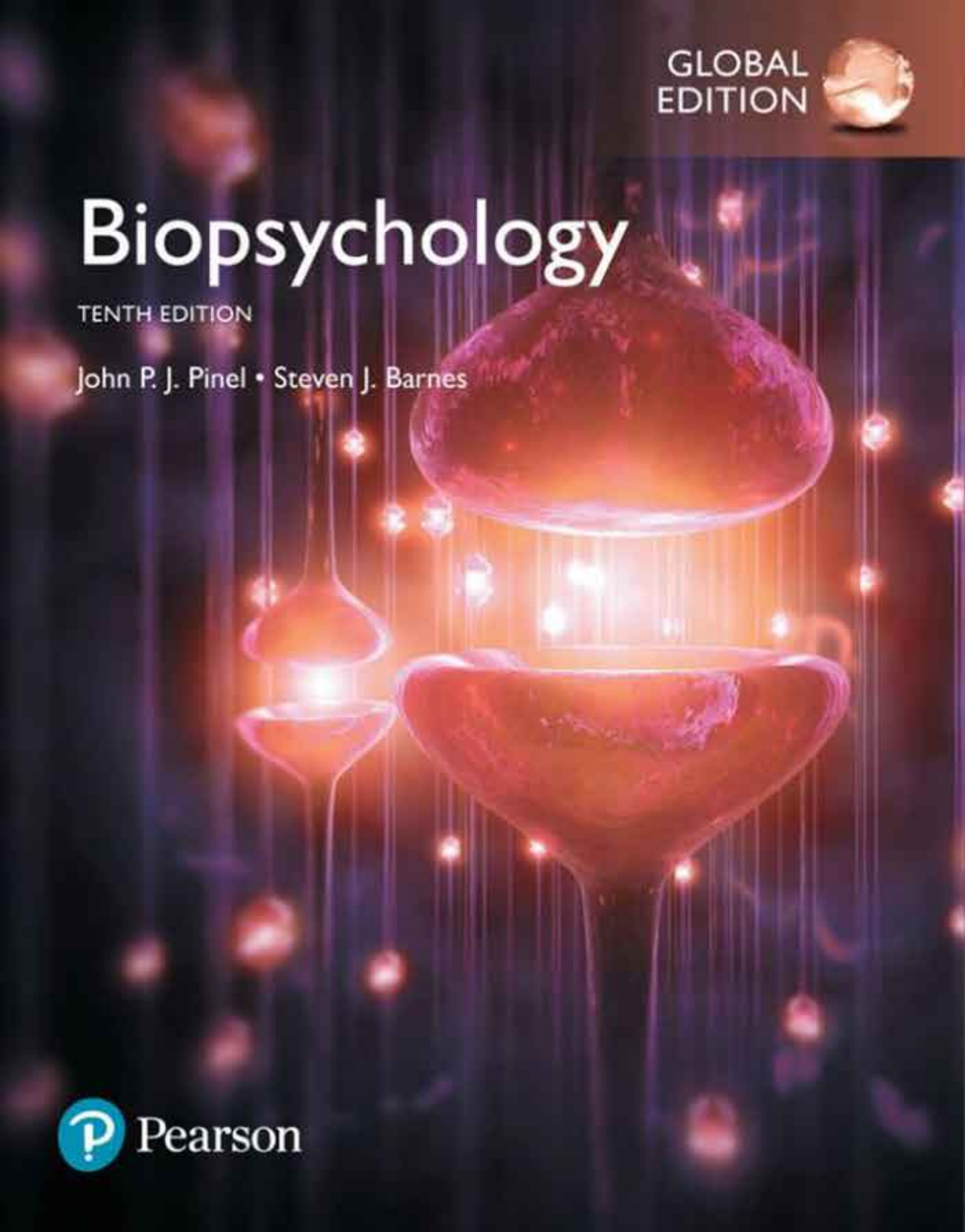
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Biopsychology

TENTH EDITION

GLOBAL EDITION

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

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

Steven Barnes: *To Behnaz and Mina, the loves of my life.*

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Brief Contents

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Contents

Preface

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

The defining feature of *Biopsychology* is its unique combination of biopsychological science and personal, reader-oriented discourse. It is a text that is "untextlike." Instead of presenting the concepts of biopsychology in the usual textbook fashion, it addresses students directly and interweaves the fundamentals of the field with clinical case studies, social issues, personal implications, useful metaphors, and memorable anecdotes.

Key Features Maintained in the Tenth 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 highlighted throughout the text by distinctive tabs: (1) thinking creatively, (2) clinical implications, (3) evolutionary perspective, and (4) neuroplasticity. 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 text. 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 text by uniquely qualified scientists. John Pinel and his artist/designer wife, Maggie Edwards, created many of the original illustrations from previous editions.

FOCUS ON BEHAVIOR In some biopsychological textbooks, 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 VOICE Arguably the strongest pedagogical feature of *Biopsychology* is its personal tone. In previous editions, 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, except the addition of Barnes as coauthor has added another friendly voice as well as making possible some new approaches to teaching.

