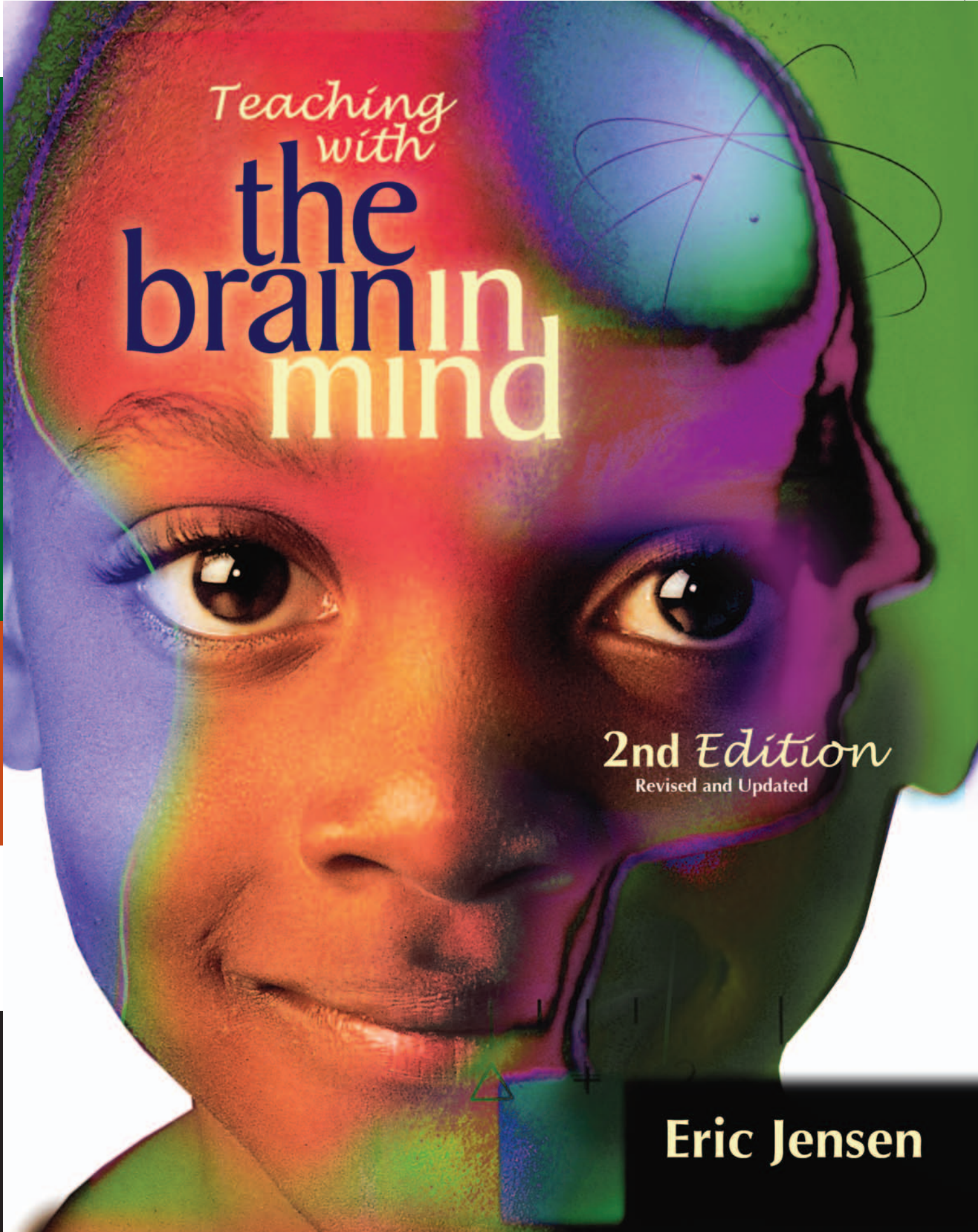
Teaching with
the brain in mind
2nd Edition
Revised and Updated
Eric Jensen

