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Firing the Right Cells Together

There is a revolution occurring in brain science. Not long ago it was thought that the brain you were born with was the brain you would die with and that the brain cells you had at birth were the maximum number you would ever possess. The brain was thought to be hardwired to function in predetermined ways. It turns out that this is not true. The brain is not hardwired; it's "soft-wired" by experience.

It has been a common belief that our genes dictate our thoughts, our emotions, and our behavior. Throughout the 1980s and the 1990s, the press was filled with stories on how genetics predetermine everything we experience. There were also stories about identical twins who were raised apart but who nevertheless had the same mannerisms or favored the same color. Popular culture saw these stories as evidence of the power of genetic hardwiring.

Neuroscientific research is now telling us that the brain is quite plastic. The brain you were born with is actually modified by your experiences throughout your life. Your brain is changing all the time. In fact, new brain cells can be born. Genes lay out potential and vulnerabilities, but they do not dictate your thoughts, your feelings,

or your behavior. It turns out that behavior is not rigidly determined. You can even turn genes on or off with your behavior.

Two of my books, *Brain-Based Therapy: Adult* and *Brain-Based Therapy: Child*, were written for professionals to help them teach their patients to rewire their brains, and they were based on these new discoveries. *Rewire Your Brain* explains how this information can be used directly by you. This book tells you how you can make use of the new discoveries in neuroscience. I will define and describe the following areas and explain how they can be relevant to your life:

- Neuroplasticity
- Neurogenesis
- Social systems, such as mirror neurons
- Nutritional neuroscience

The new discoveries in neuroscience shed light on how you can maximize your potential and minimize your vulnerabilities. I will describe how to apply these findings to rewire your brain so that you can feel calm and positive. So much hinges on these two abilities: by learning to be calm and positive, you can improve your ability to focus, face challenges, reach your goals, and be happy.

Learning to be calm means feeling less tense, less anxious, and less easily stressed. There are parts of your brain that, when not tamed, tend to overreact and add to needless tension, anxiety, and stress. In this book I'll describe how to get those parts rewired. The bottom line is this: how you train yourself to think, feel, and behave on a regular basis will rewire your brain and allow you to be calm and focused.

Thanks to the new discoveries in neuroscience, we know much more about how the brain works and how you can rewire the parts of the brain that are out of balance with the others, having become either overactivated or underactivated. I'll describe how those specific parts of your brain tend to become overactivated and deregulated when you feel down in the dumps, lose your optimism, and look only at the dark side. Things don't look as bright as they could look, and the glass is half empty when it could just as easily seem half full. I will describe how to activate the parts of your brain that

must be regulated and balanced so that you feel positive about your life and see the glass as (at least) half full. You'll learn to calm down in the face of stress and boost your mood when you're down. You'll also learn to improve your memory, have better relationships, and get a good night's sleep, all of which rewire your brain and thus enable you to be calmer and feel more positive.

Nurtured Nature

In order to rewire your brain, the first thing you should do is learn how the brain works. Your brain works in response to and in relation to the world around you. We have moved far away from the old debate on nature versus nurture; now we are able to “nurture nature.” Since your brain is not hardwired but is really “soft-wired,” your experience plays a major role in how you nurture your nature.

The brain weighs just three pounds, yet it's one of the most advanced organs in the body. It has a hundred billion nerve cells, called *neurons*, and many more support cells. That's equivalent to the number of stars in our galaxy.

Let's start with the brain's architecture. The neurons are clustered in the parts of the brain that have been called *modules*: the cortex (the outer layer, which has two hemispheres), the four lobes, and the subcortical (below the cortex) modules.

There has been a lot of hype about the character of the two halves of the brain. “Right-brain” people were said to be more creative, even more spiritual than “left-brain” people. The left-brain people were described as more rigid and picky. That hype, born in the 1970s, still exists, but many people who were instrumental in starting this fad have long since abandoned it. The truth is that the two hemispheres work together in everything you do. The brain contains a band of fibers called the *corpus callosum* that binds the two hemispheres together. It serves to connect distant neurons that fire together, adding dimension and depth to everything you do and think.

The corpus callosum of a woman is denser than that of a man. This means that the two hemispheres of a woman's brain work more

evenly together. The female brain is more symmetrical. The male brain has an asymmetrical torque, which means that the right frontal lobe is larger than the left frontal lobe, and the left occipital (back of the head) lobe is larger than the right occipital lobe.

For both sexes, the right hemisphere processes visual and spatial information, enabling you to grasp the “big picture.” The right hemisphere pays more attention to the context or the gist of a situation. The left hemisphere, in contrast, is more adept at details, categories, and linearly arranged information such as language. The right hemisphere is more active when you’re learning something new. Once the knowledge becomes routine and overlearned, the left hemisphere comes more into play. This is another reason that language is processed by the left hemisphere.

