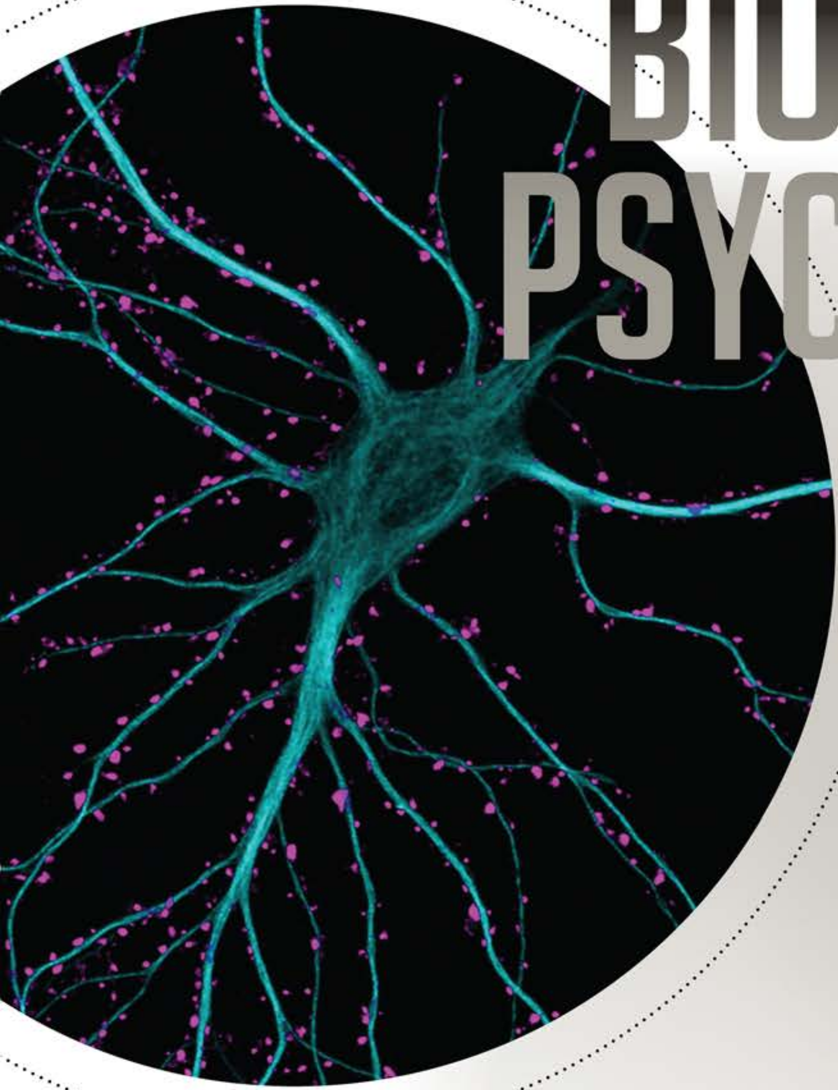
BIOLOGICAL PSYCHOLOGY

12E



JAMES W. KALAT

Biological Psychology 12e

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North Carolina State University

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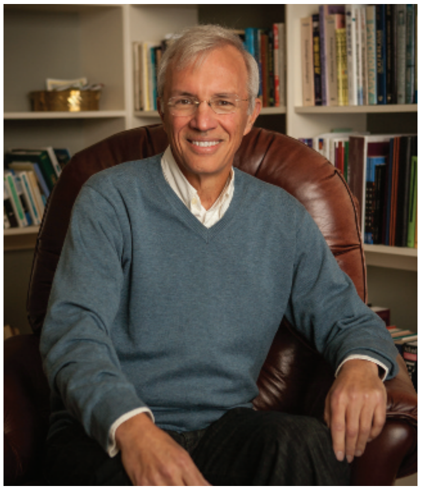

About the Author

James W. Kalat (rhymes with ballot) is professor emeritus of psychology at North Carolina State University, where he taught courses in introduction to psychology and biological psychology from 1977 through 2012. Born in 1946, he received a BA summa cum laude from Duke University in 1968, and a PhD in psychology from the University of Pennsylvania in 1971. He is also the author of *Introduction to Psychology* (10th edition) and co-author with Michelle Shiota of *Emotion* (2nd edition). In addition to textbooks, he has written journal articles on taste-aversion learning, the teaching of psychology, and other topics. He was twice the program chair for the annual convention of the American Psychological Society, now named the Association for Psychological Science. A remarried widower, he has three children, two stepsons, and four grandchildren.

To my grandchildren.

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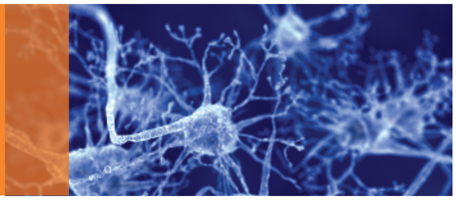

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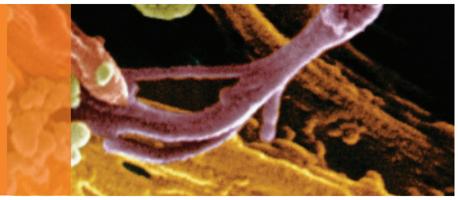

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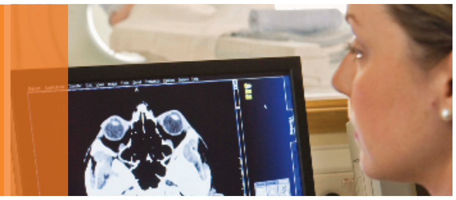

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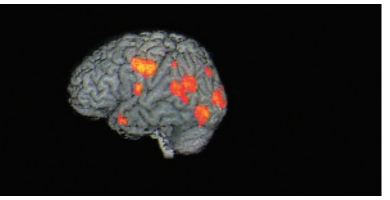

Preface

In the first edition of this text, published in 1981, I remarked, "I almost wish I could get parts of this text . . . printed in disappearing ink, programmed to fade within ten years of publication, so that I will not be embarrassed by statements that will look primitive from some future perspective." I would say the same thing today, except that I would like for the ink to fade faster. Biological psychology progresses rapidly, and much that we thought we knew becomes obsolete.

