PART ONE

The Neurobiology of Stress

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Stayin' Alive

Understanding the Human Brain and How It Responds to Stress

> Worry is like a rocking chair. It gives you
> something to do, but it gets you nowhere.
>
> —Erma Bombeck

The brain is the control center for all of our thoughts, actions, attitudes, and emotions. It's the pilothouse on the riverboat of our lives. It's Mission Control for all of our flights into space or time. It's the air traffic controller that helps us navigate and reroute our paths based on incoming and outgoing information and how we're feeling about it at the time. It's the John Williams of our personal symphony. It's the Mother Ship to our Starfleet; it's . . . (Uh, sorry, I got carried away there, but I think you get my point!)

As I was working on the drafts of this chapter, my own brain was very active, to say the least. I kept hearing in my head the words of the old Jack Scott favorite (#5 on the charts in 1960), asking me that musical question: "*What in the world's come over you?*" The song also wondered if I could ever change my mind. At first I took this message from the deep memory stores of my brain to be a protective warning about the writing task upon which I had embarked. But alas, this melodious warning was, as they say, too little and too late. Madly typing away, I banished the tune from my head. I had an unquenchable desire to tell the story of the impact of stress in the lives of kids with LD and ADHD, not to mention the fact that I had a signed book contract sitting in a folder on my desk.

The cognitive and emotional centers of my brain collaborated nicely to keep my fingers moving on the keyboard, but I understood why that song kept popping up. I was not without my own stress about writing this chapter. To say "I wrote the book on stress" is not the same as saying I had conquered it. (In fact, it's a double-entendre. Get it? . . . I wrote the book *while* stressed . . . never mind.)

Seriously! How was I ever going to write an introduction to the brain, the most complex organ in the human body, that you, my reader, would *want* to read, and that you would *understand?* Hundreds of thousands of textbooks and scholarly articles contained deep and dense discussions by brilliant scientists all over the globe who were trying to explain the mysteries of this incredible organ, and I had to do it in 70,000 words!

You'll learn in this book that the best way to combat stress is to gain some control over whatever it is that threatens you. My own stress level began to go down dramatically as I realized I didn't have to tell the entire story. I just needed to focus on the parts and systems of the brain that are most involved in the perception and processing of stress. As a neuropsychologist, I find this part of the story incredibly interesting, and hope you will as well. Trying to tell the story of stress without putting it in the context of the brain is like writing a novel without giving the characters a setting in which to act out their dramas. Without context, the reader can't see where the action is taking place.

This helps explain the perception of the many parents, kids, and even teachers who tend to view the behaviors that result from stress not as brain-based, brain-generated reactions but as premeditated oppositional or even defiant *mis*behaviors. Putting the characters of this story—the symptoms of stress—in the context of the brain and central nervous system makes it possible to understand their nature and their purpose in a way that makes scientific sense. So . . . stay with me as I set the stage for an amazing tale about how the brain deals with stress, and how the presence of neurologically based ADHD and LD put a special spin on the story.

THE HUMAN BRAIN: A BRIEF TOUR

To most people, the brain is terra incognita, a priceless piece of neurological real estate that we're glad we own but tend to take for granted unless or until something bad happens to it. So let's take a brief tour, just so you can appreciate the inestimable value of this miraculous organ called the brain. (If you're very familiar with brain anatomy and function, you might want to skip this overview and move on to "The Stress Response Explained," later in this chapter. You can always return to this section if subsequent reading reveals that you need a refresher.)

The average adult human brain weighs about three pounds (a kilogram and a half), which is a little bigger than a small cantaloupe or a large grapefruit, depending on the growing season. It starts out substantially smaller, of course, but as certain kinds of cells develop and change as a child moves into adulthood, the brain grows in size. As a result of *myelination* (the development of the outer coating of the long stem of brain cells, or neurons), and the proliferation of glial cells (the term *glial* comes from the Greek word for glue), which hold the brain together and feed it, an adult brain is about three times heavier than it was at birth. This is why you occasionally have to buy new hats.

