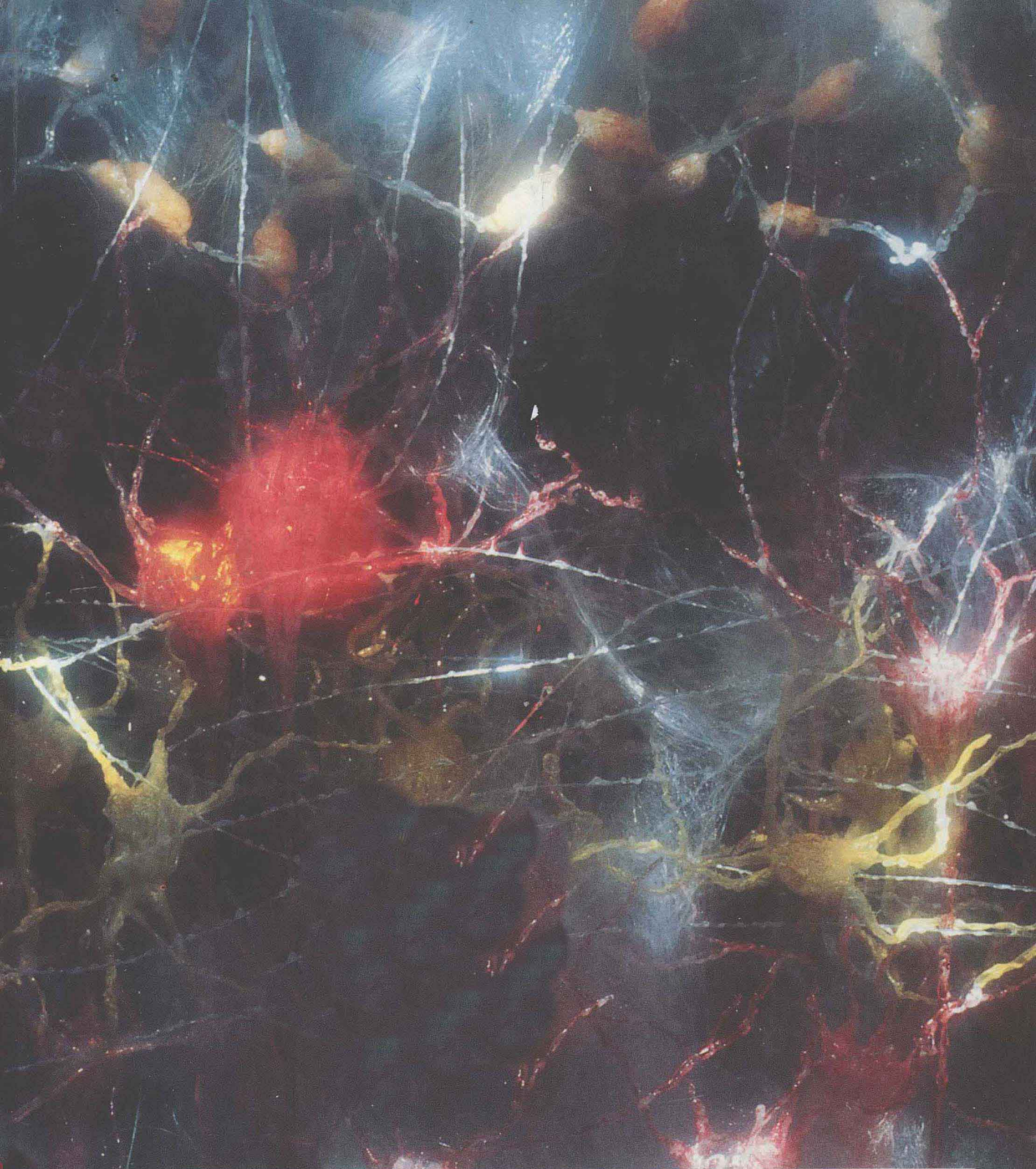

Principles of Behavioral NEUROSCIENCE

JACKSON BEATTY

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● *To Rebecca*

PREFACE

We are—I believe—in the right place at the right time. Breakthroughs in neuroscience are now arriving in torrents; whereas, at other times, discoveries seemed to have barely trickled in. The present decade is an extraordinarily good time to be studying the brain because new knowledge about that most mysterious organ is growing rapidly. Today the human brain is revealing its secrets in ever increasing quantities to brain researchers in a variety of scientific fields that together constitute the neurosciences. This book is an introduction to the human brain and its functions that provide the biological basis of behavior.

