

Principles of Behavioral Neuroscience

How does brain activity give rise to sleep, dreams, learning, memory, and language? Do drugs like cocaine and heroin tap into the same neurochemical systems that evolved for life's natural rewards? What exactly are the powerful new tools of molecular biology that are revolutionizing neuroscience? This undergraduate textbook explores the relation between brain, mind, and behavior. It clears away the extraneous detail that so often impedes learning, and describes critical concepts step-by-step, in straightforward language. Rich illustrations and thought-provoking review questions further illuminate the relations between biological, behavioral, and mental phenomena.

With writing that is focused and engaging, even the more challenging topics of neurotransmission and neuroplasticity become enjoyable to learn. While this textbook filters out non-critical details, it includes all key information, allowing readers to remain focused and enjoy the feeling of mastery that comes from a grounded understanding of a topic, from its fundamentals to its implications.

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Principles of Behavioral Neuroscience

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We held hands in the Alameda, and never let go – JH

For Suzie (Susyn), my love through thick and thin – BLJ

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Preface

The Conception

This book was conceived early one evening at an outdoor table at a restaurant near my home. Barry and I were talking about our introductory Brain–Mind courses, his at Princeton University, mine at City College of New York. He asked me which textbook I used. I told him I’d used several of the popular ones over the years. “They all have good qualities,” I said. “But in my view, they all suffer from the same problem – too much extraneous detail.” Barry felt the same way about the Biopsychology and Behavioral Neuroscience textbooks he’d used. “When chapters are loaded with so much detail, students can’t see the forest for the trees,” he said. We both agreed:

“Principles and key ideas first; details later.”

Of course, the crucial details are important to include, and leaving these out can lead to cryptic textbook passages. The extraneous details were the real culprits in the textbooks we’d used. Students were spending too much time trying to figure out what was important in the chapters. I used to tell students to try to understand entire chapters – until I read the chapters myself. Barry and I wished we could find a more manageable textbook.

By the end of the conversation, we were convinced of three points: A behavioral neuroscience textbook should filter out the non-essential, describe the key points (and *crucial* details) in a clear, conversational manner, and complement the text with compelling illustrations. By the end of this long dinner, we’d tested the waiter’s patience, and we’d decided to write a textbook.

What Could Be More Interesting?

People are naturally fascinated by the relation between brain, mind, and behavior. We’re all drawn to the shocking fact that a 3-pound hunk of biological tissue inside the skull gives rise to thought, memories, and other intangible mental phenomena. Our students all come to the course with first-hand knowledge of emotional and cognitive *products* of brain activity. We’re all experts on the subjective aspects of brain functioning.

However, readers new to the topic may be surprised to find that understanding mental processes requires some background in neurotransmission. To understand how the brain stores memories, one needs to know something about the neural plasticity that allows experiences to alter the strength of connections between neurons. No matter how much one introspects about one's own learning and memory, nothing about neural plasticity becomes apparent. There are events going on behind the scenes, outside of awareness, that influence the contents of mind and behavior.

Of course, what we learn about the brain mechanisms occurring “behind the scenes” sometimes *fits* with our inner experience in an intuitive and satisfying manner. For instance, we've all experienced dreams containing visual scenes and strong emotional content, but lacking a logical connection between the dream events. On the basis of our own introspection, we may not be surprised to learn that during REM sleep, when dreams occur, visual cortical areas associated with mental imagery are highly active; areas associated with emotional tone, such as the sympathetic nervous system, are often in high gear as well. Yet the frontal cortex, which normally tracks the sequence in which events occur, and notes violations in their logical order – this is one of the few cortical regions that goes “off-line” during REM. Here, the behind-the-scenes brain events are as one might expect on the basis of our *experience* of dreams.

