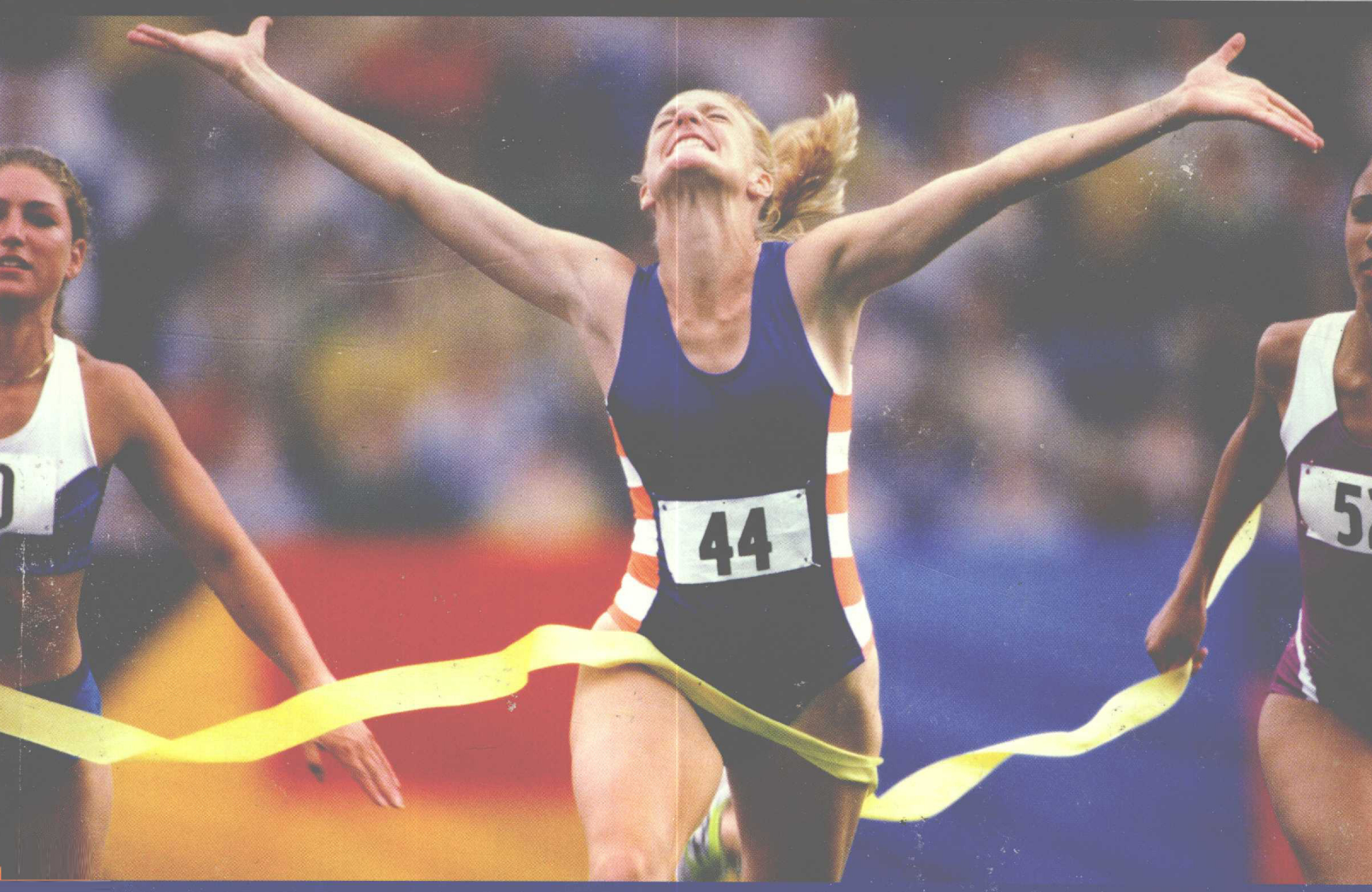
MIND, BRAIN, AND BEHAVIOR

Psychological Science



GAZZANIGA AND HEATHERTO

PSYCHOLOGICAL SCIENCE

MIND, BRAIN, AND BEHAVIOR

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DARTMOUTH COLLEGE

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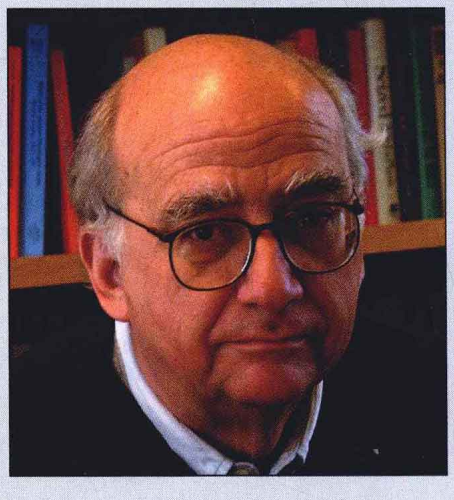

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TODD F. HEATHERTON (Ph.D., University of Toronto) is the Champion Professor of Psychological and Brain Sciences at Dartmouth College. His primary research examines the situational, individual, motivational, and affective processes that interfere with self-regulation. He has been on the executive committees of the Society of Personality and Social Psychology, the Association of Researchers in Personality, and the International Society of Self and Identity and has served on the editorial boards of the *Journal of Abnormal Psychology*, the *Journal of Personality and Social Psychology*, and the *Review of General Psychology*. He has served as Head Tutor and chair of the undergraduate program in Psychology at Harvard University and chair of the graduate program at Dartmouth College. He received the Petra Shattuck Award for Teaching Excellence from the Harvard Extension School in 1994.

ACKNOWLEDGMENTS

Writing this textbook has been both demanding and rewarding. Perhaps the most apt analogy is raising children, an all-consuming labor of love in which daily effort, occasional frustration, and frequent sacrifices yield to the joys of parental pride, as we watch in amazement as our children blossom and grow. This book is dedicated to our children, who have given us the strength and motivation to persevere. We are putting the final touches on this preface on a spectacular Sunday morning in New England, a time that is typically reserved for family. Our wives, Charlotte Gazzaniga and Patricia Heatherton, are, as ever, understanding of our absence. We begin by thanking them for their support, composure, and good humor. Both have advanced degrees in psychology and have listened patiently and provided helpful commentary when we have struggled to explain technical details in a manner comprehensible for students. Both are insightful and pragmatic, and the textbook has benefited greatly from their participation in the writing process.