Principles of Behavioral Neuroscience is designed first and foremost as a textbook that introduces undergraduates to the study of the brain and behavior. However, this book was also written with the general reader in mind: to provide a first look at the brain and behavior for anyone who is interested in that most human question, "What makes me *me?*"

Important Features of this Book

Principles of Behavioral Neuroscience was written to meet a definite number of objectives, setting it apart from any other available textbook (after all—why write a new book if an available book serves both students and instructors well). Each year at UCLA, I have taught both lower and upper division undergraduate courses, and the available textbooks often seemed more of a hindrance than a help. Thus, the goals I set for this new book are as follows:

Presenting the Most Current Information Available

The first goal was to be up-to-date and factually correct. Thus, old theories that have lost their usefulness are not presented, although they often linger in textbooks long beyond their time. Unfortunately, many textbooks have not kept pace with the rapid advances in modern behavioral neuroscience. Here, the most contemporary and exciting problems and answers are emphasized, making the instructor's task of updating lectures easy and natural. Moreover, current issues are introduced from an historical perspective wherever possible, to both provide context and to make the reader aware of just how far brain research has advanced over the past few decades.

A Focus on the Underlying Principles

This book is concerned with principles of behavioral neuroscience, the underlying brain mechanisms that are responsible for behavior. I have tried to avoid presenting a catalog of miscellaneous facts and figures, as sometimes occurs when an author is not abreast of the field. Instead, I have attempted to put forward a general understanding of how our brains work. By concentrating on

the underlying brain mechanisms that give rise to our behavior, the lessons learned from this book will serve the students well for a long time to come. Factual details may change quickly, but principles usually change more slowly.

A Strong Emphasis on the Human Brain and Human Behavior

Principles of Behavioral Neuroscience is about the human brain and human behavior. The anatomy it presents is human anatomy, not that of the laboratory rat. Human neurological and neuropsychological issues—such as language—are emphasized, not behaviors typical of nonhuman species. Not only does this approach make the book much more interesting to students, it also helps them to understand the relations between behavioral neuroscience, other areas of psychology, and the human experience.

Enrichment from Experience with Cultural Diversity

I have learned much while teaching at UCLA, one of the very most culturally and ethnically diverse universities in the United States. The multiplicity of student backgrounds—Hispanic, Asian, African American, Middle-Eastern, Anglo-Saxon, European, and others with different cultural histories—has allowed me to develop teaching methods that are effective for a wide range of talented and motivated young people, presenting behavioral neuroscience in ways that are personally interesting and meaningful. I may teach my students about the brain and behavior, but my students have taught me about the range of human experience, bringing their own unique life stories with them to the classroom. I have incorporated the perspectives taught to me by many multicultural students not only into my teaching but into this textbook as well.

Writing Clarity

I have tried to make my style of writing clear and direct, even when complex ideas are being presented. The importance of clear writing has become impressed upon me in years of university teaching. In my lectures, I believe I have been successful in presenting ideas that are often complicated, yet describing them in a way that makes them easily understood. I have attempted to do the same in this book. This not only makes the student's task of learning much easier, but also relieves the instructor of continually clarifying the obscure passages that characterize some textbooks. Historical illustrations have been chosen to complement the text and to give the reader a sense of the beauty of scientific research.

Highly Integrated Full-Color Illustrations

Art and illustrations are particularly important in *Principles of Behavioral Neuroscience.* In neurobiology, a single well-done illustration may teach the student better than paragraphs of text. Many original drawings have been especially prepared to present biological concepts clearly and effectively. Brain images and photomicrographs are used frequently to introduce brain anatomy in a direct and compelling manner. Effective illustrations are vital to helping students understand complex concepts, and attractive art makes any text more appealing to study. There is—after all—beauty in both art and science. For these reasons Brown & Benchmark and I have put a great deal of effort in creating the most visually attractive and pedagogically sound art for this book as is possible.