The right hemisphere makes better connections with the parts of the brain below the cortex, so it is more emotional by nature. In other words, it’s better able to pick up the emotional climate of a conversation. Since women’s brains have a better connection between the two hemispheres than men’s brains do, women are said to be more intuitive. Words often carry more emotional meaning for women than they do for men.

There are four lobes in each hemisphere: the frontal lobe, the parietal (middle) lobe, the temporal (side) lobe, and the occipital lobe. Each has specific talents. For example, when you appreciate a specific object, such as a chair you sat on at your friend’s house, the thoughts and feelings you have about the chair are dispersed throughout your brain. You remember the elegant shape of the chair through your right parietal lobe. You remember the words your friend used to describe his trip to Costa Rica through your left temporal lobe, and you process the tone of his voice through your right temporal lobe. You remember looking back at the chair as you were leaving the room and noticing its deep cinnamon color through your occipital lobe.

Women have a greater density of neurons in the temporal lobe, which specializes in language. This verbal advantage begins to appear during the first two years of life, when little girls develop the ability to talk about six months earlier than little boys do. When developing verbal strategies, women activate the left hippocampus (a part of the

brain related to memory) more than men do. Men generally have greater visual and spatial skills, because they show greater activity in the right hippocampus than women do.

The most recent addition to our evolutionary development is the frontal lobe, which makes up about 20 percent of the human brain. In comparison, the frontal lobe of a cat occupies about 3.5 percent of its brain. The frontal lobe is the last part of the brain to mature in humans; its development is not complete until sometime in the third decade of life.

At the forefront of the frontal lobe, the *prefrontal cortex* (PFC) gives us many of our most complex cognitive, behavioral, and emotional capacities. The PFC enables you to develop and act on a moral system, because it allows you to set aside your needs and reflect on the needs of others. The PFC is part of a system that provides you with the capacity for empathy. If your PFC is damaged, you are likely to engage in antisocial and impulsive behaviors or not engage in any purposeful behavior at all.

One of the principal parts of the PFC is the *dorsolateral prefrontal cortex* (DLPFC). *Dorsal* means “fin” or “top,” and *lateral* means “side.” The other significant prefrontal area is called the *orbital frontal cortex* (OFC), because it lies just behind the orbs of the eyes.

The DLPFC is very involved in higher-order thinking, attention, and short-term memory (which is also called working memory because it processes what you are working on at any one time). You can usually hold something you’re working on in your mind for twenty to thirty seconds. The DLPFC is the last part of the brain to fully develop, and it is also the earliest to falter during the later years of life. This is what’s behind the phenomenon of walking purposely into a room and then forgetting what you intended to do there. The DLPFC is involved with complex problem solving, so it maintains rich connections with the hippocampus, which helps you to remember things for later.

The OFC, in contrast, appears to have a closer relationship with the parts of the brain that process emotions, such as those generated by your amygdala. The OFC develops earlier in life and is closely associated with what is called the social brain. Without your OFC, you would be like the classic case of Phineas Gage. In an

accident at work, a steel rod pierced Gage's brain and skewered his OFC but left everything else in his brain intact. Gage retained his cognitive abilities but lost much of his ability to inhibit impulses. He had previously been a supervisor who was widely respected, but now he became unstable (in stark contrast to his previous emotional reserve), erratic, rude, and hard to get along with. Gage was eventually reduced to working in a circus freak show, and he died penniless in San Francisco twenty years after the injury. His skull is on display at Harvard Medical School.

Highly influenced by bonding, the OFC thrives on close relationships. If those relationships are trusting and supportive, the OFC becomes more capable of regulating your emotions. In contrast to the DLPFC, the OFC does not falter much in old age. Older adults remember faces as well as younger adults do.

Finally, there are differences between the left and the right prefrontal cortex. The right PFC helps to develop foresight and to get the gist of what's happening in a given situation. It helps you to make plans, stay on course toward your overall goal, and understand metaphor. If someone says, "Michael Phelps is a fish," it's your right PFC that enables you to understand what this person is really saying about the Olympic swimmer. Your left PFC, in contrast, helps you to focus on the details of individual events, like how many points were scored in the second half of a football game.

Neurons and Their Messengers

Within all these lobes, hemispheres, and modules are a hundred billion neurons waiting to be used. They are highly social; if they weren't used by working with neighboring neurons, they would die. Each neuron is capable of maintaining connections with about ten thousand other neurons. These connections change as you learn things, such as a new tennis swing, a new language, or the layout of a new supermarket.

