GLOBAL EDITION

Introduction to Biopsychology

NINTH EDITION

John P. J. Pinel
Steven J. Barnes

ALWAYS LEARNING

PEARSON

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Ninth Edition

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PEARSON

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To Maggie, the love of my life.

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Preface

Welcome to the Ninth Edition of *Biopsychology*! This edition builds on the strengths of its predecessors, but it also takes important new steps: In addition to covering many new cutting-edge research topics, it sharpens its focus on the human element of biopsychology and on promoting student thinking. Most importantly, this is the first edition of *Biopsychology* to focus on epigenetics. It introduces this new field, summarizes current knowledge, and most importantly stresses the relevance of epigenetic concepts to issues of human brain and behavior.

The Ninth 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 textbook that is "untextbooklike." 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 Ninth 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.

Clinical Implications | Evolutionary Perspective | Neuroplasticity | Thinking Creatively

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, 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 a uniquely qualified scientist–artist team: Pinel and his artist/designer wife, Maggie Edwards.

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. Pinel addresses students directly and talks to them with warmth, enthusiasm, and good humor about recent advances in biopsychological science. Many students report being engaged and inspired by this approach.

Additions to the Ninth Edition

Four new or expanded features appear in the Ninth Edition of *Biopsychology*.

NEW! Chapter-Opening Study Objectives Each chapter begins with a list of study objectives designed to direct students' reading and studying.

NEW! Blog-On! *Biopsychology* now comes with an accompanying author-run blog and website (www.biopsyc.com). The blog contains discussions of exciting new biopsychological research and theoretical issues not covered in the text. In addition to the blog, the website also contains a wide variety of links and materials to help students in their studying.

NEW! Even More MyPsychLab (www.mypsychlab.com) MyPsychLab is an online study resource that offers a wealth of animations and practice tests as well as additional study and research tools. This edition adds even more exciting content to MyPsychLab for students.

NEW! More Illustrations and Brain Images Building on *Biopsychology*'s strong art package, a number of new illustrations and brain images have been added. These have been carefully selected, designed, and positioned to support interest, clarity, and memorability.

New Coverage in the Ninth Edition

Biopsychology remains one of the most rapidly progressing scientific fields. Like previous editions, the Ninth Edition of *Biopsychology* has meticulously incorporated recent developments in the field—it contains more than 750 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

- 3 new citations

Chapter 2: Evolution, Genetics, and Experience

- New section on epigenetics
- A figure illustrating and emphasizing epigenetic mechanisms
- Summary of important recent discoveries of hominin fossils
- New summary of the human genome project, emphasizing the small number of human genes
- Clear statement of the failure to find major links between genes and neurological disorders
- Updated coverage of heritability estimates
- 50 new citations

Chapter 3: Anatomy of the Nervous System

- Updated coverage of glial function
- 15 new citations

Chapter 4: Neural Conduction and Synaptic Transmission

- Simplified explanation of the resting potential
- Recent discovery that action potentials originate in the axon initial segment
- Role of glia in synaptic transmission
- Additional coverage of gap junctions
- 22 new citations

Chapter 5: The Research Methods of Biopsychology

- Use of PET to determine the distribution in the brain of particular molecules
- Introduction of diffusion tensor imaging with a new illustration
- Simplified coverage of reversible brain lesions
- Updated coverage of gene replacement
- 19 new citations

Chapter 6: The Visual System

- Simplified coverage of the organization of neurons in the primary visual cortex
- Explanation of the role of context on the responses of visual neurons
- Improved discussion of dorsal and ventral streams
- Comparison of MT and fusiform face area
- 24 new citations

Chapter 7: Mechanisms of Perception: Hearing, Touch, Smell, Taste, and Attention

- Updated coverage of primary auditory cortex
- Statement of the role of cutaneous receptors in particular sensations
- More comparisons of auditory and visual cortex
- Discussion of rubber-hand illusion and bimodal neurons
- Improved coverage of the olfactory system
- Updated and clearer coverage of the gustatory system
- Updated coverage of attention
- 62 new citations

Chapter 8: The Sensorimotor System

- Shorter but clearer coverage of contralateral neglect
- Recent research on mirror neurons
- Discussion of evidence for mirror neurons in humans
- Updated discussion of functions of the cerebellum
- Simplified discussion of functional brain imaging studies of sensorimotor learning
- 37 new citations

Chapter 9: Development of the Nervous System

- Updated description of increased cell fate specification and related stem cell terminology