A Note to Students

While most brain–mind topics have obvious relevance to the reader, some may feel intimidated when it comes to learning about neurotransmission. Learning how neurons communicate with one another requires familiarizing yourself with some concepts that are new and unfamiliar. Terms like “depolarization” and “excitatory postsynaptic potential” can be off-putting at first. This is a brief word of advice to anyone who may say to themselves that technical material is “not for me”: *Don't be so sure*. We all find some kinds of material difficult at first. I recently had the experience of reading online accounting columns that described the grant money I'd spent and the amount I had left for my lab. Faced with these confusing columns, I thought “Accounting is not my thing.” (I think I literally said that to myself.) My initial solution was to simply cross my fingers and hope I don't run out of money.

Then I asked myself how much time I'd actually spent on those accounting columns. About 25 minutes total, compared to the thousands of hours I'd spent on what I considered “my kind of things,” like reading about the brain, or playing the piano. So, I set the goal of spending just 20 minutes each day on those budget pages. Within a few days (a

few hours at most), I'd discovered that they weren't difficult. My concern went away once I'd applied some time to the task. It was a good feeling.

There are some topics in this textbook that involve technical details: like neural communication or learning-related synaptic plasticity. If this doesn't seem like "your kind of thing," we hope you will put your doubts on hold. When it comes to the chapter on "How Neurons Work," relax and take the concepts one step at a time. Don't be surprised if you discover that this kind of material is *your thing* after all.

If you understand the basics of how neurons work, you will also have a deeper appreciation for the relations between brain, mind, and behavior discussed in the later chapters. We've worked hard to present the material in a clear, straightforward manner. But if you find passages that are not clear enough, please email us, and we'll see if we can make them clearer. You'll be doing a real service to other students.

What's in This Book?

Principles of Behavioral Neuroscience is for a first course in behavioral neuroscience for undergraduates. It examines key concepts and findings related to brain, mind, and behavior that motivate neuroscience researchers to dig deeper. How do we perceive, move our bodies, and carry out goals? What makes us hungry – that is, from the point of view of the brain? How does the activity of the sleeping brain change as we go from deep, "slow-wave" sleep, where the conscious mind finally quiets down, to the mentally intense stage of REM sleep, and then back again to slow-wave sleep? How does the brain give rise to learning, memory, and language?

We'll examine the effects of brain damage on language, memory, and emotion. For instance, we'll learn of the woman who lacked the amygdala (on both sides of her brain) and lost nearly all aspects of fear. To understand more precisely how brain activity contributes to cognition, motivation, and behavior, we will examine the activity of individual neurons as animals sleep, learn, attend, and seek out food and other rewards in the environment. Modern optogenetic techniques allow researchers to record the activity of specific *types* of neurons in particular brain areas, or to experimentally change the activity of these neurons while animal subjects are learning, behaving, or both. Recent work in epigenetics shows us what it means for our environment and genes to interact by revealing the ways in which certain life experiences alter the molecules surrounding our genes. Such studies pull back the curtain on the mental, emotional, and behavioral processes that make up our inner and outer worlds.

How to Use This Book

The first two chapters of this textbook concern the structure of the nervous system and neurotransmission. It is useful to begin with these chapters, or at least to present them early in the course, because the concepts introduced in these chapters appear in later chapters as well. While the subsequent chapters work well in their order within the textbook, they can be covered in the order the professor chooses. Some courses will cover all fourteen chapters; others will choose to spend more time on a smaller number of chapters.

Many professors will already have a set of topics they wish to cover, and a preferred order for covering them. We believe that readings for existing course syllabi are easily adapted to the chapters included here. Material within each chapter is broken into digestible subsections with numbered headings. This allows an instructor either to assign entire chapters or to assign subsections of chapters. Because we've worked hard to present material in a clear, conversational tone, and to avoid extraneous details, the instructor will be able to confidently assign chapters and test textbook material regardless of whether the material has been covered in class.

Pedagogical Features

In each chapter, students will find three tools that help consolidate what they've learned.