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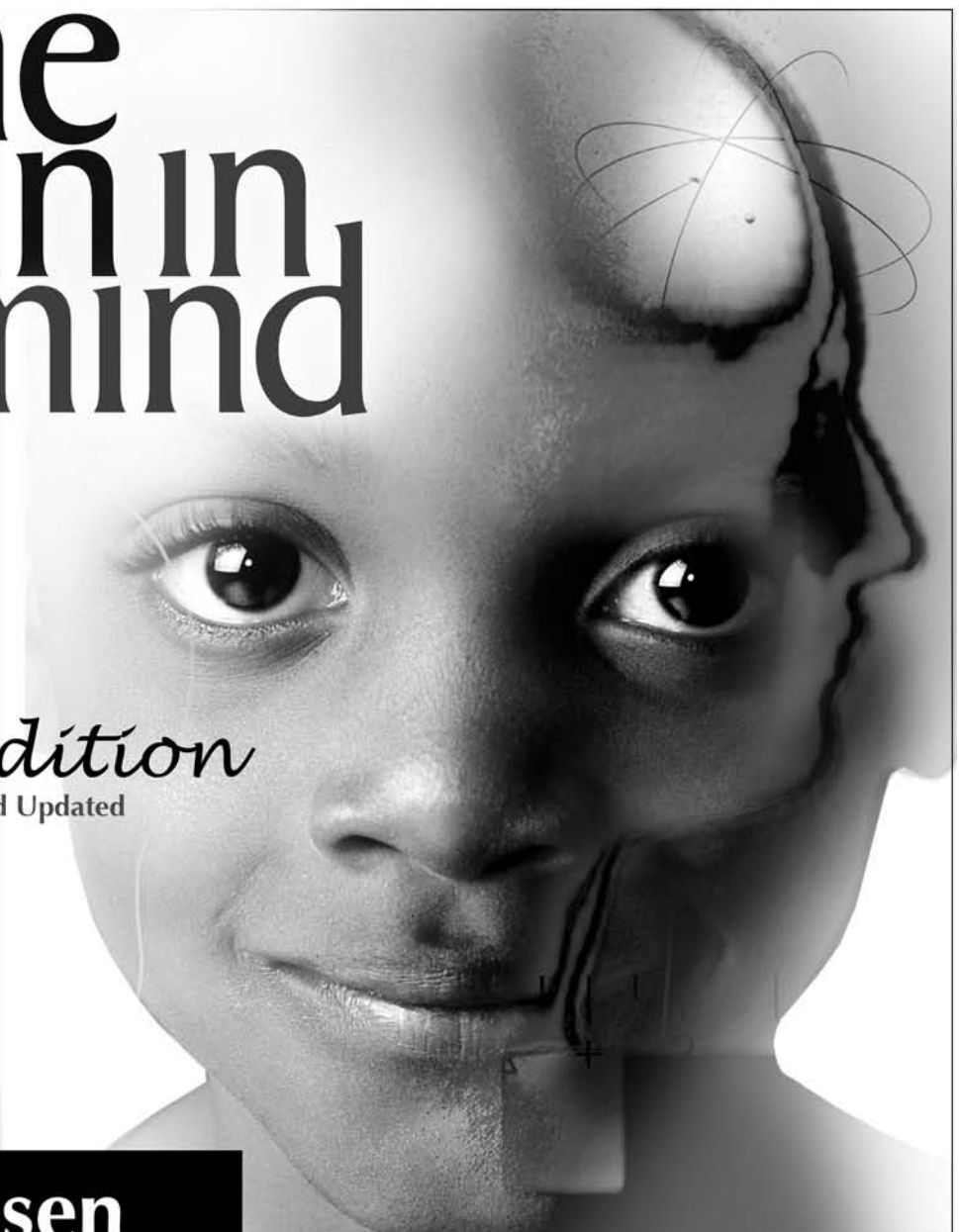

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Eric Jensen

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To all the neuroscientists, psychologists, and researchers who have graciously supported my efforts to learn how we learn and how to communicate it better.