- New description of interaction of glial and neural development
- Discovery that radial glial cells develop into neurons
- Overall editing designed to shorten and simplify
- 59 new citations

Chapter 10: Brain Damage and Neuroplasticity

- Definition of gliomas
- Improved coverage of strokes
- Updated discussion of genetic factors and neurological disorders
- Introduction of the term *absence seizures*
- More concise coverage of the etiology of multiple sclerosis
- Concise summary of genes linked to Alzheimer's disease
- Role of microbleeds in Alzheimer's disease
- Importance of early diagnosis in the treatment of Alzheimer's disease
- Improved coverage of MPTP model
- Revised coverage of recovery of function
- Neurotransplantation is revised, updated, and out in a historical perspective
- 95 new citations

Chapter 11: Learning, Memory, and Amnesia

- Tightened up coverage of HM
- New discussion of transient global amnesia
- Tightened up and updated discussion of consolidation
- New section on evolving perspectives of the role of the hippocampus in memory
- New section on neurons of the medial temporal lobes and memory
- Updated coverage of place cells and grid cells
- Introduction and focus on Jennifer Aniston neurons
- Tightened up coverage of LTP
- 35 new citations

Chapter 12: Hunger, Eating, and Health

- Shortened and simplified by aggressive editing
- 10 new citations

Chapter 13: Hormones and Sex

- New section on the modern perspective of sex differences in the brain
- New section on development of sex differences in human behavior
- Discussion of sex differences in susceptibility to disease
- Updated coverage of anabolic steroid use
- New coverage of human sexual arousal and the brain
- 56 new citations

Chapter 14: Sleep, Dreaming, and Circadian Rhythms

- Updated coverage of the relationship between REM sleep and dreaming
- Circadian activity cycles of SCN neurons
- 33 new citations

Chapter 15: Drug Addiction and the Brain's Reward Circuits

- International statistics of drug use
- Increased coverage of the therapeutic effects of THC
- Increased coverage of the effects of MDMA
- Updated description of the treatment of heroin addiction
- Section on critical thinking about illegal drugs
- Major revision of discussion of early theories of addiction
- Major update of current approaches to the study of addiction
- 102 new citations

Chapter 16: Lateralization, Language, and the Split Brain

- Discussion of the interactions between the hemispheres of split brains
- Current status of the theory that right hemispheres are specialized for emotion
- Update of research on neuroanatomical asymmetries in the brain
- Improved coverage of the motor theory of speech perception
- 24 new citations

Chapter 17: Biopsychology of Emotion, Stress, and Health

- Chapter reorganized by moving *Stress and Health* to the end
- Reference to bullying
- Updated and simplified coverage of the neural mechanisms of emotion
- New section on current perspectives of neural mechanism of human emotion
- New description of the immune system
- 45 new citations

Chapter 18: Biopsychology of Psychiatric Disorders

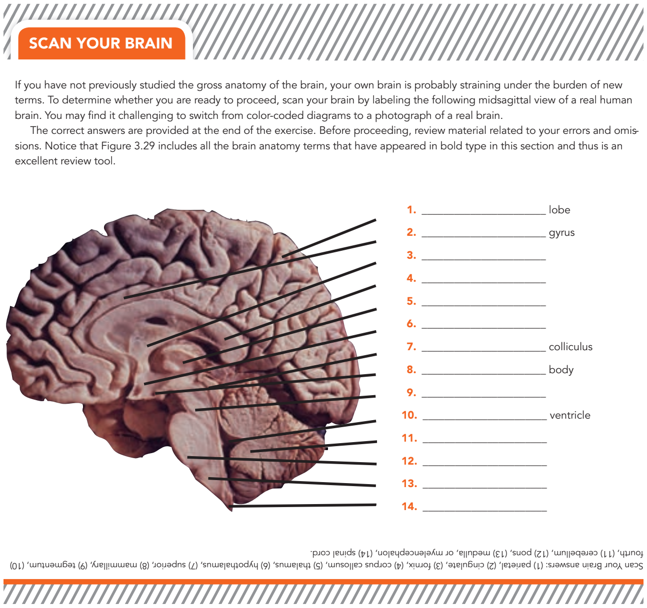
- Introduction of the anticipated DSM-V and the need for continual refinement of diagnoses
- New section on the current research and treatment of schizophrenia
- Updated coverage of treatments for depression
- Updated discussion of the monoamine theory of depression
- New description of the neuroplasticity theory of depression
- Discussion of current treatments for anxiety
- Discussion of problems with current system of diagnosis

- Introduction to the idea that pharmaceutical companies suppress negative findings
- 60 new research 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.