We are grateful recipients of phenomenal support from our colleagues during all phases of writing this textbook. Many people were particularly helpful in developing and organizing the content of specific chapters. We especially wish to thank Margaret Funnell, Todd Handy, Paul Corballis, Kathleen Vohs, Ian Wickersham, Abigail Baird, and Marin Gazzaniga. Many of our colleagues in the Department of Psychological and Brain Sciences at Dartmouth read sections, gave advice, or provided expert commentary, notably Ann Clark, William Kelley, George Wolford, Robert Leaton, Jay Hull, Howard Hughes, and especially Laura Ann Petitto. We are grateful to them for their expertise. We also benefited from the astute guidance of Endel Tulving, Steve Marcus, Michael Ullman, Steven Pinker, Roy Baumeister, Thomas Joiner, David Funder, Jane Gillette, Mikki Hebl, Peter Ruscitti, George Spilich, and many others who were willing to discuss their teaching goals for introductory psychology and their beliefs about what works and what doesn't work in introductory textbooks. We are also grateful to our exceptionally talented supplements authors: George Spilich (Washington College) who authored the Instructor's Resource Manual and developed activities for the companion Web site, Brett Beck (Bloomsburg University) and Jeff Henriques (University of Wisconsin-Madison) who authored the Study Guide, with George and Kathleen Vohs (University of Utah) who created the test item files. We are grateful to Bobbi Walling for pulling together materials for the glossaries, and Lisa Jones and Tina Wilcox for helping to keep us organized. We especially applaud the contributions of Rebecca Townsend, who not only administers the Center for Cognitive Neuroscience, but also happens to be an amazing proofreader.

There are many people at W.W. Norton who served critical roles in bringing this textbook to realization. First and foremost, we thank Jon Durbin, our editor and friend. Jon was a true believer from the earliest days of the book and has been essential at every step of the process. Jon walks a fine line between motivating and mercilessly badgering his authors, but he does so because he is committed to moving his authors to the highest levels they can attain. Jon pushed us to consider, reconsider, and reconsider again nearly every section of the textbook. His unflagging encouragement and frequent pep talks helped us stay true to the mission of producing a cutting-edge textbook that reflects the excitement of contemporary psychological science. The book would not have been possible without him and the inspiring energy and enthusiasm he brings to his work.

Our developmental editor, Joanne Tinsley, was superb. Every chapter benefited from her exceptional ability to understand the big picture and organize the material in the best possible fashion. She was brutal with us when she needed to be and she galvanized us to push the limits of traditional texts as we sought to achieve our goals. The copy editor, Kate Lovelady, made sure that not a single word was in the textbook that did not need to be there. Her ability to tighten text is stunning. Kim Yi, the project editor, kept the entire manuscript on track with her truly spectacular organizational skills and good humor. Aaron Javsicas performed essential editorial and production

duties flawlessly. Neil Hoos and his photo research team did an exceptional job conceiving of an integrated art program composed of the highest quality photography for the book. Rubina Yeh receives the highest credit for a lively and gorgeous book design that graphically serves both as the pattern and as the fabric that ties together all its individual components. We are also grateful to Frank Forney for his incredible art. His drawings are some of the finest to appear in any science textbook, and he managed to create many of these from vague ideas provided by the authors. As all general psychology instructors know, the quality of the supplements and media package play an ever-more-important role in the success of a textbook. We give special thanks to April Lange for all her creative talents and her ability to put together a high-quality team of front-line instructors to create a package that reinforces and builds upon the book's strengths. In each case, the final product is just what we wanted—first rate. Finally, we thank Roby Harrington, director of the College Division, and Drake McFeely, president of W.W. Norton, for their faith in us.

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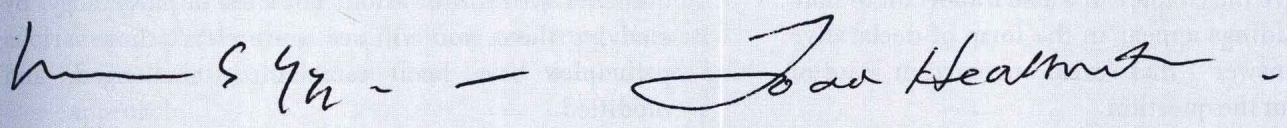
PREFACE FOR STUDENTS

DEAR STUDENT:

Our most important overarching goal for this textbook was to write it first and foremost for you, the student reader. We know that many of you are drawn to psychology to find out more about what makes you and those you know tick. We also know from our own teaching experiences in recent years, that many of you are highly interested in learning more about how the human mind works and what that means for you in everyday life. Thus, as you search for insights into the human experience, we have made every effort to focus on core psychological principles and ideas to provide a starting point (and sometimes the end point) for your quest. Our focus on principles is reinforced by the "ask and answer" approach that serves as the pedagogical foundation for the book. Each chapter consists of a series of "big questions" that focus on major psychological principles and concepts. These questions are answered in subsequent sections. Our use of declarative headings reflects our belief that psychological scientists have made headway in providing answers to these questions—perhaps not the final answers, as new research helps shape our thinking, but answers that summarize what psychological scientists have discovered about mind, brain, and behavior.