Additions to the Tenth Edition

Three new features are available in the Tenth Edition of *Biopsychology*.

NEW! 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 of this book throughout each chapter for individual student response.

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 and the Test Bank.

NEW! EXPANDED AND COMPREHENSIVE LEARNING OBJECTIVES This edition has expanded the use of learning objectives, written by Pinel and Barnes. Additional learning objectives were added in as a means of better

specifying to students what the major points are in each portion of the text.

New, Expanded, or Updated Coverage in the Tenth Edition

Biopsychology remains one of the most rapidly progressing scientific fields. Like previous editions, the Tenth Edition of *Biopsychology* has meticulously incorporated recent developments in the field—it contains more than 1,265 citations of articles or books that did not appear in the preceding edition. These recent developments have dictated changes to many parts of the text. The following list presents some of the content changes to this edition, organized by chapter.

CHAPTER 1: BIOPSYCHOLOGY AS A NEUROSCIENCE

- Nobel Prize–winning work on grid cells and place cells by John O'Keefe, May-Britt Moser, and Edvard Moser
- Coverage of the topic of translational research
- 21 new citations

CHAPTER 2: EVOLUTION, GENETICS, AND EXPERIENCE

- Updated coverage of the emergence of humankind
- Discussion of the evidence of mating between *Homo sapiens* and *Homo neanderthalensis*
- Coverage of the use of ancient DNA
- Summary of the human proteome project
- Expanded coverage of the topic of epigenetics, including coverage of the topic of transgenerational epigenetics
- 90 new citations

CHAPTER 3: ANATOMY OF THE NERVOUS SYSTEM

- Updated coverage of cerebrospinal fluid production and absorption
- Summary of the issues associated with the classification of neurons
- Updated coverage of glial cells
- 38 new citations

CHAPTER 4: NEURAL CONDUCTION AND SYNAPTIC TRANSMISSION

- 36 new citations

CHAPTER 5: THE RESEARCH METHODS OF BIOPSYCHOLOGY

- Updated coverage of positron emission tomography (PET)
- Coverage of combined use of PET and functional magnetic resonance imaging (fMRI)
- Coverage of the use of fMRI to communicate with patients who are in a "vegetative state" (patients who appear to lack consciousness)
- Introduction of the Human Connectome Project and related projects in other species
- Expanded coverage of transcranial stimulation techniques, including the addition of transcranial direct current stimulation (tDCS)
- Better explanation of how the skin conductance response (SCR) works
- Coverage of the new field of optogenetics
- 38 new citations

CHAPTER 6: THE VISUAL SYSTEM

- Explanation of the number of different sorts of retinal ganglion cells
- Coverage of retinal implants
- Expanded coverage of the dorsal versus ventral streams
- Better definition of prosopagnosia that distinguishes between developmental prosopagnosia versus acquired prosopagnosia
- Expanded coverage of prosopagnosia
- 46 new citations

CHAPTER 7: MECHANISMS OF PERCEPTION: HEARING, TOUCH, SMELL, TASTE, AND ATTENTION

- Updated coverage of the study of the auditory cortex
- Statement of the role of skin cells in somatosensation
- Two new key terms: *merkel's disks*, *ruffini endings*
- Improved definition of anosagnosia
- Updated coverage of the rubber-hand illusion
- Updated coverage of the cortical representation of pain
- Updated coverage of the gustatory system
- 79 new citations

CHAPTER 8: THE SENSORIMOTOR SYSTEM

- Recent research on the posterior parietal association cortex
- Updated coverage of contralateral neglect
- Updated discussion of the current view of the function of the primary motor cortex
- Coverage of the control of robotic limbs by patients with electrode arrays implanted in their primary motor cortex

- Coverage of the idea of an *action map* in the primary motor cortex
- 59 new citations

CHAPTER 9: DEVELOPMENT OF THE NERVOUS SYSTEM

- New figure on stem cells
- Updated coverage of neural tube defects
- Updated coverage of the development of the neural crest
- Updated coverage of the topographic gradient hypothesis
- Expanded and updated coverage of adult neurogenesis
- Substantial changes to the coverage of autism spectrum disorders—to account for changes in the diagnostic criteria in the DSM-5
- Updated coverage of savantism
- Updated coverage of the genetic basis of autism spectrum disorders
- Coverage of the potential role of glial cells in the etiology of autism spectrum disorders
- Updated coverage of Williams syndrome, including expanded coverage of its neural correlates and its genetic basis
- Coverage of the role of microglia in synapse rearrangement
- 106 new citations