- Key Concepts are summarized at several points in each chapter. This list of concepts serves to reinforce the key points that the student has just read. In addition, because each concept is boiled down to just a sentence or two, the student can use the list to go back through the chapter section and outline the details relevant to each concept.
- Review Questions allow students to test themselves on the just-presented material. Some of the questions simply allow the student to check their retention of key information in the section. Others motivate the student to review and organize their knowledge of a topic.
- Creative Thinking questions at the end of each chapter are designed to stimulate creative thinking about the chapter material. Many of these questions will be useful for group discussions.

A Final Word to Our Fellow Instructors

While some of our students will pursue careers in science, those who do not will nevertheless have the opportunity to read about new findings on brain function long into the future. Some of our former students will have the joy of reading about discoveries that come to light many years after we instructors are gone. In this course, we give them the background that allows them to do so.

Online Resources

Instructor's Resources

This text is accompanied by teaching tools that can only be accessed by instructors. These tools are designed to support lectures and classroom activities, assessments, and course planning. All resources are freely available with registration. Instructors can register at: www.cambridge.org/highereducation.

Instructor resources include:

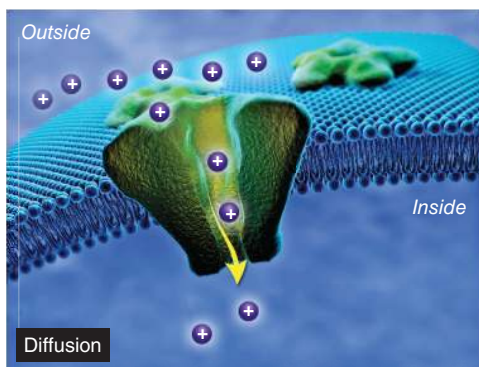
Chapter summaries

- Streamlined outline of each chapter containing the essential information and pointing to key figures, with:
 - highlighted “Useful Examples and Analogies” to illuminate key concepts
 - links to video clips and animations directly pertinent to the material at hand

Individual and group activities

- In-class activities designed for students to work creatively with chapter concepts, and to provide a sense of agency and ownership of the material

Annotated lecture slides



- Ready made lecture slides providing key concepts and select figures from each chapter
- Length is kept appropriate for coverage in one or two standard lecture periods

- In addition, a full set of figures in JPG and PDF format allows instructors to create their own sets of lecture slides, or to add to the annotated set provided by the authors

Testbanks

- Over 85 test questions for each chapter, allowing the instructor to use different sets of questions each semester
- Each question has been edited and approved for clarity by the textbook authors

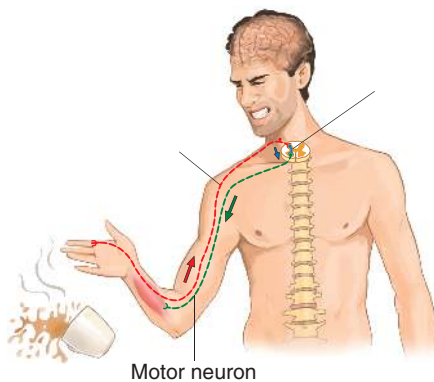
Student Resources

The companion website hosts additional content that will help you to master the material from each chapter and spur further exploration of topics covered in the text.

Organized chapter-by-chapter, this material includes various study aids, video links, and readings. This is also where you can find answers to the Test Yourself questions interspersed throughout each chapter.

Student resources include:

- Flashcards with key terms from each chapter on one side and definitions on the other.
- Figures with select labels removed so that you can test your knowledge as you review key figures, rather than simply reviewing figures in a passive manner.



- Videos and animations relevant to specific chapter material
- Additional readings to probe deeper into select chapter topics
- Answers to chapter Test Yourself questions

Blog

- Highlights the relevance of Behavioral Neuroscience course material in everyday life events, including brain underpinnings of addiction, conscious awareness, and other relevant topics.

Finally, the author would be happy to hear from you. Please send any comments, thoughts, corrections, or requests to:
HorvitzNeuroscience@gmail.com.

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Nervous Systems

Science Photo Library - SCIEPRO / BrandXPictures / Getty Images