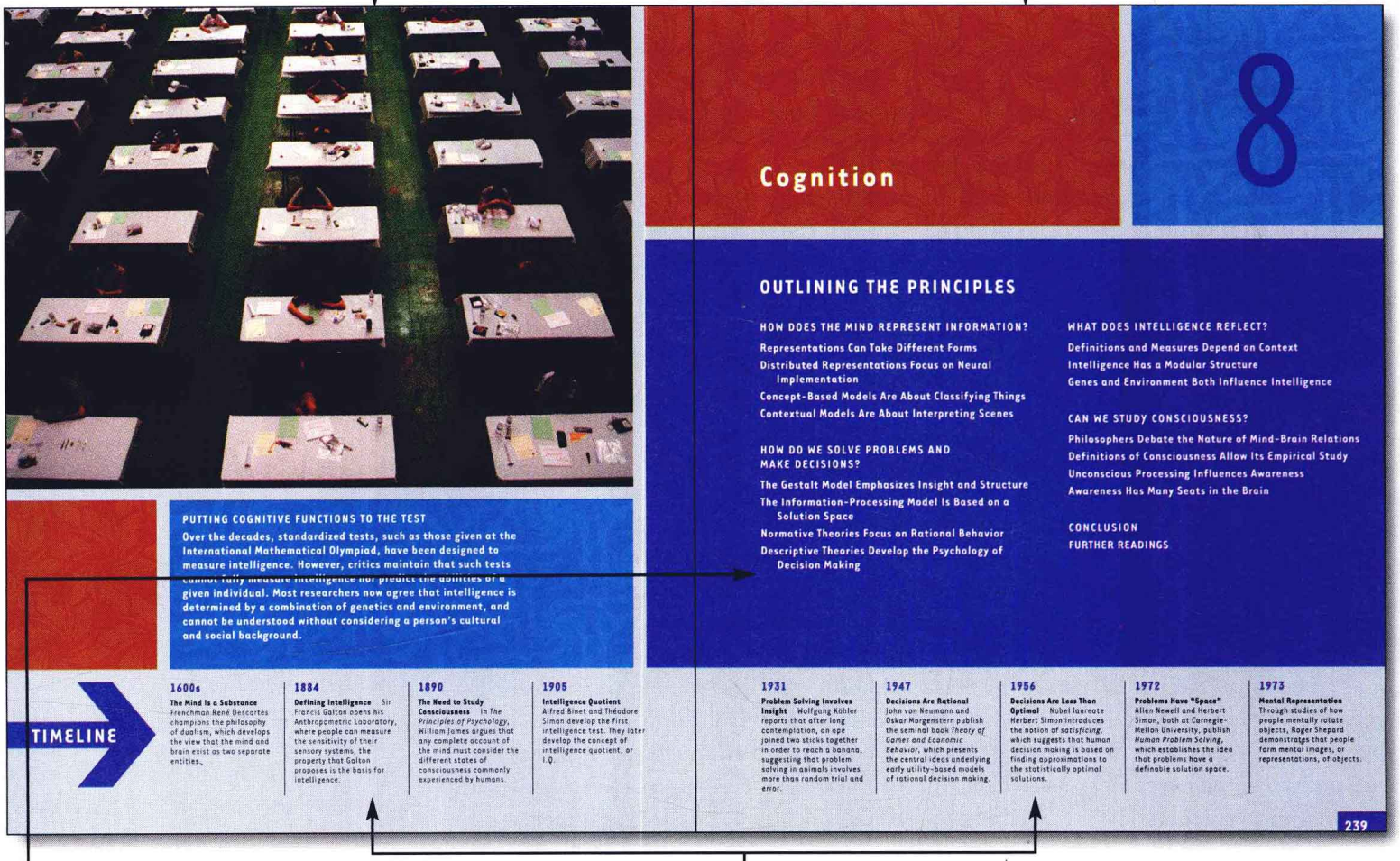
Psychological Science is intended for both those of you who wish to pursue careers in psychology and those for whom this course will be your only exposure to psychology as a science. While using this text, you will gain an integrated grounding in traditional psychology as well as an introduction to new approaches within psychological science. The material is by nature intellectually challenging, but we have tried to make it accessible and enjoyable to you as well as directly applicable to your life. We hope that *Psychological Science* spurs on your curiosity about psychological phenomena and that you will learn to think critically about issues and themes in psychological science. In the end (or the beginning!), we hope that you will also develop greater self-understanding and understanding of others.

Before you begin to read the first chapter, please take a few minutes to study the following pages so that you can gain a full understanding of how to get the most out of reading *Psychological Science*.



GUIDED CHAPTER TOUR FOR STUDENTS

1 OVERVIEW *Psychological Science's* chapters are built around core principles. The "ask and answer" approach serves as the structure and foundation for every chapter and is designed to reinforce these principles. Each chapter focuses on approximately 4–6 major principles, which are first raised in the form of questions ("ask"). Each major section in a chapter then looks to "answer" one of these questions. Here is how it works in action.