CHAPTER 10: BRAIN DAMAGE AND NEUROPLASTICITY

- Updated coverage of drug treatments for acute stroke
- Coverage of chronic traumatic encephalopathy
- New case study: Junior Seau, Football Player
- Introduction of the term *focal seizures*
- Coverage of transcranial magnetic stimulation and the ketogenic diet as treatments for epilepsy
- Updated coverage of Parkinson's disease
- Role of protein aggregation in Huntington's disease
- Updated coverage of the pathology, risk factors, and drug treatments associated with multiple sclerosis
- Updated coverage of the genetics of Alzheimer's disease
- Coverage of the role of apoliprotein E (APOE) in Alzheimer's disease
- Improved discussion of the amyloid hypothesis of Alzheimer's disease
- Further coverage of treatments for Alzheimer's disease (e.g., tissue plasminogen activator)
- Discussion of how the study of Down syndrome has informed our understanding of the neural mechanisms of Alzheimer's disease
- Coverage of the role of the tau protein in the neurofibrillary tangles of Alzheimer's disease
- Discussion of the role of glial scarring in inhibiting axonal regrowth following axonal damage
- 123 new citations

CHAPTER 11: LEARNING, MEMORY, AND AMNESIA

- Updated coverage of H.M.
- Updated coverage of reconsolidation
- Updated coverage of place cells and grid cells, and their relationship
- Introduction of the concept of "time cells" in the hippocampus
- Coverage of roles of the hippocampus in nonspatial forms of memory
- Updated coverage of Jennifer Aniston neurons (concept cells)
- New section on "engram cells"
- Updated coverage of the relationship between LTP and learning and memory
- Introduction of new key term: *metaplasticity*
- 81 new citations

CHAPTER 12: HUNGER, EATING, AND HEALTH

- Introduction of research on the gut microbiome
- New section on modern research on the role of hypothalamic nuclei in hunger and satiety
- Updated coverage of the obesity epidemic
- New section on the role of alterations to the gut microbiome in the obesity epidemic
- Updated coverage of treatments for obesity
- 78 new citations

CHAPTER 13: HORMONES AND SEX

- Updated coverage of the X- and Y-chromosomes
- Updated coverage of the role of progesterone in men
- Introduction of new key terms: *intersexed person, gay, asexual*
- Updated coverage of the role of alpha fetoprotein in humans
- Updated coverage of the development of sex differences in the behavior of humans

- Updated coverage of female sexual behavior and gonadal hormones
- New section on gender identity
- 42 new citations

CHAPTER 14: SLEEP, DREAMING, AND CIRCADIAN RHYTHMS

- Updated the sleep stages to be consistent with the guidelines set forth by the American Academy of Sleep Medicine
- New table to summarize the various sleep stages and their naming
- Updated coverage of recuperation theories of sleep
- Updated coverage of experimental studies of sleep deprivation in humans
- Improved figure of the carousel apparatus (used for sleep deprivation studies in rodents)
- Updated coverage of the role of sleep in memory
- Updated coverage of drugs that affect sleep
- Updated coverage of narcolepsy
- Introduction of new key term: *REM-sleep-behavior disorder*
- Updated coverage of the effects of shorter sleep times on health
- 85 new citations

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

- Increased coverage of marijuana
- Introduction of new key term: drug-addicted individual
- Updated coverage of the effects of marijuana on brain function
- Updated coverage of treatments for heroin addiction
- 81 new citations

CHAPTER 16: LATERALIZATION, LANGUAGE, AND THE SPLIT BRAIN

- Updated coverage of what abilities or cognitive processes are lateralized
- Updated coverage of brain differences between sinestrals and dextrals
- Updated coverage of anatomical asymmetries in the brain
- Updated coverage of the evolution of cerebral lateralization
- Improved coverage of the motor theory of speech perception
- Expanded coverage of developmental dyslexia
- 59 new citations

CHAPTER 17: BIOPSYCHOLOGY OF EMOTION, STRESS, AND HEALTH

- Updated coverage of the James-Lange and Cannon-Bard theories
- Updated coverage of the guilty knowledge technique
- Expanded coverage of current perspectives on facial expressions
- Updated coverage of aggression and testosterone
- Updated coverage of the role of the medial prefrontal lobes in human emotion
- Expanded coverage of psychoneuroimmuonology
- 76 new citations

CHAPTER 18: BIOPSYCHOLOGY OF PSYCHIATRIC DISORDERS

- Introduction of the category label *schizophrenia spectrum disorders* to reflect the associated change in the DSM-5
- Expanded coverage of causal factors in schizophrenia
- Introduction of new key terms: *antipsychotic drug typical antipsychotics*
- Updated coverage of the dopamine theory of schizophrenia
- Expanded coverage of current research on and treatments for schizophrenia
- Updated coverage of genetics of schizophrenia
- Updated coverage of brain differences associated with schizophrenia
- New and separate modules for depressive disorders and bipolar disorders to reflect the new categories in the DSM-5
- Expanded coverage of depressive disorders
- Expanded coverage of causal factors in major depressive disorder
- Introduction of new key term *peripartum depression*
- Expanded coverage of antidepressant drugs
- Expanded coverage of the brain differences associated with depressive disorders
- Expanded coverage of theories of depression
- New section on treatment of depression with brain stimulation
- Expanded coverage of bipolar disorders
- Introduction of two new key terms *bipolar disorder type II* and *bipolar disorder type I*

- New expanded three-part version of the case of S.B.
- Expanded coverage of causal factors in bipolar disorders
- Expanded coverage of mood stabilizers
- Expanded coverage of brain differences associated with bipolar disorder
- Expanded coverage of theories of bipolar disorders
- Updated module on anxiety disorders to reflect the changes made to the category in the DSM-5
- Updated section on the use of antidepressant drugs for the treatment of anxiety disorders
- Update of name of Tourette syndrome to Tourette's disorder to reflect the name change in the DSM-5
- Updated coverage of Tourette's disorder
- Expanded coverage of the neural bases and treatment of Tourette's disorder
- 127 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 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.