To all the educators who make such a difference in the world.

To my wife, Diane, for her support.

Teaching with the brain in mind 2nd Edition

Preface

For most of human history, the model for learning was simple: if you wanted to learn something new, you either had to figure it out on your own or apprentice yourself to someone who could show you how to do it. Watch, listen, and try out the new skill; this worked for peasants and royalty, parents and children, blacksmiths and monks.

So what changed all that? Massive increases in population began the first change, and the shift from plowshares to factories during the Industrial Revolution brought new models of learning. The notion developed that you could bring everyone together in a single place and offer a standardized curriculum. This paradigm of schooling, exported from Prussia, was popularized by Horace Mann in the late 1800s and early 1900s. Often referred to as the "factory model," it emphasized useful skills such as obedience, orderliness, and respect for authority. Maria Montessori commented that children often felt humiliated in this new role.

A peculiar twist to this paradigm emerged during the 1940s through the 1960s. At the time, the dominant theory of human behavior was influenced by the doctrines of psychologists John Watson and B. F. Skinner, whose thinking went something like this: "We may not know what goes on inside the brain, but we can certainly see what happens on the outside. Let's measure behaviors and learn to modify them with behavior reinforcers. If we like it, reward it. If we don't, punish it."

Considering what we knew about the brain at that time, this behaviorist approach made sense. But now, it's becoming outdated as research uncovers new understandings of how the brain works. Times have changed.

Today it's no longer suprising to see the brain on the cover of national magazines. Society in general has finally moved past the novelty stage of exclaiming, "Wow, the brain!" And collectively we've begun to grasp the endless connections between brain research and everyday life. But articles that appear in the popular media rarely offer the depth of information or point of view that today's educators need. Are the revelations and implications of brain research reaching those who work most with children? I'm not sure that they are.

If you wanted to get your car fixed, would you go to a mechanic? Certainly. If you wanted legal help, would you find an attorney? Of course. And to understand the brain and how we learn, would you go to a teacher? Probably not. Yet every year, millions of parents trust that the professionals who teach their children are knowledgeable about the brain and the processes of learning. In defense of teachers, even neuroscientists still disagree about some of the inner workings of the brain. They also disagree about how much scientific data about the brain can be applied to schools. In addition, many schools of education do not offer programs that connect neurobiology, teaching, and classroom behaviors. It's time they did.

Starting Points

I discovered for myself the concept of brain-compatible learning during a workshop I attended in June 1980. The experience was so positive, and I became so enthusiastic (some would say zealous), that I decided to share my excitement with others. Because I was a teacher, my first response was, "Why don't my own students have this kind of learning experience every day?"

Within months, I cofounded with Bobbie DePorter an experimental, cutting-edge academic program in San Diego, California, called SuperCamp. Our purpose was to use the latest research on learning to enrich and empower young students with life skills and learning tools. I reasoned that if these strategies worked with adults, they could also work with kids. We held our first session in August 1982. It was an immediate success, and we soon offered it in other states and countries. We were flooded with media attention and were featured in more than 200 articles in magazines and newspapers including *USA Today* and *The Wall Street Journal*. Later, stories about SuperCamp appeared on CNN and *Good Morning, America.*

Students in this academic program have a nearly universal positive experience. Years of follow-up have shown that the benefits lasted long after the 10-day program itself (DePorter & Hernacki, 1992). In addition, students' grades and school participation went up, and the students reported greater self-confidence. The teaching methods used at SuperCamp have been evaluated and shown to be highly effective (Benn, 2003). The experiment we began decades ago in Southern California is now an international fixture, with more than 40,000 graduates.