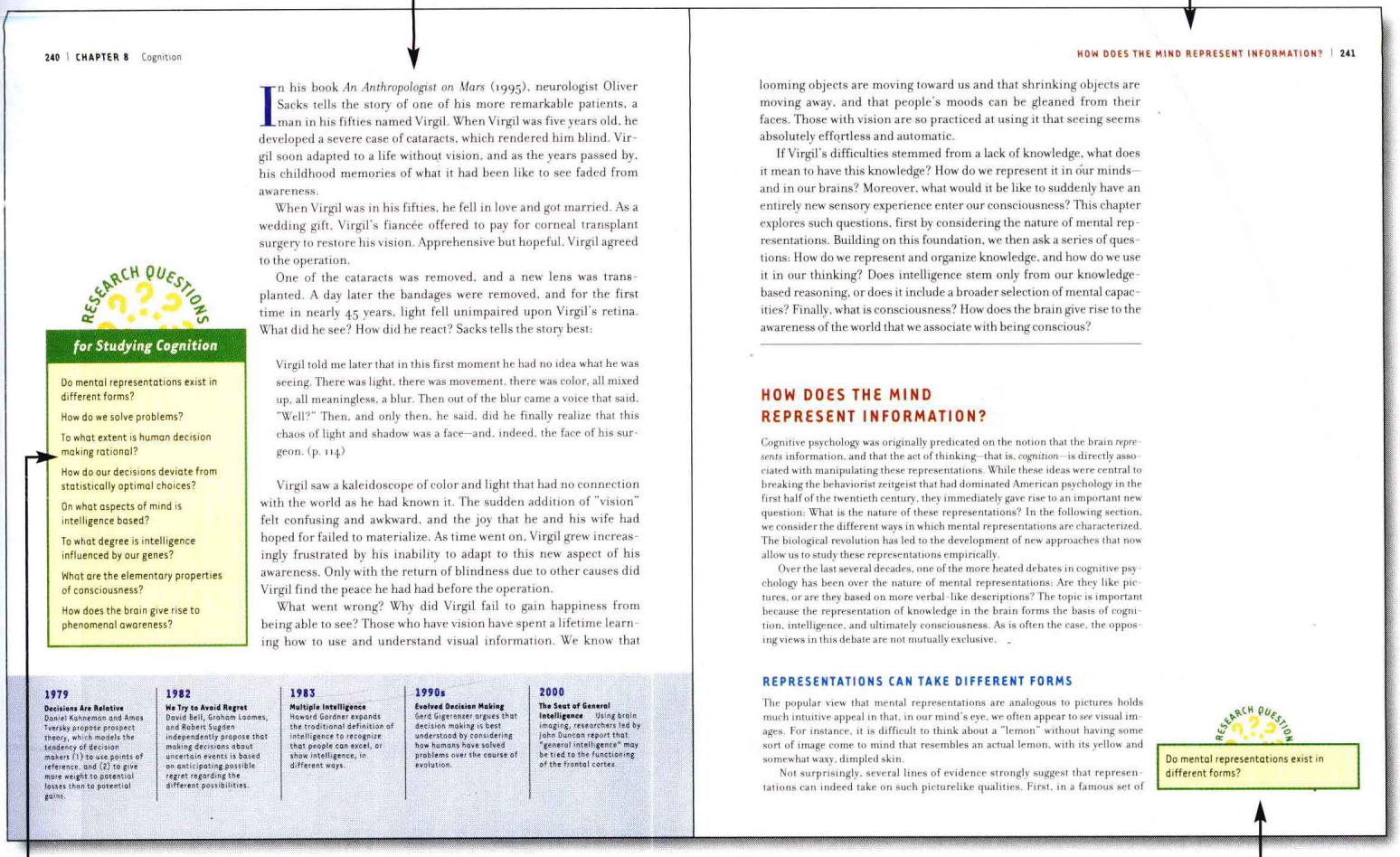


2 OUTLINING THE PRINCIPLES appears on the second page of every chapter. This pedagogical feature at one level serves as a simple outline or road map for the chapter. At another level, it reveals what major principles will be discussed in the chapter. By studying the major headings, you can see which major questions ("ask") will drive the chapter. It's also important to note that the subheadings appear in the form of declarative statements ("answer") that reveal our current state of knowledge about the question.

3 CHAPTER TIMELINES appear on the bottom of the first three pages of every chapter. *Psychological Science* is built on cumulative knowledge and experience. This is one of the major themes of the text. Basic principles, both new and old, inspire and guide thinking and research in the field. The timelines highlight major developments within the various domains of psychology. By studying them, you will see more clearly how various principles have been established, challenged, and modified.

4 CHAPTER OPENING VIGNETTES lead off each chapter. The vignettes are drawn from a variety of sources, including news media, research journals, and history. They highlight a major theme, issue, or tension point that will be discussed throughout a given chapter.

6 "ASK AND ANSWER" RUNNING HEADS are designed to reinforce the basic principles. The running heads that appear on each right-hand page repeat the question that is explored in each section. These innovative running heads will help you see the forest for the trees as you read through the chapters.



240 | CHAPTER 8 Cognition

In his book *An Anthropologist on Mars* (1995), neurologist Oliver Sacks tells the story of one of his more remarkable patients, a man in his fifties named Virgil. When Virgil was five years old, he developed a severe case of cataracts, which rendered him blind. Virgil soon adapted to a life without vision, and as the years passed by, his childhood memories of what it had been like to see faded from awareness.

When Virgil was in his fifties, he fell in love and got married. As a wedding gift, Virgil's fiancée offered to pay for corneal transplant surgery to restore his vision. Apprehensive but hopeful, Virgil agreed to the operation.

One of the cataracts was removed, and a new lens was transplanted. A day later the bandages were removed, and for the first time in nearly 45 years, light fell unimpaired upon Virgil's retina. What did he see? How did he react? Sacks tells the story best:

> Virgil told me later that in this first moment he had no idea what he was seeing. There was light, there was movement, there was color, all mixed up, all meaningless, a blur. Then out of the blur came a voice that said, "Well?" Then, and only then, he said, did he finally realize that this chaos of light and shadow was a face—and, indeed, the face of his surgeon. (p. 114)

Virgil saw a kaleidoscope of color and light that had no connection with the world as he had known it. The sudden addition of "vision" felt confusing and awkward, and the joy that he and his wife had hoped for failed to materialize. As time went on, Virgil grew increasingly frustrated by his inability to adapt to this new aspect of his awareness. Only with the return of blindness due to other causes did Virgil find the peace he had had before the operation.

What went wrong? Why did Virgil fail to gain happiness from being able to see? Those who have vision have spent a lifetime learning how to use and understand visual information. We know that

RESEARCH QUESTIONS for Studying Cognition

- Do mental representations exist in different forms?
- How do we solve problems?
- To what extent is human decision making rational?
- How do our decisions deviate from statistically optimal choices?
- On what aspects of mind is intelligence based?
- To what degree is intelligence influenced by our genes?
- What are the elementary properties of consciousness?
- How does the brain give rise to phenomenal awareness?

1979 **Decisions Are Relative** Daniel Kahneman and Amos Tversky propose prospect theory, which models the tendency of decision makers (1) to use points of reference, and (2) to give more weight to potential losses than to potential gains.

1982 **We Try to Avoid Regret** David Bell, Graham Loomes, and Robert Sugden independently propose that making decisions about uncertain events is based on anticipating possible regret regarding the different possibilities.

1983 **Multiple Intelligence** Howard Gardner expands the traditional definition of intelligence to recognize that people can excel, or show intelligence, in different ways.

1990s **Evolved Decision Making** Gerd Gigerenzer argues that decision making is best understood by considering how humans have solved problems over the course of evolution.

2000 **The Seat of General Intelligence** Using brain imaging, researchers led by John Duncon report that "general intelligence" may be tied to the functioning of the frontal cortex.

HOW DOES THE MIND REPRESENT INFORMATION? | 241

looming objects are moving toward us and that shrinking objects are moving away, and that people's moods can be gleaned from their faces. Those with vision are so practiced at using it that seeing seems absolutely effortless and automatic.

