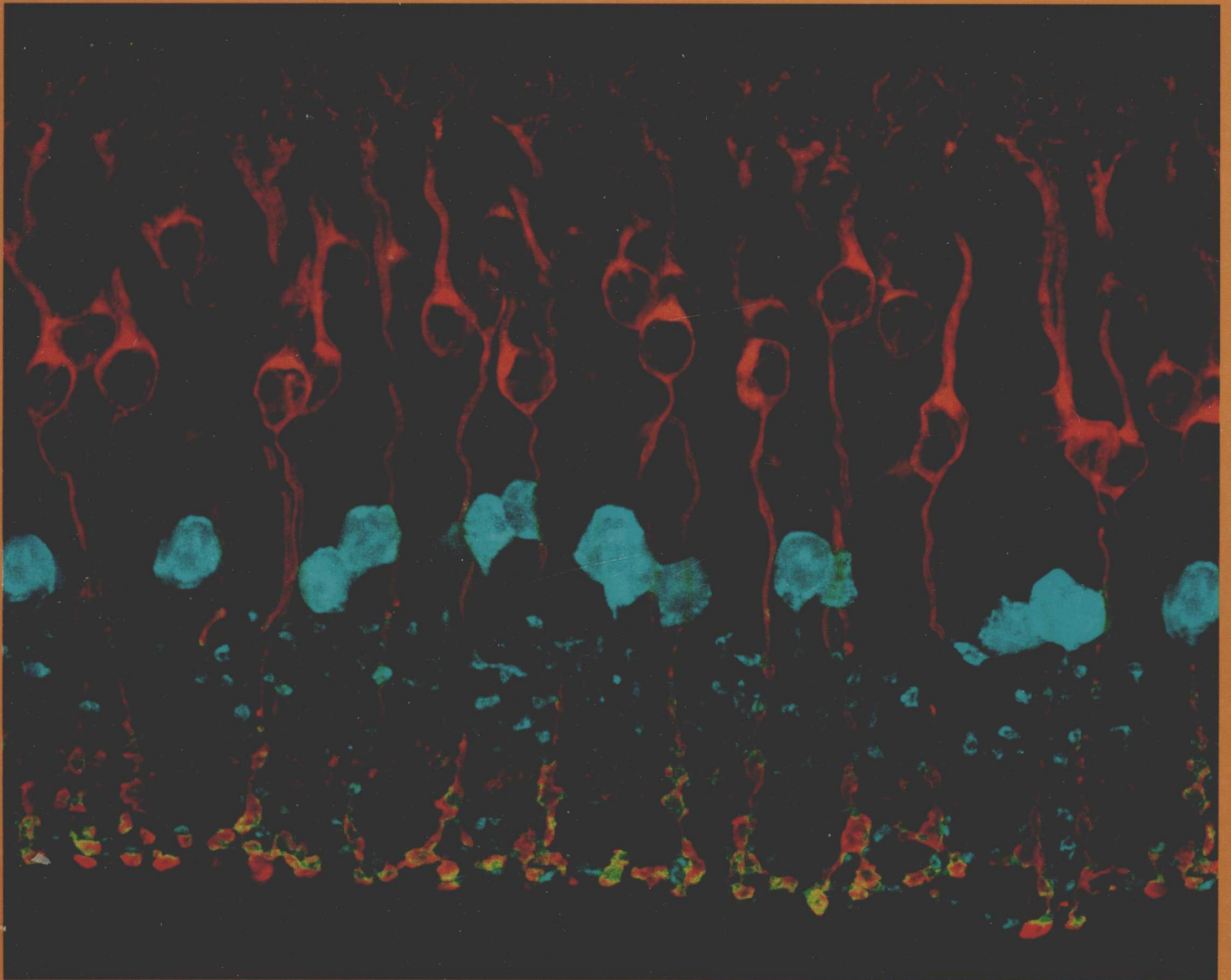


Biological Psychology

SECOND
EDITION

*AN INTRODUCTION TO BEHAVIORAL,
COGNITIVE, AND CLINICAL NEUROSCIENCE*



ROSENZWEIG • LEIMAN • BREEDLOVE

BIOLOGICAL PSYCHOLOGY

*An Introduction to Behavioral,
Cognitive, and Clinical Neuroscience*

SECOND EDITION

MARK R. ROSENZWEIG

ARNOLD L. LEIMAN

S. MARC BREEDLOVE

University of California, Berkeley

SINAUER ASSOCIATES, Inc. • Publishers
Sunderland, Massachusetts



About the cover

Section of macaque retina showing rod bipolar cells (orange) and AII amacrine cells (blue). The large rod bipolar terminals make many contacts with AII processes at the bottom of the picture. A few cone bipolar cells, terminating in the faint red band, are also stained. Courtesy of Stephen C. Massey, Department of Ophthalmology and Visual Science, University of Texas Health Science Center, Houston.