Ancillary Materials Available with *Biopsychology*

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

Test Bank The test bank for the Tenth Edition of *Biopsychology* comprises more than 2,000 multiple-choice questions, including questions about accompanying brain images. The difficulty of each item is rated—easy (1), moderate (2), or difficult (3)—to assist instructors with test construction. Each item is also labeled with a topic and a page reference so that instructors can easily select appropriate questions for their tests. Textbook authors rarely prepare their own test banks; the fact that Pinel and Barnes insisted on preparing the *Biopsychology* test bank attests to its consistency with the text—and their commitment to helping students learn.

Instructor's Manual 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 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 videos.

Standard Lecture PowerPoint Slides These slides have a more traditional format, with excerpts of the text material and artwork, and are available online at www.pearsonglobaleditions.com/pinel.

MyPsychLab MyPsychLab is an online homework, tutorial, and assessment program that truly engages students in learning. It helps students better prepare for class, quizzes, and exams—resulting in better performance in the course. It provides educators a dynamic set of tools for gauging individual and class performance.

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Four people deserve special credit for helping us create this edition of *Biopsychology*: Maggie Edwards, Linnea Ritland, Chandra Jade, and Olivia Sorley. 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 in this book. Linnea, Chandra, and Olivia are three remarkable students at 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, and Olivia helped with the drawing of some of the Chalk It Up Animations.

Pearson Education did a remarkable job of producing the original textbook. They shared the dream of a textbook 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. Thank you to Bill Barke, Stephen Frail, Susan Hartman, and other executives for having faith in *Biopsychology* and providing the financial and personal support necessary for it to stay at the forefront of its field. Special thanks also go to Amber Chow and Thomas Finn at Pearson and Ron Watson at Integra for coordinating the production—an excruciatingly difficult and often thankless job.

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To the Student

We have tried to make *Biopsychology* a different kind of text, a text that includes clear, concise, and well-organized explanations of the key points but is still interesting to read—a text from which you might suggest suitable sections to an interested friend or relative. To accomplish this goal, we thought about what kind of textbook we would have liked when we were students, and we decided to avoid the stern formality and ponderous style of conventional textbook 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 this book for you.

As we write these words, we have finished work on this new edition, and now we are waiting with great excitement for the text 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 conversion of *Biopsychology* to an electronic format and all the opportunities that it creates for effective teaching. We really hope that you will find this new format to be easy to use, interesting, and, most importantly, an effective learning tool—we already know that you will be pleased with the reduced price and the savings of natural resources.

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 Columba. 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 a faculty member in the Department of Psychology at the University of British Columbia, where he has won multiple departmental and institutional awards for his teaching and educational leadership. His current research is focused on bipolar disorders: He is a core member and the co-deputy director of the Collaborative RESearch Team to study psychosocial issues in Bipolar Disorder (CREST.BD)—a multidisciplinary international collaborative network of researchers, healthcare providers, people living with bipolar disorder, and their family members and supporters. 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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Chapter 1

Biopsychology as a Neuroscience

What Is Biopsychology, Anyway?

Chapter Overview and Learning Objectives (LOs)

What Is Biopsychology?	**LO 1.1**	Define and discuss what is meant by *biopsychology*.
	LO 1.2	Discuss the origins of the field of biopsychology.
	LO 1.3	List the six fields of neuroscience that are particularly relevant to biopsychological inquiry.
What Types of Research Characterize the Biopsychological Approach?	**LO 1.4**	Compare the advantages and disadvantages of humans and nonhumans as subjects in biopsychological research.
	LO 1.5	Compare experiments, quasiexperimental studies, and case studies, emphasizing the study of causal effects.
	LO 1.6	Compare pure and applied research.
What Are the Divisions of Biopsychology?	**LO 1.7**	Describe the division of biopsychology known as physiological psychology.

LO 1.8 Describe the division of biopsychology known as psychopharmacology.

LO 1.9 Describe the division of biopsychology known as neuropsychology.

LO 1.10 Describe the division of biopsychology known as psychophysiology.

LO 1.11 Describe the division of biopsychology known as cognitive neuroscience.

LO 1.12 Describe the division of biopsychology known as comparative psychology.

How Do Biopsychologists Conduct Their Work?

LO 1.13 Explain how converging operations has contributed to the study of Korsakoff's syndrome.

LO 1.14 Explain scientific inference with reference to research on eye movement and the visual perception of motion.