If Virgil's difficulties stemmed from a lack of knowledge, what does it mean to have this knowledge? How do we represent it in our minds—and in our brains? Moreover, what would it be like to suddenly have an entirely new sensory experience enter our consciousness? This chapter explores such questions, first by considering the nature of mental representations. Building on this foundation, we then ask a series of questions: How do we represent and organize knowledge, and how do we use it in our thinking? Does intelligence stem only from our knowledge-based reasoning, or does it include a broader selection of mental capacities? Finally, what is consciousness? How does the brain give rise to the awareness of the world that we associate with being conscious?

HOW DOES THE MIND REPRESENT INFORMATION?

Cognitive psychology was originally predicated on the notion that the brain *represents* information, and that the act of thinking—that is, *cognition*—is directly associated with manipulating these representations. While these ideas were central to breaking the behaviorist zeitgeist that had dominated American psychology in the first half of the twentieth century, they immediately gave rise to an important new question: What is the nature of these representations? In the following section, we consider the different ways in which mental representations are characterized. The biological revolution has led to the development of new approaches that now allow us to study these representations empirically.

Over the last several decades, one of the more heated debates in cognitive psychology has been over the nature of mental representations: Are they like pictures, or are they based on more verbal-like descriptions? The topic is important because the representation of knowledge in the brain forms the basis of cognition, intelligence, and ultimately consciousness. As is often the case, the opposing views in this debate are not mutually exclusive.

REPRESENTATIONS CAN TAKE DIFFERENT FORMS

The popular view that mental representations are analogous to pictures holds much intuitive appeal in that, in our mind's eye, we often appear to see visual images. For instance, it is difficult to think about a "lemon" without having some sort of image come to mind that resembles an actual lemon, with its yellow and somewhat waxy, dimpled skin.

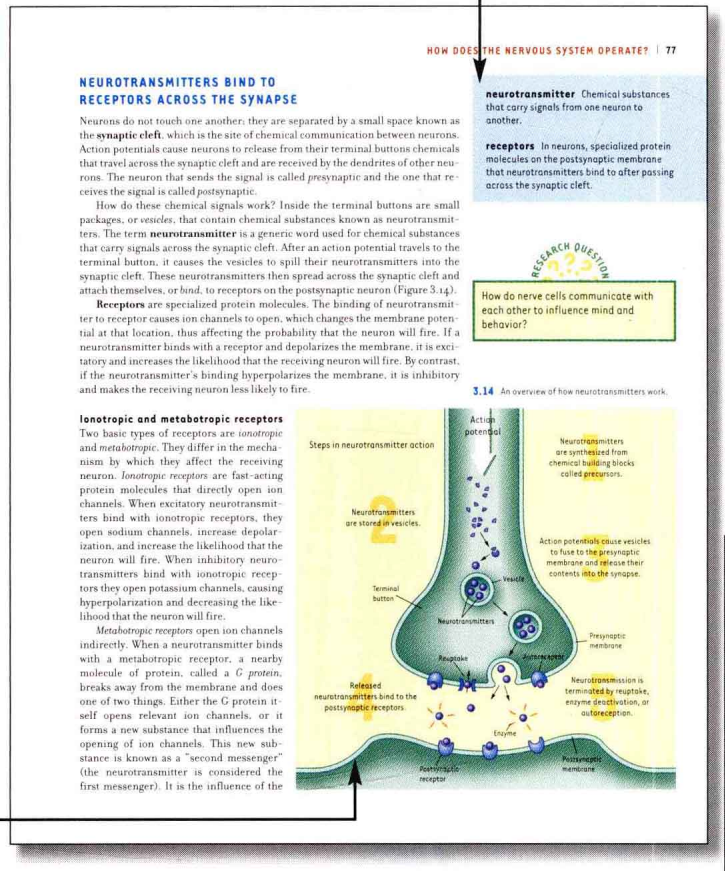
Not surprisingly, several lines of evidence strongly suggest that representations can indeed take on such picturelike qualities. First, in a famous set of

RESEARCH QUESTION

Do mental representations exist in different forms?

5 RESEARCH QUESTIONS FOR STUDYING. . . *Psychological Science* captures the excitement of contemporary ideas and research driving the field today. The research questions highlighted on the third page of every chapter suggest the kinds of questions that researchers are exploring. Many of these questions may be directly related to your own questions. These questions reappear in the margins throughout a given chapter to alert you when the relevant issues are being discussed. This is another dimension to the basic "ask and answer" approach.

7 DEFINING THE PRINCIPLES describes the marginal glossary that runs throughout each chapter. Many books highlight an overabundance of key terms for you to memorize. *Psychological Science* highlights approximately 30 key terms per chapter. This should be an excellent review tool, as are the glossaries at the end of the book and on the companion Web site.



HOW DOES THE NERVOUS SYSTEM OPERATE? | 77

NEUROTRANSMITTERS BIND TO RECEPTORS ACROSS THE SYNAPSE

Neurons do not touch one another; they are separated by a small space known as the **synaptic cleft**, which is the site of chemical communication between neurons. Action potentials cause neurons to release from their terminal buttons chemicals that travel across the synaptic cleft and are received by the dendrites of other neurons. The neuron that sends the signal is called *presynaptic* and the one that receives the signal is called *postsynaptic*.

How do these chemical signals work? Inside the terminal buttons are small packages, or *vesicles*, that contain chemical substances known as neurotransmitters. The term **neurotransmitter** is a generic word used for chemical substances that carry signals across the synaptic cleft. After an action potential travels to the terminal button, it causes the vesicles to spill their neurotransmitters into the synaptic cleft. These neurotransmitters then spread across the synaptic cleft and attach themselves, or *bind*, to receptors on the postsynaptic neuron (Figure 3.14).

Receptors are specialized protein molecules. The binding of neurotransmitter to receptor causes ion channels to open, which changes the membrane potential at that location, thus affecting the probability that the neuron will fire. If a neurotransmitter binds with a receptor and depolarizes the membrane, it is excitatory and increases the likelihood that the receiving neuron will fire. By contrast, if the neurotransmitter's binding hyperpolarizes the membrane, it is inhibitory and makes the receiving neuron less likely to fire.