The largest and most recognizable part of the brain is the large dome-shaped cerebrum, which is the outermost layer of brain tissue. If you lift off the skull and look down on the brain from above, it looks rather like what you see when you lift half the shell off a walnut. However, the cerebrum is not stiff like a nut; it has a thick, jelly-like consistency that allows it to literally bounce around inside the skull, which is why it's so important to protect the head from encounters with immovable objects.

A sheet of neural tissue called the *cerebral cortex* forms the outermost surface of the cerebrum. It includes up to six layers, each one different in terms of the arrangement of neurons and how well they connect and communicate with other parts of the brain. The cortex is distinguishable by its many little ridges (called *gyri*) and valleys (*sulci*). In terms of space, the cortex is an economically arranged region that folds in on itself many times. This results in a very large but mainly hidden surface area that contains more neurons than any other part of the brain.

Gray Matters

The term *gray matter* usually evokes an image of the cortex, because that's the part most visible in pictures of the brain. In fact, gray matter makes up not only the cerebral cortex but also the central portion of the spinal cord and areas called the *cerebellar cortex* and the *hippocampal cortex*. This dense tissue is packed full of neuronal cells, their *dendrites* (branching, root-like endings), *axon terminals* (the other end), and those sticky glial cells I mentioned earlier. The cortex is the area of the brain where the actual processing of information takes place. Because of its relative size and complexity, it's easy to understand why it plays a key role in memory, attention, perceptual awareness, thought, language, and consciousness.

A Division of Labor

A central groove, or fissure, runs from the front to back of the cortex, dividing it into right and left hemispheres. In general, the left hemisphere controls functions on the right side of the human body and the right hemisphere controls the left side, but there are significant exceptions and much sophisticated interaction *between* the two hemispheres. This communication between the left and right hemispheres is facilitated by the *corpus callosum,* a wide, flat bundle of axons located in the center of the brain, beneath the cortex. Think of it as the Lincoln Tunnel, connecting Manhattan and Jersey City. (I'll leave it to you to decide which one represents which hemisphere.)

The corpus callosum makes up the largest area of so-called white matter in the brain. White matter is made of bundles of axons each encased in a sheath of myelin. These nerve bundles lead into and out of the cortex and the cerebellum, and branch to the "old brain," the hippocampus. About 40 percent of the human brain is made up of gray matter, and the other 60 percent is white matter. It's the white matter that facilitates communication between different gray matter areas and between the gray matter and the rest of the body. White matter is the Internet of our brains. (Al Gore did not invent it.)

Evolution, tempered by experience, has employed gray matter to build what might be considered very well-developed "cognitive condos" that sit above the hippocampus. This arrangement is very important to a discussion of stress. Our old or primitive brain was primed for survival in our ancestors' environment. It's interesting to note that the brains of lower vertebrates like fish and amphibians have their white matter on the *outside* of their brain. We are blessed (and cursed) with lots of gray matter that gives us the ability to think things through (especially if we are anxious). Frogs and salamanders and their pond-side friends don't *think* about danger so much—they just get out of its way! (And while I can't be sure, I don't think that they have nightmares about giant human children armed with nets.)

How do you feel about that? In case you ever get this question on *Jeopardy* or in a game of Trivial Pursuit, the limbic system is made up of the amygdala, the hippocampus, the cingulate gyrus, fornicate gyrus, hypothalamus, mammillary body, epithalamus, nucleus accumbens, orbitofrontal cortex, parahippocampal gyrus, and thalamus. These structures work together to process emotions, motivation, the regulation of memories, the interface between emotional states and memory of events, the regulation of breathing and heart rate, the production of hormones, the "fight or flight" response, sexual arousal, circadian rhythms, and some decision-making systems. Pretty impressive job description, eh? The word *limbic* comes from the Latin word *limbus,* which translates to "belt" or "border," because this system forms the inner border of the cortex. The limbic system is part of the old brain and developed first, followed by the new brain: the cortex, which is sometimes referred to as the *neocortex.* Put *very* simply, the limbic system feels and remembers; the cortex acts and reacts. And they communicate with each other. Why is this important? The limbic system figures prominently in what's called the stress response, which is a central player in this book.