Biological psychology is the most interesting topic in the world. No doubt many people in other fields think their topic is the most interesting, but they are wrong. This really is the most interesting. Unfortunately, it is easy to get so bogged down in memorizing facts that one loses the big picture. The big picture here is fascinating and profound: Your brain activity *is* your mind. I hope that readers of this book will remember that message even after they forget some of the details.

Each chapter is divided into modules; each module begins with an introduction and finishes with a summary. This organization makes it easy for instructors to assign part of a chapter per day instead of a whole chapter per week. Modules can also be covered in a different order. Indeed, of course, whole chapters can be taken in different orders.

I assume that readers have a basic background in psychology and biology and understand such terms as classical conditioning, reinforcement, vertebrate, mammal, gene, chromosome, cell, and mitochondrion. I also assume a high school chemistry course. Those with a weak background in chemistry or a fading memory of it may consult Appendix A.

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Changes in this Edition

One new feature in this edition is a set of multiple-choice review questions at the end of each module. This edition also includes several changes in organization and many changes in content, to reflect the rapid progress in biological psychology. It includes well over 600 new references, more than 85 percent of them from 2011 or later, and many new or revised illustrations. Here are a few noteworthy items:

The module on genetics and evolution of behavior has been moved from the first chapter to the chapter on development (Chapter 4). The remainder of the first chapter (introduction to the field, concept of mind–body monism, job opportunities, ethics of animal research, etc.) is now labeled "Introduction." The introduction is brief, but I believe important. Note especially the section "Three Main Points to Remember from this Book."

The discussion of addictions, previously in the Synapses chapter, is now a module in the chapter on Psychological Disorders (Chapter 14). Material about how drugs exert their effects is integrated into the second module of the Synapses chapter (Chapter 2).

Chapter 3 (Anatomy and Research Methods) has an expanded treatment of optogenetics, rapidly becoming a more important method in neuroscience. The discussion of fMRI has new examples and a clearer emphasis that we need to be cautious about the conclusions we draw from fMRI studies.

Chapter 4 (Genetics, Evolution, Development and Plasticity) now includes a short section on brain evolution. The discussion of behavioral evolution now acknowledges that group selection is sometimes plausible. Important updates are added to the discussions of new neurons in the adult brain, fetal alcohol syndrome, and brain changes in adulthood.

Chapter 5 (Vision) is rearranged at the start to emphasize a fundamental point that a third of college students miss, sometimes even after taking courses in physics, perception, and biological psychology: We see because light enters the eyes, not because we send out sight rays! This chapter also has a revised description of the distinction between the ventral and dorsal pathways.

Chapter 6 (Other Sensory Systems) has a new section on the role of attention in hearing loss, and a new study showing that some people developed synesthesia by playing with colored refrigerator magnets during childhood.

Chapter 7 (Movement) has a substantial revision of the section about the basal ganglia, stressing their role in motivating movements.

Chapter 10 (Reproductive Behaviors) has a new section on how sex hormones affect nonsexual behaviors. The section on activating effects of hormones is reorganized in terms of males versus females instead of rodents versus humans.

Chapter 11 (Emotional Behavior) begins with a reorganized and reconsidered discussion of the relationship between emotion and autonomic arousal. A new section is titled, "Do People Have a Limited Number of Basic Emotions?" An expanded treatment of reconsolidation relates it to the possibility of alleviating learned fears.

Chapter 12 (The Biology of Learning and Memory) has some reorganization, and a more thorough explanation of the role of the basal ganglia in probabilistic learning.

Chapter 13 (Cognitive Functions) has a new short module on social neuroscience. It also has a new discussion of what Michael Gazzaniga calls "the interpreter," the tendency of the left hemisphere to invent explanations, correct or not, for unconsciously influenced behaviors. The discussion of consciousness is reorganized.

Chapter 14 (Psychological Disorders) has a new module on addictions and a new short module on autism spectrum disorders. The modules on depression and schizophrenia have been updated in many ways.

A Comprehensive Teaching and Learning Package

Biological Psychology, 12th edition, is accompanied by an array of supplements developed to facilitate both instructors' and students' best experience inside as well as outside the classroom. All of the supplements continuing from the 11th edition have been thoroughly revised and updated; other supplements are new to this edition. Cengage Learning invites you to take full advantage of the teaching and learning tools available to you and has prepared the following descriptions of each.

Online Instructor's Resource Manual

This manual, updated and expanded for the 12th edition, is designed to help streamline and maximize the effectiveness of your course preparation. It provides chapter outlines and learning objectives; class demonstrations and projects, including lecture tips and activities, with handouts; a list of video resources, additional suggested readings and related websites, discussion questions designed to work both in class and on message boards for online classes; key terms from the text; and James Kalat's answers to the "Thought Questions" that conclude each module.