Critical Thinking about Biopsychological Claims

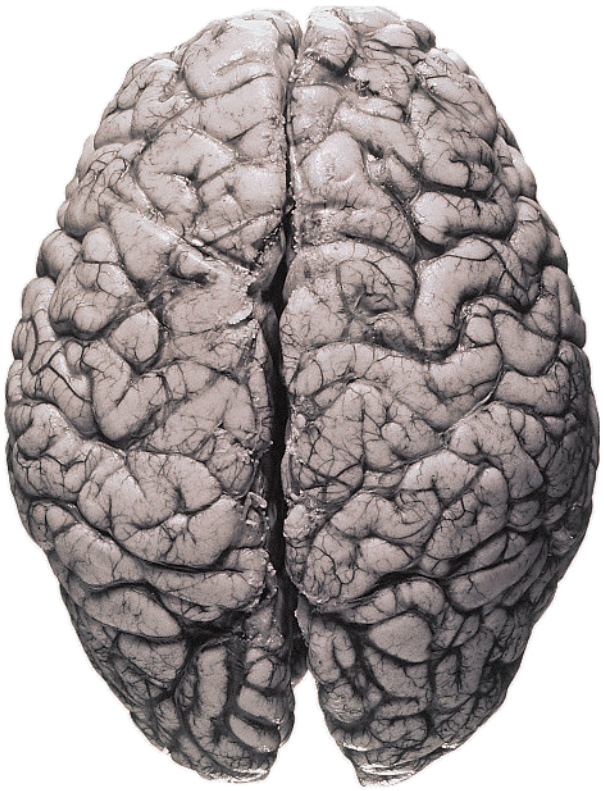
LO 1.15 Discuss Delgado's bull-ring demonstration, emphasizing its flawed interpretation.

LO 1.16 Describe the rise and fall of prefrontal lobotomy.

The appearance of the human brain is far from impressive (see Figure 1.1). The human brain is a squishy, wrinkled, walnut-shaped hunk of tissue weighing about 1.3 kilograms. It looks more like something you might find washed up on a beach than like one of the wonders of the world—which it surely is. Despite its disagreeable external appearance, the human brain is an amazingly intricate network of **neurons** (cells that receive and transmit electrochemical signals). Contemplate for a moment the complexity of your own brain's neural circuits. Consider the 90 billion neurons in complex array (see Lent et al., 2012; Walløe, Pakkenberg & Fabricius, 2014), the estimated 100 trillion connections among them, and the almost infinite number of paths that neural signals can follow through this morass (see Zimmer, 2011). The complexity of the human brain is hardly surprising, considering what it can do. An organ capable of creating a *Mona Lisa*, an artificial limb, and a supersonic aircraft; of traveling to the moon and to the depths of the sea; and of experiencing the wonders of an alpine sunset, a newborn infant, and a reverse slam dunk *must* be complex. Paradoxically, **neuroscience** (the scientific study of the nervous system) may prove to be the brain's ultimate challenge: Does the brain have the capacity to understand something as complex as itself (see Gazzaniga, 2010)?

Neuroscience comprises several related disciplines. The primary purpose of this chapter is to introduce you to one

Figure 1.1 The Human Brain.



of them: biopsychology. Each of this chapter's five modules characterizes the neuroscience of biopsychology in a different way.

Before you proceed to the body of this chapter, we would like to tell you about two things: (1) the case of Jimmie G. (Sacks, 1986), which will give you a taste of the interesting things that lie ahead, and (2) the major themes of this text.

The Case of Jimmie G., the Man Frozen in Time

Jimmie G. was a good-looking, friendly 49-year-old. He liked to talk about his school days and his experiences in the navy, which he was able to describe in detail. Jimmie was an intelligent man with superior abilities in math and science. In fact, it was not readily apparent why he was a resident of a neurological ward.

When Jimmie talked about his past, there was a hint of his problem. When he talked about his school days, he used the past tense; when he recounted his early experiences in the navy, however, he switched to the present tense. More worrisome was that he never talked about anything that happened to him after his time in the navy.

Jimmie G. was tested by eminent neurologist Oliver Sacks, and a few simple questions revealed a curious fact: The 49-year-old patient believed that he was 19. When he was asked to describe what he saw in a mirror, Jimmie became so frantic and confused that Dr. Sacks immediately took the mirror out of the room.

Returning a few minutes later, Dr. Sacks was greeted by a once-again cheerful Jimmie, who acted as if he had never seen Sacks before. Indeed, even when Sacks suggested that they had met recently, Jimmie was certain that they had not.

Then Dr. Sacks asked where Jimmie thought he was. Jimmie replied that all the beds and patients made him think that the place was a hospital. But he couldn't understand why he would be in a hospital. He was afraid that he might have been admitted because he was sick but didn't know it.

Further testing confirmed what Dr. Sacks feared. Although Jimmie had good sensory, motor, and cognitive abilities, he had one terrible problem: He forgot everything that was said or shown to him within a few seconds. Basically, Jimmie could not remember anything that had happened to him since his early 20s, and he was not going to remember anything that happened to him for the rest of his life. Sacks was stunned by the implications of Jimmie's condition.