BIOLOGICAL PSYCHOLOGY: An Introduction to Behavioral, Cognitive, and Clinical Neuroscience, Second Edition

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Sinauer Associates, Inc., P.O. Box 407, Sunderland, Massachusetts, 01375-0407 U.S.A.

Fax: 413-549-1118. Internet: publish@sinauer.com.

Library of Congress Cataloging-in-Publication Data

Rosenzweig, Mark R.

Biological psychology : an introduction to behavioral, cognitive, and clinical neuroscience /

Mark R. Rosenzweig, Arnold L. Leiman, S. Marc Breedlove. – 2nd ed.

p. cm.

Includes bibliographical references and index.

ISBN 0-87893-791-9

1. Psychobiology. I. Leiman, Arnold L. II. Breedlove, S. Marc. III. Title.

QP360.R658 1999

612.8—dc21

98-44244

CIP

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2

BIOLOGICAL PSYCHOLOGY

DON JUAN: . . . Will you not agree with me
. . . that it is inconceivable that Life,
having once produced [birds],
should, if love and beauty were her
object, start off on another line
and labor at the clumsy elephant
and hideous ape, whose grandchildren
we are?

THE DEVIL: You conclude then, that Life
was driving at clumsiness and
ugliness?

DON JUAN: No, perverse devil that you
are, a thousand times no. Life was
driving at brains—at its darling
object: an organ by which it can
attain not only self-consciousness
but self-understanding.

George Bernard Shaw
Man and Superman, Act III

*We dedicate this book affectionately to our wives, children, and grandchildren.
We appreciate their support and patience over the years of this project.*

M.R.R.

A.L.L.

S.M.B.

Janine

Lannon

Cindy

*Anne
Jim*

*Suzanne
Kent*

*Philip
Laura*

Jessica Timothy

Ben Nick Tessa Kit

*Lauren
David*

*Thomas
Caroline*

*Gregory
Elise*

Preface

As we write, today's newspaper announces the discovery of a gene that may account for sociability in many species. A TV program claims that a specific molecule can improve memory. Last week's newsmagazine featured an article on a "diet pill" that may help people to overcome obesity. Other recent news articles have dealt with the following questions:

- Can experience increase the capacity of the brain?
- Is sexual orientation inherited?
- How much sleep do we really need?

These are important questions, but the basic issues they address and the research being conducted to answer them cannot be reduced to "sound bites." A meaningful approach to questions like these requires an understanding of the bodily systems that underlie behavior and experience. Our aim in *Biological Psychology* is to provide a foundation that places these and other important problems in a unified scientific context.

This book explores the biological bases of our experience and behavior: the ways in which bodily states and processes produce and control behavior and cognition, and—just as important—the ways in which behavior, cognition, and the environment exert their influence on bodily systems. We treat biology in a broad sense. As in most textbooks of this sort, there is substantial coverage of the proximate, physiological underpinnings of behavior, but we have attempted to give due attention to ultimate causes by placing these discussions in an evolutionary framework whenever possible. The focus of the book is human behavior, but we include numerous discussions of other species' solutions to the problems of survival as well.

Many scientific disciplines contribute to these themes, so we draw upon the research of psychologists, anatomists, biochemists, endocrinologists, engineers, geneticists, immunologists, neurologists, physiologists, evolutionary biologists, and zoologists. In order to gain a panoramic view of the questions that concern biological psychologists, we have tried to rise above the limits of any single specialty.

Throughout, the text employs a five-fold approach to biological psychology—descriptive, comparative/

evolutionary, developmental, mechanistic, and applied/clinical. Finally, we emphasize neuroscience research, whether conducted by psychologists or non-psychologists, that aims to inform our understanding of behavior, and we also give great attention to work that explores the remarkable plasticity of the nervous system; a final chapter drives home the particular importance of plasticity in the psychological approach to neuroscience.