In the publishing industry, the brain-based teaching revolution officially began with Leslie Hart's groundbreaking 1983 book, *Human Brain, Human Learning.* This book invited readers to make links between what we know about the brain

and how we teach. Instead of leaving it all to sociologists, psychologists, and well-meaning educators, Hart suggested we turn to biology. How exactly *is* the brain best designed to learn? This very powerful question began a lasting paradigm shift that is continually spurred by new technology, practical teachers, and the mushrooming ranks of neuroscientists, who now number more than 30,000 worldwide.

Changing Brains, Changing Minds

The first edition of *Teaching with the Brain in Mind,* published in 1998, introduced thousands of educators to links between brain research and classroom success. This revised, second edition takes a renewed and more critical look at the research connections and examines the fruits of success. Educators throughout the world credit brain-based teaching and learning with helping to raise teacher morale, increasing teacher retention, and improving student achievement. I have seen, felt, and heard firsthand the difference it makes. Students of all backgrounds and ages, with every imaginable history of failure, can succeed and have succeeded with a brain-based approach to teaching and learning.

Although it is not a panacea, this approach provides some important guidance for decision making. The brain-based revolution has already changed school start times and influenced discipline policies, assessment methods, teaching strategies, budget priorities, lunchroom choices, classroom environments, the use of technology, school architecture, and even the way we think of the arts and physical education. Brain-based learning is no longer a prediction or a fad; the change has already occurred in thousands of schools throughout the world.

Learning in ways that are compatible with the way humans naturally function is an approach that will stand the test of time. Yes, it may attract some criticism, spurred by the kind of defensive reaction that is typical among those who wish to hold on to the status quo. But if this paradigm is solid, as I believe it is, more and more people will come to realize that if you want to understand human learning, you'd better understand the brain.

Where Do You Start?

To get started, become more "consumer literate" about brain research. Learn some of the major terms and the best sources of serious research. Learn the names of prominent people who are doing the work that is most relevant to educators. Here are some of the major technical journals that are revealing new discoveries monthly:

- *Journal of Neuroscience*
- *Learning and Memory*
- *Brain and Cognition*
- *Brain Research*
- *Nature Neuroscience*
- *Brain and Behavior*
- *Journal of Cognitive Neuroscience*

Remember, one journal or one scientist's opinion is not enough. Dig for longitudinal studies that examine diverse populations and have sufficient sample sizes. Your own questions ought to be, "What's the origin of this idea? Is it still just theory? Where's the research on it?" You'll want to know, "What was the scientific discovery that illuminated the theory? What clinical trials have

been done? Is there any evidence of successful applications in the classroom?" Don't jump to conclusions or infer something that is not stated. You may want to e-mail the scientist who did the study to find out more about it. Avoid any inferential leaps and be a critical student of the results. Here's the process I use:

- Begin with basic research. (What happens in the brain and our environment?)
- Look for clinical trials (animal and human studies) conducted under controlled conditions.
- Find educational research conducted in real classrooms. (This approach is usually but not always possible.)
- Try out the concept or strategy for yourself.

Typically, if an idea is published, someone's already tried it somewhere. But it's good to be sure. Don't embrace any idea just because someone, somewhere has labeled it as "brain based." We all want solutions to educational challenges, but we must be careful about how we apply new discoveries.

Other Considerations

First, it's unfair to expect neuroscientists to present educators with the "holy grail" of learning. That's not their job, and most of them have purposes other than education to serve. Furthermore, many paradigms have been shaken as a result of an insight from outside the field. For example, the traditional view of neurobiology is very Newtonian—a physical, matter-based explanation. The new view, the one I embrace, is equally influenced by quantum mechanics—the influence of energy and particle waves on ourselves and on systems. Any researcher, teacher, or author who thinks he or she can explain human learning and behavior at only a micro level, by describing synapses and naming neurotransmitters, is almost 100 years out of date. The newer model shows that life forms are strongly influenced by more forces that we do not yet fully understand.

