Biopsychology

11th Edition

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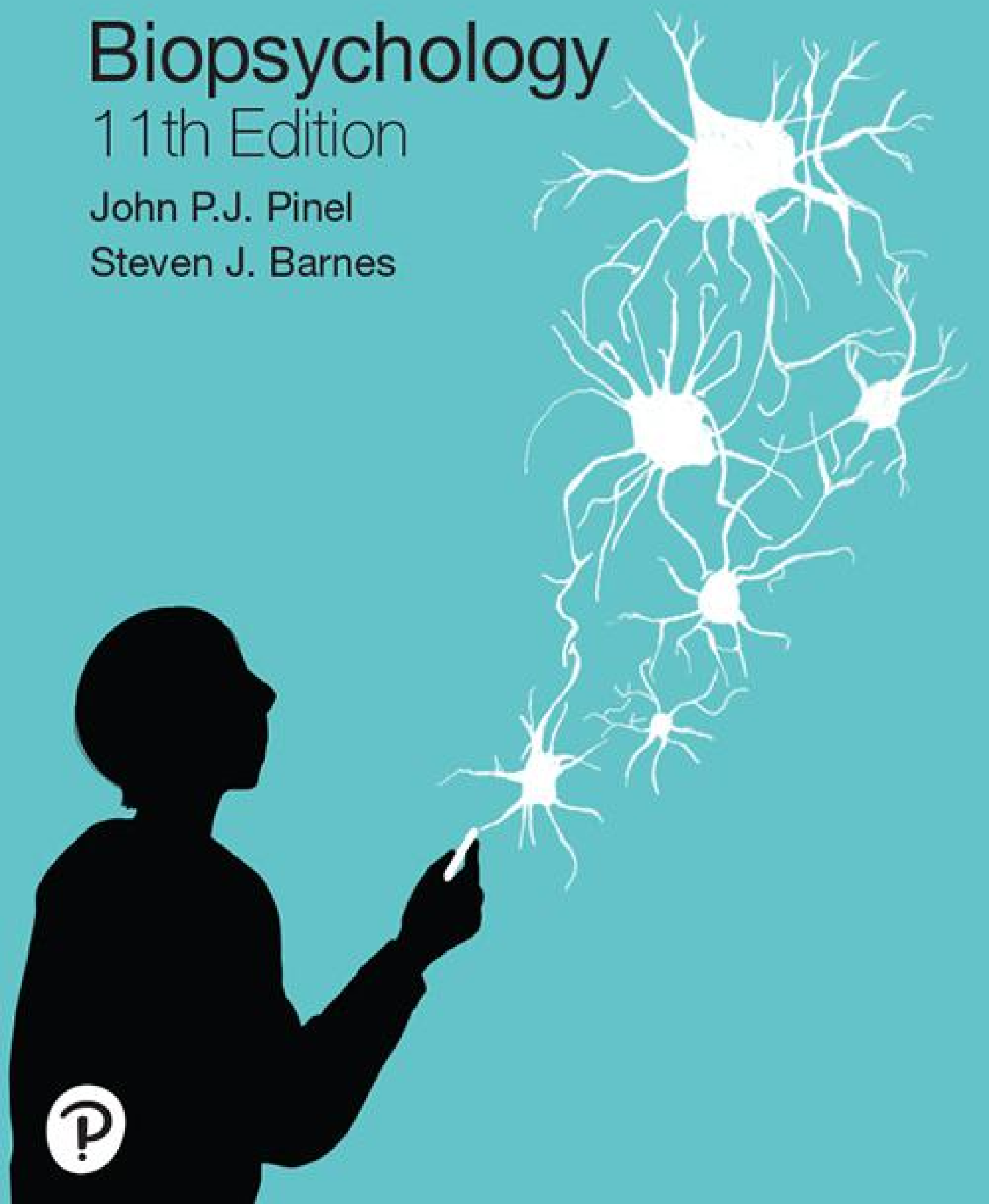

Biopsychology

ELEVENTH EDITION

John P. J. Pinel & Steven J. Barnes
University of British Columbia

John Pinel: *To Maggie, the love of my life.*

Steven Barnes: *To Behnaz and Mina, the loves of my life; to John Pinel, the best mentor one could ever hope to have; and to the countless students who have contributed to the evolution of Biopsychology.*

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Preface

Welcome to the Eleventh Edition of *Biopsychology*! The Eleventh Edition of *Biopsychology* is a clear, engaging introduction to current biopsychological theory and research. It is intended for use as a primary course material in one- or two-semester courses in Biopsychology—variously titled Biopsychology, Physiological Psychology, Brain and Behavior, Psychobiology, Behavioral Neuroscience, or Behavioral Neurobiology.