An Extensive Learning System

Principles of Behavioral Neuroscience incorporates an extensive learning system, specifically designed to enhance student comprehension and retention of

important information. Chapter outlines and an overview before each chapter provide advance organizers to assist students in forming the conceptual framework for the material to follow. High-interest chapter opening vignettes enhance interest by providing a human context for the research and theories to follow. Key terms are in boldface type throughout the chapter and interconnect with the definitions provided in each chapter glossary. Chapter summaries review the material of the chapter and help students clarify the most important issues being discussed. Finally, a comprehensive glossary of all key terms is included at the end of the book.

To the Instructor

Every behavioral neuroscience textbook—including this one—is too long to be used in its entirety in any single quarter or semester. For this reason, *Principles of Behavioral Neuroscience* was written in a highly modular fashion, with each chapter—particularly those in the later portions of the book—able to stand by itself. This gives the instructor freedom to selectively assign chapters in accordance with both the instructor's and the students' interests.

The book consists of sixteen chapters, each addressing a major topic in the study of the human brain and human behavior:

Chapter One: Introduction. Here basic issues are examined, such as the relation between mind and brain, levels of analysis, the scientific method, the fusion of brain sciences, and ethics of human and animal research. This provides the all important context for understanding why anyone would want to study behavioral neuroscience in the first place. The discussion of animal welfare and animal rights provides an important perspective for students who will later be enrolled in laboratory courses in behavioral neuroscience.

Chapter Two: Research Methods. The methods used to study the brain—including brain imaging, microscopy, electrical recording and stimulation, neurochemistry, and brain lesion analysis—are presented early in the book to give students a solid understanding of the methods that produce the data from which the principles of behavioral neuroscience are derived. The result—I believe—helps remove the common "textbook-like" flavor which occurs when facts are presented without providing an understanding of where those facts come from.

Chapter 3: Cells of the Nervous System. Nerve cells are the basic elements of the nervous system. Their basic properties are described, as are the roles played by the glial cells that support the neurons. This chapter introduces the student to the fundamental biological elements from which complex brain-behavior systems are constructed.

Chapter 4: Electrical Signaling. Nerve cells utilize the differences in electrical potential across their membranes to process and transmit information. A number of different cellular mechanisms are involved. Each, it turns out, has an exquisitely elegant means of operation that is now being understood at the molecular level. The description of electrical signaling as presented here introduces the student to the beauty of well-understood biological phenomena.

Chapter 5: Synaptic Activity. Nerve cells communicate with each other at synapses—points of connection—mainly by releasing chemicals that affect the function of the recipient cell. It is synaptic transmission that links individual nerve cells together to form the human nervous system.

Chapter 6: The Nervous System. Understanding the biology of human behavior requires knowing something about the map of the human nervous system. Here, an outline of the anatomy of the nervous system and the principles upon which it is organized are presented.

Chapter 7: Vision. The visual system is the best understood of all high-level functional systems of the brain and has provided an important key to discovering the biological principles governing human thought. The processes of visual transduction and feature extraction are presented. Then, the brain mechanisms that give rise to the psychological representation of the visual world are explained.

Chapter 8: Auditory, Vestibular, Chemical, and Bodily Senses. The principles that govern the functioning of the visual system operate in the other senses as well. This approach allows all the senses to be viewed in a common context, with some differences but many similarities.

Chapter 9: Movement. The control of our muscles is organized in a hierarchical fashion, in which spinal reflexes ease the demands on brain processes to produce both voluntary and reflexive movement.

Chapter 10: Thirst and Hunger. Thirst and hunger represent two of the most basic biological drives, motivating each of us to maintain sufficient supplies of water and food. These systems also provide insight into other aspects of human motivation, the forces that drive human behavior.

Chapter 11: Emotion, Reward, and Addiction. Within the human brain, there are neural systems that control feelings and emotions that distinguish us from neural automatons. These systems allow us to experience pleasure and pain, as well as other aspects of emotion. They are also susceptible to manipulation by psychoactive drugs, some of which can lead to addiction.

Chapter 12: Hormones and Sexual Behavior. Sex hormones control both the development of sexual anatomy and expression of sexual behavior. Much has been learned in just the past few years concerning the biological basis of human sexuality in all of its forms.