Cengage Learning Testing, powered by Cognero for *Biological Psychology*, 12th Edition

Cognero is a flexible, online system that allows you to author, edit, and manage test bank content as well as create multiple test versions in an instant. You can deliver tests from your school's learning management system, your classroom, or wherever you want.

Acknowledgments

Let me tell you something about researchers in this field: As a rule, they are amazingly cooperative with textbook authors. Many colleagues sent me comments and helpful suggestions. I thank especially Glenn Weisfeld, Wayne State University.

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I appreciate the helpful comments provided by instructors who reviewed previous editions of the text, as well as those who participated in a survey that gave us valuable insights on the issues in this course.

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I thank my wife, Jo Ellen, for keeping my spirits high, and my department head, Douglas Gillan, and my son Sam for many original and insightful ideas about brain functioning.

I welcome correspondence from both students and faculty. Write James W. Kalat, Department of Psychology, Box 7650, North Carolina State University, Raleigh, NC 27695–7801, USA. E-mail: james_kalat@ncsu.edu

James W. Kalat

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Overview and Major Issues

Introduction

It is often said that Man is unique among animals. It is worth looking at this term *unique* before we discuss our subject proper. The word may in this context have two slightly different meanings. It may mean: Man is strikingly different—he is not identical with any animal. This is of course true. It is true also of all other animals: Each species, even each individual, is unique in this sense. But the term is also often used in a more absolute sense: Man is so different, so "essentially different" (whatever that means) that the gap between him and animals cannot possibly be bridged—he is something altogether new. Used in this absolute sense, the term is scientifically meaningless. Its use also reveals and may reinforce conceit, and it leads to complacency and defeatism because it assumes that it will be futile even to search for animal roots. It is prejudging the issue.

Niko Tinbergen (1973, p. 161)

Biological psychologists study the animal roots of behavior, relating actions and experiences to genetics and physiology. In this chapter, we consider three major issues: the relationship between mind and brain, the roles of nature and nurture, and the ethics of research. We also briefly consider career opportunities in this and related fields.

OPPOSITE: It is tempting to try to "get inside the mind" of people and other animals, to imagine what they are thinking or feeling. In contrast, biological psychologists try to explain behavior in terms of its physiology, development, evolution, and function. *Source: C. D. L. Wynne, 2004*

OUTLINE

LEARNING OBJECTIVES

After studying this introduction, you should be able to:

1. Briefly state the mind–brain problem and contrast monism with dualism.
2. List three general points that are important to remember from this text.
3. Give examples of physiological, ontogenetic, evolutionary, and functional explanations of behavior.
4. Discuss the ethical issues of research with laboratory animals.

The Biological Approach to Behavior

Of all the questions that people ask, two stand out as the most profound and the most difficult. One of those questions deals with physics. The other pertains to the relationship between physics and psychology.

Gottfried Leibniz (1714) posed the first of these questions: "Why is there something rather than nothing?" It would seem that nothingness would be the default state. Evidently, the universe—or whoever or whatever created the universe—had to be self-created.

So . . . how did that happen?

That question is supremely baffling, but a subordinate question is more amenable to discussion: Given the existence of a universe, why this particular kind of universe? Could the universe have been fundamentally different? Our universe has protons, neutrons, and electrons with particular dimensions of mass and charge. It has four fundamental forces—gravity, electromagnetism, the strong nuclear force, and the weak nuclear force. What if any of these properties had been different?

Beginning in the 1980s, specialists in a branch of physics known as *string theory* set out to prove mathematically that this is the only possible way the universe could be. Succeeding in that effort would have been theoretically satisfying, but alas, as string theorists worked through their equations, they concluded that this is not the only possible universe. The universe could have taken a vast number of forms with different laws of physics. How vast a number? Imagine the number 1 followed by about 500 zeros. And that's the *low* estimate.

Of all those possible universes, how many could have supported life? Very few. Consider the following (Davies, 2006):

- If gravity were weaker, matter would not condense into stars and planets. If it were stronger, stars would burn brighter and use up their fuel too quickly for life to evolve.
- If the electromagnetic force were stronger, the protons within an atom would repel one another so strongly that atoms would burst apart.
- In the beginning was hydrogen. The other elements formed by fusion within stars. The only way to get those elements out of stars and into planets is for a star to explode as a supernova and send its contents out into the galaxy. If the weak nuclear force were *either* a bit stronger *or* a bit weaker, a star could not explode.
- Because of the exact ratio of the electromagnetic force to the strong nuclear force, helium (element 2 on the periodic table) and beryllium (element 4) go into resonance within a star, enabling them to fuse easily into carbon (element 6), which is essential to life as we know it. (It's hard to talk about life as we don't know it.) If either the electromagnetic force or the strong nuclear force changed slightly (less than 1 percent), the universe would have almost no carbon.
- The electromagnetic force is 10^{40} times stronger than gravity. If gravity were a bit stronger relative to the electromagnetic force, planets would not form. If it were a bit weaker, planets would consist of only gases.

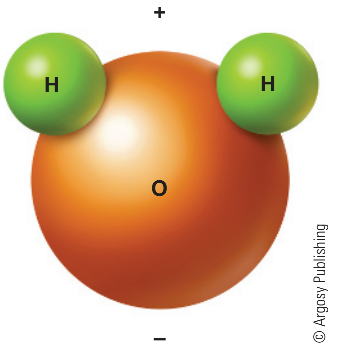

FIGURE INTRO.1 A water molecule
Because of the hydrogen-oxygen-hydrogen angle, one end of a water molecule is more positive and the other negative. The exact difference in charge causes water molecules to attract one another just enough to be a liquid.