This edition builds on the strengths of its predecessors, but it also takes an important step as the Eleventh edition will be in Revel. Pearson's Revel platform continues to offer exciting new approaches to teaching and learning, methods that were simply not possible in conventional course materials.

The defining feature of *Biopsychology* is its unique combination of biopsychological science and personal, reader-oriented discourse. Instead of presenting the concepts of biopsychology in the usual fashion, the chapters address students directly and interweave the fundamentals of the field with clinical case studies, social issues, personal implications, useful metaphors, and memorable anecdotes.

Key Features in the Eleventh Edition

The following are features that have characterized recent editions of *Biopsychology* and have been maintained or expanded in this edition.

EMPHASIS ON BROAD THEMES The emphasis of *Biopsychology* is "the big picture." Four broad themes are present throughout the chapters and a Themes Revisited section at the end of each chapter briefly summarizes how each theme was developed in that chapter. The four major themes provide excellent topics for essay assignments and exam questions.

EFFECTIVE USE OF CASE STUDIES *Biopsychology* features many carefully selected case studies, which are highlighted in the chapters. These provocative cases stimulate interest, promote retention of the materials, and allow students to learn how biopsychological principles apply to the diagnosis and treatment of brain disorders.

REMARKABLE ILLUSTRATIONS The illustrations in *Biopsychology* are special. Each one was conceptualized and meticulously designed to clarify and reinforce the chapter content by uniquely qualified scientists. John Pinel and his artist/designer wife, Maggie Edwards, created many of the original illustrations from previous editions, and Steven Barnes adapted many of these into engaging interactives for the Revel edition while also creating several new figures.

FOCUS ON BEHAVIOR In some biopsychological courseware, the coverage of neurophysiology, neurochemistry, and neuroanatomy subverts the coverage of behavioral research. *Biopsychology* gives top billing to behavior: It stresses that neuroscience is a team effort and that the unique contribution made by biopsychologists to this effort is their behavioral expertise.

EMPHASIS ON THE SCIENTIFIC METHOD *Biopsychology* emphasizes the scientific method. It portrays the scientific method as a means of answering questions that is as applicable in daily life as in the laboratory. And *Biopsychology* emphasizes that being a scientist is fun.

DISCUSSION OF PERSONAL AND SOCIAL IMPLICATIONS Several chapters of *Biopsychology*—-particularly those on eating, sleeping, sex, and drug addiction—carry strong personal and social messages. In these chapters, students are encouraged to consider the relevance of biopsychological research to their lives outside the classroom.

ENGAGING, INSPIRING VOICES Arguably the strongest pedagogical feature of *Biopsychology* is its personal tone. In the previous edition, Barnes and Pinel had addressed students directly and talked to them with warmth, enthusiasm, and good humor about recent advances in biopsychological science. This edition has not changed in this respect.

NEW! EMERGING THEMES For this edition, Barnes and Pinel have identified and highlighted two "emerging themes" throughout the chapters: Themes that they feel are quickly emerging from the biopsychology literature. The Themes Revisited section at the end of each chapter briefly summarizes how each emerging theme was developed in that chapter. The two emerging themes provide excellent topics for essay assignments and exam questions.

New, Expanded, or Updated Coverage in the Eleventh Edition

Biopsychology remains one of the most rapidly progressing scientific fields. Like previous editions, the Eleventh Edition of *Biopsychology* has meticulously incorporated recent developments in the field—it contains more than 950 citations of articles or books that did not appear in the preceding edition. These recent developments have

dictated changes to many parts of the chapters. The following list presents some of the content changes to this edition, organized by chapter.