Jimmie G.'s situation was heart-wrenching. Unable to form new lasting memories, he was, in effect, a man frozen in time, a man without a recent past and no prospects for a future, stuck in a continuous present, lacking any context or meaning.

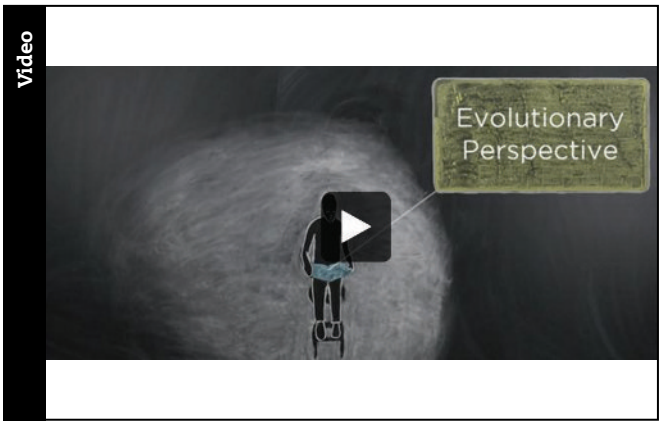
Remember Jimmie G.; you will encounter him again later in this chapter.

Four Major Themes of This Text

You will learn many new facts in this text—new findings, concepts, terms, and the like. But more importantly, many years from now, long after you have forgotten most of those facts, you will still be carrying with you productive new ways of thinking. We have selected four of these for special emphasis: Thinking Creatively, Clinical Implications, Evolutionary Perspective, and Neuroplasticity.

To help give these themes the special attention they deserve and to help you follow their development as you progress through the text, we have marked relevant passages with tabs denoting each of the four major themes, which we describe in more detail here.

Watch this video on MyPsychLab CHALK IT UP!: FOUR THEMES OF THE TEXT



THINKING CREATIVELY ABOUT BIOPSYCHOLOGY. We are all fed a steady diet of biopsychological information, misinformation, and opinion—by television, newspapers, the Internet, friends, relatives, teachers, and so on. As a result, you likely already hold strong views about many of the topics you will encounter in this text. Because these preconceptions are shared by many biopsychological researchers, they have often impeded scientific progress, and some of the most important advances in biopsychological science have been made by researchers who have managed to overcome the restrictive effects of conventional thinking and have taken creative new approaches. Indeed, **thinking creatively** (thinking in productive, unconventional ways) is the cornerstone of any science. The thinking creatively tab marks points in the text where we describe research that involves thinking "outside the box," where we have tried to be creative in the analysis of the research that we are presenting, or where we encourage you to base your thinking on the evidence rather than on widely accepted views.

Thinking Creatively

CLINICAL IMPLICATIONS. **Clinical** (pertaining to illness or treatment) considerations are woven through the

fabric of biopsychology. There are two aspects to clinical implications: Much of what biopsychologists learn about the functioning of the normal brain comes from studying the diseased or damaged brain; and, conversely, much of what biopsychologists discover has relevance for the treatment of brain disorders.

This text focuses on the interplay between brain dysfunction and biopsychological research, and each major example is highlighted by a clinical implications tab.

Clinical Implications

THE EVOLUTIONARY PERSPECTIVE. Although the events that led to the evolution of the human species can never be determined with certainty, thinking of the environmental pressures that likely led to the evolution of our brains and behavior often leads to important biopsychological insights. This approach is called the evolutionary perspective. An important component of the **evolutionary perspective** is the comparative approach (trying to understand biological phenomena by comparing them in different species). You will learn throughout the text that we humans have learned much about ourselves by studying species that are related to us through evolution. The evolutionary approach has proven to be one of the cornerstones of modern biopsychological inquiry. Each discussion that relates to the evolutionary perspective is marked by an evolutionary perspective tab.

Evolutionary Perspective

NEUROPLASTICITY. Until the early 1990s, most neuroscientists thought of the brain as a three-dimensional array of neural elements "wired" together in a massive network of circuits. The complexity of this "wiring diagram" of the brain was staggering, but it failed to capture one of the brain's most important features. In the past two decades, research has clearly demonstrated that the adult brain is not a static network of neurons: It is a plastic (changeable) organ that continuously grows and changes in response to the individual's genes and experiences. The discovery of neuroplasticity, arguably the single most influential discovery in modern neuroscience, is currently influencing many areas of biopsychological research. A neuroplasticity tab marks each discussion or study of neuroplasticity.

Neuroplasticity

What Is Biopsychology?

This module introduces you to the discipline of biopsychology. We begin by exploring the definition and origins of biopsychology. Next, we examine how biopsychology is related to the various disciplines of neuroscience.

Defining Biopsychology

LO 1.1 Define and discuss what is meant by *biopsychology*.

Biopsychology is the scientific study of the biology of behavior—see Dewsbury (1991). Some refer to this field as *psychobiology*, *behavioral biology*, or *behavioral neuroscience*; but we prefer the term *biopsychology* because it denotes a biological approach to the study of psychology rather than a psychological approach to the study of biology: Psychology commands center stage in this text. *Psychology* is the scientific study of behavior—the scientific study of all overt activities of the organism as well as all the internal processes that are presumed to underlie them (e.g., learning, memory, motivation, perception, emotion).