Ionotropic and metabotropic receptors

Two basic types of receptors are *ionotropic* and *metabotropic*. They differ in the mechanism by which they affect the receiving neuron. *Ionotropic receptors* are fast-acting protein molecules that directly open ion channels. When excitatory neurotransmitters bind with ionotropic receptors, they open sodium channels, increase depolarization, and increase the likelihood that the neuron will fire. When inhibitory neurotransmitters bind with ionotropic receptors they open potassium channels, causing hyperpolarization and decreasing the likelihood that the neuron will fire.

Metabotropic receptors open ion channels indirectly. When a neurotransmitter binds with a metabotropic receptor, a nearby molecule of protein, called a *G protein*, breaks away from the membrane and does one of two things. Either the G protein itself opens relevant ion channels, or it forms a new substance that influences the opening of ion channels. This new substance is known as a "second messenger" (the neurotransmitter is considered the first messenger). It is the influence of the

neurotransmitter Chemical substances that carry signals from one neuron to another.

receptors In neurons, specialized protein molecules on the postsynaptic membrane that neurotransmitters bind to after passing across the synaptic cleft.

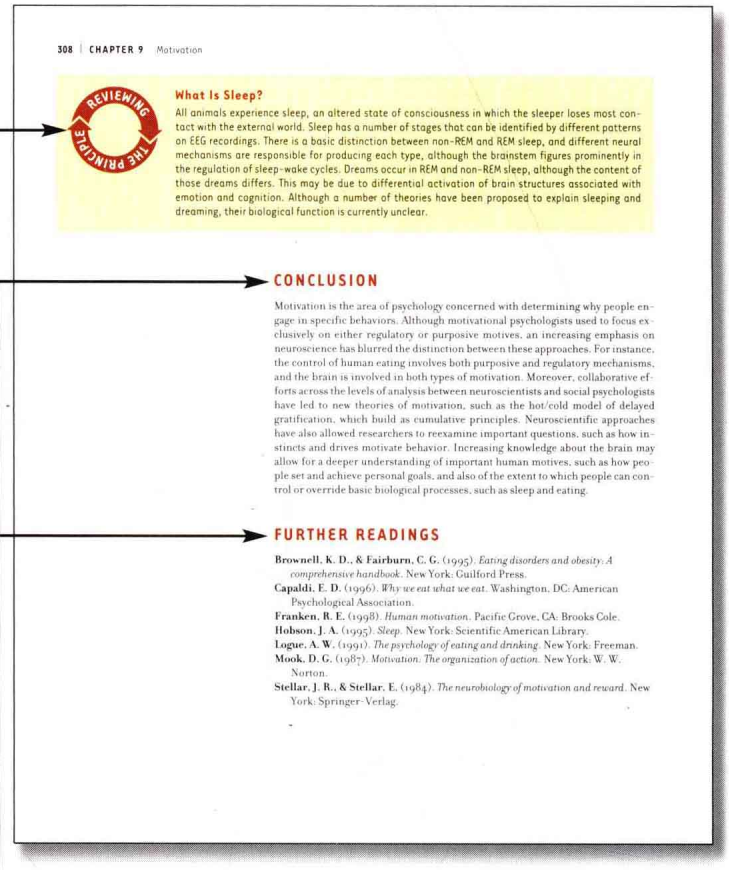
RESEARCH QUESTION

How do nerve cells communicate with each other to influence mind and behavior?

3.14 An overview of how neurotransmitters work.

8 A DYNAMIC ART PROGRAM The visual materials in *Psychological Science* should add substantially to your reading experience. The text contains a variety of visual materials, from photographs to tables and charts to drawn art. The emphasis in *Psychological Science*, however, is clearly on the drawn art. Having used many general psychology books ourselves, we wanted to take our text in a new direction. By featuring drawn art, *Psychological Science* is able to convey precisely, accurately, and meaningfully what you need to gain from every image. This high level of precision can't be gained from the use of stock photographs, which are common in many texts.

9 REVIEWING THE PRINCIPLE boxes are a key element in the "ask and answer" approach and appear at the end of each major section. They repeat the question that governed the section and provide a basic answer. The answer provided won't give you everything you need to understand the question, but it will highlight key points to remember.



308 | CHAPTER 9 Motivation

REVIEWING THE PRINCIPLE

What Is Sleep?

All animals experience sleep, an altered state of consciousness in which the sleeper loses most contact with the external world. Sleep has a number of stages that can be identified by different patterns on EEG recordings. There is a basic distinction between non-REM and REM sleep, and different neural mechanisms are responsible for producing each type, although the brainstem figures prominently in the regulation of sleep-wake cycles. Dreams occur in REM and non-REM sleep, although the content of those dreams differs. This may be due to differential activation of brain structures associated with emotion and cognition. Although a number of theories have been proposed to explain sleeping and dreaming, their biological function is currently unclear.

CONCLUSION

Motivation is the area of psychology concerned with determining why people engage in specific behaviors. Although motivational psychologists used to focus exclusively on either regulatory or purposive motives, an increasing emphasis on neuroscience has blurred the distinction between these approaches. For instance, the control of human eating involves both purposive and regulatory mechanisms, and the brain is involved in both types of motivation. Moreover, collaborative efforts across the levels of analysis between neuroscientists and social psychologists have led to new theories of motivation, such as the hot/cold model of delayed gratification, which build as cumulative principles. Neuroscientific approaches have also allowed researchers to reexamine important questions, such as how instincts and drives motivate behavior. Increasing knowledge about the brain may allow for a deeper understanding of important human motives, such as how people set and achieve personal goals, and also of the extent to which people can control or override basic biological processes, such as sleep and eating.

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10 SUMMARIZING THE PRINCIPLES is the last key component of the "ask and answer" approach. *Psychological Science*'s brief chapter conclusions highlight the big ideas and concepts and remind you how the book's four key themes wove their way through the chapter. After reading the chapter conclusion, you may want to reread the "Reviewing the Principles" sections to check what you have learned and what you haven't.

11 FURTHER READINGS represent psychological writing at its best. If any of the topics in a given chapter interested you, we encourage you to followup with one of the suggested reading titles. There are many wonderful popular psychology books that provide keen insights and pleasurable excursions into human behavior.