SCAN YOUR BRAIN

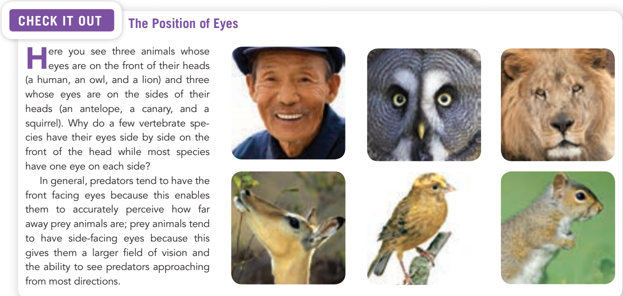
If you have not previously studied the gross anatomy of the brain, your own brain is probably straining under the burden of new terms. To determine whether you are ready to proceed, scan your brain by labeling the following midsagittal view of a real human brain. You may find it challenging to switch from color-coded diagrams to a photograph of a real brain.

The correct answers are provided at the end of the exercise. Before proceeding, review material related to your errors and omissions. Notice that Figure 3.29 includes all the brain anatomy terms that have appeared in bold type in this section and thus is an excellent review tool.

1. ______ lobe
2. ______ gyrus
3. ______
4. ______
5. ______
6. ______
7. ______ colliculus
8. ______ body
9. ______
10. ______ ventricle
11. ______
12. ______
13. ______
14. ______

Scan Your Brain answers: (1) parietal, (2) cingulate, (3) fornix, (4) corpus callosum, (5) thalamus, (6) hypothalamus, (7) superior, (8) mammillary, (9) tegmentum, (10) fourth, (11) cerebellum, (12) pons, (13) medulla, or myelencephalon, (14) spinal cord.

- **Think about It** discussion questions at the end of each chapter challenge students to think critically and creatively about the content.
- **Check It Out** demonstrations apply biopsychological phenomena and concepts for students to experience themselves.



CHECK IT OUT **The Position of Eyes**

Here you see three animals whose eyes are on the front of their heads (a human, an owl, and a lion) and three whose eyes are on the sides of their heads (an antelope, a canary, and a squirrel). Why do a few vertebrate species have their eyes side by side on the front of the head while most species have one eye on each side?

In general, predators tend to have the front facing eyes because this enables them to accurately perceive how far away prey animals are; prey animals tend to have side-facing eyes because this gives them a larger field of vision and the ability to see predators approaching from most directions.

- **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 Ninth 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 insists on preparing the *Biopsychology* test bank attests to its consistency with the text—and his commitment to helping students learn.

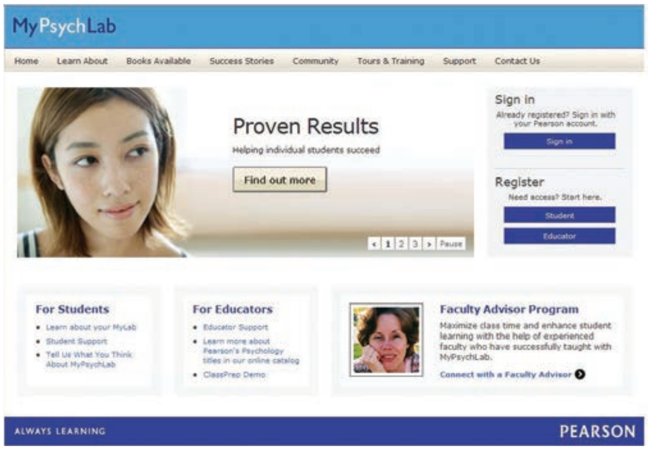
MyTest Test Bank This test bank is available in computerized format, which allows instructors to create and print quizzes and exams. Questions and tests can be authored online, allowing instructors maximum flexibility and the ability to efficiently manage assessments anytime, anywhere. Instructors can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

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. Additional resources have been added for the Ninth Edition, including information on MyPsychLab video assets and the Visual Brain.

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

NEW! MyPsychLab (www.mypsychlab.com)

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.