What Are the Origins of Biopsychology?

LO 1.2 Discuss the origins of the field of biopsychology.

The study of the biology of behavior has a long history, but biopsychology did not develop into a major neuroscientific discipline until the 20th century. Although it is not possible to specify the exact date of biopsychology's birth, the publication of *The Organization of Behavior* in 1949 by D. O. Hebb played a key role in its emergence (see Brown & Milner, 2003; Cooper, 2005; Milner, 1993). In his book, Hebb developed the first comprehensive theory of how complex psychological phenomena, such as perceptions, emotions, thoughts, and memories, might be produced by brain activity. Hebb's theory did much to discredit the view that psychological functioning is too complex to have its roots in the physiology and chemistry of the brain. Hebb based his theory on experiments involving both humans and laboratory animals, on clinical case studies, and on logical arguments developed from his own insightful observations of daily life. This eclectic approach has become a hallmark of biopsychological inquiry.

In comparison to physics, chemistry, and biology, biopsychology is an infant—a healthy, rapidly growing infant, but an infant nonetheless. In this text, you will reap the benefits of biopsychology's youth. Because biopsychology does not have a long and complex history, you will be able to move quickly to the excitement of current research.

How Is Biopsychology Related to the Other Disciplines of Neuroscience?

LO 1.3 List six fields of neuroscience that are particularly relevant to biopsychological inquiry.

Neuroscience is a team effort, and biopsychologists are important members of the team (see Albright, Kandel, & Posner, 2000; Kandel & Squire, 2000). Biopsychology can be further defined by its relation to other neuroscientific disciplines.

Biopsychologists are neuroscientists who bring to their research a knowledge of behavior and of the methods of behavioral research. It is their behavioral orientation and expertise that make their contribution to neuroscience unique (see Cacioppo & Decety, 2009). You will be able to better appreciate the importance of this contribution if you consider that the ultimate purpose of the nervous system is to produce and control behavior (see Grillner & Dickinson, 2002).

Biopsychology is an integrative discipline. Biopsychologists draw together knowledge from the other neuroscientific disciplines and apply it to the study of behavior. The following are a few of the disciplines of neuroscience that are particularly relevant to biopsychology (see Figure 1.2):

Neuroanatomy. The study of the structure of the nervous system (see Chapter 3).

Neurochemistry. The study of the chemical bases of neural activity (see Chapter 4).

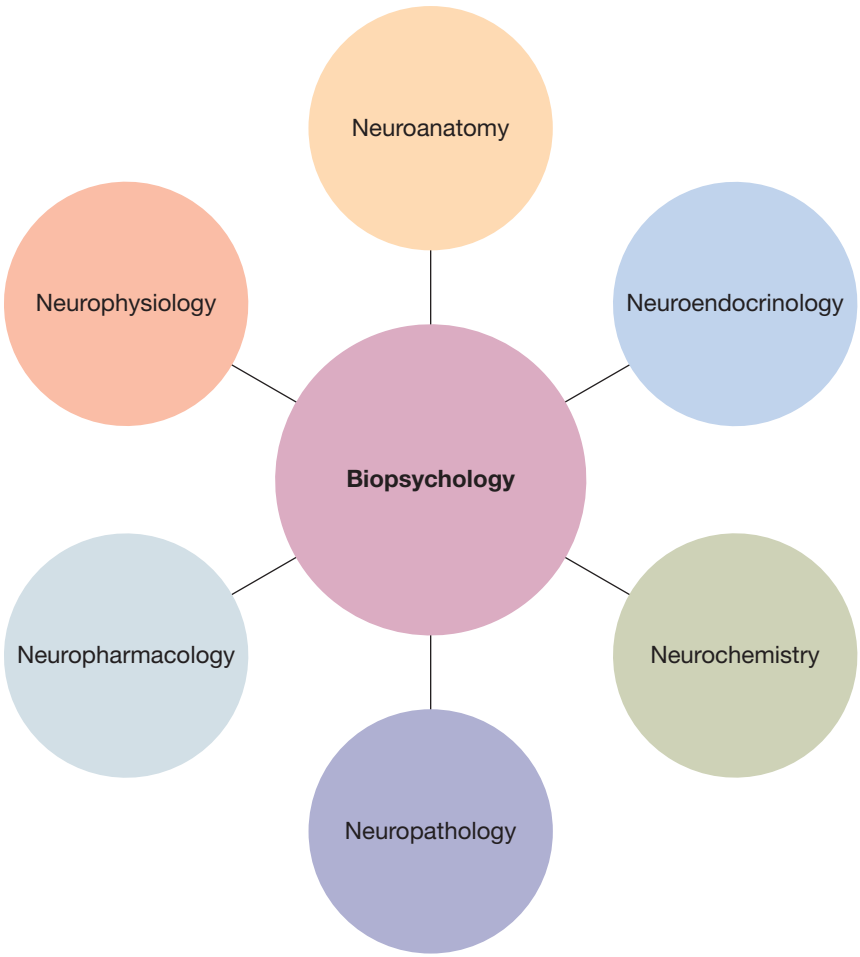
Neuroendocrinology. The study of interactions between the nervous system and the endocrine system (see Chapters 13 and 17).