Studying the Mind

PHINEAS GAGE

Perhaps the most famous historical example of brain damage is the case of Phineas Gage. In 1848, Gage was a 25-year-old foreman on the construction of Vermont's Rutland and Burlington Railroad. One day he dropped his tamping iron on a rock, which ignited some blasting powder. The resulting explosion drove the iron rod—over a yard long and an inch in diameter—into his cheek, through his frontal lobes, and out through the top of his head (Figure 4.4). Gage was still conscious as he was hurried back to town on a cart. Able to walk, with assistance, upstairs to his hotel bed, he wryly remarked to the awaiting physician, "Doctor, here is business enough for you" and said he expected to return to work in a few days. In fact, Gage lapsed into a stupor for two weeks. His condition steadily improved subsequently, though, and he recovered remarkably well.

Unfortunately, the accident had caused some personality changes. Whereas before Gage had been regarded by his employers as "the most efficient and capable" of workers, the new Gage was not. As one of his doctors later wrote: "The equilibrium or balance, so to speak, between his intellectual faculties and animal propensities seems to have been destroyed. He is fitful, irreverent, indulging at times in the grossest profanity . . . impatient of restraint or advice when it conflicts with his desires . . . A child in his intellectual capacity and manifestations, he has the animal passions of a strong man." In sum, Gage was "no longer Gage."

Unable to get his foreman's job back, Gage exhibited himself in various New England towns and at the New York Museum (owned by P. T. Barnum), worked in a stable in New Hampshire, and drove coaches and tended horses in Chile. After a decade, his health began to decline, and in 1860 he began to have epileptic seizures and died a few months later.

Gage's recovery was initially used by opponents of phrenology to argue for the uniformity of the brain, and the ability of the remaining brain to take over the work of the damaged tissue. His psychological impairments, however, were eventually recognized by the medical community as extremely significant, and they provided the basis for the first modern theories of the roles of the front part of the brain (*the prefrontal cortex*) in personality and self-control.

4.4 A computer-generated model of Phineas Gage's skull, with the iron rod that traveled through his head. Analysis of the skull revealed which brain areas had been damaged.

and it has since been repeatedly confirmed to be crucial for the production of language. This was the first of the nineteenth-century localizations to have survived the test of time.

THE BRAIN IS NOW KNOWN TO BE SPECIALIZED

RESEARCH QUESTION

Is function distributed throughout the brain or specialized in different regions?

It is now known that the brain's surface, far from being a uniform structure, is a patchwork of many highly specialized areas. However, instead of being neatly divided into regions corresponding to complex personality traits, as the phrenologists argued, brain areas are actually specialized for far more rudimentary components of perception, behavior, and mental life. A large area of the brain is devoted to different aspects of vision, for example, and another to generating rudimentary movements.

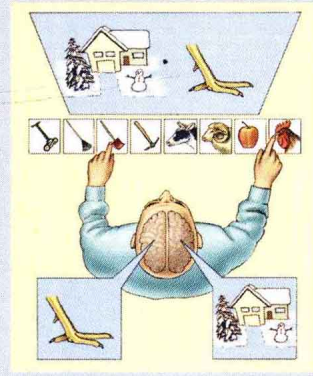
However, the notion that the brain, or at least the *cerebral cortex*, is uniform persisted well into the twentieth century. In the 1920s, physiologist Karl Lashley trained rats to run mazes and then systematically removed pieces of their brains in an effort to determine the location of their maze-navigating memories. To his

Using Psychological Science

THE MIND IS A SUBJECTIVE INTERPRETER

Another interesting dimension to the relationship between the brain's hemispheres is how they work together to reconstruct our experiences. This can be demonstrated by asking a disconnected left hemisphere what it thinks about previous behavior that has been produced by the right hemisphere. In one such experiment, different images are flashed simultaneously to the left and right visual fields and the patient is asked to point *with both hands* to pictures that seem most related to the images on the screen (Figure 4.22). As one example, a picture of a chicken claw was flashed to the left hemisphere and a picture of a snow scene to the right hemisphere. In response, the left hemisphere directed the right hand to point to a picture of a chicken head, and the right hemisphere pointed the left hand at a snow shovel. The participant was then asked why he chose those items. Clearly, the speaking left hemisphere could have no idea what the right hemisphere had seen. However, the patient (or rather his left hemisphere) calmly replied, "Oh, that's simple. The chicken claw goes with the chicken, and you need a shovel to clean out the chicken shed." The left hemisphere had evidently interpreted the left hand's response in a manner consistent with the left brain's knowledge. This left-hemispheric tendency to construct a world that makes sense is called the "interpreter."

This interpreter strongly influences the way we view and remember the world. Shown a series of pictures that form a story and asked later to choose which of another group of pictures had been seen previously, normal participants have a strong tendency to falsely "recognize" pictures that are consistent with the theme of the original series, whereas those that are inconsistent with the theme are easily rejected. The left brain, then, tends to "compress" its experiences into a comprehensible story and reconstructs remembered details on the basis of that story. The right brain seems to simply experience the world and remembers things in a manner less distorted by narrative interpretation. Given the finite capacity of the brain, the advantages of compression seem clear, though it appears that the right brain may check the left brain's unwarranted speculations.



4.22 The left brain interpreter mechanism. The left hemisphere attempts to explain the behavior of the right hemisphere on the basis of limited information.

HOW DOES THE BRAIN CHANGE?

RESEARCH QUESTION

Are there critical periods during brain development?

Despite the great precision and specificity of its connections, the brain is extremely malleable. Over the course of development, after injury, and throughout our constant stream of experience, the brain is continually changing, a property known as **plasticity**. Determining the nature of these changes, and the rules that they follow, is providing major insights into the mind, and is a direct outgrowth of the biological revolution that is energizing the field.

The brain follows a predictable development pattern, with different structures and abilities progressing at different rates and maturing at different points in

12 SPECIAL FEATURE BOXES highlight the text's basic strengths. Every chapter contains one of each of the following:

STUDYING THE MIND feature boxes highlight examples of psychological phenomena that fascinate as well as inform. These often describe case studies that reveal intriguing aspects of the biological basis of the mind, such as the effect of brain injury on motivation, emotion, and personality.

USING PSYCHOLOGICAL SCIENCE feature boxes address questions directly relevant to students. For example, Is there such a thing as photographic memory? Why do New Year's resolutions often fail? How is the mind a subjective interpreter?