- Why is water (H_2O) a liquid? Other light molecules, such as carbon dioxide, nitric oxide, ozone, and methane are gases except at extremely low temperatures. In a water molecule, the two hydrogen ions form a 104.5° angle (Figure Intro.1). As a result, one end of the water molecule has a slight positive charge and the other a slight negative charge. The difference is enough for water molecules to attract one another electrically. If they attracted one another a bit less, all water would be a gas (steam). But if water molecules attracted one another a bit more strongly, water would always be a solid (ice).

In short, the universe could have been different in many ways, nearly all of which would have made life impossible. Why is the universe the way it is? Maybe it's just a coincidence. (Lucky for us, huh?) Or maybe intelligence of some sort guided the formation of the universe. That hypothesis clearly goes beyond the reach of empirical science. A third possibility that many physicists favor is that a huge number of other universes (perhaps an infinite number) really *do* exist, and we of course know about only the kind of universe in which we could evolve. That hypothesis, too, goes beyond the reach of empirical science, as we cannot know about other universes. Will we ever know why the universe is the way it is? Maybe or maybe not, but the question is fascinating.

At the start I mentioned two profound and difficult questions. The second one is called the **mind–brain problem** or the **mind–body problem**, the question of how mind relates to brain activity. Put another way: Given a universe composed of matter and energy, why is there such a thing as consciousness? We can imagine how matter came together to form molecules, and how certain kinds of carbon compounds came together to form a primitive type of life, which then evolved into animals with brains and complex behaviors. But why are certain types of brain activity conscious?

So far, no one has offered a convincing explanation of consciousness. A few scholars have suggested that we abandon the concept of consciousness altogether (Churchland, 1986; Dennett, 1991). That proposal seems to avoid the question, not answer it. Chalmers (2007) and Rensch (1977) proposed, instead, that we regard consciousness as a fundamental property of matter. A fundamental property is one that cannot be reduced to something else. For example, mass and electrical charge are fundamental properties. Maybe consciousness is like that.

But it's an unsatisfying answer. First, consciousness isn't like other fundamental properties. Matter has mass all the

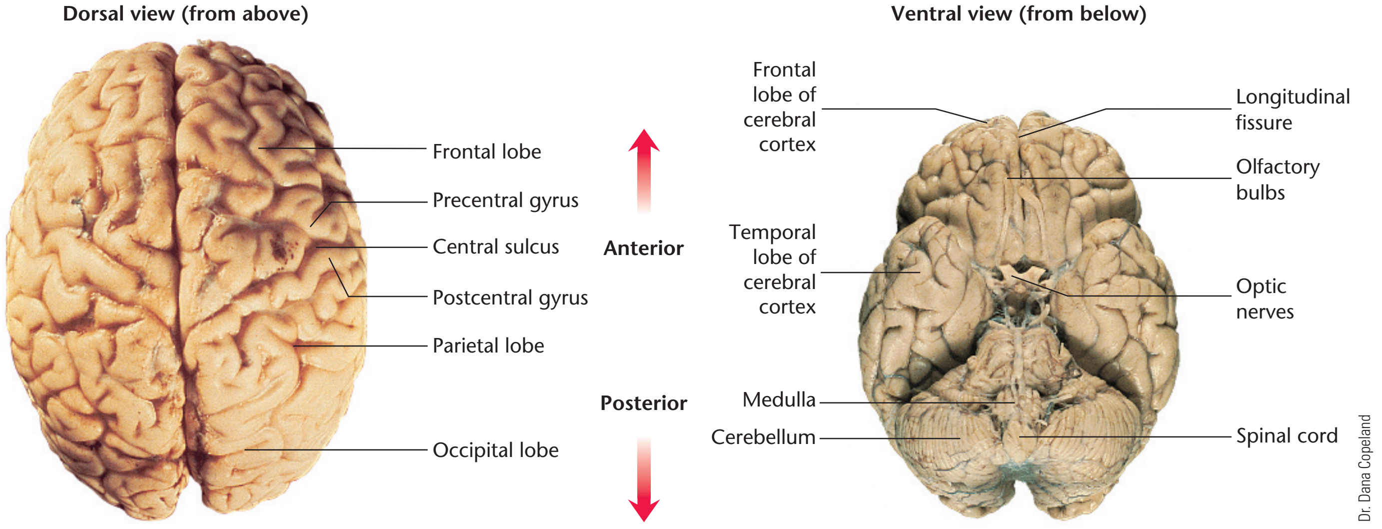

FIGURE INTRO.2 Two views of the human brain
The brain has an enormous number of divisions and subareas; the labels point to a few of the main ones on the surface of the brain.

time, and protons and electrons have charge all the time. So far as we can tell, consciousness occurs only in certain parts of certain kinds of nervous systems, just some of the time—not when you are in a dreamless sleep, and not when you are in a coma. Besides, it's unsatisfying to call *anything* a fundamental property, even mass or charge. To say that mass is a fundamental property doesn't mean that there is no reason. It means that we have given up on finding a reason. And, in fact, contemporary physicists have not given up. They are trying to explain mass and charge in terms of the Higgs boson and other elements of the universe. To say that consciousness is a fundamental property would mean that we have given up on explaining it. Certainly it is too soon to give up. After we learn as much as possible about the nervous system, maybe someone will have a brilliant insight and understand what consciousness is all about. Even if not, the research will teach us much that is useful and interesting.