These days, both our old and new brains are activated when we're under stress. The primitive part, the limbic system (notably the hippocampus), sniffs out danger well before the new brain (the neocortex) actually processes it. The old brain responds first, acting as a sort of fire alarm system. It is the neocortex, and in particular, the frontal lobe (the prefrontal cortex), that helps us make sense of the alarms.

The cortex is made up of four major sections, arranged from the front to the back. These are called the *frontal, parietal, occipital,* and *temporal* lobes. Each of the four lobes is found in both hemispheres, and each is responsible for different, specialized cognitive functions. For example, the occipital lobe contains the primary *visual* cortex, and the temporal lobe (located by the temples, and close to the ears) contains the primary *auditory* cortex.

The frontal lobes are positioned at the frontmost region of the cerebral cortex and are involved in movement, decision making, problem solving, and planning. There are three main divisions of the frontal lobes. They are the *prefrontal cortex,* the *premotor area,* and the *motor area.* The frontal lobe of the human brain contains areas devoted to abilities that are enhanced in or unique to humans. The prefrontal cortex is responsible for planning complex cognitive behaviors, the expression of personality, decision making, and social behavior, as well as the orchestration of thoughts and actions necessary for a person to carry out goals. A specialized area known as the *ventrolateral* prefrontal cortex has primary responsibility for the processing of complex language. It is more commonly called *Broca's area,* named for a nineteenth-century French physician who determined its role.

In humans and other primates, an area located at the forward part of the prefrontal cortex is called the *orbitofrontal cortex.* It gets its name from its position immediately above the *orbits,* the sockets in which the eyes are located. The orbitofrontal cortex is very involved in interpreting rewards, decision making, and processing social and emotional information. For this reason, some consider it to be a part of the limbic system.

The *amygdala,* a part of the limbic system, is a brain structure that is responsible for decoding emotions, especially those the brain perceives as threats. As we evolved as a species, many of our alarm circuits have been grouped together in the amygdala. Not surprisingly, many regions of the brain send neurons into the amygdala. As a result, lots of sensory messages travel instantaneously to the amygdala to inform it of potential dangers lurking in our neighborhood. The amygdala is our guard dog.

The amygdala is directly wired to the hippocampus, also a part of the limbic system. Since the hippocampus is involved in storing and retrieving explicit memories, it feeds the amygdala with strong emotions triggered by these recollections. Why is this important? If a child has a negative experience in school, like being terribly embarrassed when asked to read in front of the class, the hippocampus just won't let go of this memory, and it shouts it out to the amygdala. Since the amygdala has signed a no confidentiality agreement, it sends a warning to the rest of the brain to go into protection mode. A rather amazing arrangement, don't you think?

What's really interesting about this is that the hippocampus specializes in processing the context of a situation. As a result, the child under stress generalizes the entire situation and uses it as justification for anxiety or stress: "Hey, they're telling me to go to social studies class." Even though not everything about social studies may be a threat—perhaps just the fact that they read out loud in there—the hippocampus sends out a general alert. So the student responds by protesting the whole enchilada: "No way I'm going there."

The amygdala is also wired to the *medial prefrontal cortex*. Want to know why this is important? This is the area of the brain that seems to be involved in planning a specific response to a threat to safety. Here's how it works: the child is hit with the gigantic *Titanic* news (which may be just "social studies coming up next" to the rest of the group, but it's "Submerged iceberg ahead!" to the kid worried about perceived horrors there). This two-way communication between the prefrontal cortex and the limbic system (particularly the amygdala) enables us to exercise conscious control over our anxiety. The emotion-cognition connection allows us to feel that we can do something about the danger that lies ahead. The child is then faced with the necessity of choosing a course of action that looks best for getting out of danger. This seems very protective but tends to be counterproductive, because the very mechanism that allows us to create an escape plan can actually create anxiety. "Oh crud—now we have to *do* something!" The brain not only allows us to imagine a negative outcome, which can help us avoid danger, it makes it possible for us to imagine dangers that do not actually exist. This is a problem for children who have ADHD, and a huge problem for students who have both anxiety disorders and ADHD. If you do a brain scan of a person with ADHD while putting on pressure to perform in a certain way, you see that this "to do" order results in a *decrease* in activity in the prefrontal cortex (instead of increasing it, as it does in most people). This helps explain why kids with ADHD don't respond well to lists. These are read as "thou shalt" messages. What helps some of us stay organized sends some kids with ADHD up the wall.