CROSSING THE LEVELS OF ANALYSIS feature boxes explain how significant advances in our understanding of complex psychological phenomena have emerged from research that crosses interdisciplinary boundaries. We explore how psychological scientists are approaching each topic from molecular to societal levels, and how interdisciplinary teams of scientists are providing compelling new insights based on this synthesis.

dopamine A monoamine neurotransmitter that is involved in reward, motivation, and motor control.

search for food to satisfy immediate energy needs. The link between arousal and feeding is a good example of how various brain mechanisms work together to facilitate survival.

Dopamine **Dopamine** serves many significant brain functions, especially motivation and motor control. Many theorists believe dopamine is the primary neurotransmitter that communicates which activities may be rewarding. Eating when hungry, drinking when thirsty, or having sex when aroused all lead to activation of dopamine receptors and therefore are experienced as pleasurable. At the same time, dopamine activation is involved in motor control and planning, thereby guiding behavior toward objects and experiences that will lead to additional reward. One theory of drug addiction is that certain drugs are dopamine agonists;

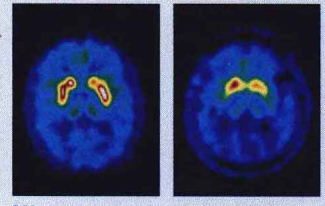
Crossing the Levels of Analysis

PARKINSON'S DISEASE

The actor Michael J. Fox has recently become as well known for his unfortunate medical condition as his acting ability. He is one among many famous people who have developed the neurodegenerative disorder Parkinson's disease, first identified by physician James Parkinson (1755–1828) in 1817. Parkinson's disease affects about 1 in every 200 older adults and occurs in all known cultures. Although most Parkinson's patients do not experience symptoms until after age 50, the case of Fox makes it clear that the disease can occur earlier. Symptoms include muscular rigidity, involuntary movements, and very specific tremors of the hand known as "pill rolling," because it looks as though the individual is rolling a small pill between the thumb and forefinger. As the disorder progresses, Parkinson's patients often develop a masklike facial expression and blink very little. At later stages people suffer from cognitive and mood disturbances. Parkinson's is a slow and degenerative disease that eventually leads to death.

Research in the past few decades has demonstrated that dopamine depletion in an area of the brain known as the substantia nigra is implicated in Parkinson's (Figure 3.16). The substantia nigra is a key area for the synthesis and transmission of dopamine throughout the brain; axons that extend from neurons in the substantia nigra to other regions of the brain have been implicated in the control of movement. With Parkinson's disease, the dopamine-producing neurons in the substantia nigra slowly die off.

What causes Parkinson's disease? At this time the answer is not clear. Some evidence of genetic involvement exists, especially the early-onset forms of the disease, but other evidence points to brain injury or even exposure to environmental toxins. Evidence for the toxin argument is based on the general finding that increasing numbers of young people are afflicted with Parkinson's and that it is more common in industrialized nations than in developing countries.



3.16 Healthy volunteers and Parkinson's patients were injected with a radioactive tracer, which allowed researchers to map the distribution of dopamine in the brain. Brighter colors indicate greater amounts of dopamine originating in the substantia nigra. You can see that healthy volunteers (left) have much more dopamine than those with Parkinson's disease (right).

Moreover, in 1982 it was found that a synthetic version of heroin (called MPTP) caused symptoms much like those associated with Parkinson's. Heroin addicts who unwittingly took MPTP all developed severe paralysis and frozen facial expressions (Figure 3.17). It later was found that chemists who had worked with MPTP early in their careers had also developed Parkinson's disease. These findings have led to the use of MPTP in animal research to study the course and treatment of Parkinson's disease.

From a treatment standpoint, drugs that enhance dopamine production can compensate for the lack of dopamine-producing neu-

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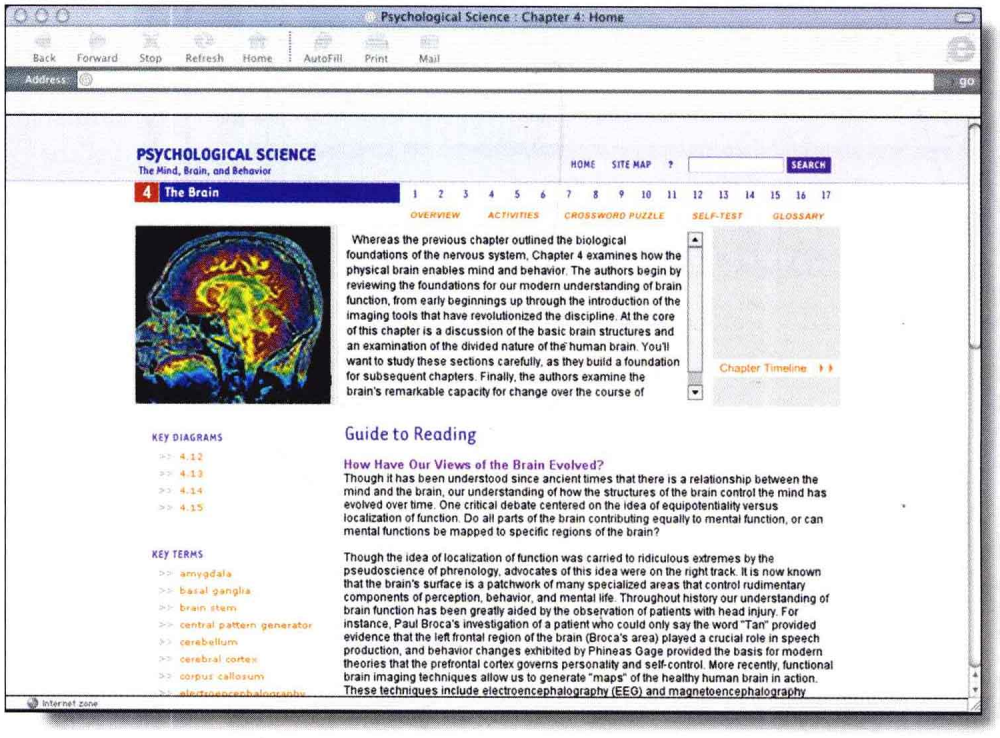

CONTENTS IN BRIEF

CONTENTS