Chapter 13: Sleep and Waking. Sleep and waking represent fundamentally different states of the human nervous system. In waking, the brain is vigilant and the person interacts with the environment. In sleep, the brain is detached from the environment. There are various neural states underlying sleep and waking. When disrupted, very strange patterns of behavior can occur.

Chapter 14: Learning and Memory. Human culture has evolved because of our capacity to learn, that is to change our own behavior as a function of our own experiences. Striking advances in understanding the biology of learning have been made in the past decade, both by studying the neuronal mechanisms of learning in simple nervous systems and the anatomy of complex learning in the human brain.

Chapter 15: Brain and Language. Human culture is not a simple consequence of learning. Instead it requires the transmission of information between individuals and between generations of individuals. Language—unique to the human nervous system—provides that capacity. The results of a century of studies of the human brain and human language are presented in this chapter, including striking new advances made in recent years by functional brain imaging procedures.

Chapter 16: Disorders of the Nervous System. When our nervous systems fail, we fail. This chapter is not just a catalog of neurological diseases. Instead, it describes some of the ways in which our nervous systems may become injured and what those injuries can teach us about the normal functions of our brain.

Supplemental Materials. The materials that accompany this text are designed to assist both instructors and students in teaching and learning as effectively as possible.

- An **Instructor's Manual with Test Item File** is the key to the teaching package. The Instructor's Manual was prepared by Laura Freberg, of California Polytechnic University in San Luis Obispo. Each chapter provides you with learning objectives, an expanded chapter outline, lecture and demonstration ideas, and test items covering the chapter content. Both essay and multiple-choice test items are provided. Multiple-choice test items are keyed to text pages and to the learning objectives. The multiple-choice items are also designated as factual, conceptual or applied, based on Benjamin Bloom's *Taxonomy of Educational Objectives.*
- Multiple-choice test items are available on **MicroTest III,** a powerful but easy-to-use test generating program created by Chariot Software Group. MicroTest is available for DOS, Windows, and Macintosh personal computers. With MicroTest, an instructor can easily view and select the test item file questions, then print a test and answer key. You can customize questions, headings, and instructions; you can add or import questions of your own; and you can print your test in a choice of fonts if your printer supports them. Adopters of this textbook can obtain a copy of MicroTest III by contacting their local Brown & Benchmark sales representative or the company's Educational Resources Department.
- A set of **40 Transparencies or Slides,** full-color reproductions of key figures from the text, is available to adopters of *Principles of Behavioral Neuroscience.* I have chosen the images to be included in the transparency set myself, based on the pedagogical importance of each figure.
- **The Brain Modules of Videodisc,** created by WNET New York, Antenne 2 TV/France, The Annenberg/CPB Foundation, and Professor Frank J. Vattano of Colorado State University, is based upon the Peabody award-winning series "The Brain." Thirty segments, averaging six minutes each, vividly illustrate an array of biological psychology topics. Consult your Brown & Benchmark sales representative for details.
- A large selection of **Videotapes** is also available to adopters based upon the number of textbooks ordered directly from Brown & Benchmark by your bookstore.
- For your students, the **Student Study Guide** was prepared by Laura Freberg of California Polytechnic University in San Luis Obispo. For each chapter of the text, students get learning objectives, a guided review of the content of the text chapter, key terms review, and practice tests.

To the Student

Years ago, when I entered the University of Michigan, I knew exactly what I wanted. I was going to become a lawyer as others in my family had been. Then—in my freshman year—I took a course in biological psychology and was fascinated. It was incredibly interesting to begin to find out how our brains and our bodies interact with our culture to make us what we are.

By the time I was a senior, law school was history for me. Instead, I eagerly entered graduate school at Michigan in biological psychology. (That field has broadened so dramatically in the past few decades that behavioral neuroscience is now a more appropriate description.)

When I received my Ph.D. from Michigan, I came immediately to the Department of Psychology at UCLA to teach and to research the biological basis of human behavior, a decision that has pleased me greatly over the years. Today, I am most grateful to the young instructor at the University of Michigan who first introduced me to the study of the biology of behavior.