- **Customizable**—MyPsychLab is customizable. instructors choose what students' courses looks like. Homework, applications, and more can easily be turned on and off.
- **Blackboard Single Sign-on**—MyPsychLab can be used by itself or linked to any course management system. Blackboard single sign-on provides deep linking to all New MyPsychLab resources.
- **Pearson eText and Chapter Audio**—Like the printed text, students can highlight relevant passages and add notes. The Pearson eText can be accessed through laptops, iPads, and tablets. Download the free Pearson eText app to use on tablets. Students can also listen to their text with the Audio eText.
- **Assignment Calendar and Gradebook**—A drag and drop assignment calendar makes assigning and completing work easy. The automatically graded assessment provides instant feedback and flows into the gradebook, which can be used in MyPsychLab or exported.
- **Personalized Study Plan**—Students' personalized plans promote better critical thinking skills. The study plan organizes students' study needs into sections such as Remembering, Understanding, Applying, and Analyzing.
- **MyPsychLab Margin Icons**—Margin icons guide students from their reading material to relevant videos and simulations.

NEW! The Visual Brain

Visual BRAiN

Explore the **Visual System module** in MyPsychLab.

Available within MyPsychLab, the new **Visual Brain** is an interactive virtual brain designed to help students better understand neuroanatomy, physiology, and human behavior. Fifteen new modules bring to life many of the most difficult topics typically covered in the biopsychology course. Every module includes sections that explore relevant anatomy, physiological animations, and engaging case studies that bring behavioral neuroscience to life. At the end of each module, students can take an assessment that will help measure their understanding. This hands-on experience engages students and helps make course content and terminology relevant. References throughout the text direct students to content in MyPsychLab, and a new feature at the end of each chapter directs students to ***MyPsychLab Brain*** modules.

For Students

MyPsychLab With this exciting new tool, students are able to self-assess using embedded diagnostic tests and instantly view results along with a customized study plan.

The customized study plan will focus on the student's strengths and weaknesses, based on the results of the diagnostic testing, and present a list of activities and resources for review and remediation, organized by chapter section. Some study resources intended for use with portable electronic devices, such as key terms flashcards and video clips, are made available exclusively through MyPsychLab. Students will be able to quickly and easily analyze their own comprehension level of the course material and study more efficiently, leading to exceptional exam results! An access code is required and can be purchased at http://www.pearsonglobaleditions.com/Pinel or at www.mypsychlab.com.

A Colorful Introduction to the Anatomy of the Human Brain, Second Edition This book, written by John P. J. Pinel and Maggie Edwards, provides an easy and enjoyable means of learning or reviewing the fundamentals of human neuroanatomy through the acclaimed directed-coloring method.

Acknowledgments

Two people deserve special credit for helping me create this edition of *Biopsychology*: Maggie Edwards and Steven Barnes. Maggie is an artist/designer/writer/personal trainer, who is my partner in life. She is responsible for the design of most of the illustrations in this book. Steven is a colleague/artist/computer wizard, whose contributions to this edition were immense. He kept my writing on schedule, prepared the manuscripts, compiled the reference list, did some editing and writing, designed all the new illustrations, created the author-run blog and website, and compiled all of the electronic links. It exhausts me just thinking about it.

Pearson Education did a remarkable job of producing this book. They shared my dream of a textbook that meets the highest standards of pedagogy but is also personal, attractive, and enjoyable. 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 Joan Foley, Amber Chow, Diane Szulecki, and Judy Casillo at Pearson and Angel Chavez at Integra for coordinating the production—an excruciatingly difficult and often thankless job.

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To the Student

In the 1960s, I was, in the parlance of the times, "turned on" by an undergraduate course in biopsychology. I could not imagine anything more interesting than a field of science dedicated to studying the relation between psychological processes and the brain. My initial fascination led to a long career as a student, researcher, teacher, and writer of biopsychological science. *Biopsychology* is my attempt to share my fascination with you.

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

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

Creative thinking is one of the major themes of this edition. Often science and creativity are considered to be opposites, but in my experience many of the major advances in biopsychological science have resulted from creative thinking. These major advances have been made by biopsychologists who have recognized that there are alternatives to the conventional ways of thinking about biopsychological issues that have been engrained in them by their culture and training and who have adopted creative new approaches. Two things in particular have fascinated me about the interplay between creative thinking and biopsychological science: how difficult it is to identify and shed conventional approaches even when they clearly haven't been working, and how often solutions to long-standing problems become apparent when approached from a new perspective. The focus of this edition on creative thinking is intended to make the study of biopsychology more interesting for you and to encourage you become a more creative thinker.

I 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 me.

About the Author

John Pinel, the author of *Biopsychology*, 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."