CHAPTER 1: BIOPSYCHOLOGY AS A NEUROSCIENCE

- Introduction of emerging themes appearing in the chapters
- Five new citations

CHAPTER 2: EVOLUTION, GENETICS, AND EXPERIENCE

- Updated schematic illustration of how biopsychologists think about the biology of behavior
- Updated coverage and new key terms related to the topic of gene expression
- Expanded coverage of the topic of transgenerational epigenetics
- Simplified coverage of the evolution of humankind
- Three new key terms: *activators*, *repressors*, *hominins*
- Twenty new citations

CHAPTER 3: ANATOMY OF THE NERVOUS SYSTEM

- Updated and expanded coverage of the functions of glial cells
- Updated anatomical description of the basal ganglia
- Sixteen new citations

CHAPTER 4: NEURAL CONDUCTION AND SYNAPTIC TRANSMISSION

- Improved explanation and coverage of the action potential
- Coverage of the mechanical transmission of membrane potentials
- Two new key terms: *graded potentials*, *voltage-gated ion channels*
- Sixteen new citations

CHAPTER 5: THE RESEARCH METHODS OF BIOPSYCHOLOGY

- Expanded coverage of magnetic-field-based brain-imaging techniques
- Improved explanations of how MRI and fMRI work
- New section on ultrasound-based imaging techniques, such as functional ultrasound imaging
- Introduction of two new transcranial stimulation techniques: transcranial electrical stimulation and transcranial ultrasound stimulation
- Expanded coverage of magnetoencephalography
- Updated coverage of intracellular unit recording
- Expanded and comprehensive coverage of genetic methods, including coverage of gene-editing techniques like the CRISPR/Cas9 method
- Updated coverage on the various ways that fluorescent proteins are used in research
- New case study: The case of the vegetative patient
- New section on the study of functional connectivity
- Nine new key terms: *functional ultrasound imaging*, *transcranial electrical stimulation*, *transcranial ultrasound stimulation*, *gene knockin techniques*, *gene editing techniques*, *CRISPR/Cas9 method*, *resting-state fMRI*, *functional connectivity*, *functional connectome*
- Forty-two new citations

CHAPTER 6: THE VISUAL SYSTEM

- Updated and expanded coverage of modern research on visual system receptive fields
- Updated and expanded coverage of how the concept of a visual system receptive field is changing
- Updated coverage of research on the ventral and dorsal visual streams
- Updated and expanded coverage of the brain pathology associated with prosopagnosia
- One new key term: *occipital face area*
- Thirty-two new citations

CHAPTER 7: SENSORY SYSTEMS, PERCEPTION, AND ATTENTION

- New chapter title
- New chapter introduction, including coverage of some interesting exteroceptive senses only found in particular nonhuman species.
- Updated coverage of the subcortical auditory pathways
- Updated coverage of the organization and functions of the primary auditory cortex
- Updated coverage of the effects of auditory cortex damage
- Introduction of the thermal grid illusion—including a new figure
- Updated coverage of neuropathic pain
- Updated coverage of taste receptors
- Updated coverage of primary gustatory cortex organization
- New module on Perception
- Three new Check It Out features related to perception

- Updated coverage of the neural mechanisms of attention
- Twelve new key terms: *sensation*, *perception*, *periodotopy*, *thermal grid illusion*, *percept*, *perceptual decision making*, *bistable figures*, *phantom percepts*, *Charles Bonnet syndrome*, *binding problem*, *attentional gaze*, *frontal eye field*
- Sixty-one new citations

CHAPTER 8: THE SENSORIMOTOR SYSTEM

- Updated coverage of the primary motor cortex
- Updated coverage of the role of the cerebellum in sensorimotor function
- Updated and expanded coverage of the role of the basal ganglia in sensorimotor function
- More concise coverage of the descending motor pathways
- Updated coverage of the neuroplasticity associated with sensorimotor learning
- New key term: *movement vigor*
- Thirty-seven new citations

CHAPTER 9: DEVELOPMENT OF THE NERVOUS SYSTEM

- Updated coverage of the case of Genie
- Extensive updates to the coverage of stem cells and neurodevelopment
- New figure on the role of glia in neurodevelopment
- Updated coverage of the mechanisms of migration and aggregation of neurons
- Updated coverage of the chemoaffinity hypothesis
- Updated coverage of synapse formation
- Extensive updates to the module on early cerebral development in humans
- New case study written by a self-advocate with autism spectrum disorder
- New case study about the autistic savant Stephen Wiltshire, known by some as the "human camera"
- Coverage of the role of transcription-related errors in individuals with ASD
- Updated coverage of face processing in autism spectrum disorder
- Updated coverage of Williams syndrome, including coverage of face processing differences
- Four new key terms: *subventricular zone*, *radial glial cells*, *radial-glia-mediated migration*, *prenatal period*
- Eighty-three new citations