Second, remember that the learning is new, the field is young, and mistakes will be made. Many other breakthroughs will follow, and some of them *do* belong in the classroom. All of us are in this together, learning and growing as we make mistakes. If you want to move things forward in your classroom or school, you just might be the best person to do it. If the potential gain is good and the potential loss is acceptable, try out new ideas.

Third, use thoughtful action learning to test some of your own ideas. We need *more* action research, not less, and you can begin in your own workplace. The usual cautions apply. Avoid biases in the study design. Start small and keep track of your results. Tell your students what you're doing. Talk to parents about the brain, and make sure other staff members know about the information you gather. Get or give administrative backing, which helps generate the long-term resources and support needed for transformation.

Finally, begin the process with this book, which can serve as a study guide and will help you sort theory from fact. Again, brain-based learning is here to stay. You can bet it will continue to affect nearly every aspect of education, including teaching strategies, discipline policies, the arts, special education, curriculum, technology, bilingual programs, music instruction, learning environments, staff development, school design, assessment, and even organizational change. The more we

understand about the human brain, the more we can apply it in our schools. Anyone who thinks this field is irrelevant is saying that the brain itself is irrelevant. Nothing could be more wrong. Understanding and applying relevant research about the brain is the single most powerful choice you can make to improve learning.

The "brain train" is leaving the station. Are you on board?

Introduction

The revolution is being televised. Countless stories on the Discovery Channel and PBS have revealed exciting new insights about the brain. Mainstream broadcast media such as ABC, NBC, CBS, and CNN and publications such as *Time* and *Newsweek* have carried stories about recent brain discoveries. Dozens of books, videos, journals, newsletters, and publishing companies have documented this burgeoning field.

Educators worldwide have taken notice, and models of how we educate are being transformed. With brain-based learning now an established paradigm, if a far from universal one, it makes sense to explore some basic questions. First, how strong and reliable is this field of brain-based learning? Second, how do we know what we know about the brain? Can we apply laboratory findings directly in a classroom? The themes implied by these questions are simple; they are about answering the critics of brain-based education, understanding the sources that underlie it, and reviewing the reliability of evidence.

Let's begin with two fundamental facts. First, students who attend school from kindergarten through secondary school typically spend more than 13,000 hours of their developing brain's time in the presence of teachers. Second, their brains are highly susceptible to environmental influences—social, physical, cognitive, and emotional. And, more important, their brains *will be altered* by the experiences they have in school. As educators, we

must—ethically, morally, and opportunistically—pay attention to how we ask students to spend time with us. These concepts are fundamental to education, yet we often take them for granted.

Answering the Critics

Despite the mounting evidence that supports brain-based learning, some critics say, "It's no big deal; there's nothing new" or, "We don't know enough to do anything." Some even say, "Nothing will change." I wonder if those same critics would have had similar things to say at Kitty Hawk in 1903, when the Wright brothers flew the first airplane only 100 yards: "It's no big deal," "It won't change anything." We are now at the doorstep of the same kind of revolution. Instead of a mechanical one fueled by new modes of transportation, it's one of neurons, chemicals, networks, and wonderful, truly historic discoveries. For the first time in human history, we are beginning to understand how our brain works. Yes, maybe we are just at the stage of the Wright brothers' first flight. But it's a great time to be alive.

Shortly after new "brain-based" thinking began to make its way into the mainstream, critics began finding fault. For example, John Bruer, president of the James S. McDonnell Foundation, noted that "well-founded educational applications of brain science may come eventually, but right now, brain science has little to offer education practice or policy" (1998, p. 14). Armed with selected willing scientists and selective studies, the critics (Bruer, 1998, 1999; Bailey, Bruer, Symons, & Lichtman, 2001) have attempted to invalidate the integration of brain-based understandings into schools. Some claim that it's still too early and we don't know enough for sure. But if we waited for irrefutable evidence on *everything* we did in education, we'd need to stay at home.