The Field of Biological Psychology

Biological psychology is the study of the physiological, evolutionary, and developmental mechanisms of behavior and experience. It is approximately synonymous with the terms *biopsychology*, *psychobiology*, *physiological psychology*, and *behavioral neuroscience*. The term *biological psychology* emphasizes that the goal is to relate biology to issues of psychology. *Neuroscience* includes much that is relevant to behavior but also includes more detail about anatomy and chemistry.

Biological psychology is not only a field of study, but also a point of view. It holds that we think and act as we do because of brain mechanisms that we evolved because ancient animals with these mechanisms survived and reproduced better than animals with other mechanisms.

Biological psychology deals mostly with brain activity. Figure Intro.2 offers a view of the human brain from the top (what anatomists call a *dorsal* view) and from the bottom (a *ventral* view). The labels point to a few important areas that will become more familiar as you proceed through this text. An inspection of a brain reveals distinct subareas. At the microscopic level, we find two kinds of cells: the *neurons* (Figure Intro.3) and the *glia*. Neurons, which convey messages to one another and to muscles and glands, vary enormously in size, shape, and functions. The glia, generally smaller than neurons, have many functions but do not convey information over great distances. The activities of neurons and glia somehow produce an enormous wealth of behavior and experience. This book is about researchers' attempts to elaborate on that word *somehow*.

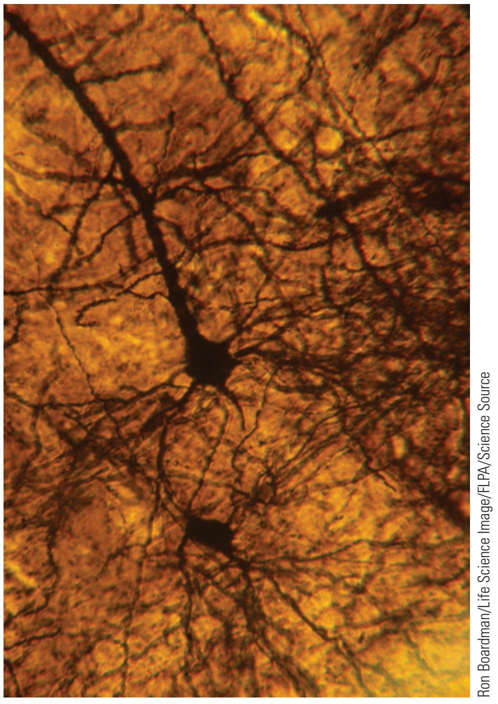

FIGURE INTRO.3 Neurons, magnified
The brain is composed of individual cells called neurons and glia.

Three Main Points to Remember from This Book

This book presents a great deal of factual information. How much of it will you remember a few years from now? If you have a career in psychology, biology, or medicine, you might continue using a great deal of the information. Otherwise, you will inevitably forget many of the facts (although you will occasionally read about a new research study that refreshes your memory). Regardless of how many details you remember, at least three general points should stick with you forever:

1. Perception occurs in your brain. When something contacts your hand, the hand sends a message to your brain. You feel it in your brain, not your hand. (Electrical stimulation of your brain could produce a hand experience even if you had no hand. A hand disconnected from your brain has no experience.) Similarly, when you see something, the experience is in your head, not "out there." You do NOT send "sight rays" out of your eyes, and even if you did, they wouldn't do you any good. The chapter on vision elaborates on this point.
2. Mental activity and certain types of brain activity are, so far as we can tell, inseparable. This position is known as **monism**, the idea that the universe consists of only one type of being. (The opposite is **dualism**, the idea that minds are one type of substance and matter is another.) Nearly all neuroscientists and philosophers support the position of monism. Whether you agree is up to you, but you should at least understand monism and the evidence behind it. The chapter on consciousness considers this issue directly, but nearly everything in the book pertains to the mind–brain relationship in one way or another.
3. We should be cautious about what is an explanation and what is not. For example, consider a study that shows us that certain brain areas are less active than usual in people with depression. Does that evidence tell us *why* people became depressed? No, it does not, unless and until we know a great deal more. For illustration, on average, the legs are also less active than average in people with depression, but inactive legs do not cause depression. Another study might tell us that certain genes are more common in people with depression than in others. Would that explain depression? Not at all, until we understand what those genes do, how they interact with the environment, and so forth. We should avoid overstating the conclusions from any research study.

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Researchers continue to debate the function of yawning. Brain mechanisms produce many behaviors that we engage in without necessarily knowing why.

Biological Explanations of Behavior

Commonsense explanations of behavior often refer to intentional goals such as, "He did this because he was trying to . . ." or "She did that because she wanted to. . . ." But often, we have no reason to assume intentions. A 4-month-old bird migrating south for the first time presumably does not know why. The next spring, when she lays an egg, sits on it, and defends it from predators, again she doesn't know why. Even humans don't always know the reasons for their own behaviors. Yawning and laughter are two examples. You do them, but can you explain what they accomplish?

In contrast to commonsense explanations, biological explanations of behavior fall into four categories: physiological, ontogenetic, evolutionary, and functional (Tinbergen, 1951). A **physiological explanation** relates a behavior to the activity of the brain and other organs. It deals with the machinery of the body—for example, the chemical reactions that enable hormones to influence brain activity and the routes by which brain activity controls muscle contractions.

The term *ontogenetic* comes from Greek roots meaning the origin (or genesis) of being. An **ontogenetic explanation** describes how a structure or behavior develops, including the influences of genes, nutrition, experiences, and their interactions. For example, the ability to inhibit impulses develops gradually from infancy through the teenage years, reflecting gradual maturation of the frontal parts of the brain.