The Thalamus Bone's Connected to the . . .

Of course, it's not really a bone; it's a plum-shaped mass of gray matter that's multilayered and multifaceted. The thalamus, another part of the limbic system, sits on top of the hypothalamus which, in turn, sits on top of the *brain stem,* which is in the center of the base of the brain. This is a great location for the thalamus because it acts as a relay system that sends nerve fibers upstairs to all parts of the cerebral cortex as well as many *subcortical* (underneath the cortex) parts of the brain. The thalamus receives information from every sensory organ and its associated neurons except the *olfactory* (smell) system. The hypothalamus gets information from the eyes, the ears, the skin, and the tongue, and it forwards these messages to the corresponding areas of the cortex where they are processed. In terms of stress, this relay system is how the brain knows that it's in a dangerous environment.

That Stinks!

There's a bulb-shaped brain structure (called, as you might guess, the *olfactory bulb*) that has the specialized task of making sense of scents. Think about this: you can't see when you are sleeping, but you can *smell*. This is awfully helpful at night, especially when there's a fire. And when you get hold of a bad piece of fish. That's probably why the nose gets its own special receptor. It's another example of how sensitive the brain is to changes in the environment, and how it's always on alert!

Amazing Related Fact: Because a dog has about 200 million smell cells in its nose (versus 5 million in the human nose), it can pick up much fainter scents. Scientists tell us that salmon, too, have remarkable noses. By smelling the ocean, they can swim their way back to the exact stream in which they were born years before.

The Little Brain Down Under

The tour continues . . . Sitting under the occipital and temporal lobes of the brain is the *cerebellum*. It's about the size of a child's fist. Because it looks like a separate brainlike structure attached to the underside of the cortex, the cerebellum is sometimes referred to as the "little brain." It's connected to the brain stem, which in turn connects the brain to the spinal cord. The cerebellum used to be relegated to the very simple role of helping us maintain balance when we walk or run, but modern neuroscience has found that the cerebellum plays a much larger and more important role than that. Like the hypothalamus, it is involved in cognitive functions, including attention and language, as well as the ability to hold mental images in the "mind's eye." This part of the brain is important to the discussion of stress, since recent research has shown that the cerebellum also plays a key role in regulating responses to pleasure and to fear—strong forces when it comes to loving school or hating it.

The BeeGees song "Stayin' Alive" reached #1 on the pop charts in 1977. Maybe it was the beat, maybe it was John Travolta's dancing. Or maybe it's that the Gibb brothers' central lyric is quite literally always playing in our head. Keeping us safe—that is, "stayin' alive"—is the primary mission of the brain. The brain works very fast and very hard—mostly in the background—to do just that. It's exquisitely positioned close to ears, eyes, nose, and mouth so the signals from those sensory organs get into it without delay. Everything we encounter in our daily lives gets sent, incredibly fast, from our ears, nose, mouth, skin, and eyes to our brain for processing. The brain controls the other organ systems of the body, either by activating muscles or by causing secretion of chemicals such as hormones. That three-pound mass of gray and white matter somewhat miraculously uses this unending and potentially overwhelming stream of information to change our physical position, our pattern of thought, and our feelings or emotions—all in the service of keeping us alive. After all, a brain without a body is, if you will forgive me, nobody at all.

Now that you have had a brief introduction to this marvelous and complex organ called the brain, it will be easier to understand what happens to the brain under stress.