CHAPTER 10: BRAIN DAMAGE AND NEUROPLASTICITY

- Updated coverage of the mechanisms of ischemic stroke
- New section on traumatic brain injuries
- Coverage of mild traumatic brain injuries
- Updated coverage of chronic traumatic encephalopathy
- Updated discussion of causal factors in epilepsy
- Updated naming of the different types of seizures based on the new diagnostic criteria from the International League Against Epilepsy
- Extensive updates to the section on Parkinson's disease
- Updated and expanded coverage of Huntington's disease
- Updated and expanded coverage of multiple sclerosis
- Extensive updates to the section on Alzheimer's disease—including a new figure
- Five new key terms: *traumatic brain injury (TBI)*, *closed-head TBI*, *subdural hematoma*, *mild TBI*, *alpha-synuclein*
- One hundred and forty-one new citations

CHAPTER 11: LEARNING, MEMORY, AND AMNESIA

- Updated coverage of H.M.
- Updated coverage of the amnesia of Korsakoff's syndrome
- New module: Amnesia after Traumatic Brain Injury: Evidence for Consolidation
- Updated coverage of the role of the hippocampus in consolidation
- Updated and improved coverage of the roles of grid cells
- Updated coverage of the relationship between place cells and grid cells
- New section: The hippocampus as a cognitive map
- Updated coverage of engram cells
- Coverage of the role of hippocampal-prefrontal connections in episodic memory
- Improved and updated coverage of long-term potentiation
- New section on nonsynaptic mechanisms of learning and memory
- Forty-eight new citations

CHAPTER 12: HUNGER, EATING, AND HEALTH

- New section: Evolution of Research on the Role of Hypothalamic Nuclei in Hunger and Satiety
- Updated and extended discussion of the role of hypothalamic circuits and gut peptides in hunger and eating

- Updated discussion of why some people gain weight, whereas others do not
- Updated coverage of leptin, insulin, and the arcuate melanocortin system
- Updated coverage of treatments for overeating
- New key term: *gut microbiome*
- Thirty new citations

CHAPTER 13: HORMONES AND SEX

- New module: Sexual development of brain and behavior
- Updated coverage of the aromatization hypothesis
- Extended and updated discussion of modern perspectives on sex differences in the brain
- Updated coverage of the role of gonadal hormones in female sexual behavior
- Extensive update to the module on sexual orientation and gender identity
- Four new key terms: *lesbian*, *transgender*, *gender identity*, *gender dysphoria*
- Forty-eight new citations

CHAPTER 14: SLEEP, DREAMING, AND CIRCADIAN RHYTHMS

- New module on dreaming
- Three new case studies directly related to the topic of dreaming
- Updated coverage of theories of dreaming
- Updated coverage of recuperation theories of sleep
- Updated coverage of the effects of sleep deprivation in humans
- Updated coverage of interventions for jet lag
- Updated coverage of the effect of shorter sleep times on health
- Two new figures
- One new key term: *lucid dreaming*
- One hundred and twenty-seven new citations

CHAPTER 15: DRUG USE, DRUG ADDICTION, AND THE BRAIN'S REWARD CIRCUITS

- Improved explanation of the relationship between drug withdrawal effects and conditioned compensatory responses
- Extensive update to coverage of nicotine
- Updated coverage of Korsakoff's syndrome
- Extensive update to coverage of marijuana
- Updated coverage of the history of cannabis use
- New discussion of the transgenerational epigenetic effects of drug taking
- Discussion of the current epidemic of opioid abuse
- Three new key terms: *smoking*, *vaping*, *drug craving*
- Eighty new citations

CHAPTER 16: LATERALIZATION, LANGUAGE, AND THE SPLIT BRAIN

- Updated coverage of sex differences in brain lateralization
- Updated coverage of anatomical asymmetries in the brain
- Updated coverage of the evolution of cerebral lateralization
- Updated coverage of the question of when cerebral lateralization evolved
- Twenty-seven new citations

CHAPTER 17: BIOPSYCHOLOGY OF EMOTION, STRESS, AND HEALTH

- Updated coverage of the facial feedback hypothesis
- Updated discussion of whether or not facial expressions are universal
- Thirty-two new citations

CHAPTER 18: BIOPSYCHOLOGY OF PSYCHIATRIC DISORDERS

- Major rewrite of this chapter
- Expanded coverage of all psychiatric disorders profiled in the chapter
- Coverage of the role of genetic, epigenetic, and neural factors for each psychiatric disorder
- Expanded and updated coverage of the discussion of the relative effectiveness of antidepressant medications
- Expanded coverage of theories of bipolar disorder
- Updated coverage of drug therapies for anxiety disorders
- Updated coverage of drug therapies for Tourette's disorder
- One hundred and seven new citations

Pedagogical Learning Aids

Biopsychology has several features expressly designed to help students learn and remember the material:

- **Scan Your Brain** study exercises appear within chapters at key transition points, where students can benefit most from pausing to consolidate material before continuing.