Neurons function partly on chemistry and partly on the electrical firing of impulses in an on-and-off manner. Neurons communicate

with one another by sending chemical messengers called *neurotransmitters* across a gap called a *synapse*. This is how one neuron gets another neuron to fire. More than sixty types of neurotransmitters exist in the brain. Some make you excited, and some calm you down. There are many different shapes and sizes of synapses, and the shape and size of a synapse changes as you learn something new.

Two neurotransmitters account for about 80 percent of the signaling in the brain: glutamate, which is excitatory and stirs activity, and gamma-aminobutyric acid (GABA), which is inhibitory and quiets down activity. Glutamate is the workhorse in the brain. When it delivers a signal between two neurons that previously had no connection, it primes the pump for later activation. The more times this connection is activated, the stronger the wiring is between these neurons. GABA, in contrast, helps to calm you down when you need to be calm. It is the target of drugs like Valium and Ativan, which used to be prescribed as a panacea for anxiety. You need optimum GABA activity to keep your anxiety down, but you don't need those drugs, as I'll explain in chapter 6.

Although glutamate and GABA are the principal neurotransmitters, there are scores of others that play important roles in the brain. They account for only a fraction of the activity between the neurons, but they have a powerful influence on those neurons. They are widely researched, and many drugs have been designed to affect them.

The three most researched neurotransmitters are serotonin, norepinephrine, and dopamine, and they are sometimes called *neuromodulators* because they alter the sensitivity of receptors, make a neuron more efficient, or instruct a neuron to make more glutamate. They can also help to lower the "noise" in the brain by working to override other signals that are coming into the synapse. Sometimes, however, they intensify those other signals. These three neurotransmitters can either act directly, like glutamate and GABA, or fine-tune the flow of information that is being processed in the synapses.

Serotonin has attracted much publicity because of the widespread use of drugs like Prozac. Serotonin plays a role in emotional tone and in many different emotional responses. Low serotonin

levels are correlated with anxiety, depression, and even obsessive-compulsive disorder (OCD).

Serotonin is like a traffic cop, because it helps to keep brain activity under control. It's common to hear people who take drugs like Prozac say, "Things don't bother me the way they used to." However, there is also a downside: these drugs generally provide such an even keel that people say, "I know that the beauty of that sunset would've had a bigger effect on me in the past, but now I'm sort of numb to things like that."

Norepinephrine activates attention. It amplifies the signals that influence perception, arousal, and motivation. Like serotonin, norepinephrine has been associated with mood and depression. It has been targeted by antidepressants such as Ludiomil and Vesta.

Dopamine sharpens and focuses attention. It has also been associated with reward, movement, and learning, and it is one of the principal neurotransmitters that code pleasure. When registering pleasure, dopamine activates an area called the *nucleus accumbens*, sometimes referred to as the pleasure center. Activation of the nucleus accumbens has been associated with drug abuse, gambling, and other types of addictive behaviors. When this area is frequently activated, it becomes hard to stop doing the things that activate it.

Drugs that activate dopamine, like Ritalin, are used to help people with attention-deficit/hyperactivity disorder (ADHD). People (usually children and adolescents) who are given Ritalin or similar drugs not only pay attention better but also report feeling calmer.

Cells That Fire Together Wire Together

In the last twenty years, there has been an overwhelming amount of evidence that the synapses are not hardwired but are changing all the time. This is what is meant by synaptic plasticity, or *neuroplasticity*. The synapses between the neurons are plastic.

Neuroplasticity is what makes memory possible. I will devote an entire chapter to how you can improve your memory; for now, the point is that the brain changes its synapses when you remember

something new. The brain would not be able to record anything new if it were hardwired. Remembering something new is, therefore, rewiring the brain. By making connections between ideas or images, you also make connections between the neurons that encode those ideas and images.

Neuroplasticity illustrates the phrase “Use it or lose it.” When you use the synaptic connections that represent a skill, you strengthen them, and when you let the skill lie dormant, you weaken those connections. It’s similar to the way that your muscles will weaken if you stop exercising.

“Cells that fire together wire together” aptly describes the way your brain reorganizes when you have new experiences. The more you do something in a particular way, use words with a specific accent, or remember something about your past, the more the neurons that fire together to make this happen will strengthen their connections. The more the neurons fire together, the more likely it is that they will fire together in the future.

Just as “Cells that fire together wire together” has become a sort of mantra in neuroscience, so too has an opposite phrase been coined: “Neurons that fire apart wire apart.” This means that neurons that are out of sync will fail to link. It is the neural explanation for forgetting.

In other words, the more you do something, the more likely it is that you will do it again in the future. That’s why baseball players go to batting practice, golfers go to driving ranges, and piano players practice for hours on end. The same goes for thinking. The more you think about your Aunt Matilda, the more she will pop into your mind again and again. Repetition rewires the brain and breeds habits.