THE STRESS RESPONSE EXPLAINED

Stress was put on the map, so to speak, by a Hungarian-born Canadian endocrinologist named Hans Hugo Bruno Selye (ZEL-yeh) in 1950, when he presented his research on rats at the annual convention of the American Psychological Association. To explain the impact of stress, Selye proposed something he called the General Adaptation Syndrome (GAS), which he said had three components. According to Selye, when an organism experiences some novel or threatening stimulus it responds with an alarm reaction. This is followed by what Selye referred to as the recovery or resistance stage, a period of time during which the brain repairs itself and stores the energy it will need to deal with the next stressful event.

What is critical to the impact of stress on kids with LD or ADHD is the third stage of the GAS proposed by Selye. He said that if the stress-causing events continue, neurological exhaustion sets in. This phenomenon came to be referred to popularly as *burnout.* It's a state of mind characterized by a loss of motivation or drive and a feeling that you are no longer effective in your work. When this mental exhaustion sets in, a person feels emotionally flat, becomes cynical, and may display a lack of responsiveness to the needs of others. Does this sound like any kids with LD or ADHD that you know?

What's going on behind the scenes to cause this exhaustion? When humans are confronted by physical or mental stress or injury, an incredibly complex and critically important phenomenon rapidly takes place. First to be put on alert is the *hypothalamus,* which is situated deep inside the brain, under the thalamus and just above the brain stem. It's only about the size of an almond, but plays a crucial role in linking the nervous system to the endocrine system. The hypothalamus is particularly interesting because it controls the production of hormones that affect how the body deals with stress. When danger looms, the hypothalamus sends a nearly instantaneous chemical message down the spinal cord to the adrenal glands, which are located just above the kidneys. This first message signals the production of a stress hormone called *adrenaline,* also called *epinephrine,* which is released into the blood stream. *Norepinephrine* also plays a role here. The interaction of these two hormones controls the amount of glucose (sugar) in the blood, speeds up the heart rate, and increases metabolism and blood pressure, all of which get the body ready to respond to the stressor.

Meanwhile, the hypothalamus has been closely monitoring these changes, as well as the source of the stress, and now releases something called a *corticotrophin-releasing hormone* (CRH). CRH travels along the neurons that go from the hypothalamus into the *pituitary gland*. This important gland, which is located at the base of the brain just above the roof of the mouth, releases something called *adrenocorticotropic hormone* (ACTH) into the bloodstream. ACTH travels down to the adrenal glands. This triggers the adrenal glands to release another hormone called *cortisol*. (Seriously, folks, isn't this just *amazing?*)

Some cortisol (it's a steroid, by the way—you've probably used cortis*one* cream to quell some itch) is present in the bloodstream all the time. Normally, it's present at higher levels in the morning and much lower at night. Incidentally, recent research has found that the opposite is true in some children with autism, a finding that might shed light on this condition. A little cortisol is a good thing. It can give you that quick burst of energy that comes in handy for survival purposes. For a brief period, it can enhance your memory and help boost your immune system. The right amount of cortisol helps keep your body systems in a healthy balance, and it can fight against inflammation and even lower your sensitivity to pain—all good things when you've been injured or if you're going into battle against a single stressful opponent. But as often happens, too much of a good thing is, well . . . you know.

The stress response described here temporarily turns down or modifies nonessential bodily functions and activates the ones we need to keep us safe and healthy. It's a wonderfully efficient system, and it's fine-tuned to do its job well. Our brains and bodies are exquisitely designed to handle occasional acute stresses or injuries. However, they're not well-equipped to handle ongoing or chronic stress.

Hans Selye's research on the impact of stress in rats formed the foundation on which most subsequent studies about stress were built. Over time, and with the aid of sophisticated brain imagining technology, Selye's hypothesis has been scrutinized and expanded. He believed that all types of stress resulted in the same reaction in the brain, but we now know that this process is much more complex. For example, contemporary research shows that the brain responds in different ways based on its perceptions of the degree of control that a person has over a stressful event. Here's how this plays out in the brain.