When I was an undergraduate, textbooks seemed to be written *at* the student, rather than *to* or *for* the student. The material that I studied was interesting of course—otherwise I would have become a lawyer—but the texts that I studied were in many ways a barrier, rather than an aid, to learning about the brain and mind.

Since then, in my twenty-five years of teaching both undergraduate and graduate students at UCLA, I have adopted a very different approach to instruction. My classes are always conversational and interactive. My students and I often carry on a true dialogue, even in an auditorium with 300 people.

I have tried to preserve the same all-important sense of personal communication in this book. Communication is—after all—the essence of both teaching and learning.

To Both Students and Instructors

Any good textbook is never a finished work but rather is an evolving set of ideas, facts, and principles. For me—as an author—it is important to learn what you like and dislike about this book. I welcome any comments, criticism, complaints, suggestions, and—yes—even compliments. Please tell me either by regular mail:

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Your comments will be truly appreciated.

Acknowledgments

First of all, I owe a special debt to the undergraduate students of UCLA who have taught me how to introduce data, principles, and concepts of brain function in a field as exciting as behavioral neuroscience. For the past twenty-five years, I have met with over twelve hundred undergraduates each year to teach my portion of UCLA's major undergraduate behavioral neuroscience classes. I think that I have taught my students well; I know that they have taught me very well. This book is in a large part a product of their tutelage.

Second, the reviewers who read, commented, and criticized drafts of this book performed an invaluable service not only to me as an author and to Brown & Benchmark as a publisher, but most importantly to the instructors and students who use this book. They helped me see where the text was working and where—as they say—it needed improvement. I did not know who these insightful instructors were when I was writing the book. Now I do, and I take particular pleasure in thanking:

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Fourth, many special thank yous to Laura Freberg, who wrote both the Instructor's Manual and Student Study Guide with an extraordinary combination of scholarly excellence and communicative skill.

I also owe many thanks to Brown & Benchmark Publishers, particularly to Franklin Lewis, who shepherded this project from its inception; to Michael Lange, the editor who supported the project with great energy and vigor; and to Sheralee Connors and Karen Pluemer, who moved this project forward with expertise, ease, and grace.

To my mind, one of the most impressive features of this book is its art, for which two people are primarily responsible. Shirley Lanners of Brown & Benchmark Publishers used her wide ranging knowledge of both photographic sources and content information to produce a rich variety of selections of photographic art from which we chose those photographs that appear in this book. Barbara Willette—as coordinator of the line art program—was strikingly successful in taking preliminary sketches and transforming them into a coherent body of drawings illustrating the central ideas of the human brain and its functions. Their work has done much to make this book what I had hoped for, a truly accessible introduction to the principles of behavioral neuroscience.

Finally, a grateful thank you to Mary Jo Gregory of York Production Services, who coordinated the production of this technically complex book.

In Conclusion

It is my hope that *Principles of Behavioral Neuroscience* will serve as a genial and perhaps wise host that easily and naturally introduces each newcomer to the many mysteries of the human brain and its functions. If the reader shares some of the excitement of modern brain research and learns some of the secrets kept by the brain within its bony skull, *Principles of Behavioral Neuroscience* will have met its two most important goals.

Much progress has been made in understanding the human brain and its workings in the more than one hundred years since Emily Dickinson, the American poet, wrote:

> *The brain is wider than the sky,*
> *For, put them side by side,*
> *The one the other will include*
> *With ease, and you beside.*

Her words still capture the sense of mystery surrounding the study of the human brain.

Jackson Beatty
Los Angeles, California
1995

BRIEF

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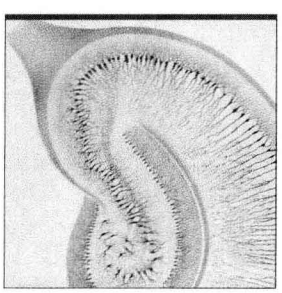

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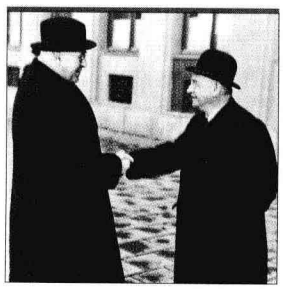

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