An **evolutionary explanation** reconstructs the evolutionary history of a structure or behavior. The characteristic features of an animal are almost always modifications of something found in ancestral species (Shubin, Tabin, & Carroll, 2009). For example, bat wings are modified arms, and porcupine quills are modified hairs. In behavior, monkeys use tools occasionally, and humans evolved elaborations on those abilities that enable us to use tools even better (Peeters et al., 2009). Evolutionary explanations call attention to behavioral similarities among related species.

A **functional explanation** describes *why* a structure or behavior evolved as it did. Within a small, isolated population, a gene can spread by accident through a process called *genetic drift*. For example, a dominant male with many offspring spreads all his genes, including some that helped him become dominant and other genes that were irrelevant or even disadvantageous. However, a gene that is prevalent in a large population probably provided some advantage—at least in the past, though not necessarily today. A functional explanation identifies that advantage. For example, many species have an appearance that matches their background (see Figure Intro.4). A functional explanation is that camouflaged appearance makes the animal inconspicuous to predators. Some species use their behavior as part of the camouflage. For example, zone-tailed hawks, native to Mexico and the southwestern United States, fly among vultures and hold their wings in the same posture as vultures. Small mammals and birds run for cover when they see a hawk, but they learn to ignore vultures, which pose no threat to healthy animals. Because the zone-tailed hawks resemble vultures in both appearance and flight behavior, their prey disregard them, enabling the hawks to pick up easy meals (W. S. Clark, 2004).

To contrast the four types of biological explanation, consider how they all apply to one example, birdsong (Catchpole & Slater, 1995):

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Unlike all other birds, doves and pigeons can drink with their heads down. (Others fill their mouths and then raise their heads.) A physiological explanation would describe these birds' unusual pattern of nerves and throat muscles. An evolutionary explanation states that all doves and pigeons share this behavioral capacity because they inherited their genes from a common ancestor.

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FIGURE INTRO.4 A seadragon, an Australian fish related to the seahorse, lives among kelp plants, looks like kelp, and usually drifts slowly, *acting* like kelp.
A functional explanation is that potential predators overlook a fish that resembles inedible plants. An evolutionary explanation is that genetic modifications expanded smaller appendages that were present in these fish's ancestors.

Type of Explanation	Example from Birdsong
Physiological	A particular area of a songbird brain grows under the influence of testosterone; hence, it is larger in breeding males than in females or immature birds. That brain area enables a mature male to sing.
Ontogenetic	In many species, a young male bird learns its song by listening to adult males. Development of the song requires certain genes and the opportunity to hear the appropriate song during a sensitive period early in life.
Evolutionary	Certain pairs of species have similar songs. For example, dunlins and Baird's sandpipers, two shorebird species, give their calls in distinct pulses, unlike other shorebirds. The similarity suggests that the two evolved from a single ancestor.
Functional	In most bird species, only the male sings. He sings only during the reproductive season and only in his territory. The functions of the song are to attract females and warn away other males.

STOP&CHECK

1. How does an evolutionary explanation differ from a functional explanation?

ANSWER

1. An evolutionary explanation states what evolved from what. For example, humans evolved from earlier primates and therefore have certain features that we inherited from those ancestors, even if the features are not useful to us today. A functional explanation states why something was advantageous and therefore evolutionarily selected.

TABLE INTRO.1 Fields of Specialization

Specialization	Description
Research fields	**Research positions ordinarily require a PhD. Researchers are employed by universities, hospitals, pharmaceutical firms, and research institutes.**
Neuroscientist	Studies the anatomy, biochemistry, or physiology of the nervous system. (This broad term includes any of the next five, as well as other specialties not listed.)
Behavioral neuroscientist (almost synonyms: psychobiologist, biopsychologist, or physiological psychologist)	Investigates how functioning of the brain and other organs influences behavior.
Cognitive neuroscientist	Uses brain research, such as scans of brain anatomy or activity, to analyze and explore people's knowledge, thinking, and problem solving.
Neuropsychologist	Conducts behavioral tests to determine the abilities and disabilities of people with various kinds of brain damage and changes in their condition over time. Most neuropsychologists have a mixture of psychological and medical training; they work in hospitals and clinics.
Psychophysiologist	Measures heart rate, breathing rate, brain waves, and other body processes and how they vary from one person to another or one situation to another.
Neurochemist	Investigates the chemical reactions in the brain.
Comparative psychologist (almost synonyms: ethologist, animal behaviorist)	Compares the behaviors of different species and tries to relate them to their habitats and ways of life.
Evolutionary psychologist (almost synonym: sociobiologist)	Relates behaviors, especially social behaviors, including those of humans, to the functions they have served and, therefore, the presumed selective pressures that caused them to evolve.
Practitioner fields of psychology	**In most cases, their work is not directly related to neuroscience. However, practitioners often need to understand it enough to communicate with a client's physician.**
Clinical psychologist	Requires PhD or PsyD; employed by hospital, clinic, private practice, or college; helps people with emotional problems.
Counseling psychologist	Requires PhD or PsyD. Employed by hospital, clinic, private practice, or college. Helps people make educational, vocational, and other decisions.
School psychologist	Requires master's degree or PhD. Most are employed by a school system. Identifies educational needs of schoolchildren, devises a plan to meet the needs, and then helps teachers implement it.
Medical fields	**Practicing medicine requires an MD plus about four years of additional study and practice in a specialization. Physicians are employed by hospitals, clinics, medical schools, and in private practice. Some conduct research in addition to seeing patients.**
Neurologist	Treats people with brain damage or diseases of the brain.
Neurosurgeon	Performs brain surgery.
Psychiatrist	Helps people with emotional distress or troublesome behaviors, sometimes using drugs or other medical procedures.
Allied medical field	**These fields ordinarily require a master's degree or more. Practitioners are employed by hospitals, clinics, private practice, and medical schools.**
Physical therapist	Provides exercise and other treatments to help people with muscle or nerve problems, pain, or anything else that impairs movement.
Occupational therapist	Helps people improve their ability to perform functions of daily life, for example, after a stroke.
Social worker	Helps people deal with personal and family problems. The activities of a social worker overlap those of a clinical psychologist.