- **Check It Out** demonstrations apply biopsychological phenomena and concepts for students to experience themselves.
- **Themes Revisited** section at the end of each chapter summarizes the ways in which the book's four major themes, and its two emerging themes, relate to that chapter's subject matter.
- **Key Terms** appear in **boldface**, and other important terms of lesser significance appear in *italics*.
- **Appendixes** serve as convenient sources of additional information for students who want to expand their knowledge of selected biopsychology topics.

REVEL™ Revel is an interactive learning environment that deeply engages students and prepares them for class. Media and assessment integrated directly within the authors' narrative let students read, explore interactive content, and practice in one continuous learning path. Thanks to the dynamic reading experience in Revel, students come to class prepared to discuss, apply, and learn from instructors and from each other.

Learn more about REVEL

www.pearson.com/revel

CHALK IT UP! ANIMATIONS Barnes and Pinel have created at least one unique and engaging chalkboard-based stop-motion animation per chapter. Pinel and his partner Maggie worked on the scripts and storyboards, and Barnes produced, directed, and hand-drew every single frame of the animations. The videos were edited by Linnea Ritland (Linnea also did the voiceovers for the animations) and Chandra Jade—two extremely talented alumni of the University of British Columbia.

The animations help to place emphasis on important and/or difficult topics, to inspire interest in students, and to illustrate complex biopsychological processes, concepts, and theories. Moreover, Barnes himself appears as a character in most of the animations.

INTEGRATED WRITING OPPORTUNITIES Questions for review and reflection are integrated into the text, giving students an opportunity to stop and think about the content presented and to respond in a written format. There are writing prompts tied to the major themes throughout each chapter for individual student response and also a Shared Writing prompt at the end of each chapter that allows students to respond to and discuss a particular concept from the chapter with their classmates.

NEW! BUILT-IN END-OF-MODULE AND END-OF-CHAPTER QUIZZES This edition includes both end-of-module and end-of-chapter formative review questions for students available in Revel and the Test Bank.

Ancillary Materials Available with *Biopsychology*

FOR INSTRUCTORS Pearson Education is pleased to offer the following supplements to qualified adopters.

***Test Bank* (0135870674)** The test bank for the Eleventh Edition of *Biopsychology* comprises more than 2,000 multiple-choice questions, including questions about accompanying brain images. Each item has answer justification, learning objective correlation, difficulty rating, and skill type designation, so that instructors can easily select appropriate questions for their tests.

***MyTest Test Bank* (0135870690)** This test bank is available in computerized format, which allows instructors to create and print quizzes and exams. Questions and tests can be authored online, allowing instructors maximum flexibility and the ability to efficiently manage assessments anytime, anywhere. Instructors can easily access existing questions and edit, create, and store questions using simple drag-and-drop controls. For more information, go to www.pearsonhighered.com/mytest.

***Instructor's Manual* (0135870704)** The instructor's manual contains helpful teaching tools, including at-a-glance grids, activities and demonstrations for the classroom, handouts, lecture notes, chapter outlines, and other valuable course organization material for new and experienced instructors.

***Video Embedded PowerPoint Slides* (0135870712)** These slides, available in the Instructor's Resource Center, bring highlights of this edition of *Biopsychology* right into the classroom, drawing students into the lecture and providing engaging visuals, and include links to the videos referenced in each chapter.

***Standard Lecture PowerPoint Slides* (0135870763)** These accessible slides have a more traditional format, with excerpts of the chapter material and artwork, and are available online at www.pearsonhighered.com/irc.