When neurons fire together often, they begin to fire together at a quicker rate. This leads to increased efficiency, because there is more precision in the number of neurons that are required to do a particular skill. For example, when you learned to ride a bicycle, you used more muscles and neurons at first as you wobbled; then, once you learned to ride efficiently, less muscular effort and fewer neurons were required, and your ride was much smoother and faster.

The neurons that were required to fire with their partners had teamed up and wired together.

As you become more talented at a specific skill, a greater amount of space in your brain is devoted to making that possible. Alvaro Pascual-Leone of Harvard Medical School used transcranial magnetic stimulation (TMS) to measure specific areas of the cortex. He studied blind people who read braille and found that the cortical maps for their reading fingers were larger than the cortical maps for their other fingers and also for the fingers of sighted readers. In other words, the sensitivity of their reading fingers required more space. Thus, cultivated movement enhances neuroplasticity, which creates extra space in the brain.

In another example of the power of neuroplasticity, musicians who play string instruments were examined to see if their brains had reorganized to accommodate more space. There was no difference between the string-instrument players and the nonmusicians in how much space was made available in the sensory motor strip (the area in the center of the brain that controls movement and physical sensation) for the fingers of the right hand (in right-handed players). However, the area of the brain devoted to the fingers of the left hand (in right-handed players) showed a dramatic difference. The fingers of the left hand must be nimble and dexterous in order to make all the fretting movements. The cortical space devoted to the fingers involved in fretting was significantly greater in these musicians than in nonmusicians. This difference was greatest if the musician had started playing the instrument before the age of twelve. In other words, although this use-dependent neuroplasticity occurs during adulthood, it is more dramatic the earlier and the longer that the person plays the instrument.

Not only does behavior change the structure of the brain through neuroplasticity; just thinking about or imagining particular behaviors can change brain structure as well. For example, researchers have shown that simply imagining a session of piano practice contributes to neuroplasticity in the area of the brain associated with the finger movements of playing the piano. Thus, mental practice alone contributes to the rewiring of the brain.

How Neuroplasticity Occurs

A process called *long-term potentiation* (LTP) occurs when the excitation between cells is prolonged. This strengthens the connections between the cells and makes them more apt to fire together in the future. Thus, LTP is relatively long-lasting.

LTP essentially strengthens the affinity between neurons by reconfiguring their electrochemical relationship. On the sending side of the synapse, the stores of glutamate (the excitatory neurotransmitter) are enhanced, and the receptor side is reconfigured to receive more. The voltage on the receptor side becomes stronger in its resting state, which attracts more glutamate. If the firing between these neurons continues, the genes within the neurons are turned on in order to construct more building blocks for the infrastructure and enhance the relationship.

One of the most important players in both neuroplasticity and neurogenesis is something called *brain-derived neurotrophic factor* (BDNF). This belongs to a family of proteins that enhance brain cells. BDNF has been shown to help build, grow, and maintain the infrastructure of cell circuitry. It is one of the hottest areas of research in neuroscience today, and more than a thousand articles have been written about its amazing fertilizer-like functions. It has even been called “Miracle Grow” by many, because when it’s applied to cells, it causes them to grow. A vivid illustration of BDNF’s super-fertilizing effect occurs when researchers sprinkle BDNF onto neurons in a petri dish. Those neurons sprouted new branches much as they do in the brain during learning and development.

BDNF does its magic in variety of ways. It works within the cell to activate the genes that increase the production of proteins, serotonin, and even more BDNF. It binds to the receptors at the synapse, triggering a flow of ions that increases the voltage, which in turn strengthens the connectivity between the neurons. In general, BDNF prevents cells from dying and enhances their growth and vitality. BDNF is activated indirectly by glutamate and increases the production of internal antioxidants and protective proteins. It stimulates LTP, which is fundamental to neuroplasticity.

LTP and BDNF go hand in hand. Researchers who work with the brains of various animals have shown that stimulating LTP by learning increases the BDNF levels. When researchers deprived the brains of BDNF, the brains also lost their capacity for LTP.

Use strengthens connections, and nonuse weakens them. Old connections that are not strengthened by relationships will fade.

Just as the brain needs the LTP mechanisms that strengthen the connections between neurons so that you can remember, it also needs those that will help it to forget. A process known as long-term depression (LTD) helps you to unlearn bad habits. (Note: LTD has nothing to do with the emotional state called depression.) LTD helps you to weaken the connections between the neurons that support an old habit. The weakening of old connections gives you more available neurons to use for the new connections that you establish with LTP.

To understand this principle, consider that the age at which you learn a language affects whether you speak with an accent. If you learn a new language while in your twenties, it's highly probable that you will speak that new language with an accent from your first language. If you learn a new language at age nine, however, you probably won't have an accent tinged by your first language. When you learn a new language as an adult, the neurons that have always connected to make specific sounds tend to continue to fire together even when you try to make different but related sounds.