Neuropathology. The study of nervous system disorders (see Chapters 10 and 18).

Neuropharmacology. The study of the effects of drugs on neural activity (see Chapters 4, 15, and 18).

Neurophysiology. The study of the functions and activities of the nervous system (see Chapter 4).

Figure 1.2 Biopsychology and a few of the disciplines of neuroscience that are particularly relevant to it.



What Types of Research Characterize the Biopsychological Approach?

Although biopsychology is only one of many disciplines that contribute to neuroscience, it is broad and diverse. Biopsychologists study many different phenomena, and they approach their research in many different ways. In order to characterize biopsychological research, this module discusses three major dimensions along which approaches to biopsychological research vary. Biopsychological research can involve either human or nonhuman subjects, it can take the form of either formal experiments or nonexperimental studies, and it can be either pure or applied.

Human and Nonhuman Subjects

LO 1.4 **Compare the advantages and disadvantages of humans and nonhumans as subjects in biopsychological research.**

Both human and nonhuman animals are the subject of biopsychological research. Of the nonhumans, mice and rats are the most common subjects; however, cats, dogs, and nonhuman primates are also commonly studied.

Humans have several advantages over other animals as experimental subjects of biopsychological research: They can follow instructions, they can report their subjective experiences, and their cages are easier to clean. Of course, we are joking about the cages, but the joke does serve to draw attention to one advantage humans have over other species of experimental subjects: Humans are often cheaper. Because only the highest

standards of animal care are acceptable, the cost of maintaining an animal laboratory can be prohibitive for all but the most well-funded researchers.

Of course, the greatest advantage humans have as subjects in a field aimed at understanding the intricacies of human brain function is that they have human brains. In fact, you might wonder why biopsychologists would bother studying nonhuman subjects at all. The answer lies in the evolutionary continuity of the brain. The brains of humans differ from the brains of other mammals primarily in their overall size and the extent of their cortical development. In other words, the differences between the brains of humans and those of related species are more quantitative than qualitative, and thus many of the principles of human brain function can be clarified by the study of nonhumans (see Hofman, 2014; Katzner & Weigelt, 2013; Krubitzer & Stolzenberg, 2014).

Evolutionary Perspective

What ethical considerations should guide biopsychological research on nonhuman animals?

Conversely, nonhuman animals have three advantages over humans as subjects in biopsychological research. The first is that the brains and behavior of nonhuman subjects are simpler than those of human subjects. Hence, the study of nonhuman species is more likely to reveal fundamental brain–behavior interactions. The second advantage is that insights frequently arise from the **comparative approach**, the study of biological processes by comparing different species. For example, comparing the behavior of species that do not have a cerebral cortex with the behavior of species that do can provide valuable clues about cortical function. The third advantage is that it is possible to conduct research on laboratory animals that, for ethical reasons, is not possible with human participants. This is not to say that the study of nonhuman animals is not governed by a strict code of ethics (Blakemore et al., 2012)—it is. However, there are fewer ethical constraints on the study of laboratory species than on the study of humans.

In our experience, most biopsychologists display considerable concern for their subjects, whether they are of their own species or not; however, ethical issues are not left to the discretion of the individual researcher. All biopsychological research, whether it involves human or nonhuman subjects, is regulated by independent committees according to strict ethical guidelines: "Researchers cannot escape the logic that if the animals we observe are reasonable models of our own most intricate actions, then they must be respected as we would respect our own sensibilities" (Ulrich, 1991, p. 197).

Watch this video on MyPsychLab ETHICS OF ANIMAL RESEARCH

Experiments and Nonexperiments

LO 1.5 Compare experiments, quasiexperimental studies, and case studies, emphasizing the study of causal effects.

Biopsychological research involves both experiments and nonexperimental studies. Two common types of nonexperimental studies are quasiexperimental studies and case studies.

EXPERIMENTS. The experiment is the method used by scientists to study causation, that is, to find out what causes what. As such, it has been almost single-handedly responsible for the knowledge that is the basis for our modern way of life. It is paradoxical that a method capable of such complex feats is so simple. To conduct an experiment involving living subjects, the experimenter first designs two or more conditions under which the subjects will be tested. Usually, a different group of subjects is tested under each condition (**between-subjects design**), but sometimes it is possible to test the same group of subjects under each condition (**within-subjects design**). The experimenter assigns the subjects to conditions, administers the treatments, and measures the outcome in such a way that there is only one relevant difference between the conditions being compared. This difference between the conditions is called the **independent variable**. The variable measured by the experimenter to assess the effect of the independent variable is called the **dependent variable**. If the experiment is done correctly, any differences in the dependent variable between the conditions must have been caused by the independent variable.

Why is it critical that there be no differences between conditions other than the independent variable? The reason is that when there is more than one difference that