Some people are simply "early adapters," and others, more skeptical, are "late adapters." By nature, critics are typically late adapters. There are also those who have more personal agendas to protect, such as a pet program, an institution, or a foundation that they fear is being threatened. Having said this, some critics have raised valid points; others have raised what I see as unwarranted objections. Here are some of the criticisms and my responses.

Criticism: Many "pop" writers were not scrutinizing the sources of their information about the brain.

Response: I agree. The general news media are not always reputable sources of information about the brain. Nor is one scientist, one critic, one famous person, or a single study; anyone seeking reliable information must consider multiple credible sources. For example, I first consider material from the basic neuroscience sources, then look at clinical studies if they're available, and finally locate reports of educational practices or action research to confirm the practical applications. Readers of research on the brain should look for significant sample sizes, blind studies, well-designed experiments, and plausible conclusions. For every source that appears in the References section of this book, there are a half dozen that I left out, just to keep the length of the list reasonable. In short, what I state in this book is solid information.

Criticism: There's nothing new here—all this brain-based stuff is a bunch of hype.

Response: I strongly disagree. Whenever someone claims there's nothing new, I reply with this abbreviated list of "Top 10 New Discoveries About

the Brain," all of which have come to light during the past 10 years:

1. We have discovered that the human brain can and does grow new neurons, that these neurons become functional and are highly correlated with memory, and that this process can be regulated.

2. We have discovered that there is no stable baseline for stress. Unlike other systems of the body, which usually revert to a prior, healthy state after suffering trauma (a process called homeostasis), the brain responds to extended periods of stress by developing a new, less healthy baseline. These "allostatic"—or adjusted—stress loads are becoming increasingly common and are associated with serious health, learning, and behaviorial risks.

3. We have discovered that aggressive behavioral therapies, new drugs, and revolutionary stem-cell implantation can be used to influence, regulate, and even repair brain-based disorders, including fetal alcohol syndrome, autism, retardation, strokes, and spinal cord injury.

4. We have discovered that "teenage behavior" may result from a complex array of fast-changing factors—not just hormones.

5. We have discovered that genes are not fixed. Evidence suggests that both gene expression and genetic makeup can be altered.

6. We have assembled tomes of evidence to support the delicate interplay between emotional states and cognition.

7. We have confirmed that music can affect cognition.

8. We have confirmed that software programs that use brain plasticity to retrain the visual and auditory systems really can improve attention, hearing, and reading ability.

9. We have discovered that exercise is strongly correlated with increased brain mass, better cognition, mood regulation, and new cell growth.

10. We have discovered that humans with implanted "brain chips" can operate thought-controlled mechanical interfaces; in other words, they can guide a robotic arm merely by thinking. The implications of these findings could revolutionize life for the physically disabled.

Anyone who says there's nothing new in brain research must have been living in a cave. The past 10 years have been the most explosive and hopeful in the entire history of neuroscience.

Criticism: Research findings are being misinterpreted; unwarranted leaps are being made.

Response: This criticism is often valid. The best-known example of this kind of extrapolation is hearing about the Mozart effect and then concluding, for example, that all music makes you smarter or all music is good for all students. Another is making an unwarranted leap from the understanding that new learning creates new synapses to the conclusion that more synapses must necessarily be a good thing. Untrue. Children with Fragile X syndrome actually have too many synapses. The best advice here is to read the studies and *wait for corroborating studies* before hopping onto a bandwagon. In addition, just because a study suggests that a certain instructional strategy may work well, the possibility remains that other strategies also work as well or better.

Mysteriously, most brain-based education books have not addressed the kinds of revolutionary discoveries found in my Top 10 list. Books on everything from "brain-based math" to "brain-based

leadership" focus on the trivial, not the fundamental, and unfortunately, some of these books are embarrassing to the critical reader and educator. Having said that, I'll add that an author *is warranted* in drawing practical conclusions when there's little or no downside risk and the conclusions are reasonable.