The more you talk to people who don't share your accent, the greater is the chance that your accent will fade. For example, both my parents grew up in the Greater Boston area. A few years after I was born, my family moved west. My parents gradually lost their Boston accents as they spoke with people who had moved west from all over the country or who had grown up there.

When you develop new ideas or insights, change in your brain occurs much more quickly than when you learn a new language or lose an accent. Certain parts of the brain are very talented at putting information together quickly so that you can make decisions without mulling things over for hours or even days.

The discovery of *spindle cells* (or *spindle neurons*) has focused attention on people's ability to make effective snap decisions. Spindle neurons are found in great numbers in the part of the brain called the *cingulate cortex*. These neurons are able to connect divergent information quickly and efficiently in ways that have not been seen in other species. Spindle cells provide a unique interface between your thoughts and your emotions. As such, they aid your ability to maintain sustained attention and self-control. They provide you with the flexibility to make quick but complex problem-solving decisions in emotionally stirring situations.

Spindle cells can't do their magic, however, if they have little to work with. In other words, you have to lay the rewiring groundwork in your brain by learning new information and forming new talents. Snap judgments and insights are made by integrating information from neural nets that you have already formed.

Snap Judgments

The spindle cell is a class of neurons that responds extremely quickly. It is found to be more abundant in the human brain than in that of any other species. The human brain has a thousand times more spindle cells than our closest ape relatives possess. Many theorists regard this as one of the reasons we can make snap judgments. These cells are so named because they look like spindles, with a large bulb at one end and a long, thick extension. Because they are about four times larger than other neurons and have such long and thick dimensions, they are believed to make high-velocity transmission possible. Hence the *snap* in *snap judgment*.

The location of spindle cells and their connection of the regions of the social brain illustrate their importance in social relatedness, emotion, and therapy. Spindle cells have rich synaptic receptors for dopamine, serotonin, and vasopressin, which play a role in mood and thus in our emotional experiences and bonding. They form connections between the cingulate cortex and the OFC.

The front portion of the cingulate cortex contains many spindle cells that connect diverse parts of the brain and are involved in bonding and social communication.

Let's say you are on your way to New Orleans for vacation when you hear a radio report that Hurricane Katrina is about to hit the city. Your spindle cells kick into action, and you immediately reroute to Houston. Once you are in Houston, you hear that hundreds of Katrina evacuees are being sent to the Astrodome, so you decide to spend part of your vacation volunteering in a soup kitchen there. These were all snap decisions that were made in complex and emotionally charged circumstances. Years later you may view that vacation as one of your most rewarding and memorable.

Every time you remember that story, certain synaptic connections are strengthened and certain ones are weakened, based on the details that you remember. As you discuss the events that led you to Houston, the story becomes modified, and so does your brain. Your friends may talk about the government's poor response, and other synaptic connections are made with those memories. You are essentially rewiring your brain every time you review the story in your mind.

Deep within the brain are two structures that are involved in memory. One is the *amygdala*, named after the Latin word for "almond," *amygdalon*, because of its shape. The amygdala is triggered by intense emotional states like fear, and it assigns emotional intensity to the incoming information. The amygdala can be triggered by a quick glance from a very attractive person or by your boss glaring at you. It often serves as a sort of panic button.

The other memory structure is called the *hippocampus*, the Greek word for "seahorse," because of its shape. Researchers have recently discovered the birth of new neurons, or *neurogenesis*, in the hippocampus. Scientists had previously believed that neurogenesis was not possible. The discovery of new neurons in a part of the brain that lays down new memories highlights the importance of cultivating your memory skills to rewire your brain.

The hippocampus and the amygdala are involved in two different types of memory: explicit and implicit, respectively. Explicit

memory is used when you try to remember what you had for dinner last night, when your next dental appointment is, or the name of a familiar-looking woman who's standing next to the water cooler. These are facts, dates, words: pieces of information. It is this type of memory that people often complain they are losing.

Implicit memory is often thought of as unconscious memory. It reacts to the emotional intensity of events and situations; when the situation is potentially dangerous, it activates the fear system in your body. This is often called the fight-or-flight response.

This alarm system is automatic; that is, it happens before you have time to think about it. Thousands of years ago, when our ancestors encountered a predatory animal like a lion, it was best to react immediately and not stand around thinking about the lion, admiring its beauty or wondering why it was bothering them instead of tracking down some tasty antelope. Thus, the fast track to the amygdala kept our ancestors alive.

A balance between your sympathetic nervous system (which activates you) and your parasympathetic nervous system (which calms you down) allows you flexibility. I'll describe this in detail in chapter 9. These systems, along with the circadian rhythm, nutrition, exercise, relaxation, and meditation, can help you to be calm and positive.