Pinel attributes much of his success to his wife, Maggie, who has at various times been a professional artist, designer, and personal trainer. Over the years, they have collaborated on many projects, and the high quality of *Biopsychology*'s illustrations is largely attributable to her skill and effort.

Pinel is an enthusiastic West African drummer who performs at local clubs, festivals, and drum circles with Nigerian drum master Kwasi Iruoje. For relaxation, he loves to cuddle his three cats: Rastaman, Sambala, and Squeak.

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CHAPTER 1

Biopsychology as a Neuroscience

What Is Biopsychology, Anyway?

Visual BRAIN

Explore the Visual Brain in MyPsychLab.

LEARNING OBJECTIVES

LO1 Define and discuss the field of biopsychology.
LO2 Biopsychology is an integrative discipline. Explain.
LO3 Describe six areas of neuroscience that are particularly relevant to biopsychological inquiry.
LO4 Compare the advantages and disadvantages of humans and nonhumans as subjects in biopsychological research.
LO5 Compare experiments, quasiexperimental studies, and case studies, emphasizing the study of causal effects.
LO6 Describe and compare the six divisions of biopsychology.
LO7 Explain how converging operations has contributed to the study of Korsakoff's syndrome.
LO8 Explain scientific inference with reference to research on eye movement and the visual perception of motion.
LO9 Explain critical thinking and its relation to creative thinking in science.
LO10 Discuss Delgado's bull-ring demonstration, emphasizing its flawed interpretation.
LO11 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 100 billion neurons in complex array (see Azevedo et al., 2009), 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 of them: biopsychology. Each of this chapter's seven sections characterizes the neuroscience of biopsychology in a different way.

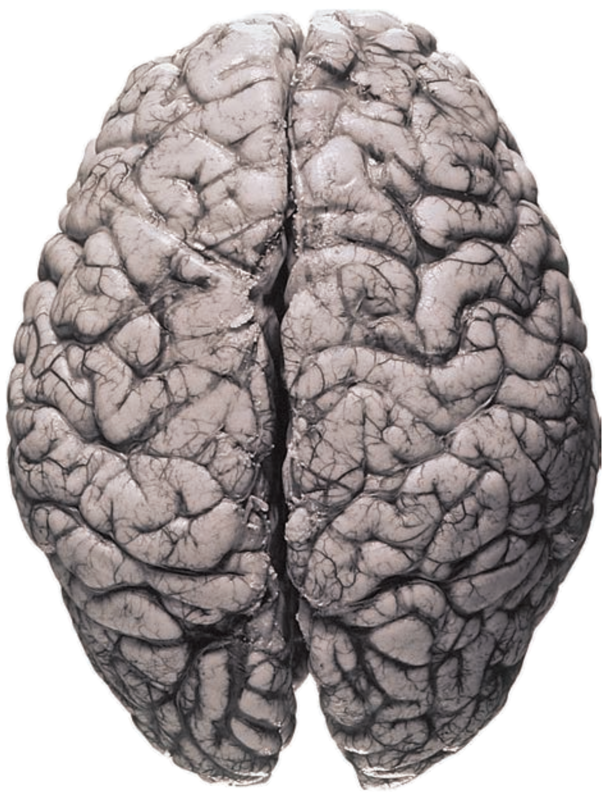

FIGURE 1.1 The human brain.

Before you proceed to the body of this chapter, I 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. I have selected four of these for special emphasis: They are the major themes of this text.

Watch *Themes* at **MyPsychLab**

To help give these themes the special attention they deserve and to help you follow their development as you progress through the text, I have marked relevant passages with tabs. The following are the four major themes and their related tabs.

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, etc. 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 I describe research that involves thinking "outside the box," where I have tried to be creative in the analysis of the research that I am presenting, or where I 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.

Clinical Implications

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

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

Evolutionary Perspective

*Based on "The Case of Jimmie G., the Man Frozen in Time," Simon & Schuster, Inc. and Pan Macmillan, London from The Man Who Mistook His Wife for a Hat and Other Clinical Tales by Oliver Sacks. Copyright © 1970, 1981, 1983, 1984, 1986 by Oliver Sacks.

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.

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 last 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 modem neuroscience, is currently influencing many areas of biopsychological research. A neuroplasticity tab marks each discussion or study of neuroplasticity.

Neuroplasticity

BLOG-ON

I have a website with blog posts, a link collection, and other items: www.biopsyc.com. Keep an eye out for "blog-on" boxes—they indicate that material on my site is relevant to what you have just been reading.