Career Opportunities

If you want to consider a career related to biological psychology, you have a range of options relating to research and therapy. Table Intro.1 describes some of the major fields.

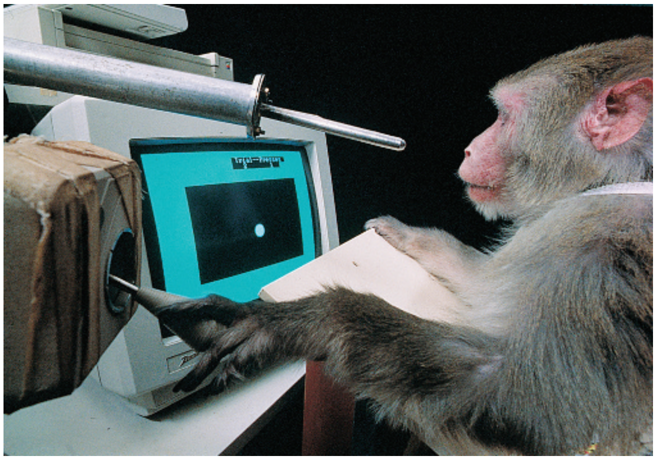
A research position ordinarily requires a PhD in psychology, biology, neuroscience, or other related field. People with a master's or bachelor's degree might work in a research laboratory but would not direct it. Many people with a PhD hold college or university positions, where they perform some combination of teaching and research. Others have pure research positions in laboratories sponsored by the government, drug companies, or other industries.

Fields of therapy include clinical psychology, counseling psychology, school psychology, medicine, and allied medical practice such as physical therapy. These fields range from neurologists (who deal exclusively with brain disorders) to social workers and clinical psychologists, who need to recognize possible signs of brain disorder so they can refer a client to a proper specialist.

Anyone who pursues a career in research needs to stay up to date on new developments by attending conventions, consulting with colleagues, and reading research journals, such as *The Journal of Neuroscience, Neurology, Behavioral Neuroscience, Brain Research, Nature Neuroscience*, and *Archives of General Psychiatry*. But what if you are entering a field on the outskirts of neuroscience, such as clinical psychology, school psychology, social work, or physical therapy? In that case, you probably don't want to wade through technical journal articles, but you do want to stay current on major developments, at least enough to converse intelligently with medical colleagues. You can find much information in the magazine *Scientific American Mind* or at websites such as the Dana Foundation at www.dana.org.

The Use of Animals in Research

Certain ethical disputes resist agreement. One is abortion. Another is the use of animals in research. In both cases, well-meaning people on each side of the issue insist that their position is proper and ethical. The dispute is not a matter of the good guys against the bad guys. It is between two views of what is good.



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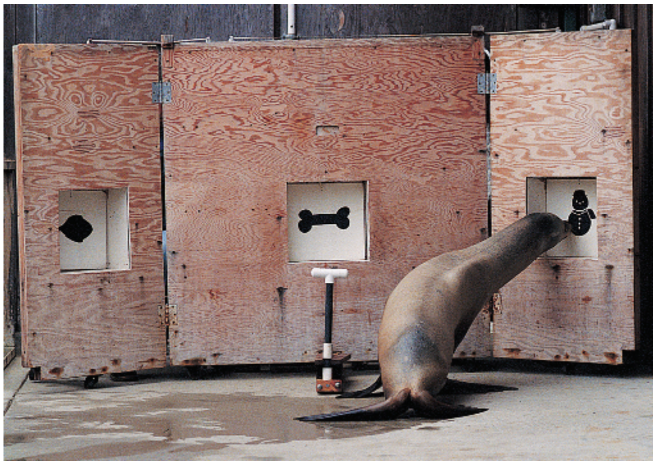

Oxygen Group/David M. Barron

Animals are used in many kinds of research studies, some dealing with behavior and others with the functions of the nervous system.

Given that most biological psychologists and neuroscientists are primarily interested in the human brain and human behavior, why do they study nonhumans? Here are four reasons:

1. *The underlying mechanisms of behavior are similar across species and sometimes easier to study in a nonhuman species.* If you want to understand a complex machine, you might begin by examining a simpler machine. We also learn about brain–behavior relationships by starting with simpler cases. The brains and behavior of nonhuman vertebrates resemble those of humans in their chemistry and anatomy (see Figure Intro.5). Even invertebrate