Let's change the Hurricane Katrina story and say that you didn't go to Houston. You might have been so filled with anxiety that you drove like mad straight north to escape the driving rain. At one point you pulled over because you couldn't see the road in front of you. A tree limb fell on your car, and you were filled with even more anxiety. Months later, during a rainstorm, you feel a surge of anxiety. You don't know why you feel this way, but your amygdala remembers quite well, because it triggers your hippocampus and cortex to remind you of the day you escaped Katrina.

The amygdala helped you by stirring enough fear in you to make you pull off the road, but it also made you oversensitive to rainstorms. The problem is that this fear system is activated even when you don't need to be fearful. In other words, sometimes it is turned on when it would be better to have it turned off. Chapter 2 describes

how you can tame your amygdala so that it doesn't become overactivated when you need to stay calm.

Your frontal lobes are sometimes called the executive brain or the executive control center because they are important in orchestrating the resources of the rest of your brain. The frontal lobes decide what to do, how to stay positive, and how to appreciate the larger picture of life. By being positive and active, you'll rewire your frontal lobes.

The OFC and some other parts of the brain constitute what has been called the social brain because this system of neurons thrives on social interaction. When these neurons are activated effectively, you experience fewer psychological problems and better mental health. Chapter 7 is devoted to the many benefits of your social brain networks.

The bonding experiences you have had with your parents since the beginning of your life have affected your social brain. Your later relationships then modify those neural connections. Positive relationships enhance your sense of well-being, whereas negative relationships leave you with the opposite feeling.

We know that neurochemicals such as oxytocin are involved in childbirth and bonding, and that later in life they become activated in intimate relationships. Higher oxytocin levels help to blunt pain and make us feel comforted by other people. For this reason, oxytocin is referred as the "cuddling hormone."

The recent discovery of *mirror neurons* has shown that parts of your brain are acutely sensitive to the movements and intentions of others. Mirror neurons allow you to mirror another person, or to feel what he or she feels without even thinking about it. For example, when a friend yawns, have you ever found yourself yawning immediately afterward? Mirror neurons are essentially the brain-based explanation of empathy.

In the story of how you helped at the Houston Astrodome after Hurricane Katrina, it was your mirror neurons that made you feel empathy for the evacuees.

Mirror neurons give people the capacity to form relationships and to thrive from them. People with autism have few mirror neurons

or dysfunctional ones. It has recently been proposed that the mirror neuron system is actively involved in your relationship with yourself as well as with others. For example, when you volunteered at the soup kitchen at the Astrodome, you felt good about yourself when people thanked you.

Some researchers have proposed that experiencing empathy and compassion through the mirror neuron system is equivalent to having compassion for yourself. Thus, “giving is receiving” is a brain-based truth. Insensitivity and selfishness are essentially bad for your brain and your mental health. In contrast, compassion and loving relationships are good for your brain and your mental health.

The mirror neuron system has also been identified as the part of the brain that is involved in mindfulness meditation and prayer. The calming and focused practice of mindfulness meditation or prayer wires the brain circuitry that promotes better health.

Many neuroscientists have recently explored the effects of meditation and prayer on the brain. Tibetan monks have been found to have rewired their brains from years of meditation practice. These monks were examined during certain types of meditation using functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and other techniques. Thanks to these studies, we have a picture of what is occurring in the meditating brain. We know that the mindful brain can promote health and well-being. You, too, can benefit by rewiring your brain through mindfulness. I will explain how this is done in chapter 9.

FEED Your Brain

Now that you have a better idea of how the brain works, let's focus on a method of rewiring your brain that involves the following four steps:

- Focus
- Effort
- Effortlessness
- Determination

To help you remember these steps, use the acronym FEED, as in feeding your brain. Now let's examine each step in detail.

Focus

You need to pay attention to the situation, the new behavior, or the memory that you want to repeat or remember. Attention activates your frontal lobes, which ensure that other parts of the brain are also engaged. You may think of this step as the alert function. You can't rewire your brain without opening the gate or initiating the change. Focus gets the ball rolling.

Attention and the frontal lobes play important roles in neuroplasticity. Think of the PFC as the brain's brain: it helps to direct the resources to what is important. When you are on automatic pilot, such as when you are driving on a highway and talking to your friend in the passenger seat, your attention is directed to the conversation. The conversation is what you will remember, not the trees and the houses along the road. If, however, you talk about what you both notice on the highway, your attention has shifted and you will remember the physical details of the journey. If you talk about these details of the journey later, you'll strengthen those memories. If you don't discuss those details later—that is, direct your attention to them—the chances are that those memories will fade.