Acknowledgments

Seven people deserve special credit for helping us create this edition of *Biopsychology*: Maggie Edwards, Linnea Ritland, Chandra Jade, Olivia Sorley, Natasha Au, Zamina Mithani, and Kim Nipp. Maggie is an artist/designer/

writer/personal trainer who is John's partner in life. She is responsible for the original designs of most of the illustrations that appear in the chapters. Linnea, Chandra, Olivia, Natasha, Zamina, and Kim are six remarkable alumni of the University of British Columbia; Linnea helped with the drawing, editing, and voiceovers for the Chalk It Up Animations; Chandra helped with the editing of some of the Chalk It Up Animations; Olivia helped with the drawing of some of the Chalk It Up Animations; Natasha and Zamina helped with collecting articles as part of the research that went into this edition; and Kim co-designed the cover of the text with Barnes.

Pearson Education did a remarkable job of producing the original *Biopsychology*. They shared the dream of a solution that meets the highest standards of pedagogy but is also personal, attractive, and enjoyable. Now they have stepped up to support the conversion of *Biopsychology* to electronic format. Special thanks also go to Kelli Strieby, Matthew Summers, and Lisa Mafrici at Pearson; Marita Bley for her development, editing, and coordination; and Annemarie Franklin at SPi Global for coordinating the production—an excruciatingly difficult and often thankless job.

We thank the following instructors for providing us with reviews of various editions of *Biopsychology*. Their comments have contributed substantially to the evolution of this edition:

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Ashkat Vyas, Hunter College
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Linda Walsh, University of Northern Iowa
Charles Weaver, Baylor University
David Widman, Juniata College
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David Yager, University of Maryland
H.P. Ziegler, Hunter College

To the Student

We have tried to make *Biopsychology* different with content that includes clear, concise, and well-organized explanations of the key points but is still interesting to read—material from which you might suggest suitable sections to an interested friend or relative. To accomplish this goal, we thought about what kind of materials we would have liked when we were students, and we decided to avoid the stern formality and ponderous style of conventional science writing and to focus on ideas of relevance to your personal life.

We want *Biopsychology* to have a relaxed and personal style. In order to accomplish this, we imagined that we were chatting with you as we wrote and that we were telling you—usually over a glass of something—about the interesting things that go on in the field of biopsychology. Imagining these chats kept our writing from drifting back into conventional "textbookese," and it never let us forget that we were writing these materials for you.

As we write these words, we have finished work on this new edition, and now we are waiting with great excitement for *Biopsychology* to be released. There is more excitement around this edition than there has been since the first edition appeared in 1990—this time the excitement is about the release of *Biopsychology* in an online-only format and all the opportunities that it creates for effective teaching. We really hope that you will find this new format easy to use, interesting, and, most importantly, an effective learning tool.

We hope that *Biopsychology* teaches you much of relevance to your personal life and that reading it generates in you the same positive feelings that writing it did in us.

About the Authors

JOHN PINEL obtained his Ph.D. from McGill University in Montreal and worked briefly at the Massachusetts Institute of Technology before taking a faculty position at the University of British Columbia in Vancouver, where he is currently Professor Emeritus. Professor Pinel is an award-winning teacher and the author of more than 200 scientific papers. However, he feels that *Biopsychology* is his major career-related accomplishment: "It ties together everything I love about my job: students, teaching, writing, and research."

STEVEN BARNES obtained his Ph.D. from the University of British Columbia. He then worked as a postdoctoral fellow—first in the Department of Epileptology at the University of Bonn and then in the School of Interactive Arts and Technology at Simon Fraser University. He is currently an Associate Professor of Teaching, and Associate Head of Undergraduate Affairs, in the Department of Psychology at the University of British Columbia.

Steven is well-regarded for his work related to online learning technologies (e.g., the Tapestry Project; see tapestrytool.com), student mental health and wellbeing, and bipolar disorder (BD). Steven co-directs the Collaborative RESearch Team to study psychosocial issues in BD (CREST.BD, see crestbd.ca), a BD research and knowledge exchange network, which received the 2018 Canadian Institutes for Health Research Gold Leaf Prize for Patient Engagement, Canada's most prestigious recognition for patient engagement in research across all health disciplines.

Steven is the recipient of multiple institutional awards for his teaching, including the prestigious Killam Teaching Prize and the 3M National Teaching Fellowship—the top national award given for teaching in any discipline in any postsecondary institution in Canada.

When he isn't teaching, writing, or doing research, he engages in the production of traditional pieces of visual art as well as interactive electronic artworks—some of which have been exhibited at prominent international venues. He sees his involvement in the creation of this new edition of *Biopsychology* as a complement to everything he loves to do: teaching, writing, visual and interactive art, and research.

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