In our experience, students enrolled in biological psychology courses can be quite diverse in terms of their academic backgrounds and their personal interests, so we have taken pains to make the subject as accessible as possible to the widest spectrum of students by providing both the behavioral and biological foundations for each main topic. Some students will feel comfortable skipping or skimming some of this background material, but others will benefit from studying it carefully before moving on to the core of each chapter.

We have given considerable thought to the ordering of the chapters and in this revision have made what we believe are positive changes in that regard. However, we realize that some instructors may still prefer to teach topics in a different order or to omit some chapters entirely, so we have written each chapter as a relatively self-contained unit. Recognizing that courses also vary in length from a single quarter or semester to two semesters, we wrote the text with the intent that it could be reasonably covered in a single quarter by omitting a few chapters, but the text provides enough material for a two-quarter or even a two-semester course. Specific suggestions for creating syllabi with different emphases can be found in the *Instructor's Resource Book*. For example, in a two-semester course the instructor can take advantage of the additional material cited as Special Topics and found on our Website (www.biopsychology.com). We have successfully taught the course using the book in each of these formats.

Many features of the text are designed to enhance students' mastery of the material:

- We have created what we believe is the finest full-color illustration program in any current biological psychology text. The acclaimed art program from the first edition has undergone hundreds of addi-

tions and refinements, always with a clear pedagogical goal in mind. Data from original sources have been recast in ways that are designed to aid the student's understanding. All-new photographs of the human brain—clear, detailed, and consistent—are another feature of this edition.

- Each chapter opens by laying the groundwork for the content by placing it in a “real-world” context, and concludes with a concise Summary and list of Recommended Reading.
- Key terms are set in boldface type where first defined, and are also included in an improved, more comprehensive Glossary.
- “Boxes” describe interesting applications, important methods, sidelights, or refreshers on theoretical concepts relevant to biological psychology, or place the findings in the chapter in a historical perspective.
- A brand-new *Student Study Guide*, by Neil V. Watson of Simon Fraser University, offers a complete chapter outline, a review of general concepts, a list of study objectives, illustrations from the text with study questions, chapter tests, self-evaluation exercises, concept applications, and answers to questions and exercises.
- Icons in the margins call attention to five special aspects of the text:

Competing hypotheses



We frequently underscore the point that science is a process, and that it advances by continually testing competing hypotheses to account for observations. As examples in the text illustrate, sometimes further research indicates which of a group of hypotheses is correct; sometimes all the hypotheses are rejected for a new, more adequate hypothesis.

Important method



Many of the stunning advances in neuroscience in recent years are due to the introduction of powerful new methods that have made it possible to make progress on previously intractable problems. This icon highlights these new methods as well as more venerable research techniques.

Animal model



Students are reminded of the importance of animal research in biological psychology by the identification of important animal models, which often enable investigators to make progress on questions that have significant implications for both human and animal welfare.

Genes and behavior



The revolution in molecular biology is clarifying many of the mechanisms involved in genetic influences on behavior, and this icon highlights important examples.

As noted above, plasticity of the nervous system is a repeated theme in the text. This icon calls attention to particularly robust examples of plasticity.



Neural plasticity

- Two other icons integrate ancillary materials into the discussion:

Sylvius is an interactive neuroanatomy tutorial on the CD-ROM packaged in this text. Developed by S. Mark Williams of Duke University Medical Center, it is based on stunning sections of one human brain. This icon identifies places in the text where reference to *Sylvius* will be of particular help in visualizing and understanding particular neural structures.



Sylvius

Students and instructors have the option of reading additional material that enriches the discussion on the *Student CD-ROM* or at the www.biopsychology.com Website. The Special Topics icon is a pointer to this resource.



Special topic

Some of the most satisfying experiences in writing—and revising—this book have been the lively and creative discussions among the three of us. Each of us has a different research focus, and each of us is involved in certain fields more fully than the others. Pooling our experiences and discussing the relevance of findings in one area to other aspects of biological psychology has been a rewarding experience, and we believe that this integration of knowledge from diverse but complementary fields has enriched the book.

Acknowledgments

In preparing this book we benefited from the help of many people. These include members of the staff of Sinauer Associates: Peter Farley, Editor; Paula Noonan, Production Editor; Kathaleen Emerson, Ancillaries Editor; Christopher Small, Production Manager; Jefferson Johnson, Book Designer and Electronic Production; and Janice Holabird and Wendy Beck, Electronic Production. Copy editor Stephanie Hiebert consistently contributed thoughtful improvements under intense deadlines. Patrick Lane, Mike Demaray, and colleagues at J/B Woolsey Associates patiently and skillfully transformed our rough sketches into the handsome and dynamic art program of this text. Mark Williams produced the *Sylvius* CD-ROM and kindly provided images for the text as well. Molly Lojo organized our references and glossary with skill and cheer.