Thus, simply focusing attention doesn't ensure that your brain has been rewired. You focus on a hundred thousand experiences every day, and your brain can't possibly remember all the things you experienced. Focus allows you to pay attention to what's happening here and now, and this starts the process of neuroplasticity.

Effort

Effort shifts your attention from perception to action. Making a focused effort activates your brain to establish new synaptic connections. When you begin to make an effort, your brain uses a lot of glucose to learn something new. By observing PET scans, neuroscientists have amassed considerable information in the last two decades about what parts of the brain light up in the scan due to glucose metabolism when someone is thinking or feeling something.

When you're making an initial effort to do something, the area of your brain associated with that task shows up in the scan as being in use.

Effortlessness

After a new behavior, thought, or feeling has been established, it takes less energy to keep it going. It's like learning a new tennis swing or how to say hello in a new language. In the beginning, it takes focus, effort, and more energy in your brain, but after you make the swing or say hello enough times, it becomes effortless. Thus, to rewire your brain you'll have to stay with the new behavior long enough to make it become fairly automatic. In time, practice will make it effortless. Your brain won't have to work as hard once you reach this level.

The body and the brain follow natural laws, and the natural law that applies to the concept of effortlessness is called the Law of the Conservation of Energy. This means that the things that happen are usually things that happen easily. For example, all water flows downhill. The deeper the creek, the more water flows in it. The same is true for your brain: the more you use certain brain cells together, the more you will use them together in the future.

As PET scans illustrate, when a person becomes more proficient in a particular skill, the brain region associated with that skill labors less. This illustrates the fundamental principle of efficiency: what comes easily will be repeated because it's easy.

Once you have developed a pattern—the tennis swing or saying hello in French with the right amount of inflection—it will become easier to do the next time you try. What if you stop doing it, however? If you haven't played tennis in ten years, you won't swing as well immediately. If you go to France ten years after taking a class in French, you won't be as fluent as you were in the class (unless, of course, you have practiced in the meantime). You have to do the activity often to retain the ability. You'll certainly play tennis better than if you never played before, or your French will come back more quickly, but if you practice doing these things, your brain will remain wired to perform them effortlessly.

Determination

The final step in feeding your brain is staying in practice. Do the activity again and again. Being determined in this way need not be tiring and painful. If you practice the other three steps in feeding your brain, by the time you get to this one, it should come easily. That's because effortlessness precedes it. Thus, determination simply means that you stay in practice. By being determined, you'll complete the feeding process to rewire your brain.

Now that you know the four basic steps or principles, we'll look at how you can apply them in your daily life. In chapter 2, we'll discuss dealing with anxious feelings, needless worries, or just plain fear, and in chapter 3 we'll address how you can avoid feeling down in the dumps.

The story below illustrates how important it is to make a commitment to take an active role in rewiring your brain. This is not like simply learning a new trick; it requires the process we have described as feeding your brain.

Marlee Feeds Her Brain

Marlee came to see me, complaining that she was fed up with being moody and "always feeling out of sorts." She said that she tended to be irritable and easily stressed, and when she started to feel that way, it was hard to shake it.

"I want to be positive and enjoy my life like everyone else," she said, shaking her head woefully. "I heard that you know how to rewire people's brains. Please rewire mine."

"Are you willing to do the work that it will take to change your brain?" I asked.

"Why can't you do whatever it is that you do?" she insisted. "I'm tired of trying all these gimmicks that are supposed to work but never do."

"When you try something new, how long do you stay with it?" I probed.

“Long enough to know that it doesn’t work,” she stated matter-of-factly.

I gently prodded her for a clear answer of how long.

“A day or two is enough to know,” she said, as if that confirmed her strong effort.

I explained that for neuroplasticity to work, especially for mood-related issues, she would have to stay with the new behavior until it became effortless to do it. “You must practice doing it until it becomes a new habit,” I told her. “The key is that you need to get started. Usually, that means doing what you don’t feel like doing and continue doing it until it becomes easy.”

“You mean forcing myself to do something against my nature?” she asked incredulously. “Isn’t that unnatural?”

“Actually, it’s very natural,” I answered. “That’s how you learn new skills. When you study for a test you go over material repeatedly until it’s not hard to remember it.”

“I just crammed the night before and it worked just fine,” Marlee informed me. “I passed the courses. That’s all I cared about.”

“Do you remember the subject matter now?” I asked. She shook her head no. I invited her to pick a habit that she wanted to break.

“My family would say it’s my irritability,” she admitted.

“Do you feel bad about it?” I wanted to know.

“When it happens, it seems as if they deserve what I say to them,” she noted. “Only later does it become obvious that I was shooting my mouth off and they didn’t deserve it.”