1.1 What Is 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 I 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, and emotion).

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.

1.2 What Is the Relation between Biopsychology and the Other Disciplines of Neuroscience?

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:

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 Chapter 10).

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).

1.3 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 section 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

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, I am 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 Nakahara et al., 2002; Passingham, 2009; Platt & Spelke, 2009).

Evolutionary Perspective

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 subjects. This is not to say that the study of nonhuman animals is not governed by a strict code of ethics (see Demers et al., 2006; Goldberg & Hartung, 2006)—it is. However, there are fewer ethical constraints on the study of laboratory species than on the study of humans.

In my 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).

BLOG-ON

Concerned about the ethics of biopsychological research on nonhuman species? Go to www.biopsyc.com/animalresearch

EXPERIMENTS AND NONEXPERIMENTS

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 could affect the dependent variable, it is difficult to determine whether it was the independent variable or the unintended difference—called a

Simulate *Elements of an Experiment* at **MyPsychLab**

confounded variable—that led to the observed effects on the dependent variable. Although the experimental method is conceptually simple, eliminating all confounded variables can be quite difficult. Readers of research papers must be constantly on the alert for confounded variables that have gone unnoticed by the experimenters.

An experiment by Lester and Gorzalka (1988) illustrates the prevention of confounded variables with good experimental design. The experiment was a demonstration of the **Coolidge effect**. The Coolidge effect is the fact that a copulating male who becomes incapable of continuing to copulate with one sex partner can often recommence copulating with a new sex partner (see Figure 1.2).

FIGURE 1.2 President Calvin Coolidge and Mrs. Grace Coolidge. Many students think the Coolidge effect is named after a biopsychologist named Coolidge. In fact, it is named after President Calvin Coolidge, of whom the following story is told. (If the story isn't true, it should be.) During a tour of a poultry farm, Mrs. Coolidge inquired of the farmer how his farm managed to produce so many eggs with such a small number of roosters. The farmer proudly explained that his roosters performed their duty dozens of times each day.

"Perhaps you could point that out to Mr. Coolidge," replied the First Lady in a pointedly loud voice.

The President, overhearing the remark, asked the farmer, "Does each rooster service the same hen each time?"

"No," replied the farmer, "there are many hens for each rooster."

"Perhaps you could point that out to Mrs. Coolidge," replied the President.

Before your imagination starts running wild, I should mention that the subjects in Lester and Gorzalka's experiment were hamsters, not students from the undergraduate subject pool.

Lester and Gorzalka argued that the Coolidge effect had not been demonstrated in females because it is more difficult to conduct well-controlled Coolidge-effect experiments with females—not because females do not display a Coolidge effect. The confusion, according to Lester and Gorzalka, stemmed from the fact that the males of most mammalian species become sexually fatigued more readily than the females. As a result, attempts to demonstrate the Coolidge effect in females are often confounded by the fatigue of the males. When, in the midst of copulation, a female is provided with a new sex partner, the increase in her sexual receptivity could be either a legitimate Coolidge effect or a reaction to the greater vigor of the new male. Because female mammals usually display little sexual fatigue, this confounded variable is not a serious problem in demonstrations of the Coolidge effect in males.

Lester and Gorzalka devised a clever procedure to control for this confounded variable. At the same time a female subject was copulating with one male (the familiar male), the other male to be used in the test (the unfamiliar male) was copulating with another female. Then, both males were given a rest while the female was copulating with a third male. Finally, the female subject was tested with either the familiar male or the unfamiliar male. The dependent variable was the amount of time that the female displayed **lordosis** (the arched-back, rump-up, tail-diverted posture of female rodent sexual receptivity) during each sex test. As Figure 1.3 illustrates, the females responded more vigorously to the unfamiliar males than they did to the familiar males during the third test, despite the fact that both the unfamiliar and familiar males were equally fatigued and both mounted the females with equal vigor. The purpose of this example—in case you have forgotten—is to illustrate the critical role played by good experimental design in preventing confounded variables.

Thinking Creatively

Quasiexperimental Studies It is not possible for biopsychologists to bring the experimental method to bear on all problems of interest to them. Physical or ethical impediments frequently make it impossible to assign subjects to particular conditions or to administer the conditions once the subjects have been assigned to them. For example, experiments on the causes of brain damage in human alcoholics are not feasible because it would not be ethical to assign a subject to a condition that involves years of alcohol consumption. (Some of you may be more concerned about the ethics of assigning subjects to a control condition that involves years of sobriety.) In