We also want to thank our past undergraduate and graduate students ranging back to the 1950s for their

helpful responses to our instruction, and the colleagues who provided information and critical comments about our manuscript: Brian Derrick; Karen De Valois; Russell De Valois; Jack Gallant; Ervin Hafter; Richard Ivry; Lucia Jacobs; Dacher Keltner; Raymond E. Kesner; Joe L. Martinez, Jr.; James L. McGaugh; Frederick Seil; Arthur Shimamura; and Irving Zucker, as well as Bruno E. Will and Nicole Bonaventure, Université Louis Pasteur, Strasbourg.

We remain grateful to the reviewers whose comments helped shape the first edition, including:

Duane Albrecht, *University of Texas*
 Catherine P. Cramer, *Dartmouth College*
 Loretta M. Flanagan-Cato, *University of Pennsylvania*
 James Gross, *Stanford University*
 Wendy Heller, *University of Illinois*
 Janice Juraska, *University of Illinois*
 Joseph E. LeDoux, *New York University*
 Michael A. Leon, *University of California, Irvine*
 Randy J. Nelson, *Johns Hopkins University*
 James Pfaus, *Concordia University*
 Jeffrey D. Schall, *Vanderbilt University*
 Dale R. Sengelaub, *Indiana University*
 Matthew Shapiro, *McGill University*
 Cheryl L. Sisk, *Michigan State University*
 Franco J. Vaccarino, *University of Toronto*
 Cyma Van Petten, *University of Arizona*
 Charles J. Vierck, *University of Florida*
 Walter Wilczynski, *University of Texas*

Three instructors—Stephen A Maren, University of Michigan; Neil V. Watson, Simon Fraser University; and Mark C. Zrull, Appalachian State University—acted as “diary reviewers,” keeping detailed records of their teaching experience with the first edition in or-

der to provide us with feedback toward this revision. We thank them for their careful assessment of the book and their students’ reactions to it.

The following reviewers provided insightful suggestions for refining the manuscript for this edition, and we are thankful for their assistance:

Anne E. Powell Anderson, *Smith College*
 Mark S. Blumberg, *University of Iowa*
 Eliot A. Brenowitz, *University of Washington*
 Catherine P. Cramer, *Dartmouth College*
 Francis W. Flynn, *University of Wyoming*
 Diane C. Gooding, *University of Wisconsin*
 Janet M. Gray, *Vassar College*
 Mary E. Harrington, *Smith College*
 Robert J. McDonald, *University of Toronto*
 Robert L. Meisel, *Purdue University*
 Jeffrey S. Mogil, *University of Illinois*
 Lee Osterhout, *University of Washington*
 Helene S. Porte, *Cornell University*
 Scott R. Robinson, *University of Iowa*
 David A. Rosenbaum, *Pennsylvania State University*
 Martin F. Sarter, *Ohio State University*
 Robert Wickesberg, *University of Illinois*

Finally, we would like to thank all our colleagues who contribute research in biological psychology and related fields. We welcome all comments and suggestions from instructors, students, or colleagues. You may e-mail them to us at: biopsych@sinauer.com.