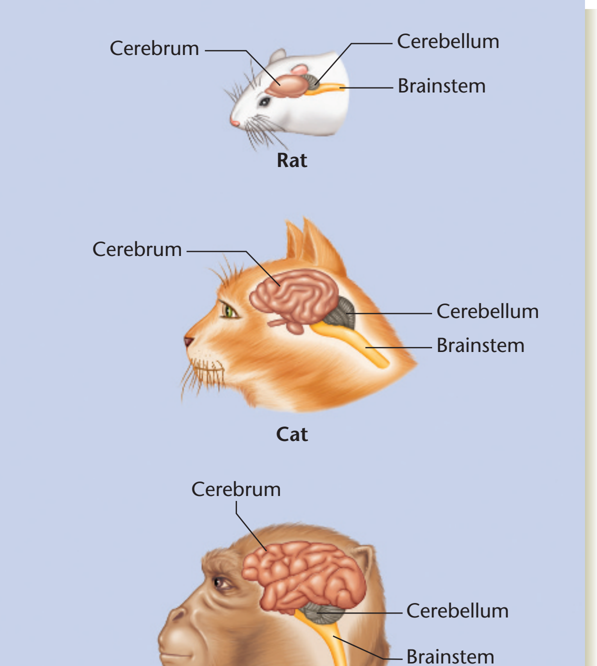

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FIGURE INTRO.5 Brains of several species
The general plan and organization of the brain are similar for all mammals, even though the size varies from species to species.

neurons and their connections resemble our own. Much research has been conducted on squid nerves, which are thicker than human nerves and therefore easier to study.

2. *We are interested in animals for their own sake.* Humans are naturally curious. We would love to know about life, if any, elsewhere in the universe, regardless of whether that knowledge would have any practical use. Similarly, we would like to understand how bats chase insects in the dark, how migratory birds find their way over unfamiliar territory, and how schools of fish manage to swim in unison.
3. *What we learn about animals sheds light on human evolution.* How did we come to be the way we are? What makes us different from chimpanzees and other primates? Why and how did primates evolve larger brains than other species? Researchers approach such questions by comparing species.
4. *Legal or ethical restrictions prevent certain kinds of research on humans.* For example, investigators insert electrodes into the brain cells of rats and other animals to determine the relationship between brain activity and behavior. They also inject chemicals, extract brain chemicals, and study the effects of brain damage. Such experiments answer questions that investigators cannot address in any other way, including some questions that are critical for medical progress. They also raise an ethical issue: If the research is unacceptable with humans, is it acceptable with other species? If so, under what circumstances?

STOP&CHECK

2. Describe reasons biological psychologists conduct much of their research on nonhuman animals.

ANSWER

2. Sometimes the mechanisms of behavior are easier to study in a nonhuman species. We are curious about animals for their own sake. We study animals to understand human evolution. Certain procedures that might lead to important knowledge are illegal or unethical with humans.

In some cases, researchers simply observe animals in nature as a function of times of day, seasons of the year, changes in diet, and so forth. These procedures raise no ethical problems. In other studies, however, including many discussed in this book, animals have been subjected to brain damage, electrode implantation, injections of drugs or hormones, and other procedures that are clearly not for their own benefit. Anyone with a conscience (including scientists) is bothered by this fact. Nevertheless, experimentation with animals has been critical to the medical research that led to methods for the prevention or treatment of polio, diabetes, measles, smallpox, massive burns, heart disease, and other serious conditions. Most Nobel Prizes in physiology or medicine have been awarded for research conducted on nonhuman animals. The hope of finding methods to treat or prevent AIDS, Alzheimer's disease, stroke, and many other disorders depends largely on animal research. In much of medicine and biological psychology, research would progress slowly or not at all without animals.

Degrees of Opposition

Opposition to animal research ranges considerably in degree. "Minimalists" tolerate certain types of animal research but wish to prohibit others depending on the probable value of the research, the amount of distress to the animal, and the type of animal. (Few people have serious qualms about hurting an insect, for example.) They favor firm regulations on research. Researchers agree in principle, although they might differ in where they draw the line between acceptable and unacceptable research.

The legal standard emphasizes "the three Rs": *reduction* of animal numbers (using fewer animals), *replacement* (using computer models or other substitutes for animals, when possible), and *refinement* (modifying the procedures to reduce pain and discomfort). In the United States, every college or other institution that receives government research funds is required to have an Institutional Animal Care and Use Committee, composed of veterinarians, community representatives, and scientists that evaluate proposed experiments, decide whether they are acceptable, and specify procedures to minimize pain and discomfort. Similar regulations and committees govern research on human subjects. In addition, research laboratories must abide by national laws requiring standards of cleanliness and animal care. Similar laws apply in other countries, and scientific journals accept publications only after researchers state that they followed all the laws and regulations. Professional organizations such as the Society for Neuroscience publish guidelines for the use of animals in research (see Appendix B).

In contrast to "minimalists," the "abolitionists" see no room for compromise. Abolitionists maintain that all animals have the same rights as humans. They regard killing an animal as murder, regardless of whether the intention is to eat it, use its fur, or gain scientific knowledge. Keeping an animal in a cage (presumably even a pet) is, in their view, slavery. Because animals cannot give informed consent to research, abolitionists insist it is wrong to use them in any way, regardless of the circumstances. According to one opponent of animal research, "We have no moral option but to bring this research to a halt. Completely. . . . We will not be satisfied until every cage is empty" (Regan, 1986, pp. 39–40). Advocates of this position sometimes claim that most animal research is painful and that it never leads to important results. However, for a true abolitionist, neither of those points really matters. Their moral imperative is that people have no right to use animals at all, even if the research is highly useful and totally painless.

The disagreement between abolitionists and animal researchers is a dispute between two ethical positions: "Never knowingly harm an innocent" and "Sometimes a little harm leads to a greater good." On the one hand, permitting research