Criticism: Some of the brain studies cited involved animals, not humans.

Response: This is true, but not a definitive reason to discount those studies' findings. Animal studies *do* offer much that we can transfer and learn from. Lab experiments with rats or primates are clearly more credible than those with sea slugs or fruit flies. Some studies may never be done on humans for ethical reasons. And although obvious differences distinguish humans and rats, science tells us that there are more similarities than differences (Cenci, Whishaw, & Schallert, 2002).

Overman & Bachevalier (2001) have studied the question of animal models versus human models, designing and testing learning trials in which humans and animals negotiated comparable mazes. They concluded, "In most instances . . . the procedures of animal testing can be directly applied to children . . ." (p. 120). This is not a blanket justification for applying the results of all animal studies to human situations. But neuroscientists study Norway rats and macaque monkeys for a reason—these animals have significant neuroanatomical similarities compared to humans. Yes, whenever possible, human studies are ideal, ensuring greater reliability and confidence in the results. But, as noted, for ethical reasons, it's not always possible to conduct human studies.

Criticism: The field of brain-based education is not "brain based" enough; many ideas are actually from psychology, sociology, or psychiatry.

Response: The error in thinking that it's not "brain based" *enough* is simple: it's *all* about the brain. The disciplines of psychology, biology, sociology, psychiatry, and pedagogy are all concerned, to some degree, with understanding human behavior. And, increasingly, those looking to understand human behavior are looking at the brain. Most of the newer books in these fields include chapters on brain function, anatomy, or processes. We cannot explore learning and the brain without having our inquiry overlap those of these other disciplines. Besides, where's the wisdom in studying ways to improve student learning without considering issues that affect it, such as nutrition, racism, poverty, trauma, and stress?

A slightly different problem occurs when some "brain-based education" presenters simply recycle their favorite pedagogy—such as that of Dewey, Piaget, Montessori, Kolb, Hunter, Lozanov, McCarthy, or Gardner—with a brain-based spin. "Brain-based" rightfully means that the actual work and conclusions were based on recent findings about the brain. Dewey, Piaget, and Montessori have much to offer, but their models might more correctly be called "brain compatible," meaning that the work and conclusions are *aligned with* or *compatible with* recent brain research. Besides, if the work of these giants was valid before, it's still valid now; we don't need to look for proof in the latest brain scan.

For the critics of brain-based learning, my message is this: you are fighting a losing battle. Thousands of neuroscience studies are being

produced every year, and some of them *do* apply to the classroom. In the classroom are millions of teachers who need real-world solutions today, not 50 years from now. Educators are practical; they will try out almost any reasonable, ethical strategy, but they will keep using it only if *it works*. And thousands of educators are already using brain-based strategies with great success. To the critics in an office or a laboratory I say, "Get out in the real world—and teach for a week!"

One developmental neuroscientist recently stated, "If the likely risk-reward ratio is good, I see nothing wrong with classroom teachers trying out new ideas straight from neuroscience" (Jernigan, 2003). Sufficient studies support the things that I argue for in this book, and the references are solid. Many teachers are already doing action research to find out for themselves what works and what doesn't. They know brain-based teaching works.

I believe that over time the ideas and approaches I advocate in this book will become the standard. Why? Because when we teach in ways that make sense for the brain, that match how we were designed to learn, everyone wins.

Making Sense of Brain Research

A new breed of science of the brain is developing: educational neuroscience. No current journal carries that title, but one will probably appear soon. How else will we be able to integrate fields like psychiatry, sociology, nutrition, learning, emotions, and memory into a single social construct? Today dozens of new disciplines serve as examples of things to come. They have multiplied within the thriving biological community and find expression in journals such as *Social Neuroscience, Biological Psychiatry,* and *Nutritional Neuroscience.* Education will soon be part of this trend. The key to introducing and integrating these new fields is visionary researchers with a multidisciplinary approach.