“It’s important to establish that it’s *you* who really wants to change and not just that your family wants you to,” I emphasized. Motivation is a very critical component of neuroplasticity. You can’t change unless *you* really want to change. A passive effort just won’t work. The activation of the PFC, the brain’s brain, marshals all the resources.

“Yes. I’m sick of myself like this,” she said solemnly. “I’m ready to do something.”

“Let’s start at the point at which you feel the impulse to say something,” I instructed. “That’s when we want to interrupt your impulse.

You say something before you allow yourself the time to think first and then do something else.”

The first step for Marlee was to stop what she was doing and *focus* her attention on the moment before she reacted impulsively. A time-out step like this is used in anger management classes, yet here the task is to go further and focus on being an observer who is detached from the immediacy of the emotional reaction. This allows the PFC to gain better inhibitory control over the amygdala-driven emotional reactions. Marlee’s PFC had to develop better adaptive strategies in order to draw attention to what she was angry about rather than the way she expressed her anger.

Next, Marlee needed to make an *effort* to do something different from her usual impulsive verbal comment. She had to act in a way that was different from her usual irritable manner in which she spoke first and thought later. She needed to learn to think first and speak later.

Marlee needed to repeat this effort enough times so that she eventually found it *effortless* to do so. She worked with focus and effort until it was effortless, feeding her brain for several weeks; then she came back in and said, “Well, I don’t have to work on that anymore—I’ve got that down.”

I told her that she needed to continue working with *determination* to solidify the new habit. Rather than become lazy and take a break, she had to continue to “work out” in order to “stay in shape.” It is only by staying determined that she will be able to rewire her brain.

Test Yourself

Here is a quick quiz that will get to the heart of what’s holding you back from rewiring your brain.

1. To rewire your brain, it’s important to do what?
 - a. Stay within your comfort zone
 - b. Do what comes naturally to you
 - c. Challenge yourself to change your behavior and then stay with it

- d. Wait until you feel motivated to change
- 2. What does the acronym FEED, a mnemonic device to help you remember the steps to rewire your brain, stand for?
 - a. Feel good, Exhale, Excite, and Dictate
 - b. Focus, Effort, Effortlessness, and Determination
 - c. Fail, Engage, Encourage, and Describe
 - d. Freedom, Effortlessness, Entertainment, and Doing little
- 3. If you're troubled by anxiety, it's best to do which of the following?
 - a. Avoid what makes you anxious so that your amygdala will calm down
 - b. Take some medication to numb your amygdala
 - c. Expose yourself gradually to what makes you anxious
 - d. Ask your family to shield you from stress
- 4. If you're down in the dumps, it's best to do which of the following?
 - a. Hide out from family and friends until you feel up to seeing them
 - b. Draw the drapes, stay inside, and rest
 - c. Get out of the house, exercise, and engage in activities
 - d. Self-medicate with alcohol and/or sweets to soothe your feelings
- 5. When you're trying to improve your memory, it's best to do which of the following?
 - a. Rest your mind so that you will have enough energy to remember
 - b. Multitask
 - c. Rely on your friends to remember things for you
 - d. Focus your attention, form associations, and review your memories
- 6. What should you do to improve your diet so that you can more easily rewire your brain?
 - a. Eat large amounts of fried foods, sugar, and processed foods
 - b. Eat three balanced meals per day and hydrate with water throughout the day

- c. Eat one good hearty meal and consume plenty of caffeine for energy
 - d. Vary your food intake to meet your hunger pains
7. In old age, what is the best way to boost cognitive reserve and delay or prevent dementia?
- a. Minimize your mental strain by staying with a monotonous routine
 - b. Vary your activities, learn new things, and stay socially connected
 - c. Rest and stay away from any kind of stress
 - d. Have a cocktail in the evening and ruminate about the past
8. Five habits that form the foundation for a healthy brain can be remembered as “planting SEEDS.” What does this acronym stand for?
- a. Safety, Escape, Exit, Distance, and Soothingness
 - b. Sensation, Entertainment, Ecstasy, Distraction, and Slipping away
 - c. Stifle, End, Execute, Do, and Stonewall
 - d. Social medicine, Exercise, Education, Diet, Sleep hygiene
9. To build a resilient brain, you should do which of the following?
- a. Cultivate optimism, inoculate yourself with manageable stress, and challenge yourself
 - b. Make pessimism your default mode so that you will never be surprised
 - c. Avoid stress at all costs
 - d. Save your energy for times of need
10. A mindful brain does which of the following?
- a. Shuts down, checks out, and is otherwise mindless
 - b. Is in the here and now, savoring every moment and sensation
 - c. Looks for constant distraction from the stress and strain of the moment
 - d. Is holier than thou

I will explain in detail what you need to know to answer these questions in the remaining chapters of this book.