The more stress people are under, or *think* they are under, the greater the amount of cortisol that's pumped into the blood by the adrenal glands. If too much cortisol is produced (as in acute stress) or is maintained at high levels in the bloodstream for too long (as in chronic stress), it can be very harmful. This hormone can cause a variety of physical problems, including blood sugar imbalances like *hypoglycemia* (a disturbance in the functioning of the thyroid), a decrease in muscle tissue and bone density, and high blood pressure. It can also make the body susceptible to disease by lowering immunity and inflammatory responses in the body and making it harder for wounds to heal. Prolonged exposure to excessive amounts of cortisol has been implicated in the rise of obesity because too much cortisol has been shown to be related to an increase in the amount of abdominal fat. Being overweight can lead to a host of other problems, including a decrease in "good" cholesterol (HDL) and an elevation of "bad" cholesterol (LDL) as well as metabolic disorders, heart attacks, and strokes. Most important to our discussion of stress in the lives of students with LD and ADHD is that too much cortisol can cause brain changes that result in impaired cognitive performance.

The Human Brain Likes to Be in Balance

Fortunately, the brain has some built-in safety systems. Too much cortisol in the blood signals the brain and adrenal glands to decrease cortisol production. And under normal conditions, when the stress is overcome or brought under control (by fighting, fleeing, or turning into an immobile statue, *or by mastering the threat*), the hypothalamus starts sending out the orders to stand down. Stop producing cortisol! Event over! Under *continuous* stress, however, this feedback system breaks down. The hypothalamus keeps reading the stress as a threat, furtively sending messages to the pituitary gland, which screams out to the adrenal glands to keep pumping out cortisol, which at this point begins to be neurotoxic—poison to the brain.

Bruce Perry and Ronnie Pollard, a well-respected psychiatrist-neurologist team, have contributed much to our understanding of the impact of stress and how it affects this sense of balance, or *homeostasis*, in the brain. Sometimes when stress is so intense, the delicate interaction among the brain systems designed to handle it are thrown off balance. Other researchers have also shown that intense, acute, or traumatic stress presents such a shock to the brain and the stress response system that it actually reorganizes the way the brain responds to stress. For example, neuroendocrinologist Bruce McEwen and neuroscientist Frances Champagne have shown that repeated activation of the stress response can result in physical changes, caused by too many inflammatory proteins being pumped into the bloodstream. The research of Michael Meany, a neurobiologist at McGill University, shows that adverse early childhood events (traumas) can actually change the chemistry of DNA in the brain. By a process known as methylation, little chemical markers attach themselves to the genes that control the stress hormone receptors. This makes it hard for the brain to regulate its response to stress.

Let me explain it this way: It's rather like the keys of a piano being hit so hard that the impact puts the strings out of tune. The piano still plays, but it plays differently. While another hard hit on the keys might have broken a tuned piano wire, the now-slack wire can withstand another hit . . . and another. If the hits are even harder, the wire stretches more. You can almost hear the piano (and the brain under acute stress) saying, "Go on, hit me again! I can take it." But the cost is that both are out of tune and the melody is never quite the same. In the human nervous system, this kind of adjustment or *adaptation* protects the brain from harm by changing the way it responds to stress. Perry and Pollard point out that repeated exposure to stress—chronic stress—results in a new way of coping with a continuous stressor, but it is *less effective*. Not a good thing.

Both repeated traumas and chronic stress can result in a number of biological reactions. Neurochemical systems are affected that can cause a cascade of changes in attention, impulse control, sleep, and fine motor control. Other researchers have zeroed in on specific parts of the brain that are affected by stress, and their work shows us just how refined and complex this process is. For example, Walker, Toufexis, and Davis suggest that an area of the brain called the *bed nucleus of the stria terminalis* plays a role in certain types of anxiety and stress responses. Although this area is not thought to be involved in *acute* traumatic events, these authors have shown that it is responsible for processing the slower-onset, longer-lasting responses that frequently accompany *sustained* threats. (Aha!) These authors further posit that the physiological reactions in this area may persist *even after* the threat goes away. (Ah-*HA!!*) Why is this relevant? Even when teachers and other professionals try to get these kids to move forward, the memory of past traumatic events lingers on—and impedes efforts to lead students to a higher level of competence.