The prevailing belief is that information is doubling in our society about every 18 months. In the field of neuroscience, the pace seems even faster. In short, we are learning about the brain at an unprecedented rate. It's generally acknowledged that research more than two years old is already "old information." In the coming years, we can expect new and more accurate technologies to further illuminate the brain's mysteries.

Even with all the exciting new research, it's easy to understand why many educators were turned off by the early attempts at applying it in the classroom. Typically, select and qualified "translators" of brain research shared their knowledge with staff developers and administrators who, in turn, set up professional development sessions to share the translated knowledge with classroom teachers. If these professional development sessions used role modeling and other effective techniques, the teachers often had reactions like "Wow! This is great stuff!" But if "application of brain research to the classroom" was presented as dry science, the responses were more along the lines of "Ho-hum. Tell me something new." Some educators got such a shallow, trivialized version of (mis)understanding—advice like "put water bottles in the classroom"—that it was difficult to have a serious conversation about the value of the research.

Let's remember, too, that errors of omission, commission, or enthusiasm come with every major paradigm shift. Educators have also seen laughable "translations" of learning styles, cooperative learning,

multiple intelligences, and differentiated instruction. Early in any movement, it's tougher to separate the wheat from the chaff. But it's important to stay the course and consider recent brain research as part of the major rationale for today's educational practices. Why? Because *all learning involves the brain*. The more we can understand how the brain naturally works, the better we can structure educational practices to align with that functionality.

Here's a simple example. A good bit of evidence from studies of both animals and humans suggests that 30 minutes of vigorous exercise at least three times a week can contribute to enhanced mood, increased brain mass, better circulation, more brain cells, and improved cognition (Adlard, Perreau, Engesser-Cesar, & Cotman, 2003; Churchill et al., 2002; Markakis & Gage, 1999; Sutoo & Akiyama, 2003; Tomporowski, 2003; Van Praag, Kempermann, & Gage, 1999). This research suggests that schools that eliminate physical education programs may be more than shortsighted; they may be reckless and hurting their own causes.

Here's another example. Each year, tens of thousands of students are helped by a computer software program called FastForWord, which helps them develop phonological awareness (Temple et al., 2003). Several neuroscientists developed this educational program as a direct result of brain research.

Yet, despite all that we're learning from brain researchers, school boards and shortsighted policymakers continue to scream "budget cuts" and eliminate the things that can make the biggest difference. If your physical education program is ineffective, don't throw it out, fix it. When done right, PE can improve health, increase brain mass, reduce the likelihood of childhood-onset diabetes and teen depression, boost neurogenesis, and provide a host of other benefits. I know of no other subject or discipline that can make those claims. Choosing to keep a physical education program is choosing well—*with the brain in mind.* Although every school decision does not need to be made by consulting recent studies from neuroscience, we should be paying more attention to what the research says. Brain-based learning is a force to be reckoned with, and it's here to stay.

1

Meet Your Amazing Brain

Key Concepts

- Basic brain anatomy
- How the brain changes over time
- Cooperation and competition in the brain
- How the brain learns

You've heard for much of your life that the human brain is amazing. It's true. That soft, squishy blob between your ears—the blob that runs your life—*is* pretty amazing. Every day in classrooms around the world, teachers are amazed by what the human brain can do. Because exploring *all* the facets of the brain is beyond the scope of this chapter, we'll focus on three relevant and essential features:

- *Adaptability.* The brain changes constantly.
- *Integration*. Brain structures compete and cooperate.
- *Sophistication*. The brain is highly complex.

These themes help to establish the nature of the brain: it is constantly working; it operates with a high level of structural cooperation; and seemingly simple processes, like learning to read, are actually highly complex. This dynamic and versatile structure is unlike anything else on earth. That may be why we are so attracted to the study of the brain—it evokes both wonder and curiosity. At the simplest level, the brain is an