MARK R. ROSENZWEIG
 ARNOLD L. LEIMAN
 S. MARC BREEDLOVE

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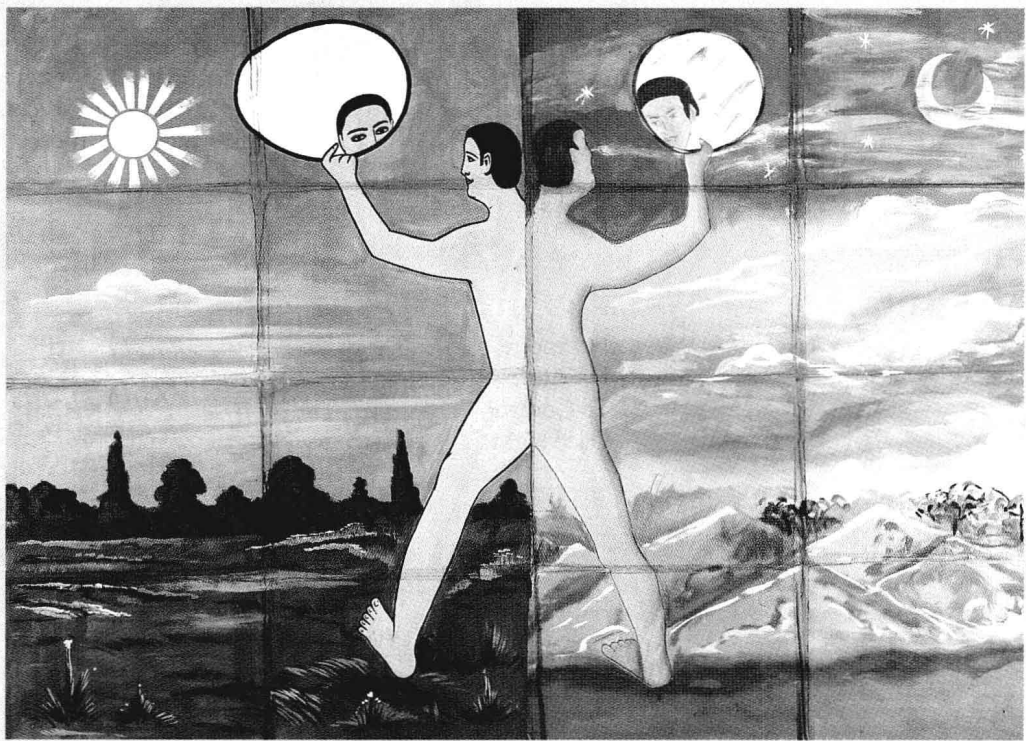
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Biological Psychology: Scope and Outlook

A legend from India (retold by Thomas Mann in *The Transposed Heads*) provides a colorful introduction to the main theme of this book. In this story the beautiful Sita marries a slender, intellectual merchant, but she is also attracted to his best friend, a spirited, brawny blacksmith. One day each young man beheads himself in a temple of the goddess Kali. Sita enters the temple, looking for them, and finds them lying in pools of blood in front of the statue of Kali. Horrified, Sita prays to Kali, begging the goddess to restore the men



Francesco Clemente, *Untitled*, 1985. Gouache on paper

to life. Kali grants the wish and instructs Sita to place the heads carefully on the bodies. Sita undertakes the task with feverish energy and soon sees the men come back to life. Only then does she realize that she has placed each head on the wrong body! Now the three young people are faced with a baffling problem: Which man is Sita's spouse? The one with the intellectual's head and the muscular body? Or the blacksmith's head on the intellectual's body? The legend explores the complexities of how each head affects the body that it now controls, and how each body influences the head.

This old Hindu legend emphasizes that individual identity, personality, and talents are functions of brain-body interactions.

What Is Biological Psychology?

In this book we explore the many ways in which the structures and actions of the brain produce mind and behavior. But that is only half of our task. We are also interested in the ways that behavior in turn modifies the structures and actions of the brain. One of the most important lessons we hope to convey is that interactions between brain and behavior are reciprocal. The brain controls behavior, and in turn behavior alters the brain.

Our goal is to provide an interesting and coherent account of the main ideas and research in biological psychology, which is of great popular as well as scientific interest (Figure 1.1). Because there are so many pieces to tie together, we try to introduce a given piece of information when it makes a difference to the understanding of a subject—especially when it forms part of a story. Most important, we seek to communicate our own interest and excitement about the mysteries of mind and body.

Many Disciplines Contribute to Biological Psychology

No treaty or trade union agreement has ever defined the boundaries of biological psychology. It is a field that includes many players who come from quite different backgrounds—psychologists, biologists, physiologists, engineers, neurologists, psychiatrists, and many others. Further, it shares concepts and research approaches with many other disciplines. Figure 1.2 maps the relations of biological psychology to other disciplines. Clearly, the biological psychology umbrella is very wide.

Biological psychology is the field that relates behavior to bodily processes, especially the workings of the brain. The main goal of this area of study is to understand behavior and experience in terms of their biological substrates. Like other sciences, biological psychology is dedicated to improving the human condition. As Einstein once said in an address to students, concern for humanity and its fate must always form the chief interest of all scientific endeavor “in or-

1.1 Biological Psychology in the News

Many newspaper and magazine articles feature topics in biological psychology.