All of this research has incredible significance in the discussion of kids who are under stress as a consequence of their LD and ADHD. It also has implications for students with other disorders, such as Asperger syndrome and autism. Pollard and Perry tell us that chronic activation of certain parts of the brain involved in the fear response, such as the hypothalamic-pituitary-adrenal (HPA) axis, can wear out other parts of the brain such as the hippocampus, which is involved in cognition and memory. Again, *cognition and memory:* two of the most important building blocks for successful learning, attention, and social communication.

What's Bullying Got to Do with It?

The underlying thesis of this book is that chronic stress changes brain chemistry and therefore brain function. This connection is made even stronger by a burgeoning amount of provocative new research that sheds light on the adverse impact of bullying on the brains of victims. Dr. Martin Teicher, a neuroscientist at McLean Hospital, a Harvard teaching hospital, scanned the brains of young adults who reported that they had been bullied by peers when they were younger. The brain cells in their corpus callosum, that fibrous bundle of tissue that connects the two hemispheres of the brain, showed evidence of cellular changes that were not seen in a comparable group of students who had not been bullied. The neurons in this part of the brains of victims had less myelin, that is, less of the protective coating that covers the nerves. Since myelin facilitates communication between cells, reduced myelin results in a slowdown in the transmission of brain signals. Rapid and efficient transmittal of neurological impulses in the brain is a prerequisite for effective learning and memory.

Here's the reason this is so important to the discussion of stress: because of the differences that many children with LD and ADHD exhibit (impulsive behavior, poor receptive and expressive language, poor social perception, and so on), they are more likely than other children to be victims of bullying. This is borne out both by research and by clinical observation.

What *is* clear is that a slowdown in neural transmission in the still-developing brains of young people affects learning, memory, and emotional reactivity. Dr. Tracy Vaillancourt, a psychologist at the University of Ottawa, and her colleagues found that both occasional and frequent bullying can recalibrate the amount of the stress hormone cortisol produced by a group of twelve-year-old victims. Interestingly, she also found that boys who had been bullied had very high levels of cortisol, while corresponding levels were abnormally *low* in girls who had been harassed. The exact reasons are yet unclear, but we do know that the amount of cortisol is reset or recalibrated in people and animals that are in a state of chronic stress. If girls are neurobiologically more vulnerable to stress, this might account for the difference. Dr. Vaillancourt points out that high levels of cortisol can damage and even kill neurons in the hippocampus. The impact of stress damage can be seen in the results of formal testing. Dr. Vaillancourt found that bullied teens performed more poorly than their peers on tests of verbal memory. She concludes, "Bullying likely diminishes a person's ability to cope with stress, possibly placing them at risk for psychopathology and ill health."

And here's another interesting piece of information generated by Martin Teicher's work that relates to Dr. Vaillancourt's. While Teicher did not determine a cause-and-effect relationship, he found that students who had been verbally or physically harassed reported more psychiatric symptoms, including depression and anxiety, than their bully-free classmates.

While additional research is necessary, it is impossible to avoid wondering whether the disability-bullying-stress connection is a significant factor in the lives of many of the children you and I care for and care about.

TO FIGHT, FLEE, OR FREEZE—THAT IS THE QUESTION

With a better understanding of the neurobiology of stress, the LD-ADHD-stress connection becomes clear. Students with learning disabilities or ADHD, confronted with the stress created by exposure to tasks that are *in reality or in their perception* too difficult (and thus threatening), exhibit the protective behavior of any organism under extreme stress: *They fight, they flee, or they freeze.* When these kids don't understand why they can't do what other kids can do (master the stressor), and they can't see any way to get out of a situation that won't go away, they begin to shut down. Trapped in this situation, from which there is no apparent exit, they may lash out with words or fists. They may tear up papers, throw books, or overturn desks. As much as they love their teacher, they may bite the hand that feeds them. If they override their impulse to act up or act out to escape the stress caused by a feeling of cognitive incompetence, these kids may freeze like the proverbial deer in the headlights.

Now that I've redefined No-Brainer as Know-Brainer . . . let's move on to Chapter Two, where I introduce a few kids who will help illustrate how this plays out in the classroom. Let's see what happens when stress goes to school.